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Flood Operations of Wivenhoe and Somerset Dams

Notes on the Analysis of the Late December 2010 Flood Event

Introduction

This modelling has been undertaken to investigate whether the flood storage in Somerset and Wivenhoe Dams could be drained down to 75% of the current Full Supply Level (FSL) storage capacity following the 'Late December 2010' flood event.

This report looks at the effect of adopting different operational releases during the final stage of the final drainage phase of the flood storage in Wivenhoe Dam following the 'Late December 2010' flood event prior to the onset of the January 2011 flood event.

The performance of the dams depends on:

- the magnitude of the flood event coming into dams
- the timing and the magnitude of downstream inflows
- the required 'end of event' target storage levels in each reservoir

The following scenario was modelled.

- Flood operations in accordance with Revision 7 of the Flood Mitigation Manual for flood operations for Wivenhoe and Somerset Dams (Seqwater, 2010).
- Initial storage levels as they were prior to the late December 2010 flood event i.e. Wivenhoe Dam at EL 67.3 mAHD and Somerset Dam at EL 99.45 mAHD.
- Somerset Dam was assumed to be operated the same way it actually was operated during the late December flood event. This was reasonable because the flood storage in Somerset was effectively drained into Wivenhoe Dam well before the start of the January event and variations would not significantly affect the overall results.
- After the peak of the event as it passed through Wivenhoe Dam, the flood storage would be drained to return Wivenhoe Dam to EL 67.0 mAHD and Somerset Dam to EL 99.0 mAHD. This part of the drainage phase would follow the existing flood operating rules contained in Revision 7 of the FMM.
- Following the event, final drainage of Wivenhoe Dam from EL 67.0 mAHD (100%) to EL 64.0 mAHD (75%) would be undertaken using an operational release not exceeding an adopted maximum Lowood discharge criteria.

Under the current Manual the flood storage should be drained within seven days of the peak in Wivenhoe Dam. However it is recognised that, for major flood events, this period may need to be extended so as not to cause additional flooding problems during the drainage phase. Similarly, for relatively small flood events, it may be possible to reduce the drainage time to prepare the storages for the next event earlier. It is up to the Senior Flood Operations Engineer to determine how quickly the flood storage should be drained and whether/how this needs to be adjusted because of the magnitude of the event and whether more rain is forecast in the catchment.

Details of the 'Late December 2010' flood event were taken from the Seqwater flood event report for this event (Seqwater,2011).

Details of Modelling

The model was based on an EXCEL spreadsheet which was developed following the January 2011 flood event to model the operations of Wivenhoe Dam and Somerset Dam. Macros were developed to mimic the strategies contained in the *Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam* (version 7, November 2010) (the Manual).

For the purposes of this modelling, it was adopted that the event started at midnight on the night of the 25th December 2010. There were some inflows prior to this time but these are reflected in the starting level at that time. i.e. When the FSL of Wivenhoe was EL 67.0 mAHD, the starting level for the modelling was EL 67.3 mAHD and the level in Somerset was EL 99.45 mAHD.

Inflow hydrographs were based on the modelled inflow hydrographs set out in the Seqwater Flood Event report (Seqwater, 2011).

Note that in the Figures displaying the results of the flood routing studies in this report, the Lockyer discharge hydrographs were 'brought forward' by two hours to more clearly show how the hydrographs would have combined when the flows combined with the Brisbane River flows. Similarly, the Bremer River flows were brought forward by fifteen hours to allow for the travel time from Wivenhoe Dam to where the Bremer River joins the Brisbane River.

The discharge from Wivenhoe Dam was controlled by:

(a) Applying the operating strategies set out in the Flood Mitigation Manual

(b) Limiting the discharge from Wivenhoe to magnitude of the maximum inflows into the storage up to that time so that releases did not aggravate downstream flooding.

(c) Limiting the discharge from Wivenhoe to limit the maximum discharge at Lowood to 1900 m^3/sec. Note that while Strategy W2 was triggered there was no need to increase the discharge beyond 1900 m^3/sec to control the flood event.

(d) Once the peak headwater level in Wivenhoe Dam had been achieved, the strategy was to continue at the maximum discharge during the drainage phase down to EL 67.0 mAHD until the flow could be reduced to a targeted maximum operational release and to open downstream crossings.

(e) Once the Wivenhoe headwater level drops below EL 67.0 mAHD, the releases from Wivenhoe Dam during the final drainage to EL 64.0 mAHD transitioned to the maximum operational release. This analysis examined maximum operational releases of 430 m^3/sec and 700 m^3/sec.

(f) File: G:\WIR\Dam Safety\QLD Floods Commission\Modelling\Effect of Late Dec flood\GateOPsv4a-Dec 2010 Case 4 67 to 64 restricted to 430.xls

Limitations on the Accuracy of this Modelling

Overall the results of these analyses should be indicative of what would have occurred during the actual event had Wivenhoe Dam been operated in the way indicated.

However, any such modelling is always an approximation of what might actually occur in real life. Usually, the more detailed the modelling, the more accurate the

results will be. These limitations limit the ability to transfer the results to actual events and the results need to be treated with care.

These limitations, which are discussed in more detail in the following paragraphs, relate to:

(a) The accuracy of the modelling of the physical processes involved; and

(b) The way the dams are operated during the flood

Because of these limitations, the results are more 'a relative indication' of what might occur for these events rather than a real time simulation.

Accuracy of the Modelling of Physical Processes

The model does not take into account any of the attenuation effects as the flood peaks from the dams move downstream. Instead the discharges from the Lockyer were lagged by 2 hours and the discharges from the Bremer were lagged by 15 hours to take into account the approximate travel time between Wivenhoe Dam and the locations where these tributaries enter the Brisbane River.

Because no damages were involved in this flood event, the consequences of this 'simplification' are not considered very significant.

Accuracy of Modelling of Flood operations

The modelling is in effect done in 'hindsight' with the actual flows known to a relatively high degree of accuracy. As such, it did not consider the uncertainties that Duty Flood Operations Engineers must consider when determining the magnitude of flood releases. These include:

- The degree of saturation of the Brisbane River catchments. They would have been saturated at the time and would have responded quickly to rainfall.
- The accuracy of the BoM forecast rainfalls and their intensity
- The 'representativeness' of the recorded rainfalls
- The accuracy of the hydrologic modelling converting the 'recorded' rainfall already on the ground into runoff and the discharge estimates downstream tributary inflows
- Short term local flooding effects in downstream areas which may occur after the releases have been made from the dam.
- The consequences of 'getting it wrong'. For instance, if a crossing was inundated unexpectedly and someone was injured/killed as a result, who would wear the blame?

The flood engineers consider all these things when determining the magnitude of releases. There thinking on these issues was not known at the time this modelling was undertaken.

Because this modelling was based on an historical flood event, the magnitude and the timing of the flood hydrographs were 'known'. This meant that the dams could be operated 'aggressively' in this simulation without fear of 'getting it wrong' and right up to the limits specified in the Manual.

Thus some conservatism would have been appropriate if, for instance, a maximum release of 430 m^3/sec was targeted to keep Burton's Bridge trafficable. Because of the potential consequences of unforecast rainfall, the Duty Engineer might have considered it judicious to limit the discharge to about 350 m^3/sec to provide a margin for 'error'.

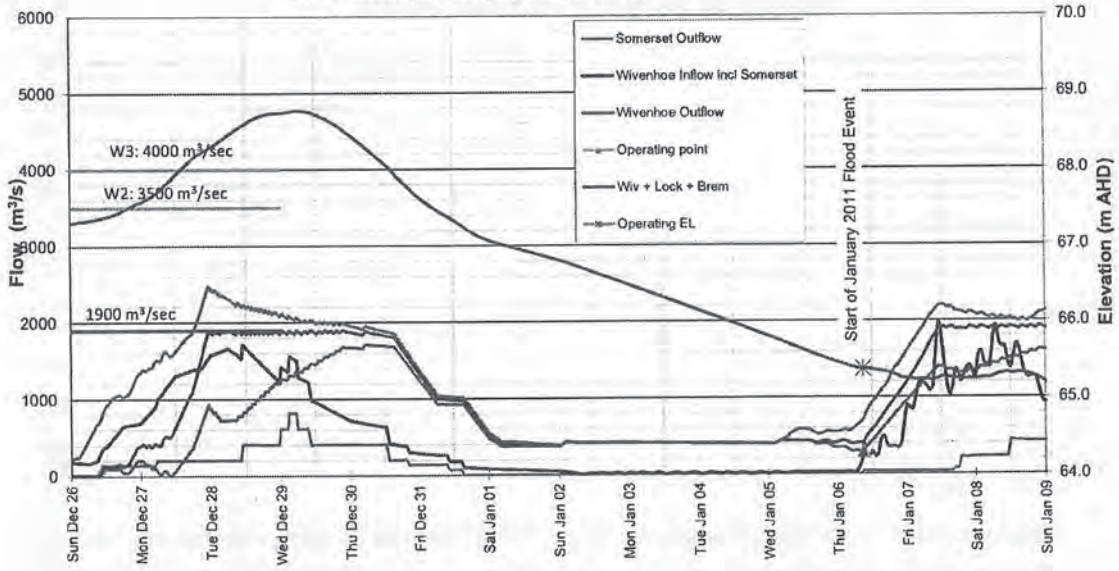
Maximum Operational Release of 430 m^3/sec

The results of this analysis are summarised in the following Figure. They indicate:

1. If the maximum operational release is 430 m^3/sec, it would not have been possible to drain the flood storage before the onset of the January 2011 flood event and the mobilisation of the Flood Operations Centre at 9:00 am on the 6th January.
2. This would have made Burton's Bridge trafficable after about 5 days during the late December flood event. This is important because Burton's Bridge is the sole point of access for people living on the left bank of the Brisbane River at that point.
3. At the time of the mobilisation of the Flood operations Centre, Wivenhoe would have been at about 86% of the Full supply Level (FSL) storage capacity and the benefits of reducing the FSL to 75% capacity would have been only partly achieved.
4. It would also have taken about 8 days to drain to that point – well beyond the preferred 7 days specified in Revision 7 of the FMM.
5. It is difficult to see how the Flood Operations Engineers would have foreseen how such a big flood event as the January 2011 event was coming at that time so that discharges could have been increased ahead of this event.

Wivenhoe Dam: Late December lead into January 2011 Flood Event

Starting with FSL at EL 67.0 mAHD, returning to EL 64.0 mAHD with a maximum discharge of 430 m^3/sec



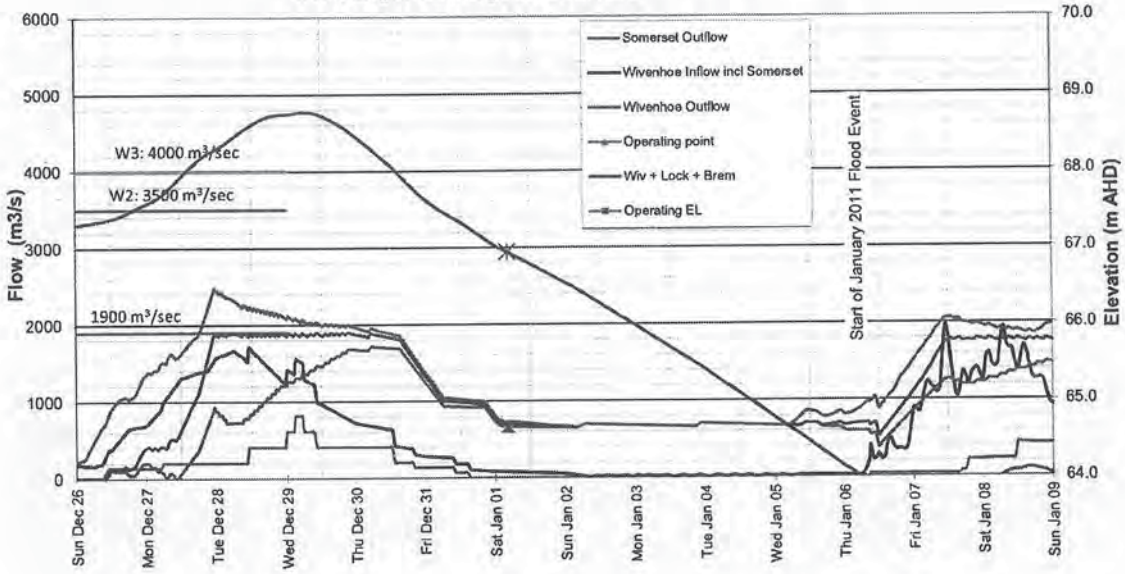
Maximum Operational Release of 700 m^3/sec

Given the benefit of hind sight, an operational release of about 700 m^3/sec is required to reduce the level in Wivenhoe down to EL 64.0 mAHD prior to the January 2011 flood. This is illustrated in the following Figure.

One important consequence of this scenario is that access across Burton's Bridge would have been unavailable for about 23 days during the late December flood event until it would have reopened about the 19th January 2011.

Wivenhoe Dam: Late December lead into January 2011 Flood Event

Starting with FSL at EL 67.0 mAHD, returning to EL 64.0 mAHD with a targed discharge of 700 m^3/sec.



References

- Seqwater, 2010 "Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam", version 7, November.
- Seqwater, 2011 "October - December 2010, Flood Events, Report on the Operation of Somerset Dam and Wivenhoe Dam", May

Peter Allen
23nd August 2011
RPEQ 2979.
Project Director, Dam Safety
Office of Water Supply Regulator
Department of Environment and Resource Management

INCIDENT ALERT
ENRR DIVISION

TYPE OF ALERT:	Dam Safety Incident
INCIDENT NAME:	**Plunge Pool Erosion: Wivenhoe Dam**
ALERT DATE:	**24 January 2011**
ALERT VERSION:	**Update**
ECOTRACK & FILE REF:	**DAM/130/000(0377)**
RESPONSIBLE MINISTER	Stephen Robertson MP, Minister for Natural Resources, Mines and Energy and Minister for Trade
CONTACT OFFICER:	**Peter Allen**

NAME OF ALLEGED SOURCE:
- John Tibaldi, Seqwater

DATE AND TIME OF INCIDENT:
- 05:30am 19 January 2011

INCIDENT NOTIFIED BY: *(entity and person)*
- John Tibaldi, Seqwater

DATE, TIME, METHOD OF NOTIFICATION:
- Approximately 5.30 am, 19 January 2011, by phone to Peter Allen (Director, Dam Safety)

LOCATION OF INCIDENT:
- Wivenhoe Dam

SUMMARY OF INCIDENT AS NOTIFIED:
- The flood waters released by the Wivenhoe dam spillway gates pass through a plunge pool energy dissipater and along a rock chute to return to the Brisbane River.
- After a major flood event such as has been experienced, some erosion around the edges of the plunge pool is likely. This has apparently occurred
- It is a reportable dam safety incident (It does not relate to the Flood Mitigation Manual)

POTENTIAL IMPACTS:
- If the erosion is very severe, then it could ultimately compromise the safety of the dam. However, Seqwater staff have advised that the erosion does not look serious, and will not affect dam operations—including operation of the flood gates

RELEVANCE TO NEIGHBOURING LANDHOLDERS:
- There is no apparent safety risk

ACTIONS TAKEN BY COMPANY OR SOURCE OF THE INCIDENT:

- Seqwater undertook a preliminary inspection on the morning of the incident. Russ McConnell of OWSR Dam Safety also inspected the site for that inspection. His report is available on request.

- SunWater has undertaken a bathymetric survey of plunge pool and spillway chute and the results of this survey should be available soon. However, preliminary reports indicate that the damage is minor in the plunge pool and non threatening in the spillway chute.

DERM's ASSESSMENT AND PLANNED ACTIONS:

- Based on Seqwater's advice, there is no dam safety risk, and there are no impediments to the flood gates' operations.
- A senior DERM dam safety engineer has been dispatched to the site by road. A copy of his report is available if needed.

NEXT UPDATE EXPECTED : When Seqwater report becomes available.

COMMUNICATION:

- No other parties have been notified
- If media statements are required, then these would normally be progressed through the dam owner i.e. Seqwater.

MAP OR PLAN OF SITE:

seqwater
WATER FOR LIFE

WIVENHOE DAM

Post January 2011 Flood Event Embankment Analysis

June 2011

Revision		Draft for Review
Report Prepared by	Michael Peel / Barton Maher	
Reviewed and Certified	Barton Maher (RPEQ 6833)	
Approved for Issue	Jim Pruss (EGM Water Delivery)	

TABLE OF CONTENTS

1 INTRODUCTION

The Queensland Bulk Water Supply Authority trading as Seqwater took over ownership of Wivenhoe Dam from the South East Queensland Water Corporation Pty Ltd on 1 July 2008. In accordance with the Dam Safety Conditions issued by the Dam Safety Regulator for Wivenhoe Dam a comprehensive surveillance report was prepared and submitted to the DERM Dam Safety Regulator in September 2010.

In January 2011, Wivenhoe Dam experienced the flood of record post construction. During this flood event, the storage level reached approximately EL75, or more than 4m higher than the previous flood of record in 1999. This represented a first fill for the upper part of the two main dam embankments, two saddle dam embankments, and the fuse plug embankments. The fuse plug embankments were installed in the auxiliary spillway during the flood security upgrade of the dam in 2004 / 2005.

During the January 2011 flood, the peak outflow from the dam was approximately 7,500m^3/s. This discharge resulted in significant erosion of the plunge pool floor downstream of the primary gated spillway and significant damage to the sandstone walls and recreation facilities in the spillway channel. Given the magnitude of the flood event and the subsequent damage, this document has been prepared as a special report to:

1. Detail the inspections undertaken
2. Assess the performance of the dam, and
3. Advise of the proposed actions to remediate the damage to the dam.

2 EXECUTIVE SUMMARY

The September 2010 comprehensive surveillance report found that:

> *"Wivenhoe Dam is generally in very good condition. The recent comprehensive design reviews undertaken by the Wivenhoe Alliance and GHD in 2003 and 2009 respectively conclude that the design of the dam is in accordance with modern day standards and that there are no outstanding design issues that require investigation at the present time.*
>
> *Data obtained from the dam safety instrumentation at the dam shows that the structural performance of the dam is satisfactory and in accordance with design expectations. No issues were identified as a result of the comprehensive review of the instrumentation data. The physical infrastructure at the dam is generally maintained in good condition and all other major dam components are performing satisfactorily.*
>
> *As part of the Comprehensive Inspection, Queensland Hydraulics completed a comprehensive investigation and review of the hydraulics systems that power the operation of the radial gates and crane. The subsequent report (see Appendix C) concluded that these systems are in good condition and should have a minimum of 10 addition years of working life before requiring major refurbishment. These systems will be reviewed again as part of the next comprehensive inspection in 2015."*

During the January 2011 flood event, the dam operators noted an increase in tail water level and turbulence in the spillway channel as the discharges were decreased after the flood peak. The increase in tail water was caused by a large amount of rock that had been deposited in the spillway chute. This was reported to Seqwater Dam Safety Staff and an inspection undertaken immediately after the closure of the spillway gates at the end of the flood event. The DERM Dam Safety Group was notified of the spillway scour and attended the site inspection.

3 DAM DESCRIPTION

Wivenhoe Dam was designed by the Queensland Water Resources Commission. Construction began in 1977 and when completed in 1984, Wivenhoe Dam was a 56 metre high, zoned earth and rock embankment separated into two parts by a concrete gravity spillway. The spillway is controlled by 5 radial gates, each 12.0 metres wide by 16.0 metres high. Two saddle dam embankments are located on the left side of the reservoir. The Brisbane Valley Highway was relocated to pass over and along the crest of the dam embankment.

The Left Bank embankment is approximately 1.1 kilometres long and is constructed with a sloping upstream core. The core is protected by filters (located both upstream and downstream) and supported by a downstream shell of miscellaneous fill. Batter slopes are 3 horizontal to 1 vertical on the upstream face and 2 horizontal to 1 vertical on the downstream face. Riprap is also in place on the upstream and downstream shoulders of the embankment.

The Right Bank embankment is 1.2 kilometres long and 56 metres high with a central clay core. The embankment contains both upstream and downstream filters supported by outer shells of compacted sandstone with river run gravel in the upper portion. The shoulder slopes are 2 horizontal to 1 vertical with a local steepening in the upper portion to 1.5 horizontal to 1 vertical. Riprap is in place on both the upstream and downstream shoulders of the embankment.

Two saddle dams close off low points located along the left abutment of the dam. Saddle Dam 1 is a homogeneous embankment constructed from miscellaneous fill. Saddle Dam 2 is the higher of the two embankments and is constructed with a central clay core and random fill shoulders. Rip Rap is provided for both embankment on the upstream face for wave protection and the downstream slope is topsoiled and grassed. The Saddle Dams have a crest level at EL 80 and have a maximum height of 10 m. The Saddle Dams only retain water during flood operation.

The dam spillway capacity was upgraded in 2005 by the Wivenhoe Alliance. The works associated with this upgrade are summarised as follows:

- Construction of a 164 metre wide secondary spillway through the right abutment of the existing dam, in an excavated chute that included concrete works for a 3 metre ogee crest, apron slabs, chute lining and the divider walls to enable construction of three eroding earth fill fuse plug embankments;
- Upgrading of the wave wall on the two main embankments to handle the new Maximum Flood Level (MFL) of EL 80.0;
- Strengthening of the primary spillway with post-tensioned anchors to cater for the increased loading due to the raised flood level.
- Provision of a steel deflection baffle upstream of the radial gates to ensure the gates clear the flow profile for the raised MFL.

These works raised the dam crest flood from a 1 in 22,000 AEP event to 1 in 100,000 AEP flood event. The initial trigger level for the first fuse plug embankment is at EL 75.7m (approximately the 1 in 6,000 AEP flood event).

The dam has four main functions by providing:

- A 1.165 GL storage at full supply level (FSL EL 67.0) providing an urban water supply for Brisbane and surrounding areas;
- Flood mitigation in the Brisbane River by providing a dedicated flood storage volume of 1.45 GL up to EL77 (the MFL was increased to EL80m as part of the Wivenhoe Alliance Upgrade works in 2005 changing the flood storage volume to 2.0GL at EL80m);
- A source of supply for the Split Yard Pumped Hydro-Electric power station which has a 500 MW generating capacity;
- A recreation area.

The dam has an EXTREME hazard classification under ANCOLD guidelines because of the significant development downstream in the Brisbane and Ipswich metropolitan areas, with the population at risk (PAR) numbering in the hundreds of thousands.

4 DAM INFORMATION

seqwater WATER FOR LIFE	WIVENHOE DAM
Population at Risk	Sunny Day Failure: 244,000 Flood: >1,000 (not fully assessed)
Failure Impact Rating	2
Hazard Category	Extreme
Dam Owner	Seqwater
Name of Reservoir	Lake Wivenhoe
Year Complete	1984
Location	Approximately 5km upstream of Fernvale
Water Course	Brisbane River
Purpose	Town water and flood mitigation
Type of Construction	Zoned earth and rockfill embankment
Outlet Works	Radial gated spillway with supplementary fuse plug spillway
Catchment Area	7,020km^2
FSL	67m AHD
Full Supply Capacity	1,165,238 ML
Surface Area at FSL	10,750ha
Main Dam Crest	79m AHD
Main Dam Embankment Length	2,300m
Maximum Height of Main Dam Embankment	56m
Width at Top of Main Dam Embankment	10.0m
Spillway Crest	57.0m AHD
Spillway Length	60m
Gates	5 radial gates 12m wide x 16.0 m high
Top of Closed Gate	EL 73.0m
Saddle Dam Crest	80.0m AHD
Saddle Dam Length	3 x total length of 518
Maximum Height of Saddle Dam Embankment	10.0m
Peak Water Level as a Result of PMF	Dam Overtopped
Spillway Capacity (including Fuse Plugs)	28,100m^3/s (EL 79.0m)
Maximum Discharge as a Result of PMF	37,400m^3/s
AEP of Spillway Capacity (including Fuse Plugs)	1 in 100,000 (EL 79.0m)
Regulator valves	1 x 1.5m cone dispersion valve
Mean annual pan evaporation	1,600mm (BOM estimate)
Mean annual rainfall	986mm
Hydroelectric Facilities	4.3 mw mini-hydro
Notable events (Post Dam)	1986, 1989 (x 2), 1999, 2011
Maximum Historic Storage Level	74. 8 m AHD January 2011

Comment	Besides being a major source of urban water supply, Wivenhoe Dam provides a significant flood mitigation capacity to protect the urban areas downstream of the dam. During periods of heavy rainfall, flood water is temporarily stored in Wivenhoe Dam and released at a controlled rate to minimise the impact of downstream flooding. The dam was built in conjunction with Splityard Creek Dam and water from Wivenhoe is pumped into Splityard Creek Dam where it is used to generate electricity during periods of high demand.

5 JANUARY 2011 FLOOD

Flood data and a description of dam operations during the January 2011 event are contained in Seqwater's report entitled 'January 2011 Flood Event – Report on the operation of Somerset Dam and Wivenhoe Dam' dated 2 March 2011 which has been submitted to DERM. Please refer to this report for any additional information or clarification regarding the January 2011 Flood Event. Key points for the January 2011 flooding include:

1. The flood can be categorised as a large (Annual Exceedance Probability [AEP] of 1 in 100) to rare (AEP of 1 in 2,000 years) event as defined by *Australian Rainfall and Runoff (Book 6)* (AR&R).

2. The volume of total inflow into Wivenhoe Dam during the Event was 2,650,000ML.

3. This flood event had a peak inflow of approximately 10,600m^3/s.

5.1 Wivenhoe Flood Mitigation and Dam Operations

For the January 2011 floods, there were three distinct events within the flood. Reference Figure 1 and Figure 2.These were:

1. Flood event that occurred from 5 to 7 January 2011:
    - Peak inflow of approximately 2,000m^3/s
    - Peak outflow was approximately 475m^3/s
2. The first of the two major flood events then began to enter Wivenhoe Dam at around 1 am on 8 January 2011 with the peak occurring at 10 pm on 8 January 2011.
    - Peak inflow of approximately 10,600$^{m3}/s$
    - Peak outflow of approximately 4,000$^{m3}/s$.
3. The second of the two major flood events then began to enter Wivenhoe Dam at around 8 pm on 9 January 2011 with the peak occurring at 10 am on 10 January 2011.
    - Peak inflow of approximately 9,800 $^{m3}/s$
    - Peak outflow was approximately 7,500 $^{m3}/s$

Following the peak discharges from the dam, the dam operators reported to the flood operations centre an increase in the observed tail water levels and the turbulent flow as discharges passed over the rock pile at the end of the chute.

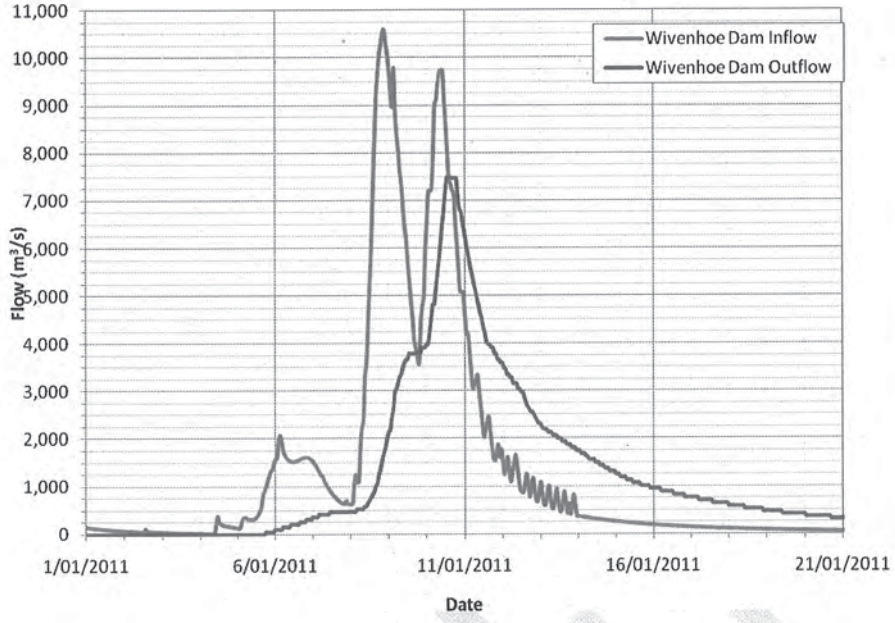


Figure 1 - Inflow and Outflow Hydrographs at Wivenhoe Dam for January 2011 Floods

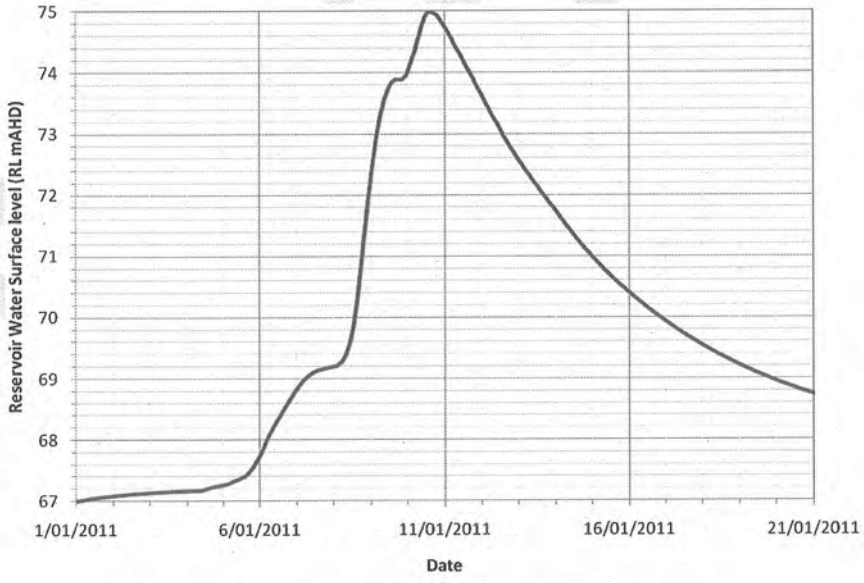


Figure 2- Wivenhoe Lake Level during January 2011 Floods

5.2 Inspections of the Damage

After the peak outflow of the flood event, operators at the dam noted that the tail water level had increased and was artificially high following the closing of the gates. There was also significant turbulence in the middle of the spillway chute.

Once flows from the spillway were reduced, large rocks were noted at the end of the plunge pool and reported to the flood control centre. However, it was not until the gate closing sequence was initiated at the end of the flood event that the scale of the erosion was apparent to the operators at the dam. The Seqwater Principal Engineer Dam Safety (John Tibaldi) was notified of the scour and an inspection was arranged as soon as it was possible to shut off the spillway gates. The Office of the Dam Safety Regulator at DERM was also notified of the scour and invited to attend the inspection of the spillway upon closing the spillway gates.

On the morning of the 19th of January, the storage level was approaching EL 67m and the spillway gates were able to be closed, enabling an inspection of the Wivenhoe spillway channel. The inspection team comprised of Mr Barton Maher (Seqwater Principal Dams & Weirs Planning), Mr John Tibaldi (Seqwater Principal Engineer Dam Safety), Mr Jim Pruss (Seqwater Executive General Manager Water Delivery), Rob Drury (Seqwater Manager Dam Safety and Source Operations) and Russ McConnell from the Office of the Dam Safety Regulator (DERM).

- January 19th @ 6:00 am
    - The inspection commenced on site. The scour of the spillway was viewed from the crest, adjacent recreational areas, and wherever safe access could be achieved to observe/assess the large pile of rocks. The consensus from the inspection team at this time was that the rock had most likely been removed from the floor of the plunge pool based on the observations of the side walls of the spillway chute. Safe access to the rocks within the spillway outlet channel was not possible at that time due to the releases from the radial gates. Therefore the inspection team undertook an inspection of the dam crest and the auxiliary spillway.
    - Further inspection of Wivenhoe Dam along the main embankment crests revealed no signs of any movement, cracking, or misalignment along the road pavement and wave wall of the main embankment and the left hand side embankment.
    - Longitudinal cracks were identified along the upstream side of the crest of the fuse plug embankments. These cracks were excavated but only persisted through the road base capping on the clay core. These appeared to be due to small movements at the joint of the rockfill and the clay core and were only 100mm deep at the most. It is considered that they were most likely due to settlement of the upstream rip rap following the drawdown of the storage.
    - The upstream training walls in the auxiliary spillway chute had evidence of water leaking through the horizontal construction joints in the concrete facing. This was predominantly where the concrete facing was decreased in thickness to 150mm from the maximum section of 300mm. There was water seeping from various drains. There was no visible evidence of misalignment or movement for the chute walls. Aside from the small longitudinal cracks in the road base capping the fuse plug embankments appeared to be in good condition with no sign of movement, bulging of the toe or misalignment.

- January 19th @ 11:00 am
    - The spillway gates were closed, allowing a more detailed inspection of the erosion in the primary spillway chute. It was noted that the mound of boulders (in excess of 1000 tons) developed approximately 150 metres downstream of the dam spillway. It was agreed that these boulders were most likely excavated from the floor and the side benches of the spillway outlet channel by the force of the water being released during the peak outflow of the flood event. This opinion was derived from the observation of the side walls of the spillway channel where the vertical sides of the excavated rock were still intact. The symmetrical operation of the spillway gates appeared to have successfully prevented damage to the side wall of the spillway outlet channel immediately below the flip bucket. Preliminary comments from the inspection team in relation to this mound of boulders were:
        - The development of the mound of boulders is consistent with design expectations based on the physical modelling of the dam and was expected to occur during an extreme release of water from the dam such as the one recently experienced.
        - A diving inspection should be undertaken as soon as possible to determine if there had been any head cutting of the plunge pool rock that could undermine the concrete apron protecting the spillway structure.
        - There was no immediate threat to the safety of the dam as the concrete apron slab downstream of the flip bucket was intact and showed no evidence of any damage.
        - Remedial works would be required if there was any evidence of the erosion undercutting the concrete apron downstream of the flip bucket.

Contact was made with a diving company that had been previously utilised by Seqwater. Arrangements were made to undertake a diving inspection of the plunge pool the following morning.

SunWater surveyor, Bill Hewitt was on site on the 19th of January undertaking the annual deformation survey for the dam. SunWater hydro graphic and GPS equipment was available on site which also enabled a hydrographical survey of the plunge pool to be undertaken in conjunction with the diving inspection. Results are detailed in section 5.4 of this report.

- January 20th
    - The diving inspection was undertaken and showed that no significant under-cutting of the spillway structure had occurred as a result of the development of the boulder mound. There was evidence of some very localised undercutting in two locations, potentially indicating the presence of weaker seams in the rock mass. The extent of this undercutting was very limited. It should be noted that even if extensive undercutting had occurred, the spillway post-tensioning that was undertaken in 2005 would have ensured the safety of the dam. The observations made during the inspection were:
        - At Mono S2, approximately one third of the way across the apron slab from the left hand joint there was undercutting of the concrete apron. The undercutting occurred over a length of 1.5m horizontally and extended 0.5m underneath the concrete apron. The diver was able to follow the vertical face of the concrete apron down to the rock. A rock ledge extended out from the concrete approximately 1m into the plunge pool. This rock was

approximately 1 – 1.5m deep and formed a roof over the undercutting. The undercutting beneath this rock roof extended back underneath the concrete apron. Dimensions for the erosion hole were 1.5m horizontally, 1m, vertically and 1.5m from the front edge to the back of the hole.

- At Mono S5, there was evidence of a very small undercut of the concrete apron. This was approximately 0.4m under the concrete and extended for only 0.5m horizontally with a depth of 0.2m.

- Preliminary results were obtained for the hydro graphic survey. These results showed that the majority of the erosion had occurred at the downstream end of the excavated plunge pool and there was no evidence that the sides of the spillway channel had been eroded significantly.

Additional conclusions from the inspection team included:

- The boulder mound could be advantageous in for large flood events in the short term because it causes elevated tail water levels that aid energy dissipation and scouring depth. However the down side is that the elevated water levels may adversely impact the cone valve operations during routine, low volume water releases downstream (releases are still possible, but the elevated tail water will cause minor but repairable damage to the valve over time; a spare valve is also available at the dam). The boulder mound will however have absolutely no impact on low volume water releases from either the radial gates or mini-hydro. Note: it will impact on the head and thus the generation capacity of the hydro releases.

- The future of the boulder mound will be considered over coming weeks. Options to be examined in detail include leaving the mound as is, removing small sections, or removing it entirely. In the very short term, it will be left undisturbed because it causes no significant operational issues.

5.2.1 DERM Inspection Report Summary

Russ McConnell, Manager Containment System, OWSR, DERM inspected and issued report s.37 Consultation, RTI Act 2009, DERM Application No. 10-207. The report outlines the background and observations of Wivenhoe Dam from his site visit on 19th January 2011. Detailed out are outstanding issues regarding his investigation and expected action steps for Seqwater.

Post Inspection Issues:

1. "By lateral expansion of the plunge pool cavity at depth to beneath the walls of the spillway, thus decreasing their stability; or"

2. "By head ward erosion of the plunge pool cavity upstream towards or to beneath the apron and flip of the spillway structure."

Expected Actions Steps:

1. "Undertake a bathymetric survey of the plunge pool floor by a depth gauge attached to a boat starting on 20th January 2011."

2. "Investigate lateral expansion extent (if any) by professional divers in the spillway walls and the spillway toe starting on 20th January 2011"

The bathymetric survey and diving inspection undertaken by Seqwater have confirmed that:

1. Lateral expansion of the plunge pool has not occurred. Most rock has been removed at the downstream side of the excavated plunge pool.

2. Very little head ward erosion has occurred with no significant undercutting of the concrete apron slab protecting the flip bucket.

5.3 Description of the Damage

During the January 2011 flood event, the flow rate released from Wivenhoe Dam Spillway peaked at approximately 7,500 m^3/s. The area directly downstream of the Wivenhoe Dam Spillway experienced significant erosion and scour damage to the plunge pool, outlet discharge channel, lower dam access roads, and spillway lookout recreational area. Initial estimates of the volume of the rock eroded from the plunge pool of over 25,000 m^3 of material. In particular, multiple boulders in excess of 700 tons have been displaced and deposited downstream. The two lower dam access roads, used for equipment entry to the low level gates and hydropower station, were washed out.

Flows spilling out of the spillway channel at the downstream end of the spillway chute resulted in significant erosion. Material was removed down to moderately weathered rock. Significant damage was found on the left hand side of the channel downstream of the lookout where mudstone joints were washed out and significant amounts of rock removed.

The spillway lookout recreational area had erosion cut down to the underlying rock material, leaving behind near vertical soil slopes up to 3 metres high, as well as damage to the bitumen roads and parking lots. The following photos are representative before and after shots of the January 2011 flood.

Photo 1- Wivenhoe Outlet Channel and Spillway Prior to January 2011 Flood

Photo 2- Wivenhoe Outlet Channel and Spillway Post January 2011 Flood

Photo 3- Wivenhoe Outlet Channel and Spillway Prior to January 2011 Flood

Photo 4- Wivenhoe Outlet Channel and Spillway Post January 2011 Flood

Photo 5- Wivenhoe Outlet Channel and Spillway Post January 2011 Flood

Photo 6- Wivenhoe Outlet Channel and Spillway Post January 2011 Flood

5.4 Survey Results

The hydrographical survey of the spillway and plunge pool was conducted on the 20th of January immediately after the flood releases could be stopped. The surveyor utilized a boat, GPS, and depth sounding equipment to obtain the data on the spillway erosion. Figure 3 below shows a plan view of the locations of cross-sections. Figure 4 is the cross-section profile at location A-A. Additional information is available in the Appendix B.

It can be seen from cross section A-A in Figure 4 (left to right represents upstream to downstream) that the majority of material removed from the base of the plunge pool was located at the downstream side of the excavation. The plunge pool depth was decreased to a depth of EL14m and up to 10m of rock was removed from areas of the spillway structure. However, it should be noted that there was minimal head cutting of the upstream side of the plunge pool.

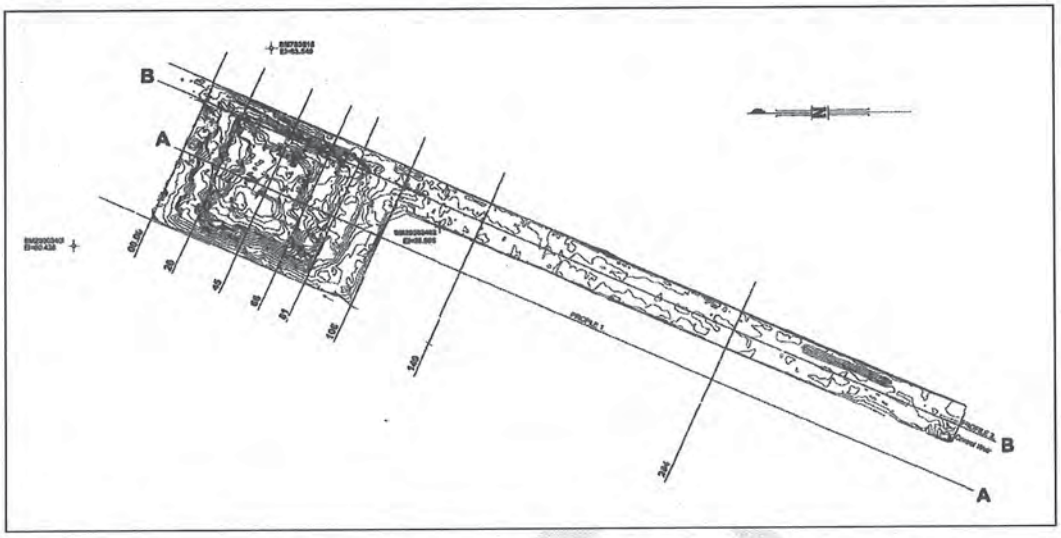


Figure 3 - Survey of Wivenhoe Outlet Channel and Spillway Post January 2011 Flood

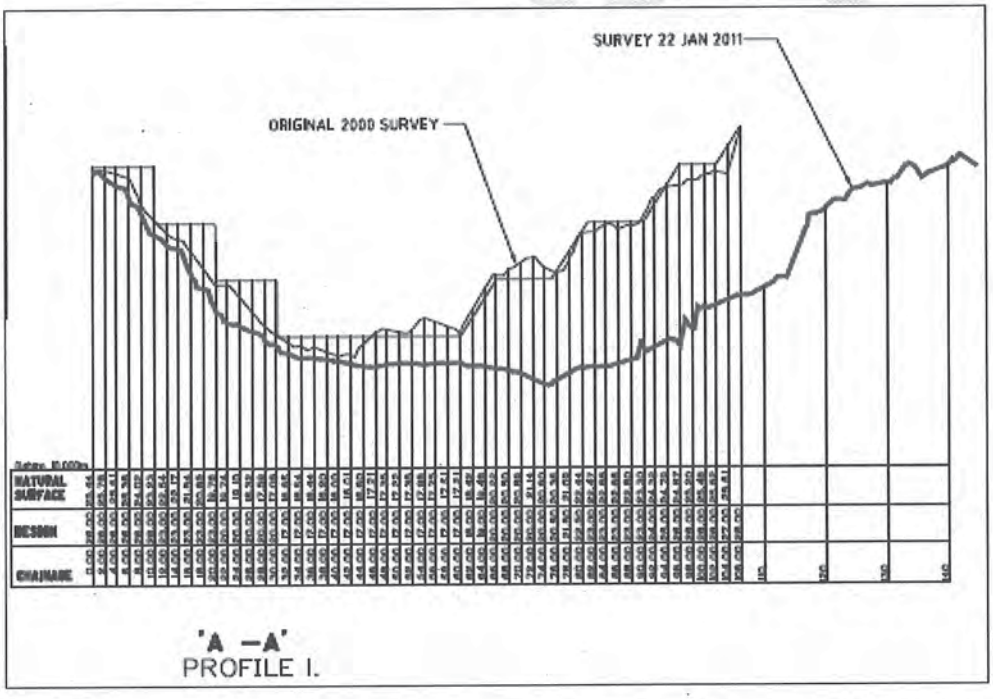


Figure 4 - Survey of Wivenhoe Outlet Channel and Spillway Pre and Post January 2011 Flood

6 SPILLWAY DESIGN

6.1 General

According to the Wivenhoe Dam Design Report (DPI Water Commercial, 1995), the excavated channel for the spillway has a total length of approximately 1,100m. It has a low level channel to serve the outlet works, which was also used for diversion during construction, and a higher approach channel serving the other four overflow monoliths. Downstream of the spillway flip bucket, the discharge channel was excavated an additional 11 m where the discharge jet impinges, to form a plunge pool, which is designed to dissipate the energy and control scouring.

Bays on the spillway overflow crest are five in number, each 12 m wide. A high level spillway flip bucket, of uniform radius directs an overflow jet well away from the crest structure. Steel radial gates of 90 t mass are mounted off piers supported on the crest, lifting winches being located behind each gate leaf. Each pier is a constant 3.5 m width for 12 m from its nose and then tapers to 2 m at its downstream end. At the base of each pier an extension is provided to reduce unsteady flow conditions in the spillway flip bucket.

Twin bridges cross the spillway. One carries the highway and is sported on cantilevers off the piers. A second bridge supports a 79 t gantry crane provided to install the bulkhead gate during maintenance of any radial gate.

An intake structure for the outlet works is slotted into the left bank spillway retaining wall just upstream of the spillway crest. Outlet pipes of 1,900 mm and 3,600 mm diameter, one above the other, connect the intake to the discharge valves adjacent to the spillway flip bucket. The 3,600 mm diameter pipe was providing as a possible power station penstock.

The dam site lies on the Helidon Sandstone, formerly known as the Wivenhoe Sandstone. This rock is a massive, thickly bedded, fine to coarse grained argillaceous sandstone of varying hardness, commonly showing current bedding which is approximately horizontal. Shale, claystone and coal are also present in occasional seams and lenses.

6.2 Hydraulic Modelling

Most of the hydraulic data for the spillway design was obtained by testing of two physical hydraulic models. A 'pilot' model was used to determine the feasibility of the flip bucket spillway and to assess overall hydraulic behaviour of the spillway, the approach flow conditions and discharge back to the river. The second 'main spillway' model, was tested to determine the spillway structure geometry, hydraulic loading data, gate discharge ratings, proposed sequencing of gate openings for flood discharge, and dissipation performance in the plunge pool.

During the design of the spillway using the physical model, it was deemed virtually impossible to reproduce in the model the scour of the rock material in the discharge channel. It was determined that if the discharge channel had a non-erodible bed at El. 28.0 supercritical flow was possible with a hydraulic jump being formed at the downstream end of the channel. This was considered undesirable. Massive scour could develop in the less resistant rock at the downstream end of the discharge channel and result in uncontrolled back erosion, progressing upstream from the end of the channel and potentially putting the dam at risk. For this reason, a pre-excavated scour hole was experimented with to ensure that energy dissipation occurred in the region where the jet impacted the bed of the discharge channel and thus controlled the location of the major scour expected from the design flows. This concept was further tested in the main spillway model utilizing a gate controlled discharge of 5,000 m^3/s and an uncontrolled discharge of 11,700 m^3/s. The design

discharge of 3,000 m^3/s was estimated to be a zero damage discharge and subsequently not tested in the physical model.

The pre-excavated plunge pool was considered necessary to initiate the scour hole downstream of the flip bucket in a controlled manner. The basic consideration in the development of the pre-excavated plunge pool shape was that the large scale turbulence should be concentrated away from the unprotected sidewalls of the spillway discharge channel. The final plunge pool configuration of the excavated benches protected the sidewalls from undermining, and sloping the downstream bench faces reduced the possibility of deflecting the jet laterally.

It was therefore anticipated, at the time of design, that the plunge pool would undergo further scour when subjected to flows above 5,000 m^3/s. The extent of the scour was not able to be determined due to the difficulty of modelling the scouring process. However, using a moveable bed in the physical model resulted in scouring of the plunge pool to a level of EL -20m.

Below are a series of photographs taken during the construction of the Wivenhoe Outlet and Spillway Plunge Pool.

Photo 7- Wivenhoe Outlet and Spillway Plunge Pool Construction

Photo 8- Wivenhoe Outlet and Spillway Plunge Pool Construction

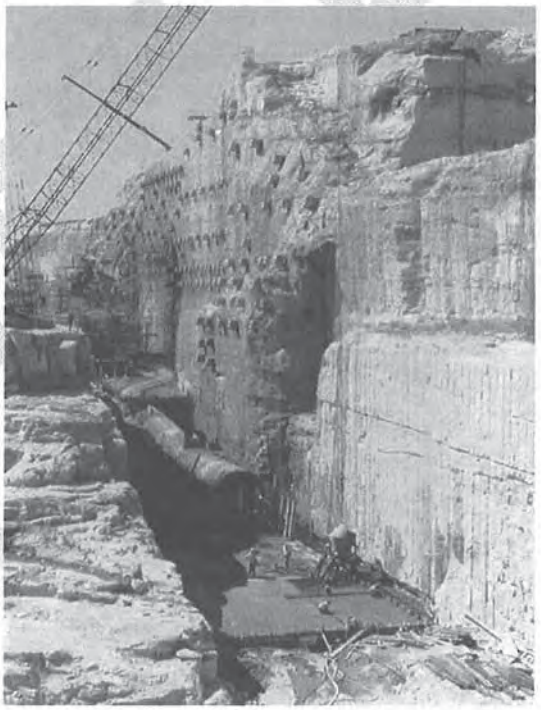


Photo 9- Wivenhoe Outlet and Spillway Plunge Pool Construction

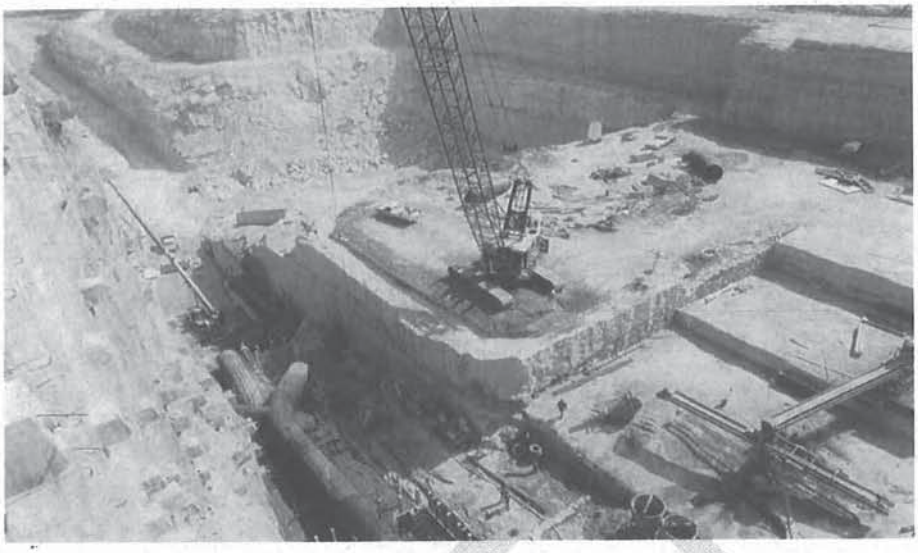


Photo 10- Wivenhoe Outlet and Spillway Plunge Pool Construction

Photo 11- Wivenhoe Outlet and Spillway Plunge Pool Construction

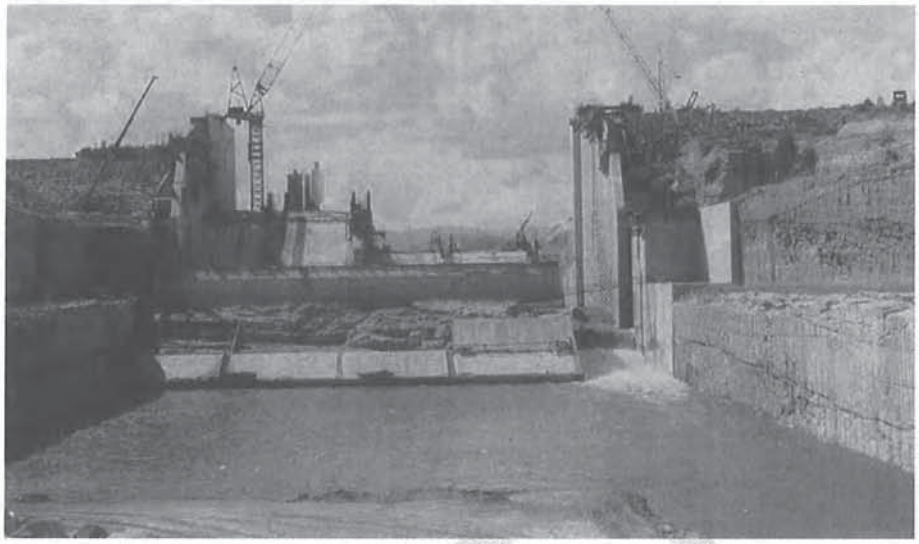


Photo 12- Wivenhoe Outlet and Spillway Plunge Pool Construction

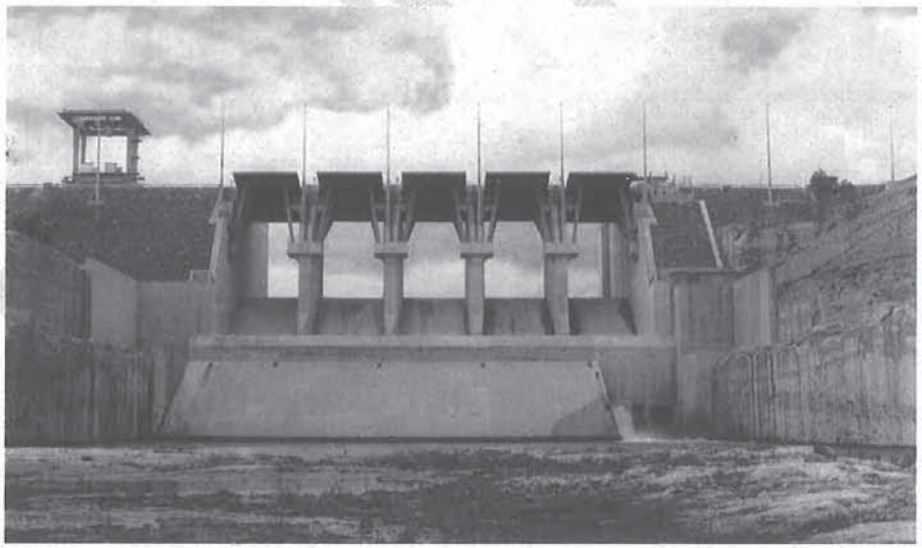


Photo 13- Wivenhoe Outlet and Spillway Plunge Pool Construction

7 INSTRUMENTATION

A summary of the dam safety monitoring instrumentation at Wivenhoe Dam is contained in the following table.

WIVENHOE DAM – DAM SAFETY INSTRUMENTATION	
TYPE	**DESCRIPTION**
Pore Pressure (Hydraulic Piezometers)	There are 60 hydraulic piezometers installed at the dam to monitor pore pressure. There are 24 piezometers at Ch 1600 and 22 piezometers at Ch 1800, in the right bank earth embankment. There are 14 piezometers at Ch 1200, in the concrete spillway section. There are 5 piezometers at Ch 1960, in the core of the diversion channel section of the right bank embankment. These instruments are read monthly.
Pore Pressure (Total Pressure Cells)	There are 25 total pressure cells installed at the dam. There are 11 total pressure cells at Ch 1600 and 11 total pressure cells at Ch 1800, in the right bank earth embankment. There are 3 total pressure cells at Ch 1960, in the core of the diversion channel section of the main embankment. The reading of these instruments was abandoned in the 1990s (see discussion below).
Deformation Monitoring-Dam Embankment	There are 60 movement monitoring points installed at the dam to measure embankment movement. There are 48 movement monitoring points installed in the right bank earth embankment and 12 movement monitoring points installed in the right abutment spillway. A deformation survey is undertaken annually.
Deformation Monitoring-Fuse Plug	There are 12 movement monitoring points installed at the fuse plug and the adjacent areas to measure the movement of this structure. A deformation survey is undertaken annually.
Structural Movement	There are 10 inclinometers installed at the dam to measure structural movement. There are 4 inclinometers installed in the right bank earth embankment and 6 inclinometers installed in the right abutment spillway. These instruments are read monthly.
Seepage	V-notch weirs are located in lower gallery of spillway and in the diversion channel section of the right bank embankment to measure seepage. V-notch weirs are also used to measure seepage flows from the left and right bank embankment drainage systems. These instruments are generally read on a daily basis.

Rainfall and Storage Level	Alert canisters transmit this data continuously in real time. All data is stored by Seqwater within a database.

Monitoring Frequencies

Monitoring frequencies are undertaken in accordance with the following table that meets ANCOLD Guidelines.

WIVENHOE DAM – DAM SAFETY INSTRUMENTATION	
TYPE	**MONITORING FREQUENCY**
Rainfall and Storage Level	Monitored daily through ALERT
Seepage	Daily
Pore Pressure	Monthly
Structural Movement	Monthly
Deformation Monitoring	Yearly

The Hazard Category of Wivenhoe Dam is Extreme. Instrumentation monitoring is undertaken in accordance with ANCOLD Guidelines.

8 DAM EMBANKMENT DEFORMATION

Dam embankment investigations identify three key phases during a dam timeline for deformation analysis: during the construction, at the first filling, and long term performance. An additional cause of deformation, particularly after the first fill, is an abnormal change in the normal forces. These forces are identified but not limited to earthquakes and unplanned reservoir fluctuations. In the case of Wivenhoe Dam, it has experienced a drought and flood of record all within the previous 3.5 years. Water level fluctuations increased almost 25 m during this time. The reservoir draw down was gradual in nature, but the January 2011 flood event alone increased the water level 7.5 m from FSL in a week with ongoing spillway releases of up to 7,500 m^3/s. Ideally, the best way to assess the performance of Wivenhoe Dam is a comparative analysis to similar constructed embankment structures utilizing applicable instrumentation data and determines what the typical deformation values are.

8.1 Pore Pressure (Hydraulic Piezometers)

The January 2011 flood inflicted damage to the piezometer data recording housing unit and the data was not retrievable until May 2011. Unrecoverable data includes information dated January 13th and February 28th. Detailed graphs showing the behaviour of individual piezometers over time are contained in Appendix C.

PIEZOMETERS	DESCRIPTION	COMMENTS	CURRENT TRIGGER
WVH01 WVH02 WVH03	These three piezometers are located within the sandstone foundation at EL 15 metres under the embankment core at Ch 1600. WVH01 is 11 metres upstream of the embankment centreline, WVH02 is on the embankment centreline and WVH03 is 11 metres downstream of the embankment centreline. The grout curtain in located midway between WVH01 and WVH02.	The pressure drop across the grout curtain remains in the order of five metres, indicating some leakage across the curtain. This is in line with historical performance. Due to damages to the piezometer housing, it is possible that WHV02 readings exceed the trigger level of 42 metres during the January 2011 flood event. After the flood, the piezometers levels have receded, as expected, and fall in line with historical trending.	Any reduction in the pressure differential between WVH01 and WVH02 to a value equal to or below 4.5 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV02 in excess of EL 42 metres should trigger additional monitoring and investigation.
WVH04 WVH05 WVH06 WVH07 WVH08	These six piezometers are located at EL 25 metres within the embankment core and downstream filter at Ch 1600. The piezometers are fairly evenly spaced. WVH04 and WVH05 are within the core, 11 metres and 5 metres	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger	Any increase in the pressure reading for WHV05 in excess of EL 55 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV08 in excess of EL 35

WVH09	respectively, upstream of the embankment centreline. WVH06 is within the core on the embankment centreline. WVH07 and WVH08 are within the core, 5 metres and 9.5 metres respectively downstream of the embankment centreline. WVH09 is within the downstream filter, 13.6 metres downstream of the embankment centreline.	levels for this section.	metres should trigger additional monitoring and investigation.
WVH10 WVH11 WVH12 WVH13	These four piezometers are located at EL 35 metres within the embankment core at Ch 1600. The piezometers are fairly evenly spaced. WVH10 and WVH11 are 8 metres and 3 metres respectively, upstream of the embankment centreline. WVH12 and WVH13 are 3 metres and 8 metres respectively downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. Due to damages to the piezometer housing, it is possible that the readings exceeded the trigger levels during the January 2011 flood event. After the flood, the piezometers levels have receded, as expected, and fall in line with historical trending	Any increase in the pressure reading for WHV11 in excess of EL 47 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV13 in excess of EL 37 metres should trigger additional monitoring and investigation.
WVH14 WVH15 WVH16 WVH17	These four piezometers are located at EL 45 metres within the embankment core at Ch 1600. The piezometers are fairly evenly spaced. WVH14 and WVH15 are 7.5 metres and 2.5 metres respectively, upstream of the embankment centreline. WVH16 and WVH17 are 2.5 metres and 6 metres respectively downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988 with the exception of WHV17. Due to damages to the piezometer housing, it is possible that WHV17 readings exceed the trigger level during the January 2011 flood event. After the flood, the piezometers levels have receded, as expected, and fall in line with historical trending.	Any increase in the pressure reading for WHV15 in excess of EL 54 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV17 in excess of EL 47 metres should trigger additional monitoring and investigation.
WVH18 WVH19	These three piezometers are located at EL 55 metres within the embankment	The pressure readings from these piezometers are consistent with historical	Any increase in the pressure reading for WHV19 in excess of EL 58

WVH20	core at Ch 1600. WVH18 is 4 metres upstream of the embankment centreline, WVH19 is on the embankment centreline and WVH20 is 4 metres downstream of the embankment centreline.	performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	metres should trigger additional monitoring and investigation.
WVH21 WVH22	These two piezometers are located at EL 65 metres within the embankment core at Ch 1600. WVH21 is 3 metres upstream of the embankment centreline and WVH22 is on the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988 with the exception of WHV22. Due to damages to the piezometer housing, it is possible that WHV22 readings exceed the trigger level during the January 2011 flood event. After the flood, the piezometers levels have receded, as expected, and fall in line with historical trending.	Any increase in the pressure reading for WHV22 in excess of EL 64.5 metres should trigger additional monitoring and investigation.
WVH23 WVH24	These two piezometers are located at EL 32 metres within the alluvium at Ch 1600. WVH23 is 42 metres upstream of the embankment centreline and WVH24 is 42 metres downstream of the embankment centreline.	As expected, WVH23 is connected directly to the storage and WVH24 is free draining with no apparent connection to the storage. The trigger level should be verified. WHV24 is on the downstream side of the embankment and this trigger level is viewed as abnormally conservative.	Any increase in the pressure reading for WHV24 in excess of EL 64.5 metres should trigger additional monitoring and investigation.
WVH25 WVH26 WVH27	These three piezometers are located within the sandstone foundation at EL 15 metres under the embankment core at Ch 1800. WVH25 is 11 metres upstream of the embankment centreline, WVH26 is on the embankment centreline and WVH27 is 11 metres downstream of the embankment centreline. The grout curtain in located midway between WVH25	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any increase in the pressure reading for WHV26 in excess of EL 35 metres should trigger additional monitoring and investigation.

	and WVH26.		
WVH28 WVH29 WVH30 WVH31 WVH32 WVH33	These six piezometers are located at EL 25 metres within the embankment core and downstream filter at Ch 1800. The piezometers are fairly evenly spaced. WVH28 and WVH29 are within the core, 11 metres and 5 metres respectively, upstream of the embankment centreline. WVH30 is within the core on the embankment centreline. WVH31 and WVH32 are within the core, 5 metres and 9.5 metres respectively downstream of the embankment centreline. WVH33 is within the downstream filter, 13.6 metres downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. It appears that the core has dried out to some extent during the recent drought as there is currently quite a steep pressure drop between WVH28 and WVH29, that is in excess of the levels experienced prior to 2001. This gradient is not of concern and would be expected to reduce over time if the level of the storage remained high.	Any increase in the pressure reading for WHV29 in excess of EL 57 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV32 in excess of EL 36 metres should trigger additional monitoring and investigation.
WVH34 WVH35 WVH36 WVH37	These four piezometers are located at EL 35 metres within the embankment core at Ch 1800. The piezometers are fairly evenly spaced. WVH34 and WVH35 are 8 metres and 3 metres respectively, upstream of the embankment centreline. WVH36 and WVH37 are 3 metres and 8 metres respectively downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988 with the exception of WHV37. Due to damages to the piezometer housing, it is possible that WHV37 readings exceed the trigger level during the January 2011 flood event. After the flood, the piezometers levels have receded, as expected, and fall in line with historical trending.	Any increase in the pressure reading for WHV36 in excess of EL 53 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV37 in excess of EL 41 metres should trigger additional monitoring and investigation.
WVH38 WVH39 WVH40 WVH41	These four piezometers are located at EL 45 metres within the embankment core at Ch 1800. The piezometers are fairly evenly spaced. WVH38 and WVH39 are 7.5 metres and 2.5 metres respectively, upstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger	Any increase in the pressure reading for WHV39 in excess of EL 59 metres should trigger additional monitoring and investigation. Any increase in the pressure reading for WHV41 in excess of EL 48

	WVH40 and WVH41 are 2.5 metres and 6 metres respectively downstream of the embankment centreline.	levels for this section.	metres should trigger additional monitoring and investigation.
WVH42 WVH43 WVH44	These three piezometers are located at EL 55 metres within the embankment core at Ch 1800. WVH42 is 4 metres upstream of the embankment centreline, WVH43 is on the embankment centreline and WVH44 is 4 metres downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any increase in the pressure reading for WHV44 in excess of EL 57 metres should trigger additional monitoring and investigation.
WVH45 WVH46	These two piezometers are located at EL 65 metres within the embankment core at Ch 1800. WVH45 is 3 metres upstream of the embankment centreline and WVH46 is on the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in. However the reading from WVH46 appears to be high and the reason for this high reading requires further investigation.	Any increase in the pressure reading for WHV46 in excess of EL 66 metres should trigger additional monitoring and investigation. This is currently occurring and further investigations will be undertaken.
WVH47 WVH48 WVH49	These three piezometers are located at EL 28 metres within the embankment core at around Ch 1960. WVH47 is 10.5 metres upstream of the embankment centreline. WVH48 is on the embankment centreline. WVH49 is 10.5 metres downstream of the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in. However the reading from WVH49 appears to be triggered and the reason for this high reading requires further investigation.	Any increase in the pressure reading for WHV49 in excess of EL 29 metres should trigger additional monitoring and investigation.
WVH50 WVH51	These two piezometers are located within the embankment core at around Ch 1960. WVH50 is at EL 30 at an unknown distance upstream of the embankment centreline. WVH51 is at EL 34 on the embankment centreline.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988.	No trigger levels are considered valid for these piezometers.

WVH52 WVH53 WVH54 WVH55 WVH56 WVH57	These six piezometers are located between EL 44 and EL 36 at the interface of spillway monolith 52 and the spillway foundations, at Ch 1170. The piezometers are spaced over a distance of approximately 25 metres, with WVH57 being the most upstream piezometer moving sequentially downstream to WVH52, the most downstream piezometer.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any trend showing an increase in the pressure reading for any piezometer.
WVH58	This piezometer is located at EL 38 at the interface of spillway monolith 53 and the spillway foundations, at Ch 1185 (spillway centreline). The piezometer is located directly under the lower gallery.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any trend showing an increase in the pressure reading for the piezometer.
WVH59 WVH60 WVH61 WVH62 WVH63 WVH64	These six piezometers are located between EL 44 and EL 38 at the interface of spillway monolith 54 and the spillway foundations, at Ch 1200. The piezometers are spaced over a distance of approximately 25 metres, with WVH64 being the most upstream piezometer moving sequentially downstream to WVH59, the most downstream piezometer.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any trend showing an increase in the pressure reading for any piezometer.
WVH65	This piezometer is located at EL 39 at the interface of spillway monolith 55 and the spillway foundations, at Ch 1215. The piezometer is located directly under the lower gallery.	The pressure readings from these piezometers are consistent with historical performance dating back to the first filling of the dam in 1988. There is nothing to indicate that any of the piezometers have approached the trigger levels for this section.	Any trend showing an increase in the pressure reading for the piezometer.

8.2 Pore Pressure (Total Pressure Cells)

The Total Pressure Cells were primarily installed to monitor embankment settlement following construction. Collection of data from the Total Pressure Cells appeared to cease in the 1980s and no record on why this decision was made can be found. Additionally, no data records at all can be located.

8.3 Deformation Monitoring

8.3.1 Dam Embankment Deformation

Deformation surveys are undertaken annually at Wivenhoe Dam. The last survey was undertaken after the January 2011 flood and is contained in Appendix B. Following a review of the movements, no values could be found that are cause for any immediate concern. The deformation at this dam is lower than expected for an embankment dam of 56 m in height. The rate of deformation has slowed and has stayed relatively consistent since the end of construction. Annualized summarization of settlement and displacement in relation to the specified time interval for all of the Wivenhoe Dam Embankment Monuments are shown in Figure 5 and Figure 6.

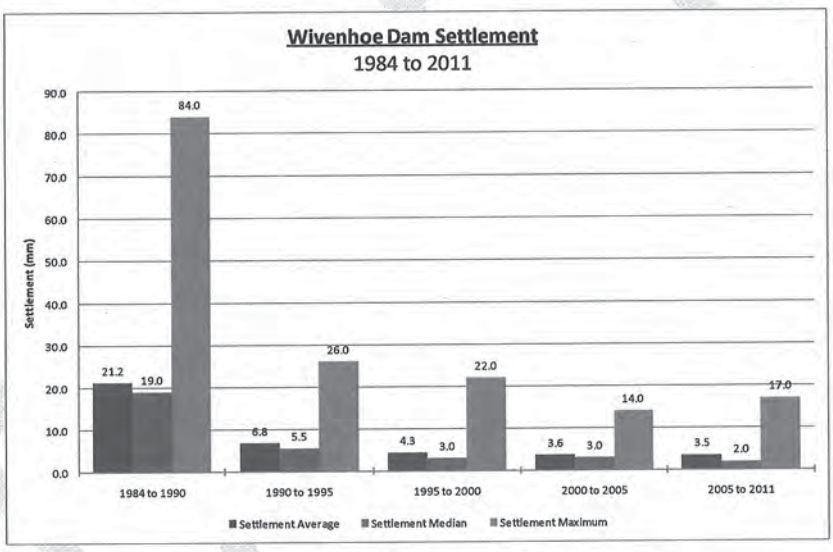


Figure 5 - Wivenhoe Dam Settlement Relative to the Time Interval

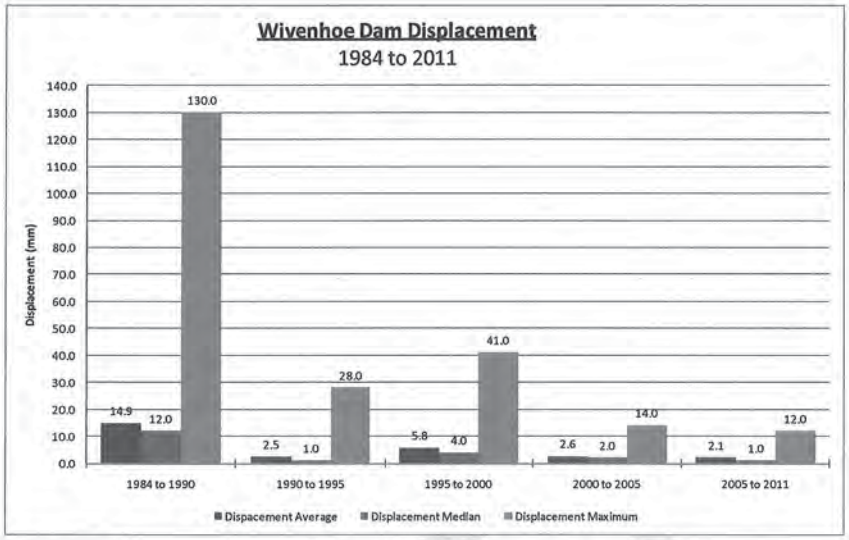


Figure 6 - Wivenhoe Dam Displacement Relative to the Time Interval

There are two cross sections of deformation monitoring instrumentation installed at the maximum sections of Wivenhoe Dam. They are located at chainage 1,600 & 1,800. Both of these cross sections were analysed for settlement and displacement amid concerns of the unprecedented hydraulic loading on the dam from the January 2011 flood event. These locations are identified on Figure 7 below.

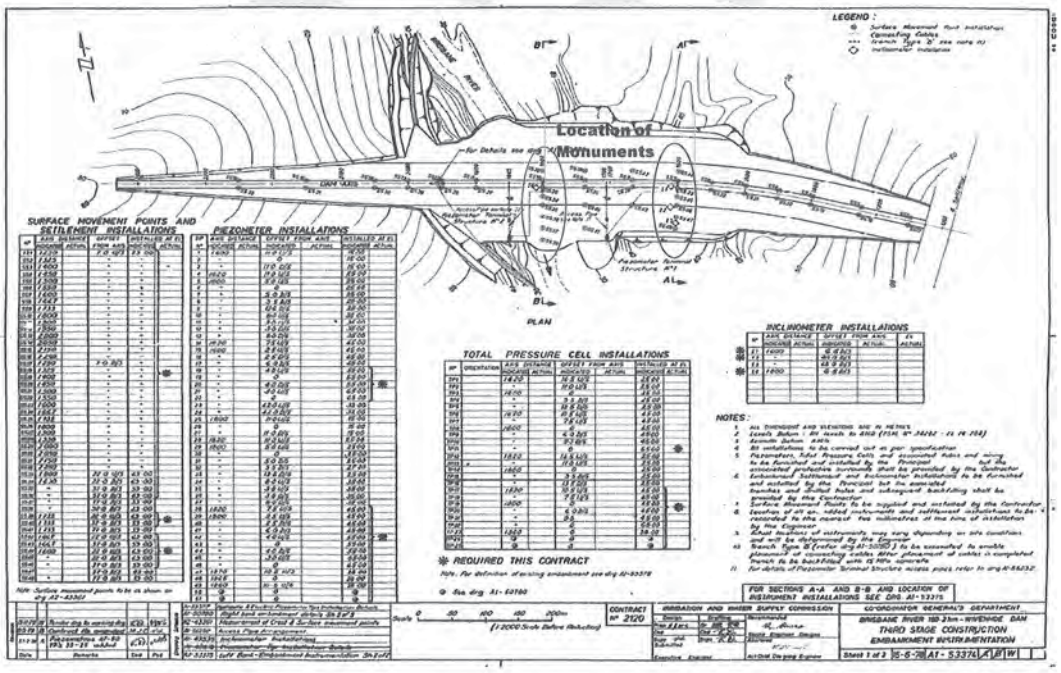


Figure 7 - Location of monuments analysed for chainages 1,600 and 1,800

i). Embankment Settlement

Figure 8 and Figure 9 present the post construction deformation settlement versus time for both of the previously stated chainages. The maximum values of settlement at the two maximum sections are 138 mm, with an average settlement of 53.6 mm at ch. 1,600 and 43.8 mm at ch. 1,800. To note, the maximum settlement at each of the locations occurred on the upstream edge of the dam crest.

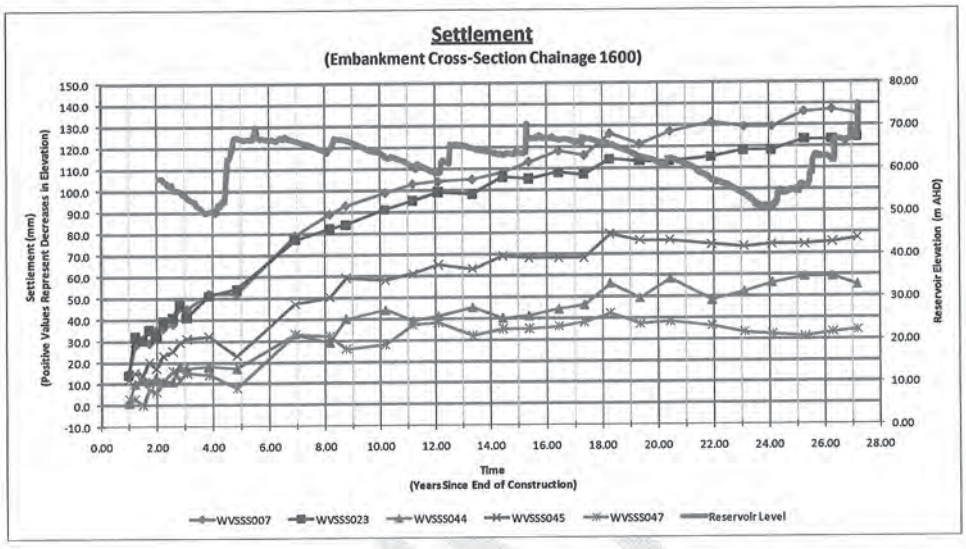


Figure 8 - Settlement of monuments analysed for chainages 1,600

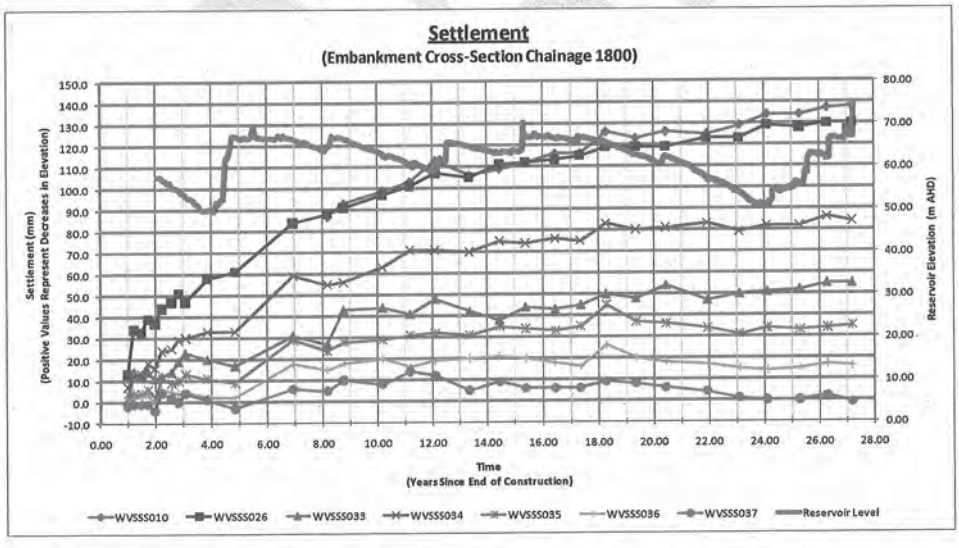


Figure 9 - Settlement of monuments analysed for chainages 1,800

Figure 10 and Figure 11 present the same monument settlement but is displayed as a % of the dam height. This provides an additional tool to analyse the data trending of deformation. This settlement is in line with similar embankment sizes and designs. A point of concern to be noted regarding the settlement monuments WVSSS036, WVSSS037 at chainage 1,800 and WVSSS047 at chainage 1,600. The monuments are located on the downstream slope of the embankment near the dam toe. Within

the last 15 years, these monuments are showing a trending of increasing in elevation. The maximum value of increased elevations of the previous mentioned monuments is 15 mm.

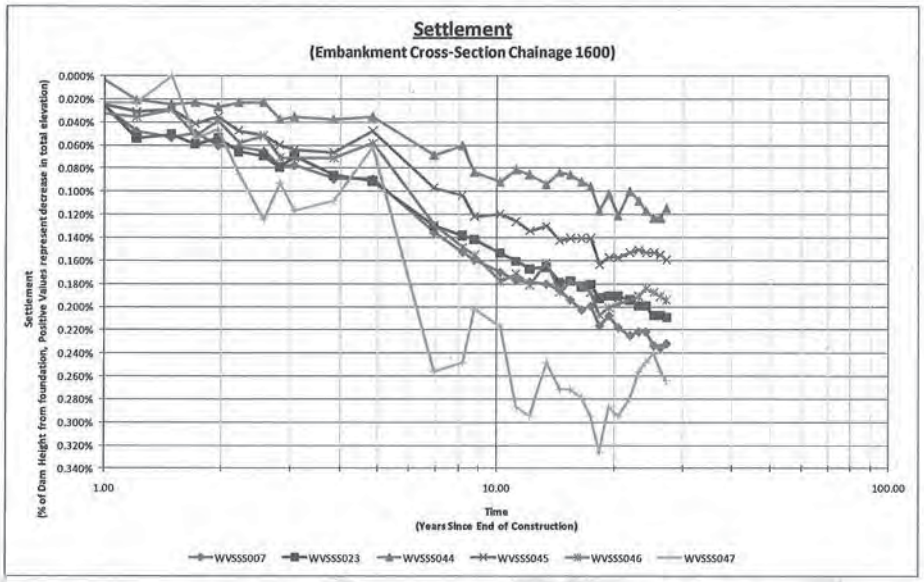


Figure 10 - Settlement of Monuments Analysed for Chainages 1,600

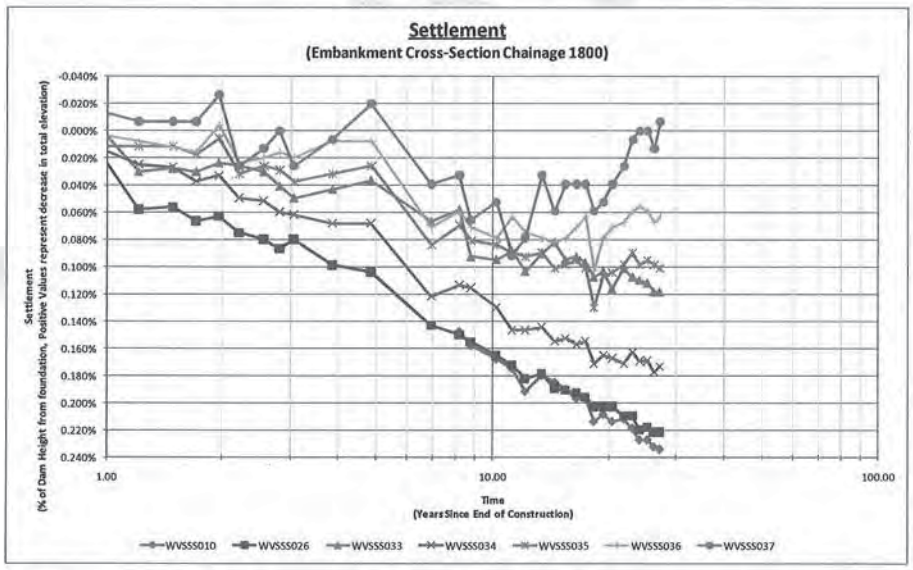


Figure 11 - Settlement of Monuments Analysed for Chainages 1,800

ii). Embankment Displacement

Figure 12 and Figure 13 present the post construction deformation displacement, normal to the dam, versus time for chainages 1,600 and 1,800. The maximum value of displacement, at the two maximum sections is 116 mm, with an average settlement of 25.3 mm at ch. 1,600 and 27.7 mm at ch. 1,800. Similar to the dam settlement, the maximum displacement at each of the chainages occurred at the monuments located on the upstream edge of the dam crest.

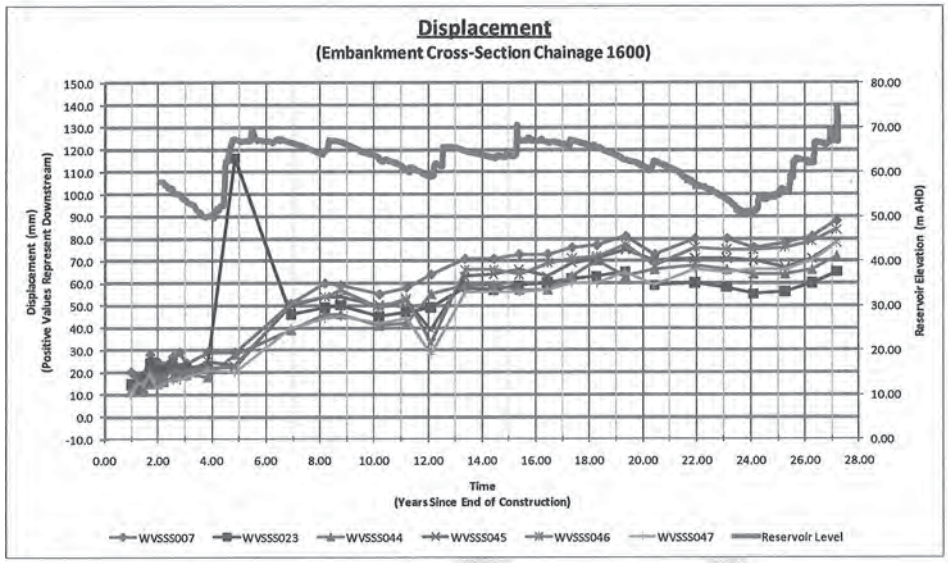


Figure 12 - Displacement of Monuments Analysed for Chainages 1,600

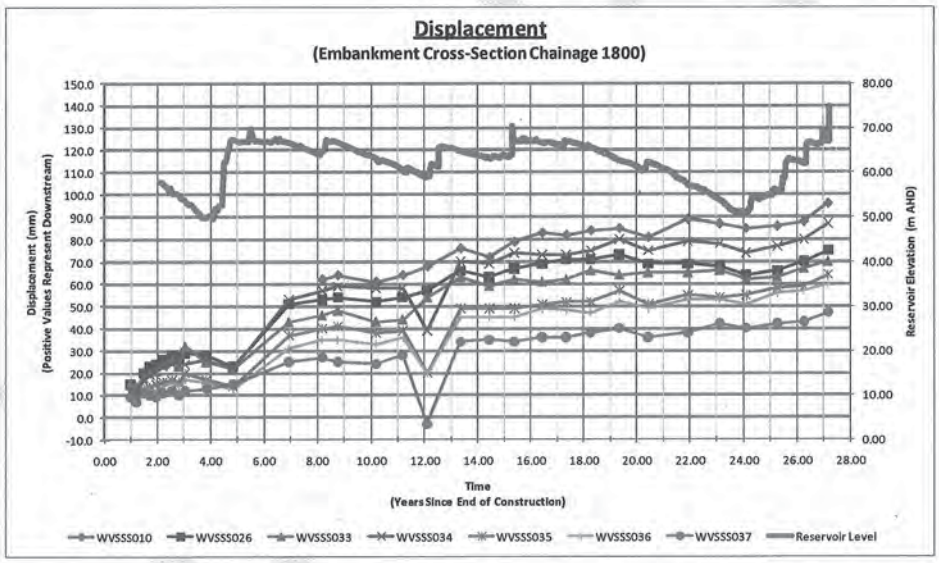


Figure 13 - Displacement of Monuments Analysed for Chainages 1,800

Additional results outside of the chainage 1,600 and 1,800, the maximum settlement since the 1990 base survey was 64 mm that was measured at Point 8, which is near the highest section of the embankment. This is in line with other settlements at surrounding points 3 to 12 which are greater than 24 mm. The maximum horizontal movement of 19 mm at point 6 is considered insignificant.

The survey shows that control point No. 109 is displaying significant progressive settlement of 52 mm between 2007 and 2009 and a further 9 mm in 2010. This control point was established on loose material downstream of the embankment following the 2005 spillway upgrade and may need to be re-established. It is recommended that this issue be investigated in conjunction with the 2011 survey.

8.3.2 Fuse Plug Deformation

Deformation surveys are undertaken annually at Wivenhoe Dam. The last survey was undertaken after the January 2011 flood. Following a review of the movements, no values could be found that are cause for any concern. The Wivenhoe Fuse Plugs are a bit over 5 years from construction. There is not a long enough track record to determine a rate of deformation with any consistency.

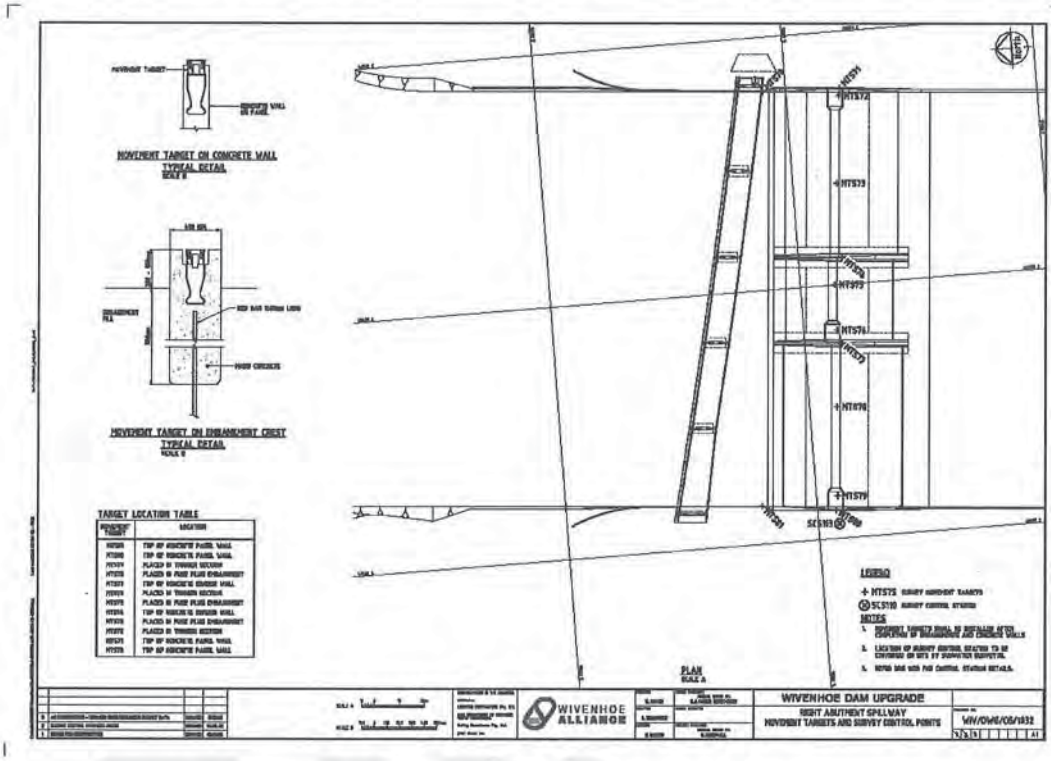


Figure 14 - Location of monuments Analysed for the Fuse Plug

i). Fuse Plug Settlement

Figure 15 presents the post construction deformation settlement versus time for the fuse plugs. The maximum value of settlement is 15 mm, with an average settlement of 5.8 mm. There is an issue to be investigated for the settlement of all the monuments, WVSSS070 through WVSSS081, that are located on or around the fuse plug. Within the last two plus years, there is a clear trend that the entire structure is gaining in elevation. It can be seen in the following Figure 15 that all the monuments are settling (or rising) at similar rates. A cross-section of the fuse plug design can be found in Appendix A.

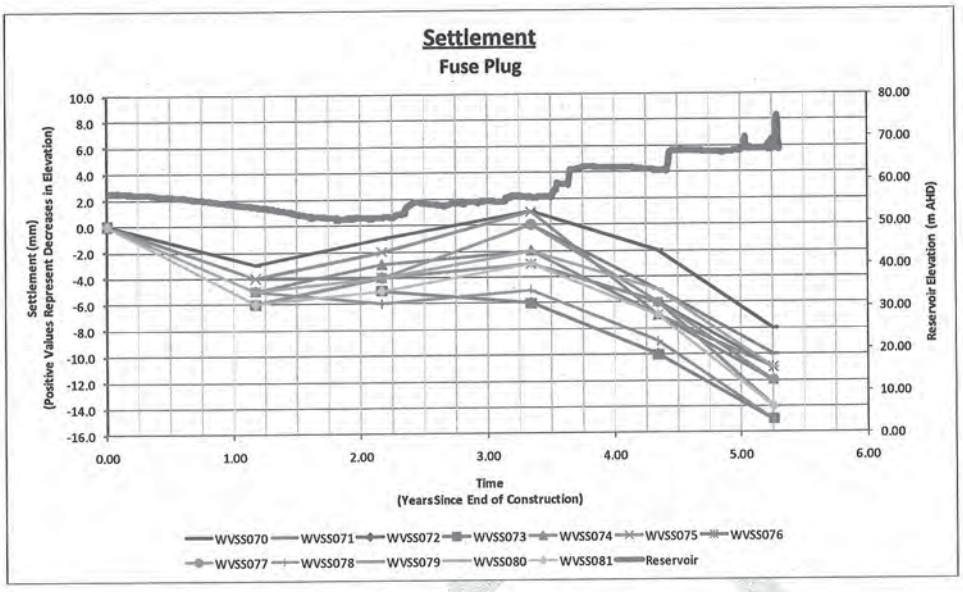


Figure 15 - Settlement of Monuments Analysed for Fuse Plug

ii). Fuse Plug Displacement

Figure 16 presents the post construction deformation displacement versus time for the fuse plugs. The maximum value of displacement is 8 mm, with an average of 3.1 mm. With the exception of monument WVSSS075, all the monuments are operating as expected. Monument WVSSS075 is located in the embankment portion of the middle fuse plug and it should be noted that it has not been trending in line with the other monuments for the last year plus.

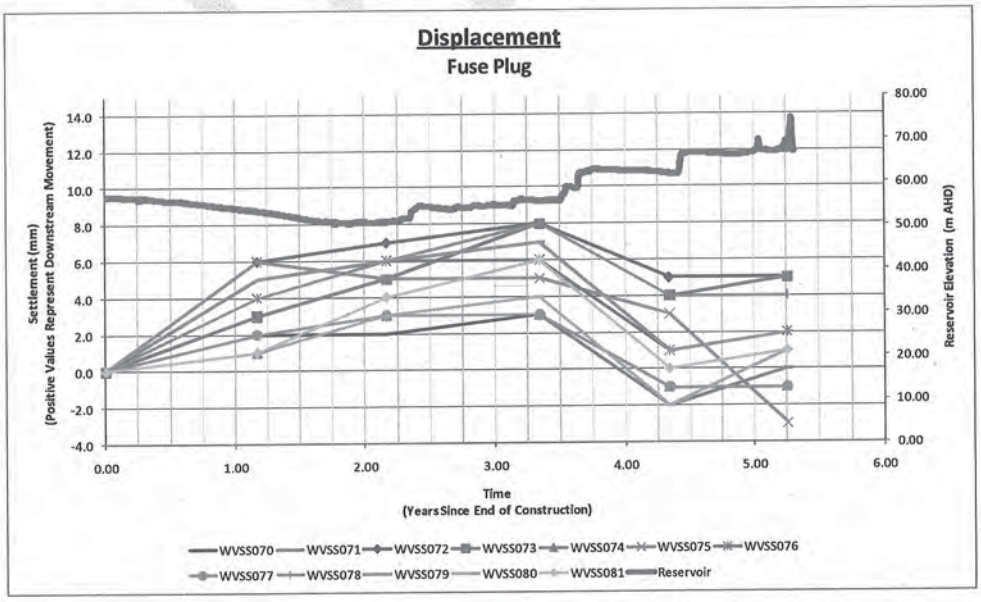


Figure 16 - Displacement of Monuments Analysed for Fuse Plug

8.4 Structural Movement (Inclinometers)

A summary of the inclinometer results is shown in the table below. Detailed graphs showing the behaviour of individual inclinometers over time are contained in Appendix C. Plans showing the locations of the inclinometers are shown in Appendix A.

INCLINOMETER	DESCRIPTION	COMMENTS
I1 I2 I3	These three inclinometers are located in the embankment at Ch 1,600. I1 is 6.5 metres downstream of the embankment centreline and is 60 metres in depth. I2 is 40 metres downstream of the embankment centreline is now 18 metres in depth as an old instrument is jammed at this depth. I3 is 68 metres downstream of the embankment centreline and is 24 metres in depth.	Cumulative displacement since the dam was constructed is generally less than 28 millimetres over the length of the inclinometer along the normal axis of the dam. The reading dated 22-Jan-11 (Post Flood) shows a deviation from the trending. This will be monitored and the inclinometer will continue to be read on a monthly basis.
I4	This inclinometer is located in the embankment at Ch 1,800. I4 is 6.5 metres downstream of the embankment centreline and is 68 metres in depth.	Cumulative displacement since the dam was constructed is generally less than 20 millimetres over the length of the inclinometer along the normal axis of the dam. The reading dated 22-Jan-11 (Post Flood) shows a deviation from the trending. This will be monitored and the inclinometer will continue to be read on a monthly basis.

8.5 Seepage

The seepage weirs were inundated during the January 2011 flooding event. No data was recorded. Plans showing the locations of the seepage points are shown in Appendix A.

8.6 Post Tensioning

Post tensioning analysis has not been conducted since the January 2011 flood event. As noted in the 2009 Annual Inspection, most of the posts tensioning anchors were load tested in 2009 in accordance with ANCOLD guidelines.

9 CONCLUSIONS

In January 2011, Wivenhoe Dam experienced the flood of record for the post construction era. During this flood event, the storage level reached approximately EL75, or more than 4 m above the previous post construction flood of record. occurrence in 1999 This represented a first fill for the upper part of the two main dam embankments, two saddle dam embankments, and the fuse plug embankments. The fuse plug embankments were installed in 2004 / 2005 in the auxiliary spillway.

During the flood event, the flow rate released from Wivenhoe Dam Spillway peaked at approximately 7,500 m^3/s. The area directly downstream of the Wivenhoe Dam Spillway had significant erosion and scour damage to the plunge pool, outlet discharge channel, lower dam access roads and spillway lookout recreational area. Initial estimates of the volume of the rock eroded from the plunge pool are over 25,000 m^3 of material. In particular, several boulders in excess of 700 tons have been displaced and deposited downstream.

It is concluded from a review of the design and monitoring data available for the dam that:

1. During the 2011 flood event, the dam performed as designed.

2. The erosion of the plunge pool was anticipated during the design of the dam, but it was not quantified at that time due to the difficulty of modelling the erosive processes. The initial excavated plunge pool was based on an assumed flow of 5,000 m^3/s and was intended to limit erosion from the downstream end of the spillway chute.

3. Erosion was predicted to occur for large floods, even with the pre-excavated plunge pool. However the predicted erosion would not impact the safety of the dam. As part of the original design, the concrete apron on the downstream end of the flip bucket was constructed to minimise the risk to uncontrollable head cutting to the toe of the flip bucket.

4. Although there was significant scour of the pre-excavated plunge pool particularly in downstream sloping face, observations also appear to show that the stability of the valley slopes and the foundation of the dam and spillway have not been compromised and are in a safe condition with rock scouring not resulting in head cutting back to the flip bucket toe and its sloping apron.

5. The deformation survey of the dam did not show any significant movements of the dam embankment following the flood event.

6. The post flood piezometer readings do not show any significant changes in the internal pore pressures of the dam.

7. Due to the elevated tail waters during the flood event it was not possible to monitor the seepage through the embankment. Post flood readings do not indicate any significant change in the seepage from the dam.

8. An analysis of the instrumentation monitoring data highlighted a few items to be aware of during future reviews.

10 RECOMMENDATIONS

The following recommendations are made from this review. It should be noted that a consultancy has already been initiated to investigate the spillway plunge pool and evaluate the need for further remedial works. The consultant's review and recommendations are not incorporated into this report at this time.

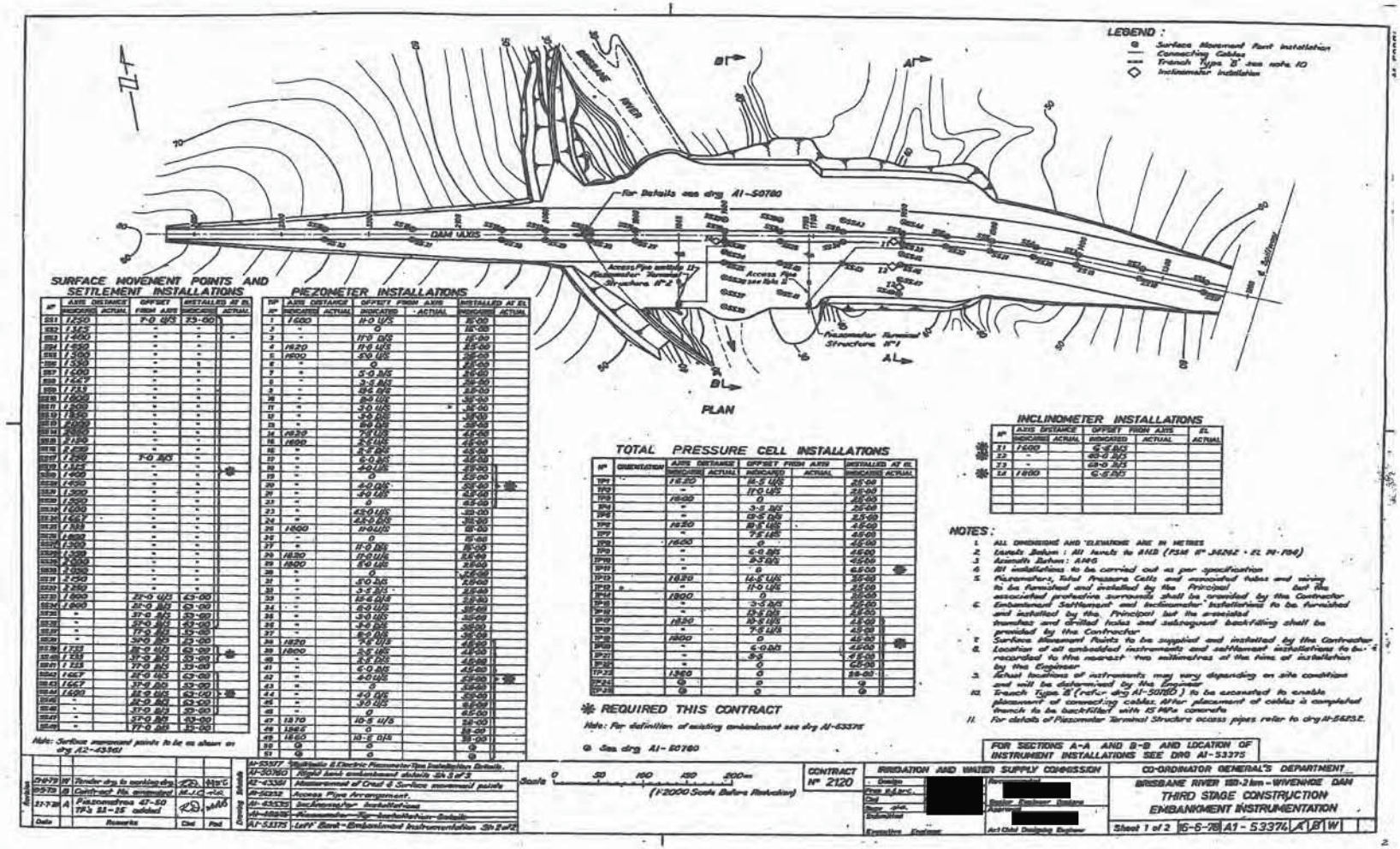
Issue	Recommendations
Erosion and scour damage to the plunge pool and downstream spillway chute.	1. Investigate options to open a channel through the rock deposited by the erosion in the spillway outlet channel in order to restore the ability to operate the FDC Valve without cavitation and improve the efficiency of the hydro power station. 2. Investigate the performance of the spillway dissipator following the enlarging of the plunge pool to ensure that safe operation can occur for the full range of flood events. In particular, analyse recirculation flows in the plunge pool which may lead to erosion of the side walls or the head cutting of the upstream rock face. 3. Reestablishment of the water measurement weir to help regulate outflow rates for water delivery purposes.
Damage to the side walls of the spillway outlet channel	4. Carry out a safety assessment of the side wall of the spillway chute and the lookout structure and assess the need for any remedial works where weak joints have been eroded.
Damage to the access ladders and bench road from the spillway discharges.	5. Investigate options to reinstate maintenance access to the concrete bench above the hydro power station. 6. Repair the ladders and access platforms damaged by the spillway flows to restore safe access to the FDC dissipator chamber and the hydropower station.
Damage to the recreation facilities	7. Investigate options to repair the damage to the recreation areas and access roads including the road embankment leading to the spillway lookout. 8. Reinstate fencing and other safety barriers along the edges of the spillway chute. 9. Batter back vertical cuts in the soil profile to a safe slope and protect the face of the batters from further erosion during rain events.
Some piezometers have reached the nominated trigger levels – inconsistency in piezometric levels.	10. Changes in the piezometer levels should be reviewed and the impact on stability assessed. Validate and possibly re-establish the trigger levels. 11. The piezometer lines should be flushed given the inundation of the piezometer hut during the January 2011 flood event.

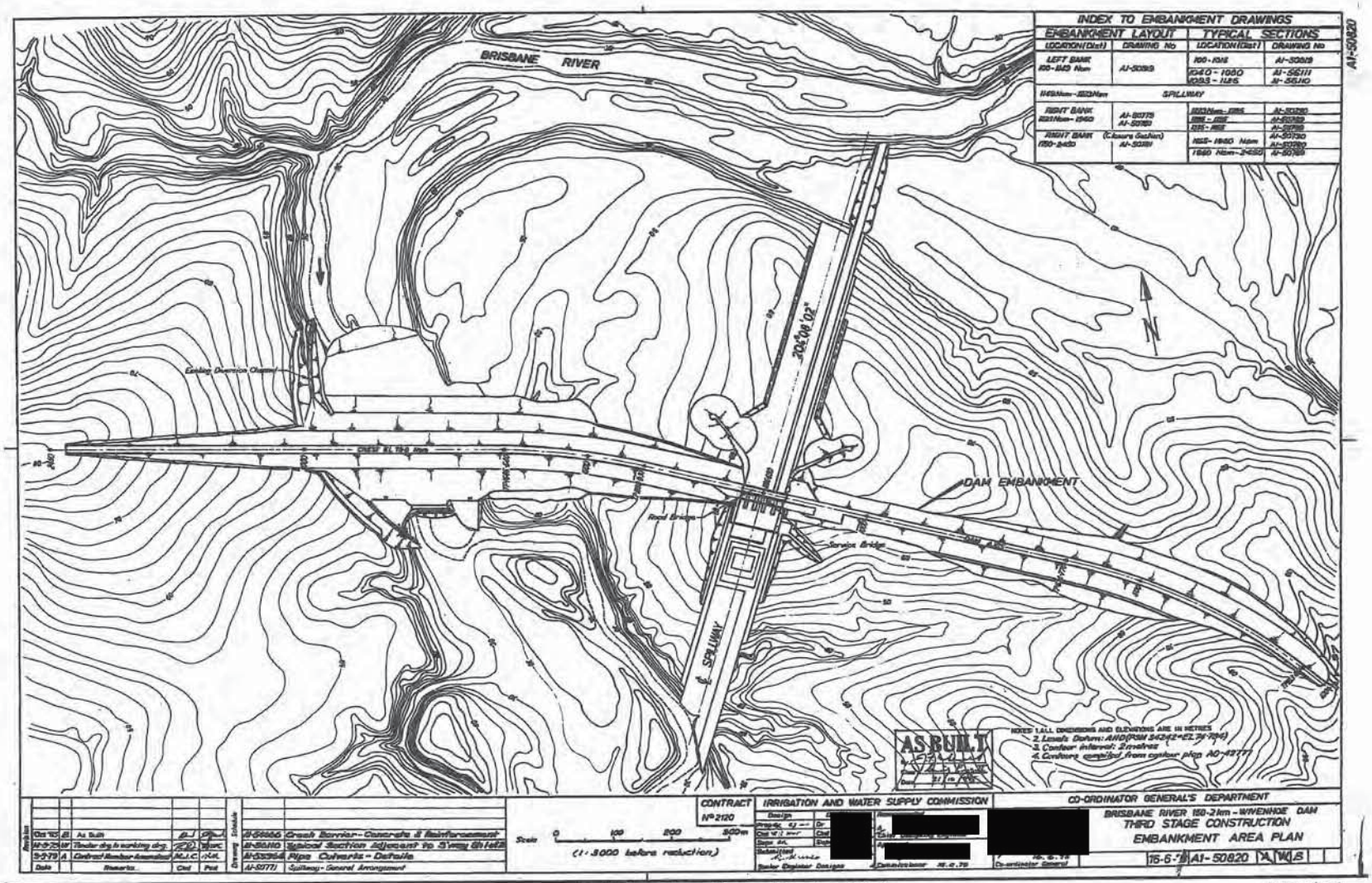
	12. The piezometer data should be reviewed monthly to assess any further changes in pressures.
Data was not recorded during the flood due to the inability to access the piezometer huts at the toe of the main embankment.	13. Repair gauge boards and consider the feasibility of remote monitoring of the piezometer gauges during flood events.
Settlement monuments WVSSS036, WVSSS037 at chainage 1800 and WVSSS047 at chainage 1600 are increasing in height (approximately 15 mm).	14. The monuments are located on downstream slope of the embankment near the dam toe. Within the last 15 years, these monuments are showing a reversing trend and are increasing in elevation. The maximum value of increased elevations of the previous mentioned monuments is 15 mm. The annual surveys should be continued and if the trends identified continue further analysis will be undertaken into the deformation of the dam.
Settlement of all the monuments, WVSSS070 through WVSSS081. Within the last two plus years, there is a clear trend that the entire structure is gaining in elevation. All the monuments are settling (or rising) at similar rates.	15. The network of survey monuments should be checked at the next annual survey to confirm that the apparent increase in elevation is actually occurring. 16. Following confirmation of the accuracy of the survey, investigate the upwards tend to determine the cause for the abnormal settlement trending.
All four of the inclinometer cumulative displacement plots show dam movement in the normal (downstream) direction that is inconsistent.	17. Review the inclinometer readings at the next annual inspection with a particular emphasis placed on the incremental changes in the reading over the preceding 12 months.

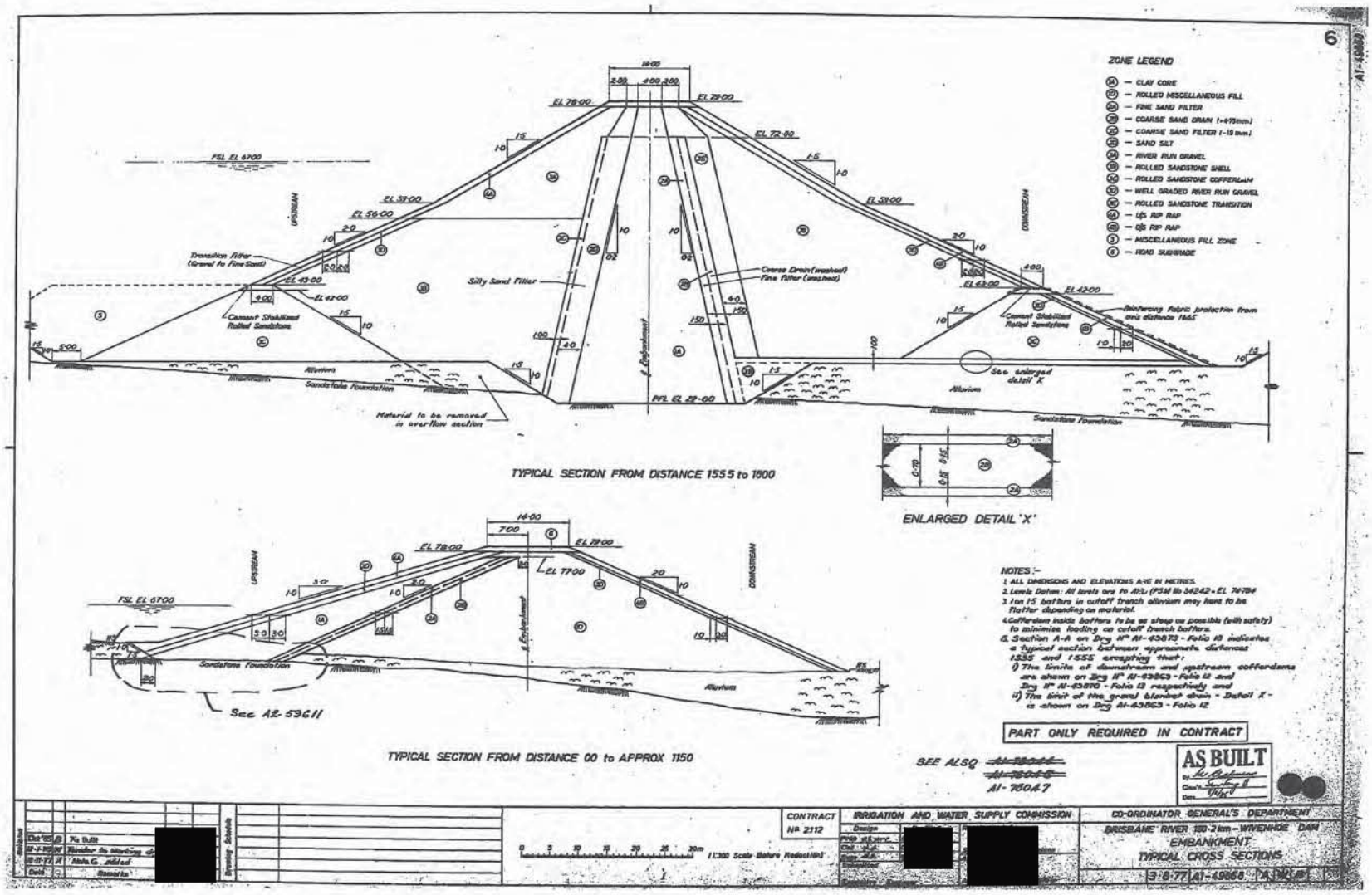
11 REFERENCES

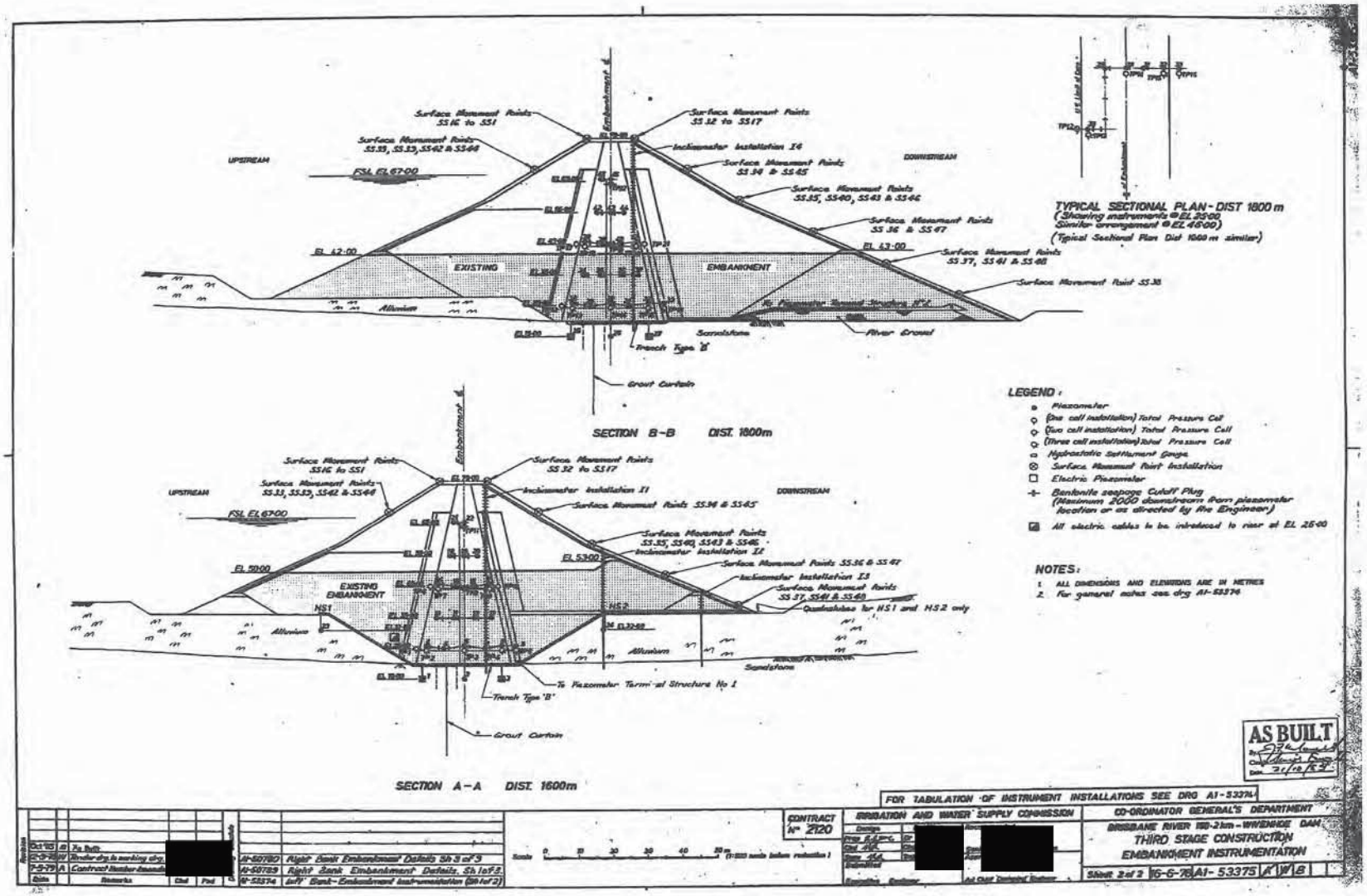
- (DPI Water Commercial 1995) "Wivenhoe Dam Design Report", September 1995.
- (GHD, 1997) "Wivenhoe Dam Safety Review", April 1997.
- (SunWater) "Detailed Stability Check of the Spillway Wall Monoliths at Wivenhoe Dam", June 2001.
- (SunWater 2001) "Assessment of Piping Potential in the Wivenhoe Saddle Dams", November 2001.
- (Wivenhoe Alliance 2005) "Wivenhoe Upgrade Design and Construction Report", December 2005.
- (Glen Hobbs and Associates 2006) "Wivenhoe Dam Radial gate Trunnion Bearings Review", May 2006.
- (NSW Department of Commerce 2006) "Wivenhoe Dam Comprehensive Inspection Draft Report", July 2006.
- (Seqwater 2009) "Wivenhoe Dam – Emergency Action Plan, September 2009.
- (Seqwater 2009) "Wivenhoe Dam – Standing Operating Procedures, March 2009.
- (Seqwater 2009) "Wivenhoe Dam – Operation and Maintenance Manuals, March 2009.
- (GHD 2009) "Report for Raising Wivenhoe Dam Full Supply Level Review", December 2009.
- (URS 2009) Dartmouth Dam- Appendix B Deformation Analysis
- (Seqwater, 2011) "January 2011 Flood Event- Report on the operation of Somerset and Wivenhoe Dam", March 2011.
- (DERM, 2011) "Wivenhoe Dam Spillway Development, s.37 Consultation, RTI Act 2009, DERM Application No. 10-207" Russ McConnell, Manager Containment System, OWSR

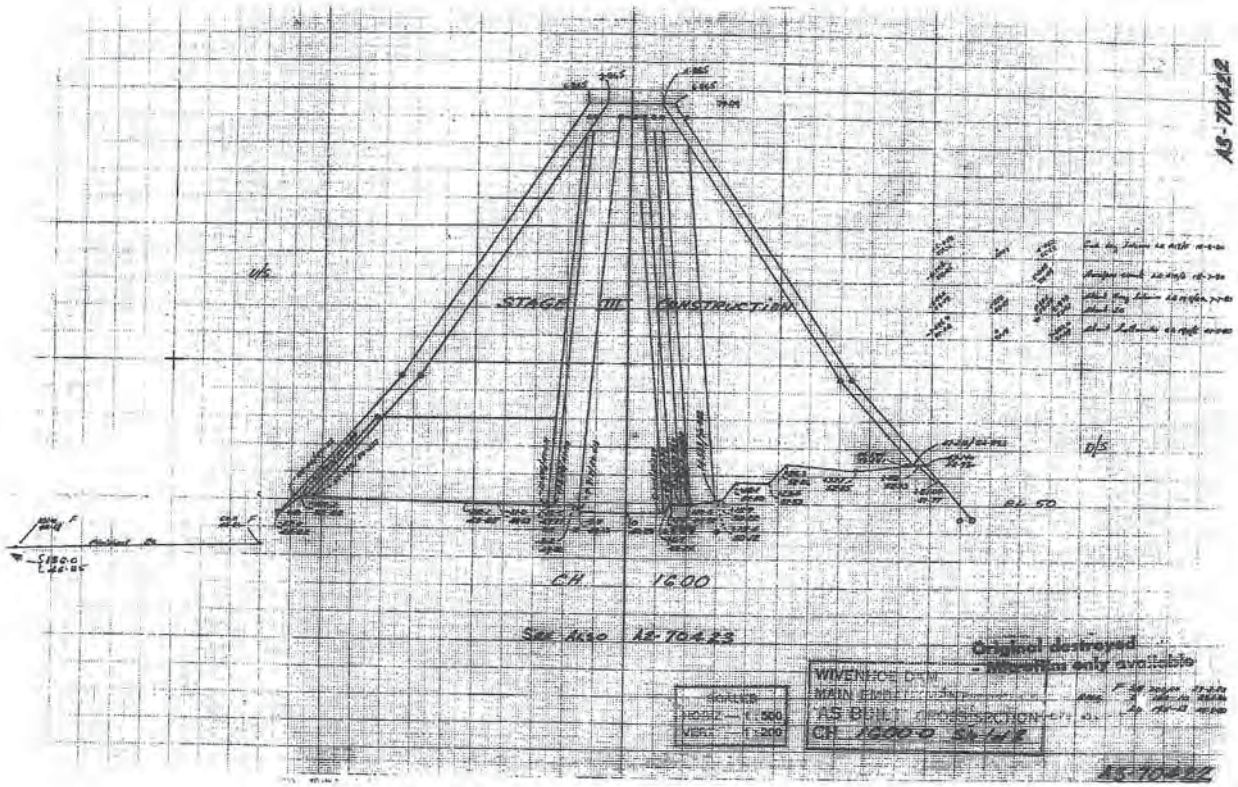
APPENDIX A DRAWINGS


LEGEND :
Surface Movement Point Installation
Connecting Cables
Trench Type 'B' see note 10
Inclinometer Installation
BRISBANE RIVER
DAM AXIS
For Details see drg AI-50760
Access Pipe with Piezometer Terminal Structure N°2
Access Pipe see Note 9
Piezometer Terminal Structure N°1
PLAN
SURFACE MOVEMENT POINTS AND SETTLEMENT INSTALLATIONS
PIEZOMETER INSTALLATIONS
TOTAL PRESSURE CELL INSTALLATIONS
INCLINOMETER INSTALLATIONS
REQUIRED THIS CONTRACT
NOTES :
1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES
2. Levels Datum : All levels to AHD (PSM 8" 34242 - EL 29.194)
3. Azimuth Datum : AMG
4. All installations to be carried out as per specification
5. Piezometers, Total Pressure Cells and associated tubes and wiring to be furnished and installed by the Principal but the associated protective surrounds shall be provided by the Contractor
6. Embankment Settlement and Inclinometer installations to be furnished and installed by the Principal but the associated trenches and drilled holes and subsequent backfilling shall be provided by the Contractor
7. Surface Movement Points to be supplied and installed by the Contractor
8. Location of all embedded instruments and settlement installations to be recorded to the nearest two settlements of the time of installation by the Engineer
9. Actual locations of astruments may vary depending on site conditions and will be determined by the Engineer
10. Trench Type B (refer drg AI-50760) to be excavated to enable placement of connecting cables. After placement of cables is completed trench to be backfilled with 15 MPa concrete
11. For details of Piezometer Terminal Structure access pipes refer to drg AI-54752.
FOR SECTIONS A-A AND B-B AND LOCATION OF INSTRUMENT INSTALLATIONS SEE DRG AI-53375
CONTRACT N° 2120
IRRIGATION AND WATER SUPPLY COMMISSION
CO-ORDINATOR GENERAL'S DEPARTMENT
BRISBANE RIVER 100-2 km - WIVENHOE DAM
THIRD STAGE CONSTRUCTION
EMBANKMENT INSTRUMENTATION
Sheet 1 of 2 16-6-78 AI - 53374 A B W

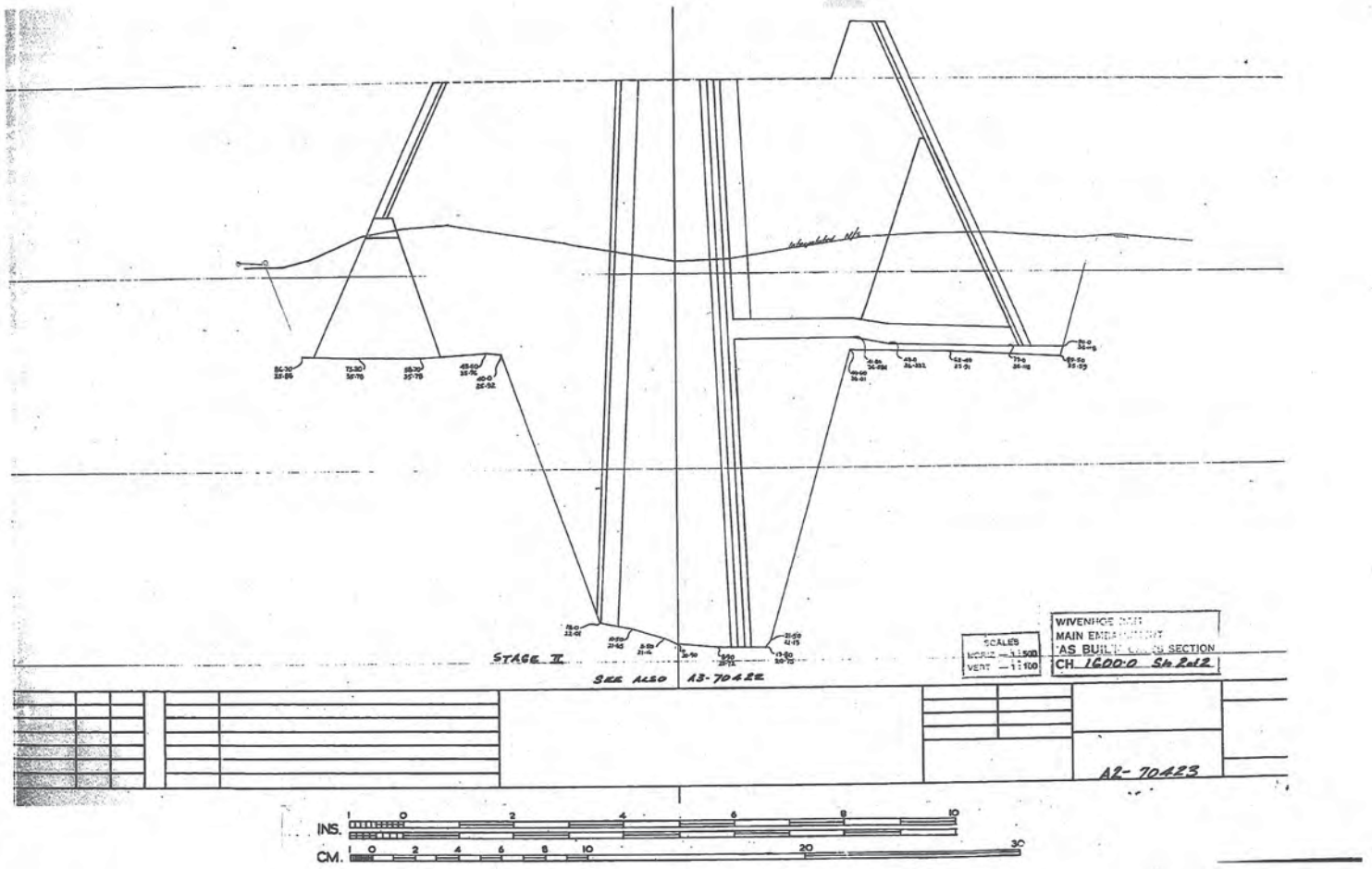

BRISBANE RIVER
DAM EMBANKMENT
SPILLWAY
AS BUILT
INDEX TO EMBANKMENT DRAWINGS
EMBANKMENT LAYOUT
TYPICAL SECTIONS
LOCATION (Dist)
DRAWING No
LEFT BANK
RIGHT BANK
SPILLWAY
CONTRACT Nº 2120
IRRIGATION AND WATER SUPPLY COMMISSION
CO-ORDINATOR GENERAL'S DEPARTMENT
BRISBANE RIVER 150·2km - WIVENHOE DAM
THIRD STAGE CONSTRUCTION
EMBANKMENT AREA PLAN
15-6-76 A1-50820 A W B

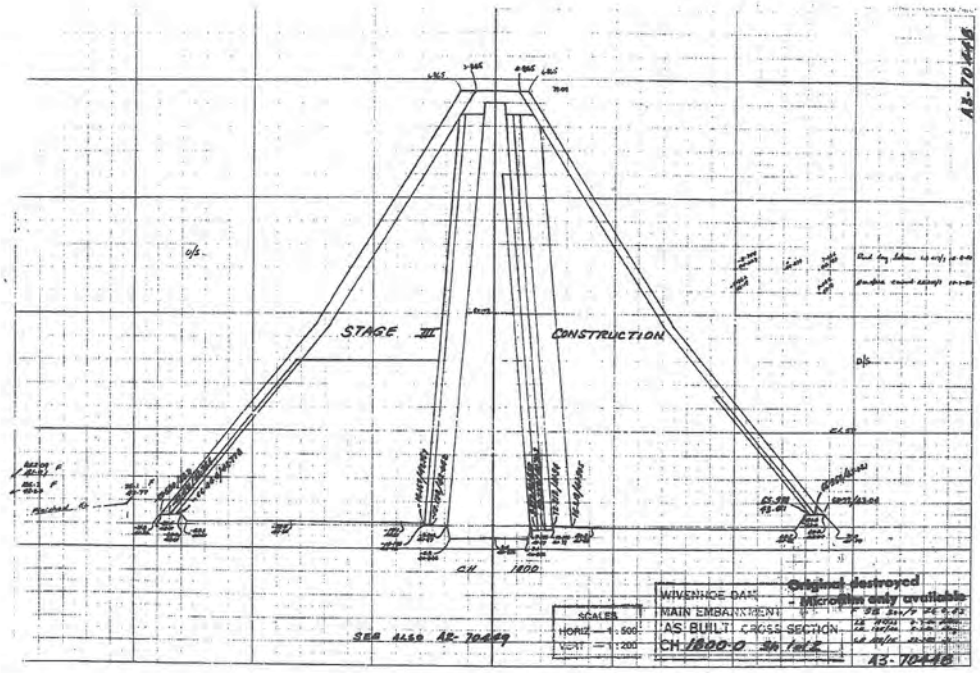

6
ZONE LEGEND
CLAY CORE
ROLLED MISCELLANEOUS FILL
FINE SAND FILTER
COARSE SAND DRAIN (+4·75mm)
COARSE SAND FILTER (-19 mm)
SAND SLT
RIVER RUN GRAVEL
ROLLED SANDSTONE SHELL
ROLLED SANDSTONE COFFERDAM
WELL GRADED RIVER RUN GRAVEL
ROLLED SANDSTONE TRANSITION
U/S RIP RAP
D/S RIP RAP
MISCELLANEOUS FILL ZONE
ROAD SUBGRADE
FSL EL 67·00
EL 78·00
EL 72·00
EL 53·00
EL 42·00
UPSTREAM
DOWNSTREAM
Transition Filter (Gravel to Fine Sand)
Silty Sand Filter
Coarse Drain (washed)
Fine Filter (washed)
Cement Stabilised Rolled Sandstone
Reinforcing Fabric protection from arm distance 1665
Alluvium
Sandstone Foundation
Material to be removed in overflow section
PFL EL 22·00
See enlarged detail K
TYPICAL SECTION FROM DISTANCE 1555 to 1600
ENLARGED DETAIL 'X'
EL 78·00
EL 77·00
EL 77·00
See AI-59611
TYPICAL SECTION FROM DISTANCE 00 to APPROX 1150
NOTES :-
1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. Lewis Datum: All levels are to AHD (PSM No 34242 - EL 74·784
3. 1 on 1·5 batters in cutoff trench alluvium may have to be flatter depending on material.
4. Cofferdam inside batters to be as steep as possible (with safety) to minimise loading on cutoff trench batters.
5. Section A-A on Drg No AI-43873 - Folio 10 indicates a typical section between approximate distances 1535 and 1555 excepting that:
i) The limits of downstream and upstream cofferdams are shown on Drg No AI-43863 - Folio 12 and Drg No AI-43870 - Folio 13 respectively and
ii) The limit of the gravel blanket drain - Detail K - is shown on Drg AI-43863 - Folio 12
PART ONLY REQUIRED IN CONTRACT
SEE ALSO AI-76047
AS BUILT
CONTRACT No 2112
IRRIGATION AND WATER SUPPLY COMMISSION
CO-ORDINATOR GENERAL'S DEPARTMENT
BRISBANE RIVER 100·2 km - WIVENHOE DAM
EMBANKMENT
TYPICAL CROSS SECTIONS
3·8·77 AI-49868


TYPICAL SECTIONAL PLAN - DIST 1800 m
(Showing instruments @ EL 3900, Similar arrangement @ EL 4800)
(Typical Sectional Plan Dist 1600 m similar)
SECTION B-B DIST. 1800m
SECTION A-A DIST. 1600m
LEGEND :
NOTES :
1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES
2. For general notes see drg A1-53374
AS BUILT
FOR TABULATION OF INSTRUMENT INSTALLATIONS SEE DRG A1-53374
IRRIGATION AND WATER SUPPLY COMMISSION
CO-ORDINATOR GENERAL'S DEPARTMENT
BRISBANE RIVER 160-21km - WIVENHOE DAM
THIRD STAGE CONSTRUCTION
EMBANKMENT INSTRUMENTATION
CONTRACT No 2120
A1-53375

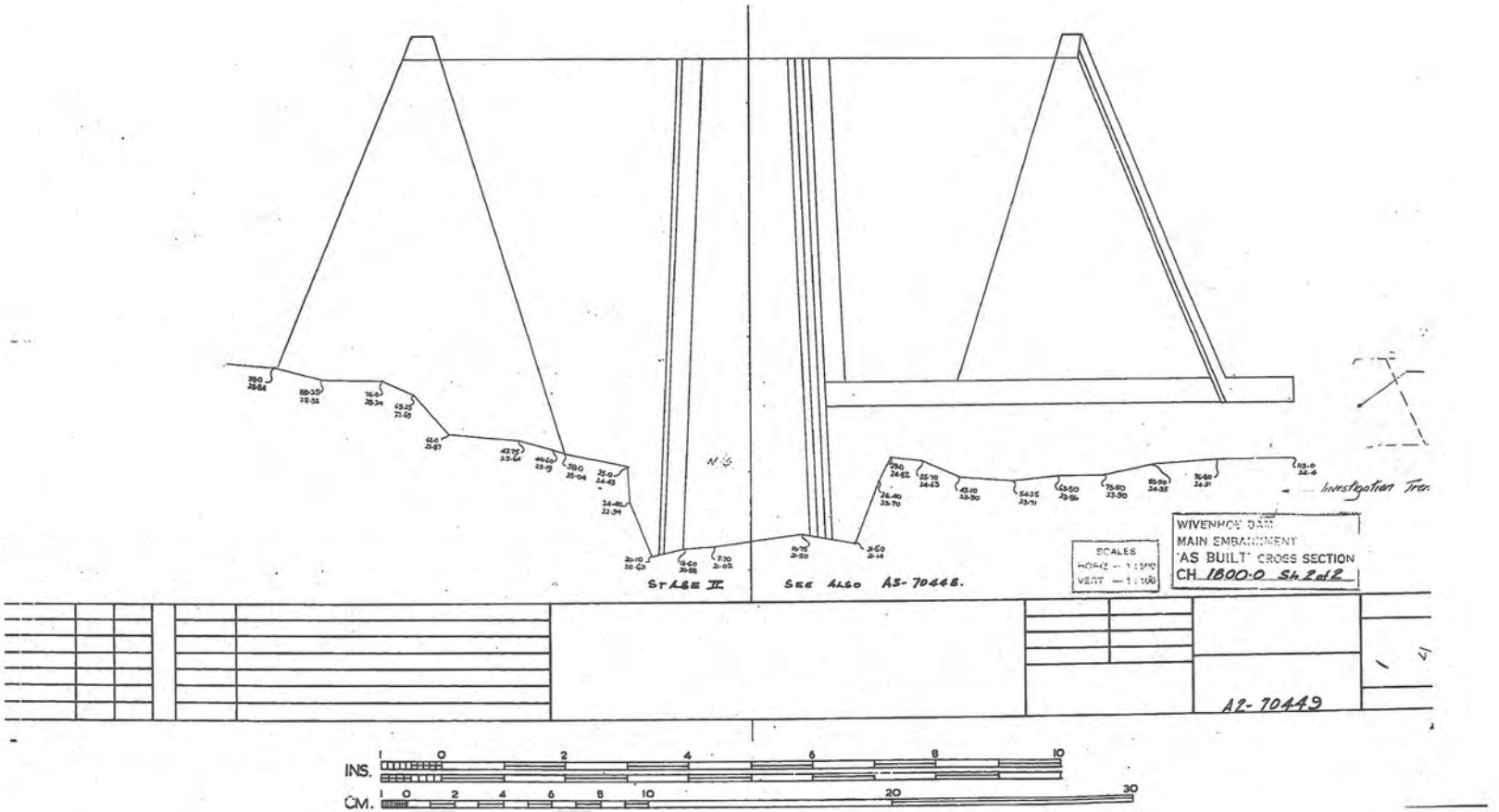

STAGE III CONSTRUCTION
CH 1600
See Also 12-704.23
Original destroyed
- Microfilm only available
WIVENHOE DAM
MAIN
AS BUILT
CH 1600.0


INS.
CM.


STAGE II
SEE ALSO A3-70422
SCALES
HORIZ — 1:500
VERT — 1:100
WIVENHOE DAM
MAIN EMBANKMENT
AS BUILT CROSS SECTION
CH 1600·0 Sh 2of2
A2-70423
INS.
CM.


STAGE III CONSTRUCTION
WIVENHOE DAM
MAIN EMBANKMENT
AS BUILT CROSS SECTION
CH 1800·0
SCALES
HORIZ — 1:500
VERT — 1:200
Original destroyed
- Microfilm only available
AS-704A


INS.
CM.


WIVENHOE DAM
MAIN EMBANKMENT
'AS BUILT' CROSS SECTION
CH 1800·0 Sh 2 of 2
SCALES
HORIZ — 1:500
VERT — 1:100
STAGE III
SEE ALSO AS-70448.
AS-70449
INS.
CM.

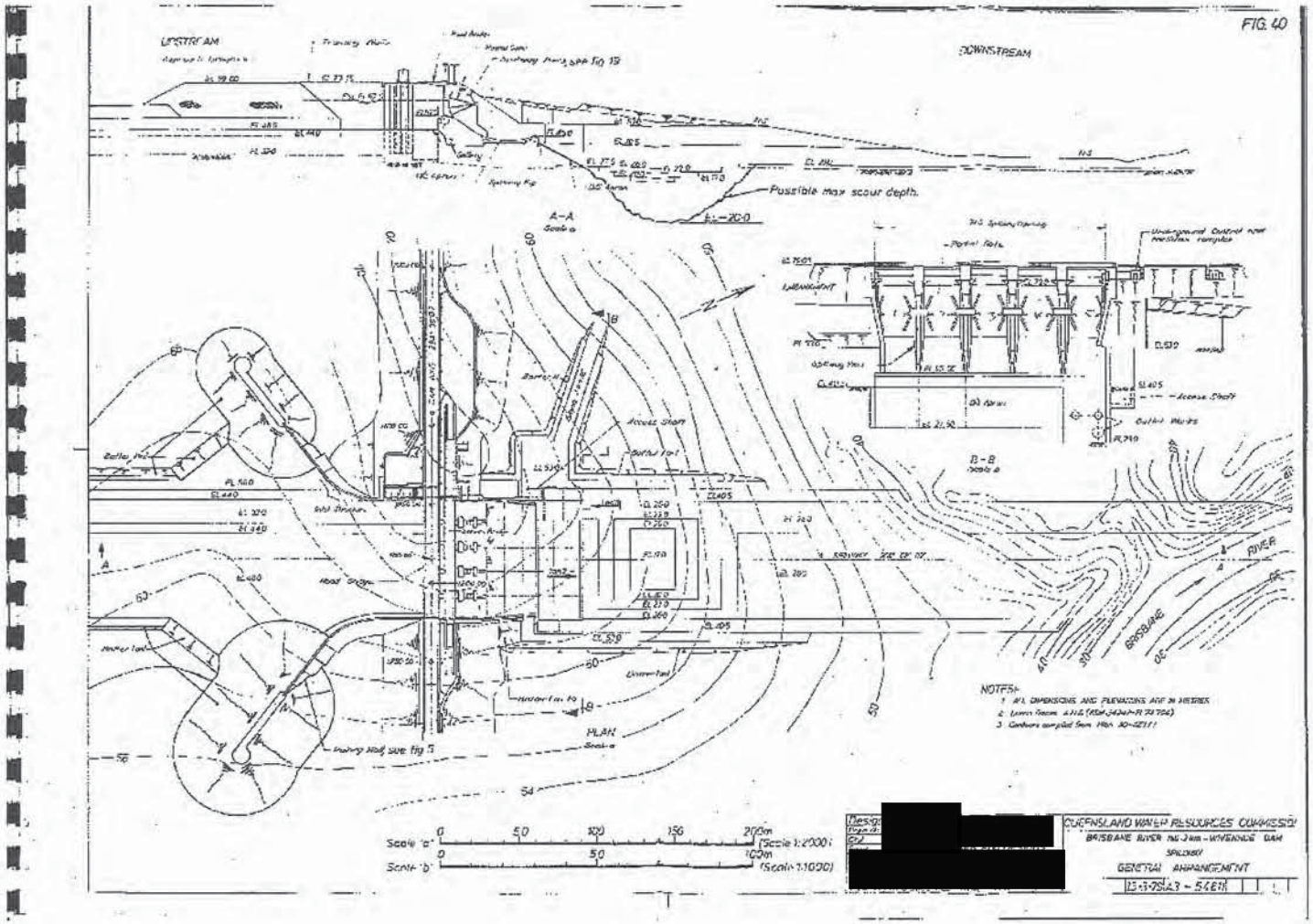
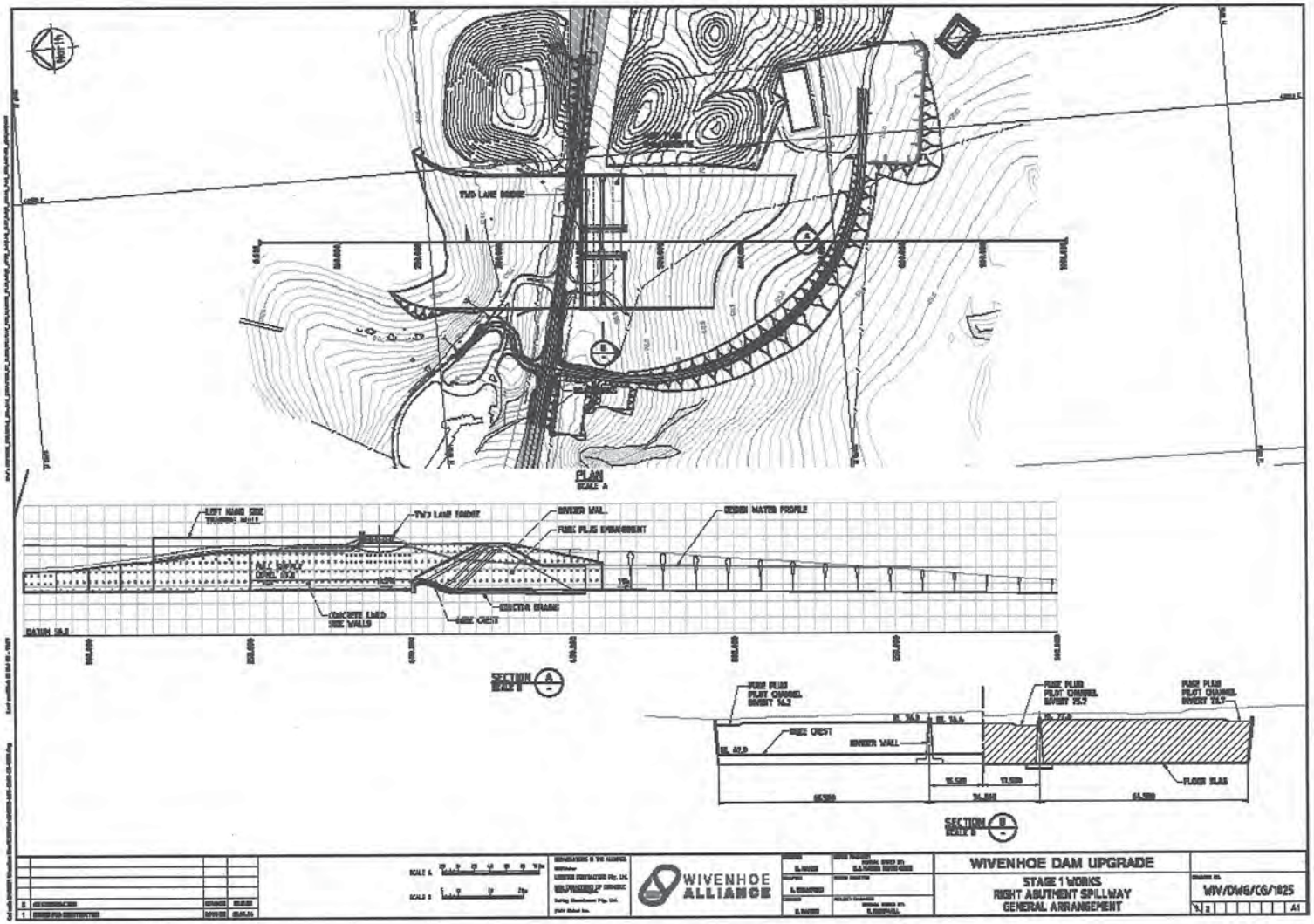
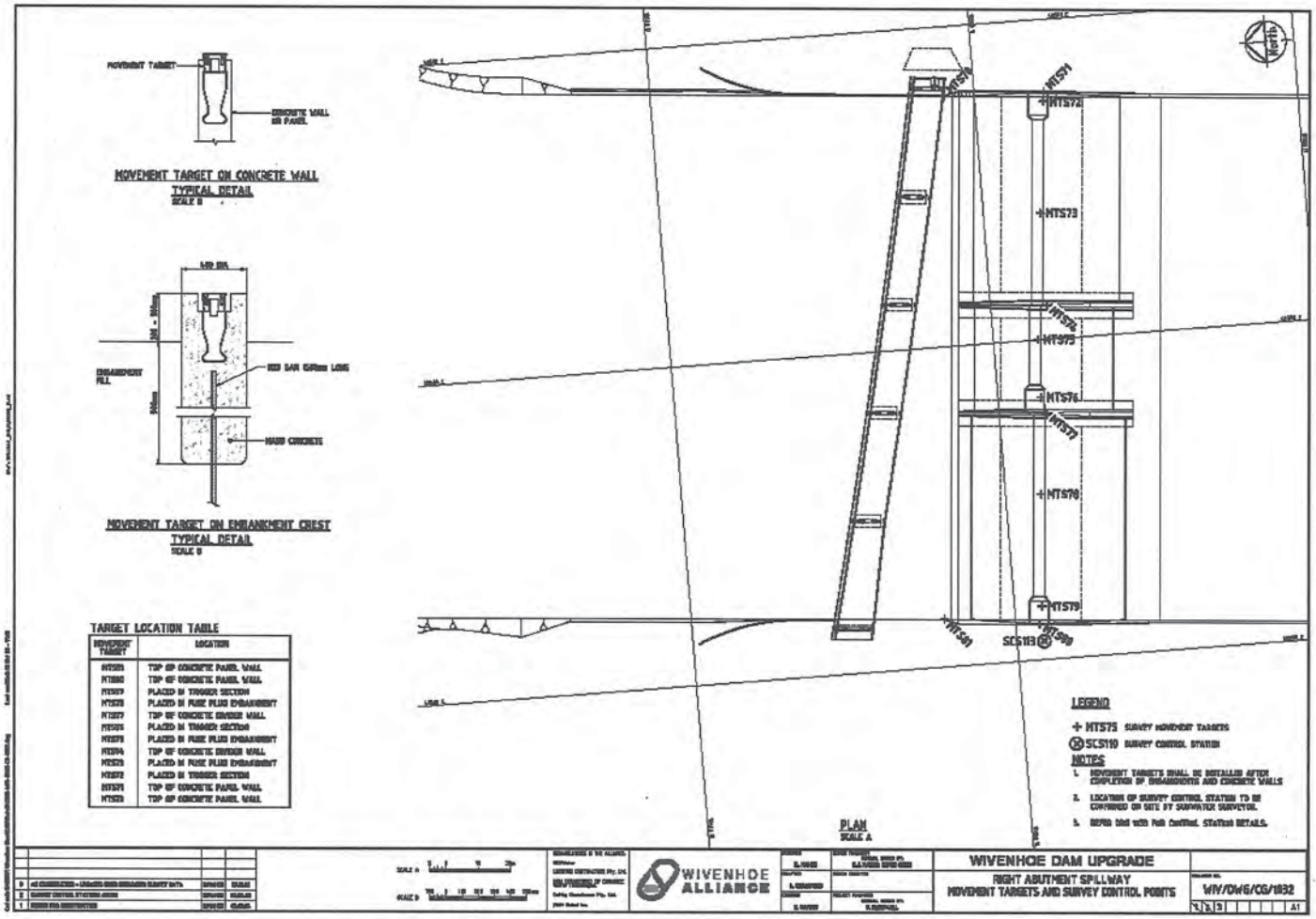
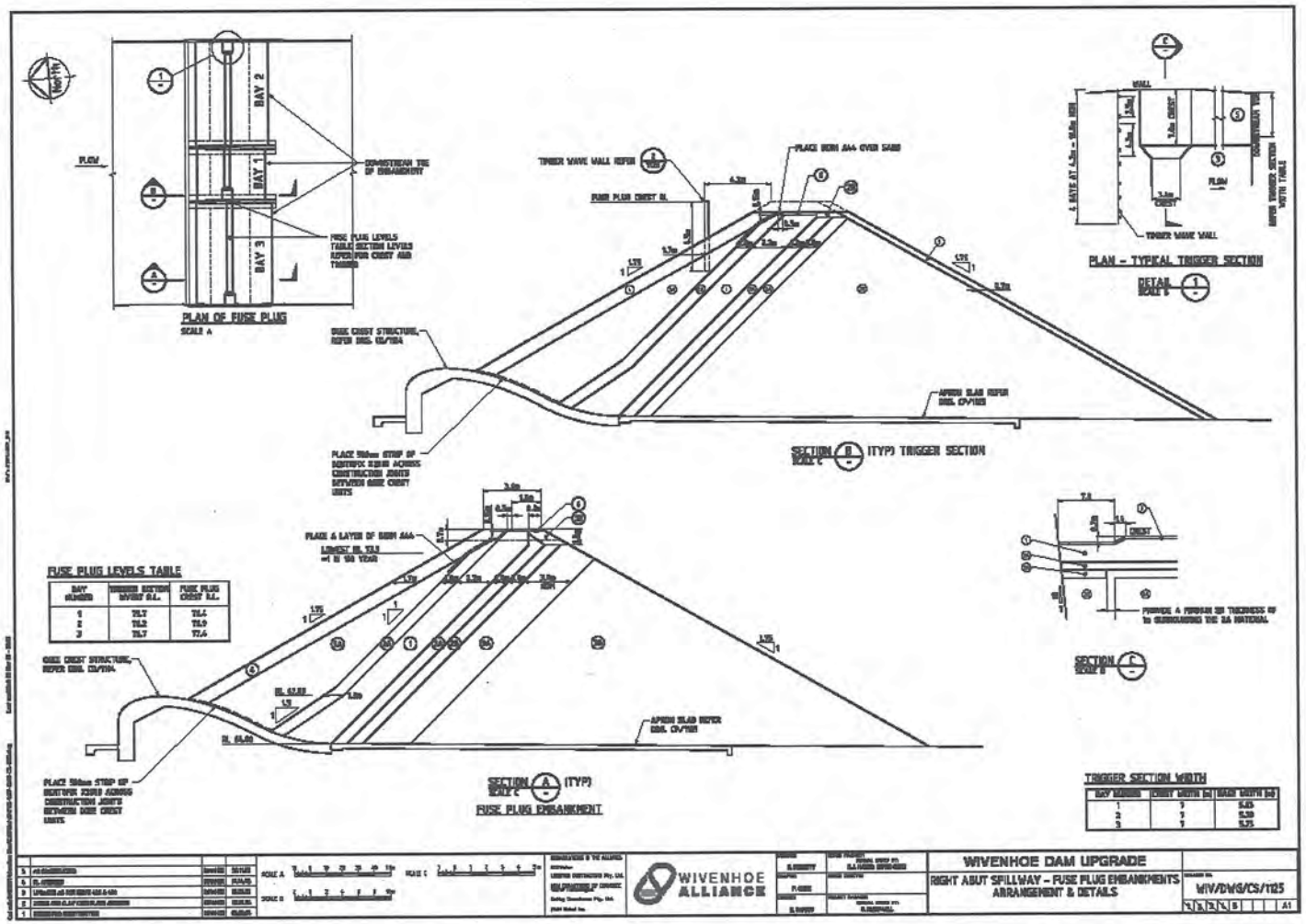


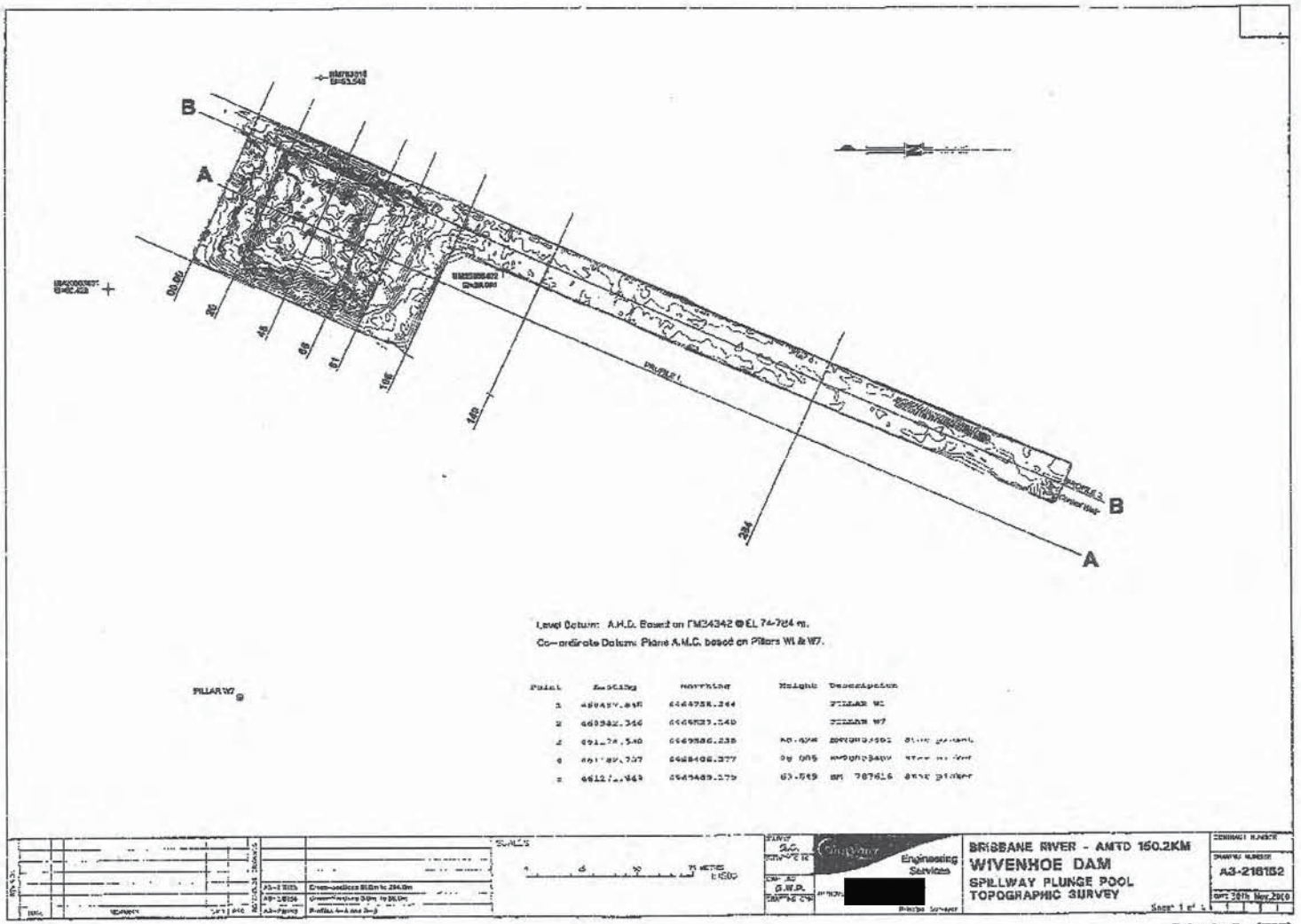
FIG. 40
DOWNSTREAM
Possible max scour depth.
A-A
B-B
PLAN
NOTES:
QUEENSLAND WATER RESOURCES COMMISSION
BRISBANE RIVER (NO 3) DAM - WIVENHOE DAM
SPILLWAY
GENERAL ARRANGEMENT
BRISBANE
RIVER

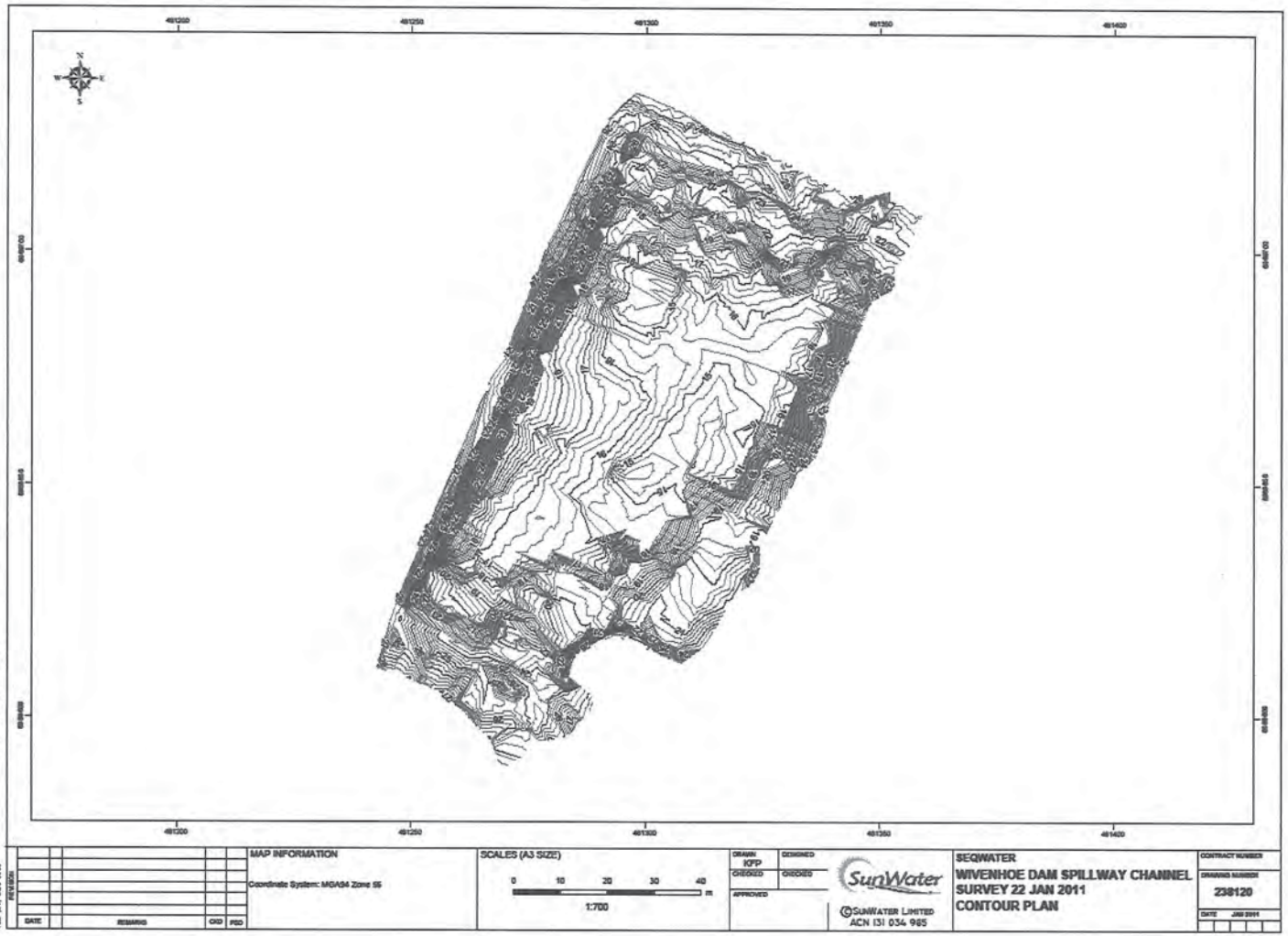

PLAN
SCALE A
TWO LANE BRIDGE
LEFT HAND SIDE TRAINING WALL
TWO LANE BRIDGE
RIVER WALL
FUSE PLUG EMBANKMENT
DESIGN WATER PROFILE
ALL WEATHER ACCESS TRACK
CONCRETE LINED SIDE WALLS
EJECTOR DRAINS
CREST
DATUM AHD
SECTION A
SCALE B
FUSE PLUG PILOT CHANNEL INVERT 14.2
FUSE PLUG PILOT CHANNEL INVERT 25.2
FUSE PLUG PILOT CHANNEL INVERT 28.7
CREST
RIVER WALL
FLOOR SLAB
SECTION B
SCALE B
WIVENHOE ALLIANCE
WIVENHOE DAM UPGRADE
STAGE 1 WORKS
RIGHT ABUTMENT SPILLWAY
GENERAL ARRANGEMENT
WIV/DWG/CG/1825
A1

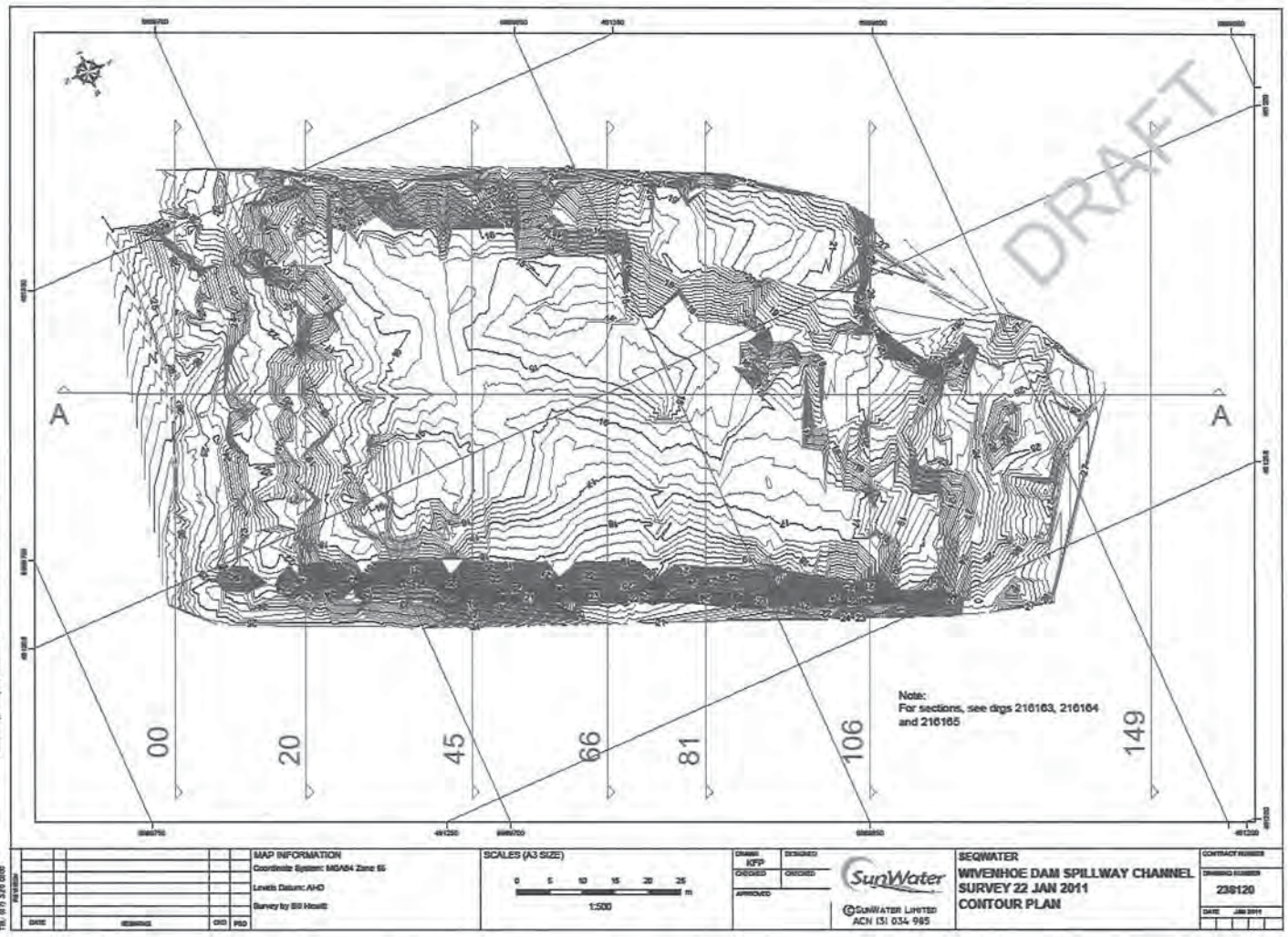

MOVEMENT TARGET
CONCRETE WALL
MOVEMENT TARGET ON CONCRETE WALL
TYPICAL DETAIL
SCALE B
EMBANKMENT FILL
MOVEMENT TARGET ON EMBANKMENT CREST
TYPICAL DETAIL
SCALE B
TARGET LOCATION TABLE
MOVEMENT TARGET
LOCATION
PLAN
SCALE A
LEGEND
MTS75 SURVEY MOVEMENT TARGETS
SCS110 SURVEY CONTROL STATION
NOTES
1. MOVEMENT TARGETS SHALL BE INSTALLED AFTER COMPLETION OF DIAPHRAGMS AND CONCRETE WALLS
2. LOCATION OF SURVEY CONTROL STATION TO BE CONFIRMED ON SITE BY SURVEYOR SURVEYOR.
3. REFER SHEET WITH PATH CONTROL STATION DETAILS.
WIVENHOE ALLIANCE
WIVENHOE DAM UPGRADE
RIGHT ABUTMENT SPILLWAY
MOVEMENT TARGETS AND SURVEY CONTROL POINTS
WIV/DWG/CG/1832
A1

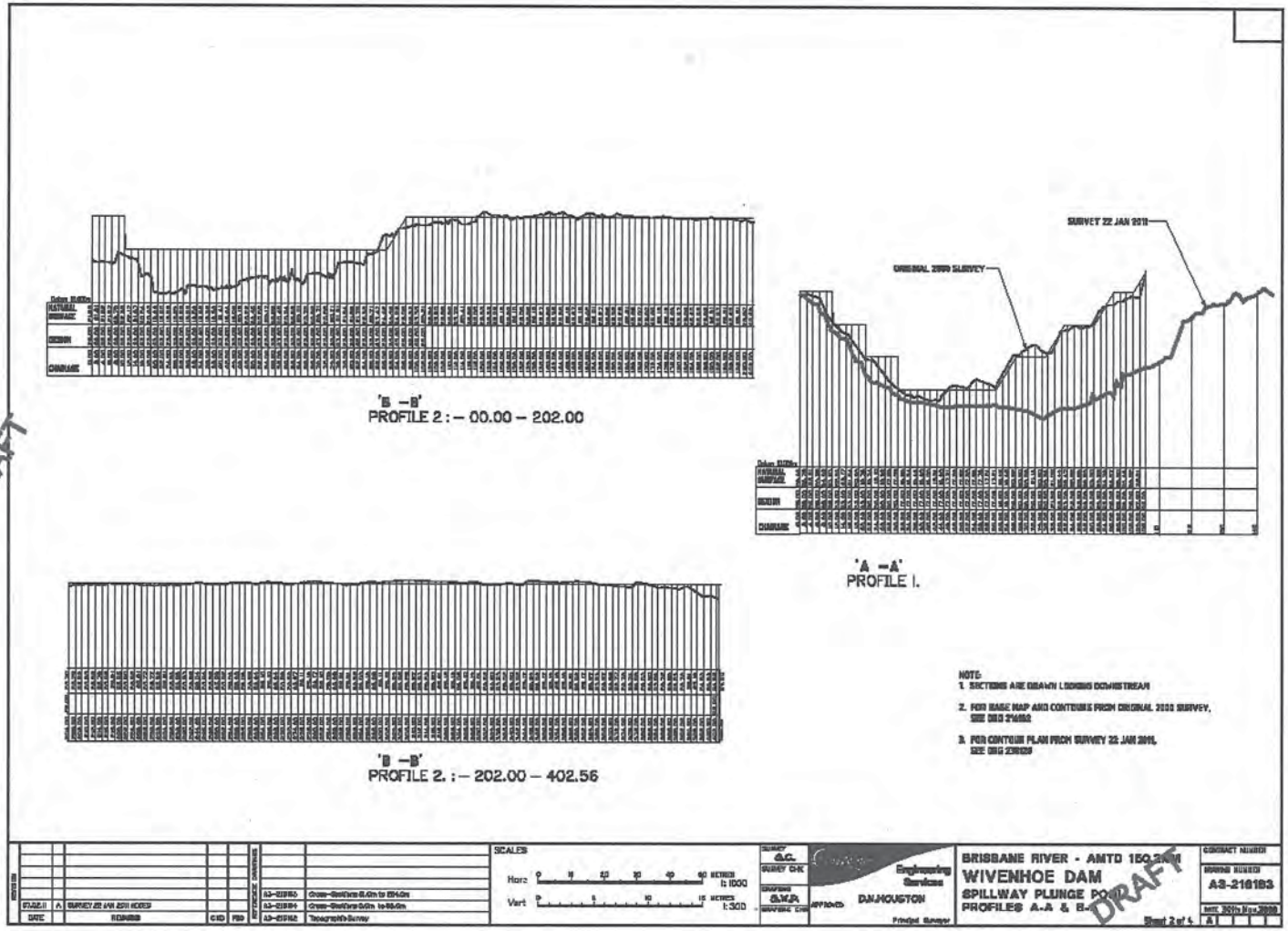

PLAN OF FUSE PLUG
SCALE A
BAY 1
BAY 2
BAY 3
FLOW
DOWNSTREAM TOE OF EMBANKMENT
FUSE PLUG LEVELS TABLE SECTION LEVELS REFER PIER CREST AND TRIGGER
TIMBER WAVE WALL REFER
PLACE 300mm AAA OVER SAND
FUSE PLUG CREST RL
SHEE CREST STRUCTURE REFER DRG. 03/1104
APRON SLAB REFER DRG. 04/1105
PLACE 150mm STRIP OF BITUTEX 2000 ACROSS CONSTRUCTION JOINTS BETWEEN SHEE CREST UNITS
SECTION (B) (TYP) TRIGGER SECTION
PLAN - TYPICAL TRIGGER SECTION
DETAIL (1)
WALL
CREST
TIMBER WAVE WALL
FLOW
SECTION (C)
PROVIDE A MINIMUM 3m THICKNESS OF TO SURROUNDING THE AA MATERIAL
FUSE PLUG LEVELS TABLE
DAY NUMBER
TRIGGER SECTION INVERT R.L.
FUSE PLUG CREST R.L.
1 73.7 73.4
2 73.2 73.9
3 73.7 77.4
PLACE A LAYER OF 600H AAA
LOWEST RL 73.2
=1 IN 100 YEAR
SHEE CREST STRUCTURE REFER DRG. 03/1104
APRON SLAB REFER DRG. 04/1105
PLACE 150mm STRIP OF BITUTEX 2000 ACROSS CONSTRUCTION JOINTS BETWEEN SHEE CREST UNITS
SECTION (A) (TYP)
FUSE PLUG EMBANKMENT
TRIGGER SECTION WIDTH
DAY NUMBER
CREST WIDTH (m)
BASE WIDTH (m)
1 7 8.65
2 7 8.30
3 7 8.25
WIVENHOE ALLIANCE
WIVENHOE DAM UPGRADE
RIGHT ABUT SPILLWAY - FUSE PLUG EMBANKMENTS ARRANGEMENT & DETAILS
WIV/DWG/CS/1125
A1

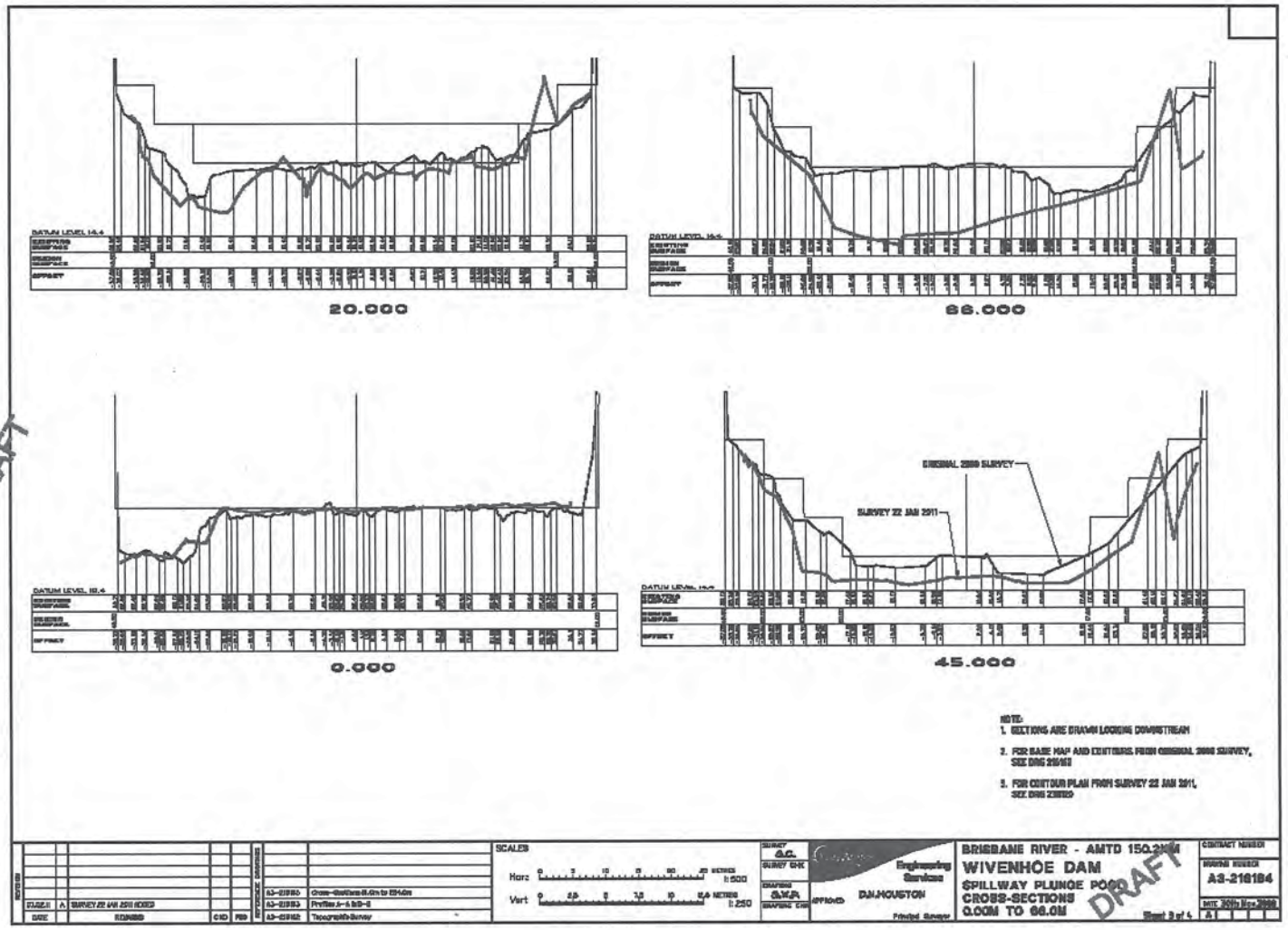
APPENDIX B January 2011 Spillway Survey

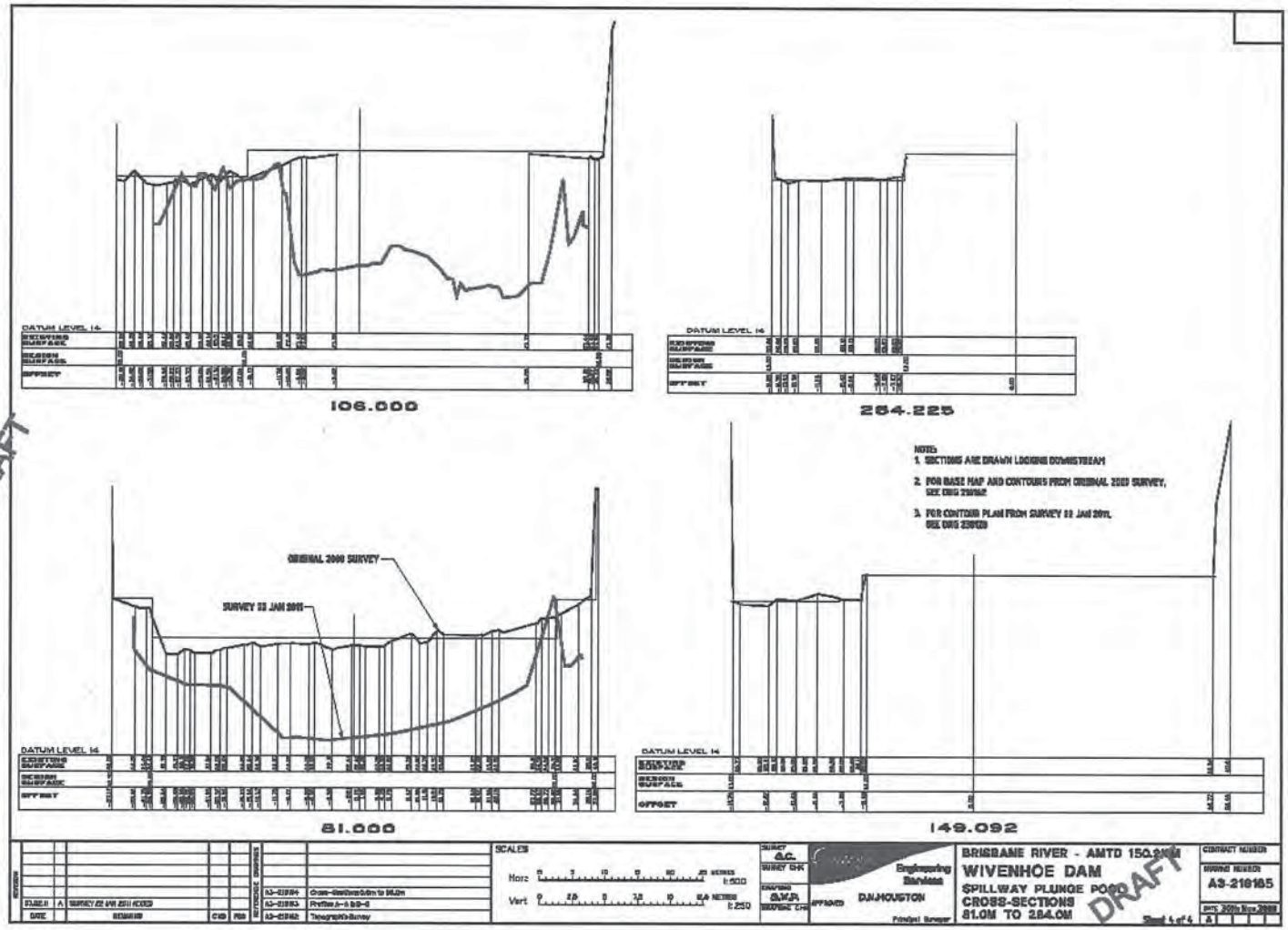

B
A
B
A
PROFILE 1
PILLAR W2
Level Datum: A.H.D. Based on PM24342 @ EL 74.724 m.
Co-ordinate Datum: Plane A.M.G. based on Pillars W1 & W7.
Point
Eastings
Northing
Height
Description
1
PILLAR W1
2
PILLAR W7
SCALE 1:500
Engineering Services
BRISBANE RIVER - AMTD 160.2KM
WIVENHOE DAM
SPILLWAY PLUNGE POOL
TOPOGRAPHIC SURVEY
DRAWING NUMBER
A3-216152
DATE 28th Nov 2000


MAP INFORMATION
Coordinate System: MGA94 Zone 56
SCALES (A3 SIZE)
0 10 20 30 40 m
1:700
SEQWATER
WIVENHOE DAM SPILLWAY CHANNEL
SURVEY 22 JAN 2011
CONTOUR PLAN
238120
SunWater
SunWater Limited
ACN 131 034 985


DRAFT
A
A
00
20
45
66
81
106
149
Note:
For sections, see dgs 216163, 216164
and 216165
MAP INFORMATION
Coordinate System: MGA94 Zone 56
Levels Datum: AHD
Survey by Bill Hewitt
SCALES (A3 SIZE)
0 5 10 15 20 25 m
1:500
SunWater
©SUNWATER LIMITED
ACN 131 034 985
SEQWATER
WIVENHOE DAM SPILLWAY CHANNEL
SURVEY 22 JAN 2011
CONTOUR PLAN
236120

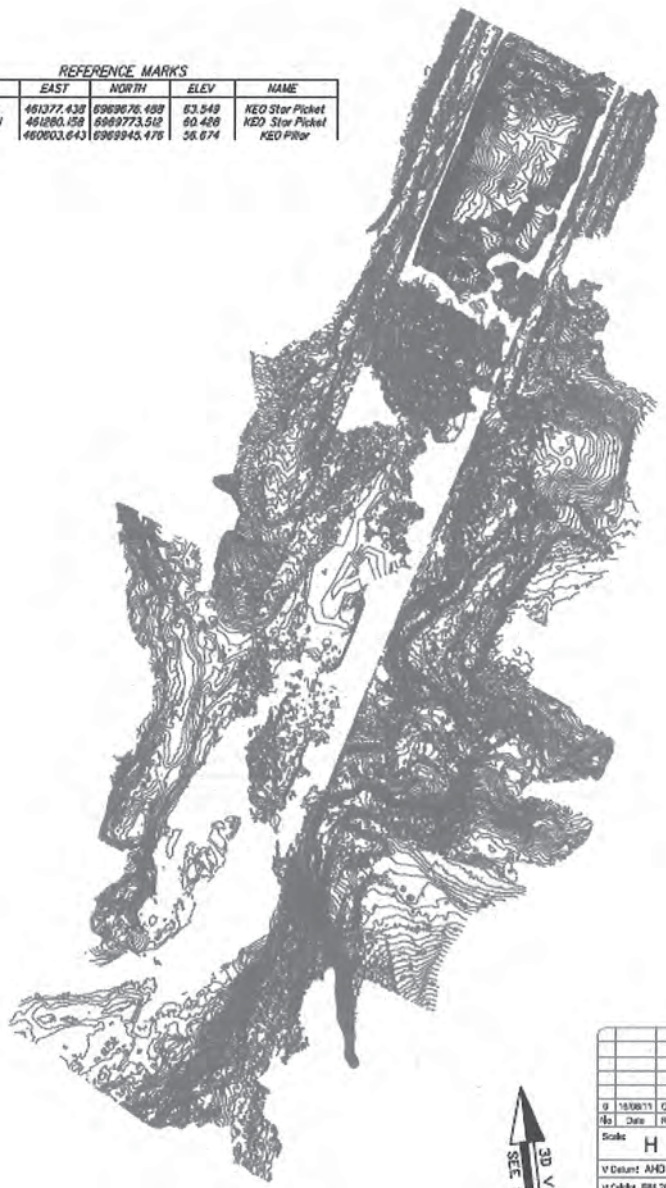

DRAFT
'B –B'
PROFILE 2 : – 00.00 – 202.00
SURVEY 22 JAN 2011
ORIGINAL 2000 SURVEY
'A –A'
PROFILE 1.
'B –B'
PROFILE 2. : – 202.00 – 402.56
NOTE:
1. SECTIONS ARE DRAWN LOOKING DOWNSTREAM
2. FOR BASE MAP AND CONTOURS FROM ORIGINAL 2000 SURVEY,
SEE DRG 216152
3. FOR CONTOUR PLAN FROM SURVEY 22 JAN 2011,
SEE DRG 238228
SCALES
Horz 1:1000
Vert 1:300
Engineering Services
BRISBANE RIVER - AMTD 150.2[illegible]
WIVENHOE DAM
SPILLWAY PLUNGE POO[illegible]
PROFILES A-A & B-[illegible]
DRAFT
Sheet 2 of 4
A3-216183


20.000
66.000
0.000
45.000
ORIGINAL 2000 SURVEY
SURVEY 22 JAN 2011
DRAFT
NOTE:
1. SECTIONS ARE DRAWN LOOKING DOWNSTREAM
2. FOR BASE MAP AND CONTOURS FROM ORIGINAL 2000 SURVEY, SEE DRG 216183
3. FOR CONTOUR PLAN FROM SURVEY 22 JAN 2011, SEE DRG 216183
SCALES
Horz 1:500
Vert 1:250
Engineering Services
D.M.HOUSTON
Principal Surveyor
BRISBANE RIVER - AMTD 150.2[illegible]
WIVENHOE DAM
SPILLWAY PLUNGE POOL
CROSS-SECTIONS
0.00M TO 66.0M
DRAFT
CONTRACT NUMBER
A3-216184


DRAFT
106.000
264.225
ORIGINAL 2000 SURVEY
SURVEY 22 JAN 2011
81.000
149.092
NOTES:
1. SECTIONS ARE DRAWN LOOKING DOWNSTREAM
2. FOR BASE MAP AND CONTOURS FROM ORIGINAL 2000 SURVEY, SEE DRG 230162
3. FOR CONTOUR PLAN FROM SURVEY 22 JAN 2011, SEE DRG 230120
SCALES
Horz 1:500
Vert 1:250
BRISBANE RIVER - AMTD 150.2KM
WIVENHOE DAM
SPILLWAY PLUNGE POOL
CROSS-SECTIONS
81.0M TO 264.0M
DRAFT
A3-216165

REFERENCE MARKS

POINT	EAST	NORTH	ELEV	NAME
783618	461377.438	6969676.488	63.549	KEO Star Picket
2003401	461280.158	6969773.512	60.428	KEO Star Picket
WI	460603.643	6969945.476	56.674	KEO Pillar



0	15/08/11	Original Issue
No	Date	Revision
Scale	H 1:2000	A3 (ANSI)
V Datum: AHD (Dat)	Contour Int.	0.25m
V Origin: BM 2003401	RL 60.428m	
H Datum: PLANE REC BASED ON MGA MERIDIAN		
Local Authority: BRISBANE CITY COUNCIL		
Surveyed: BL	Date:	25/05/2011
Drawn: BL	Date:	15/08/2011
File Ref: 102271002	File:	GIS
SHEET 1 OF 2		

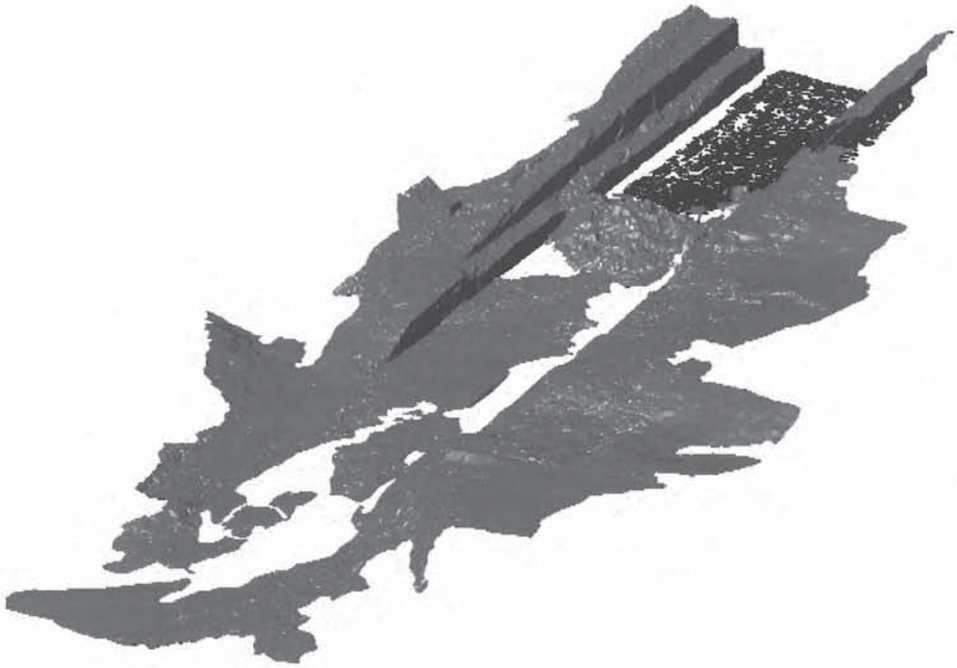
Scale 1:2000 – Lengths are in Metres.

20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280

Title/Project: WIVENHOE DAM SPILLWAY
BRISBANE VALLEY HIGHWAY
Client: SMEC Australia Pty Ltd

North Surveys PTY LTD
Creating exceptional value

Dwg: 102271#001 Rev: 0



D	16/06/11	Original Issue
No	Date	Revision

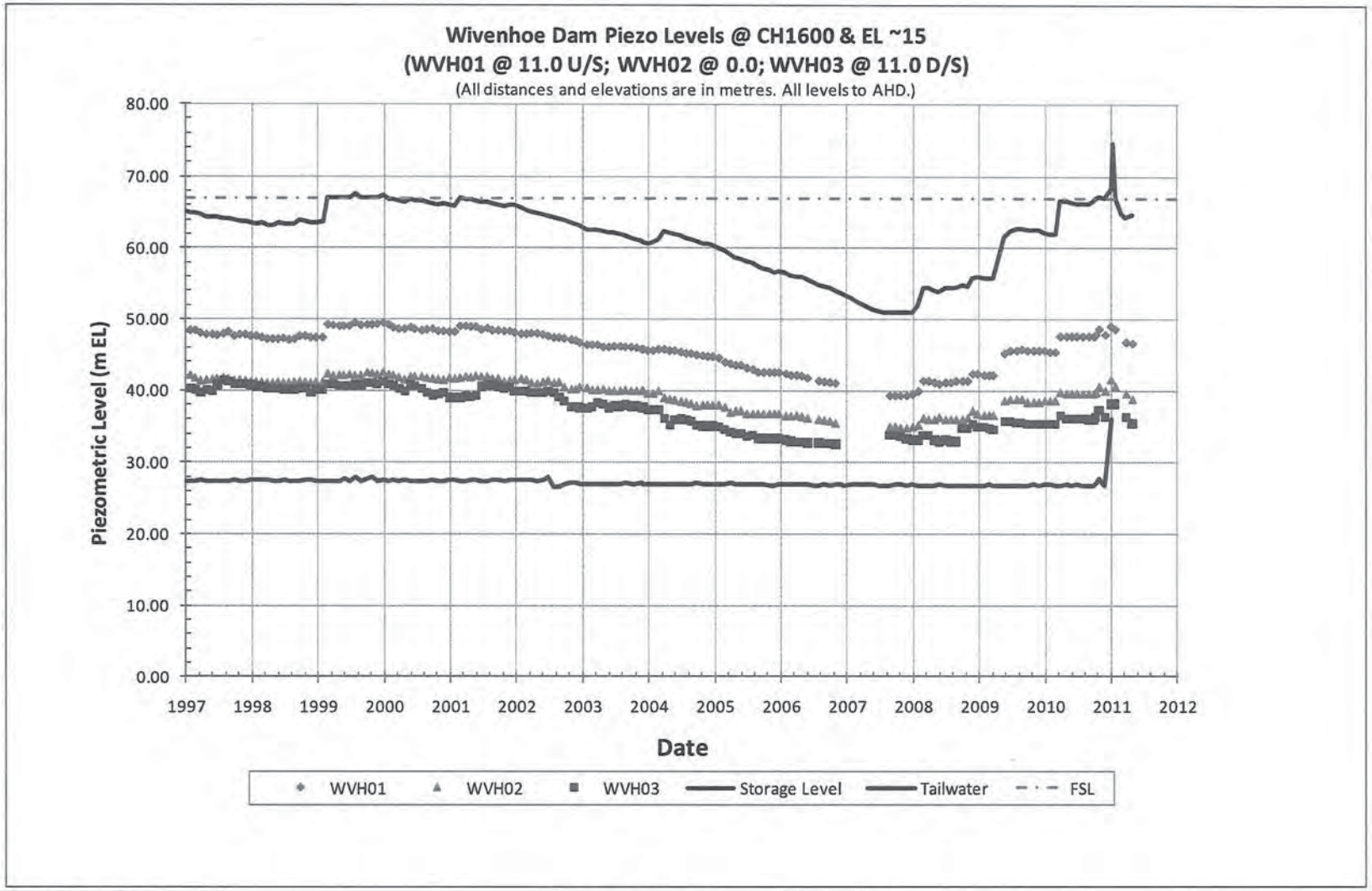
Scale: Not to Scale	A3
V Datum: AHD (Der)	Contour Int. 0.25m
V Origin: BM 20003401 RL 60.428m	
H Datum: PLANE REC BASED ON MGA MERIDIAN	
Local Authority: BRISBANE CITY COUNCIL	
Surveyed: BL	Date: 25/05/2011
Drawn: BL	Date: 15/06/2011
File Ref: 102271002	FB: GS
SHEET 2 OF 2	

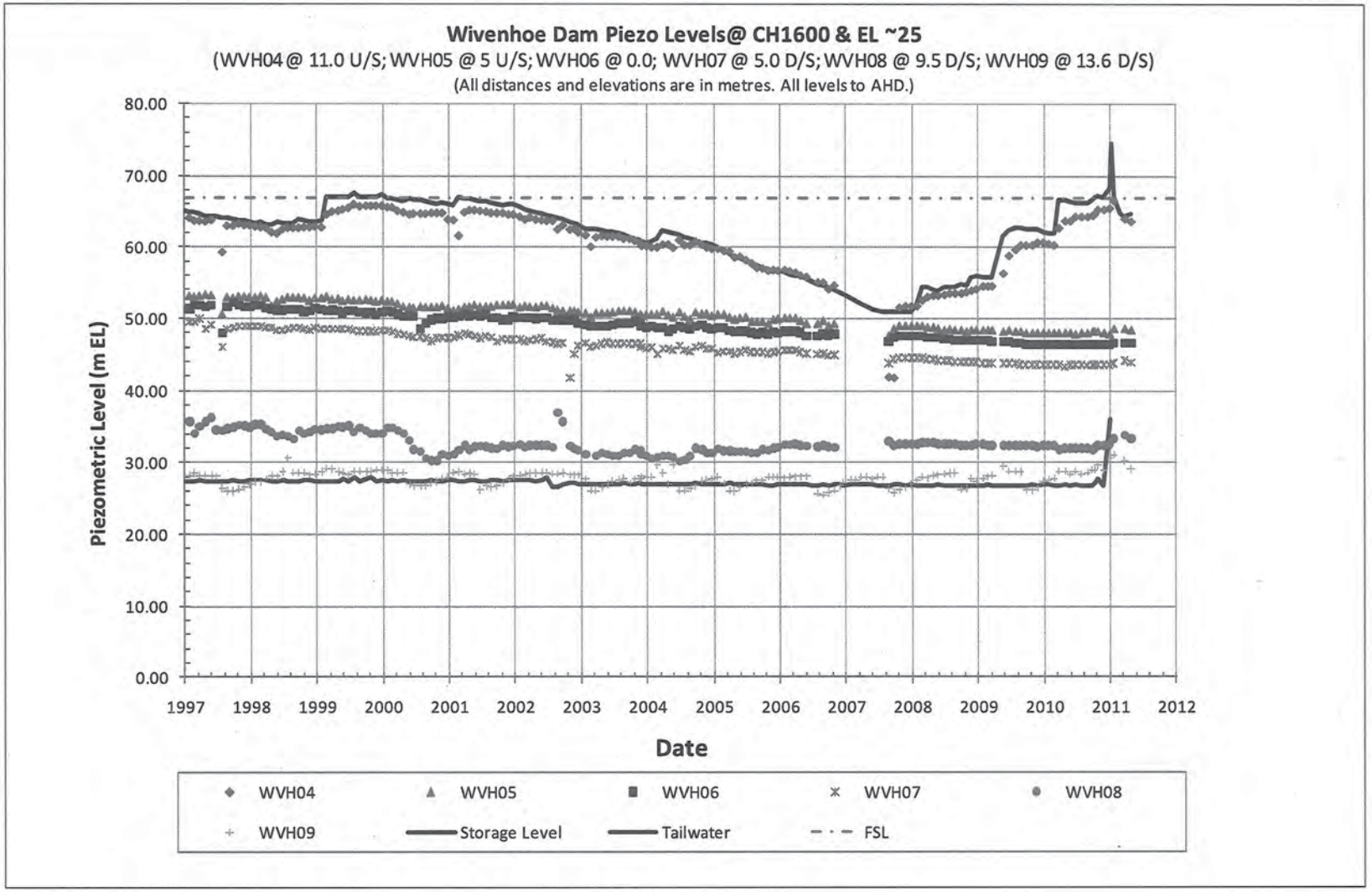
Title/Project: WIVENHOE DAM SPILLWAY
BRISBANE VALLEY HIGHWAY
Client: SMEC Australia Pty Ltd

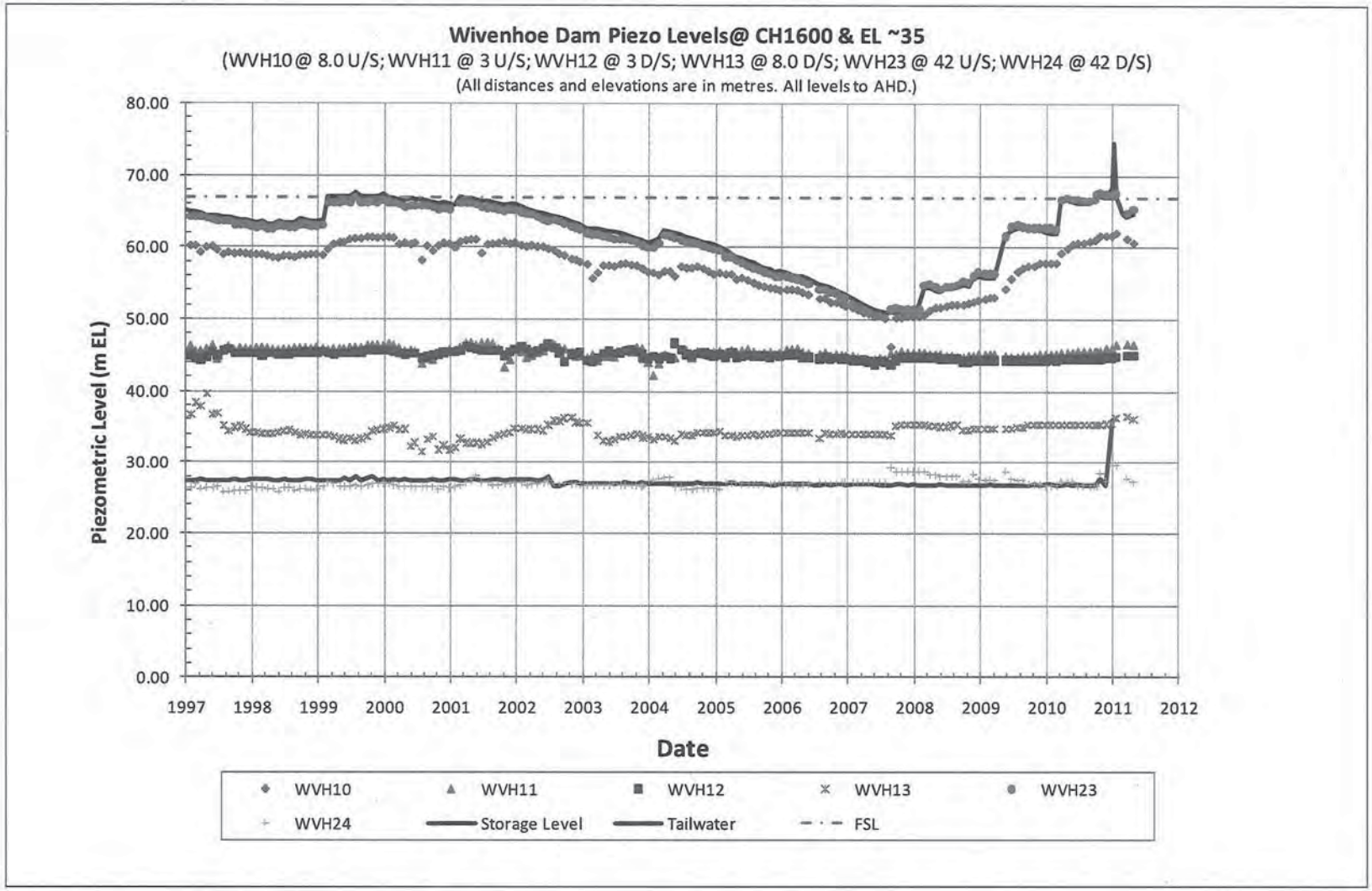
North Surveys PTY LTD
Creating exceptional value

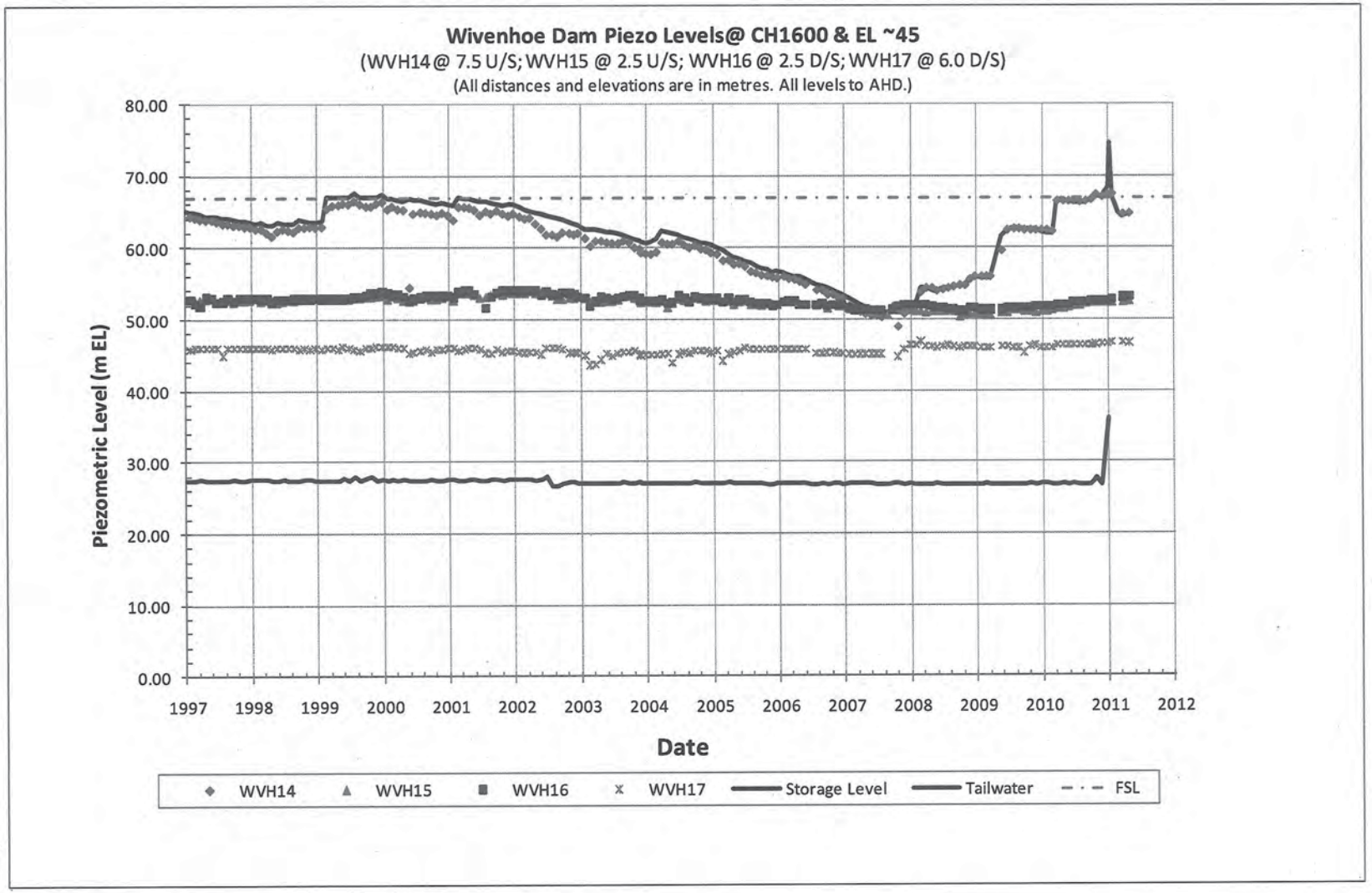
Dwg: 102271#001 Rev: 0

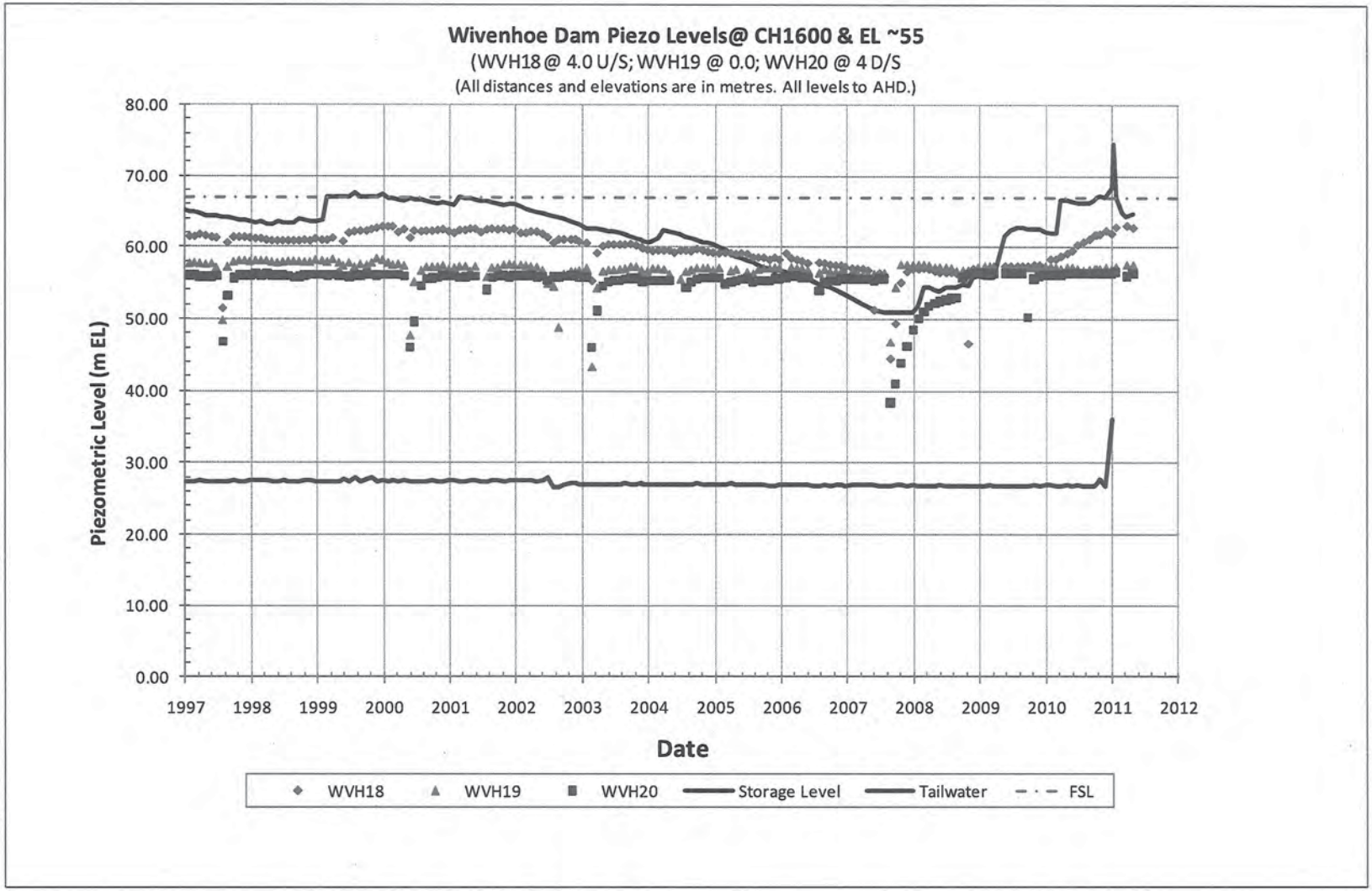
APPENDIX C INSTRUMENTATION DATA

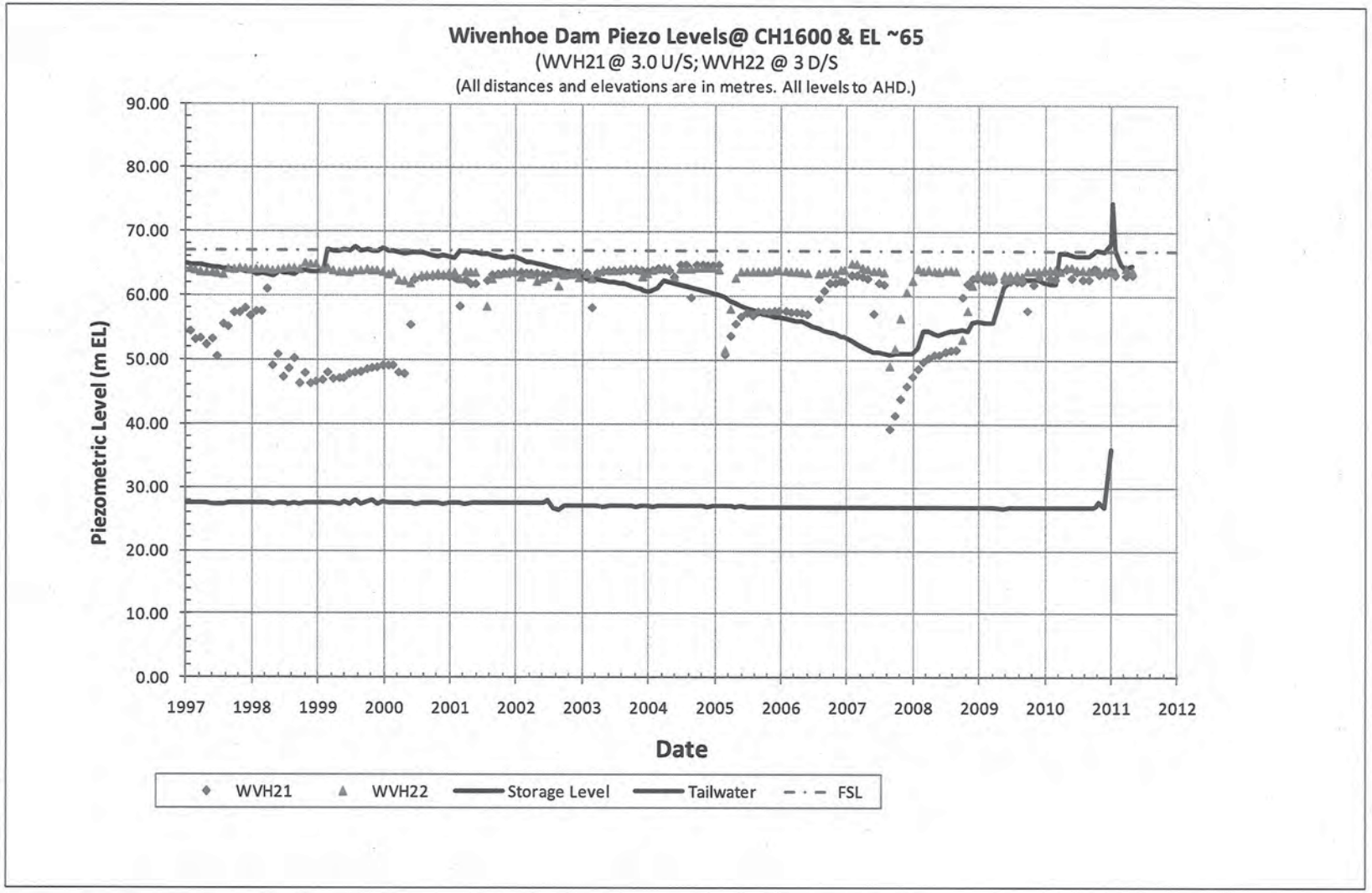

Wivenhoe Dam Piezo Levels @ CH1600 & EL ~15
(WVH01 @ 11.0 U/S; WVH02 @ 0.0; WVH03 @ 11.0 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH01
WVH02
WVH03
Storage Level
Tailwater
FSL

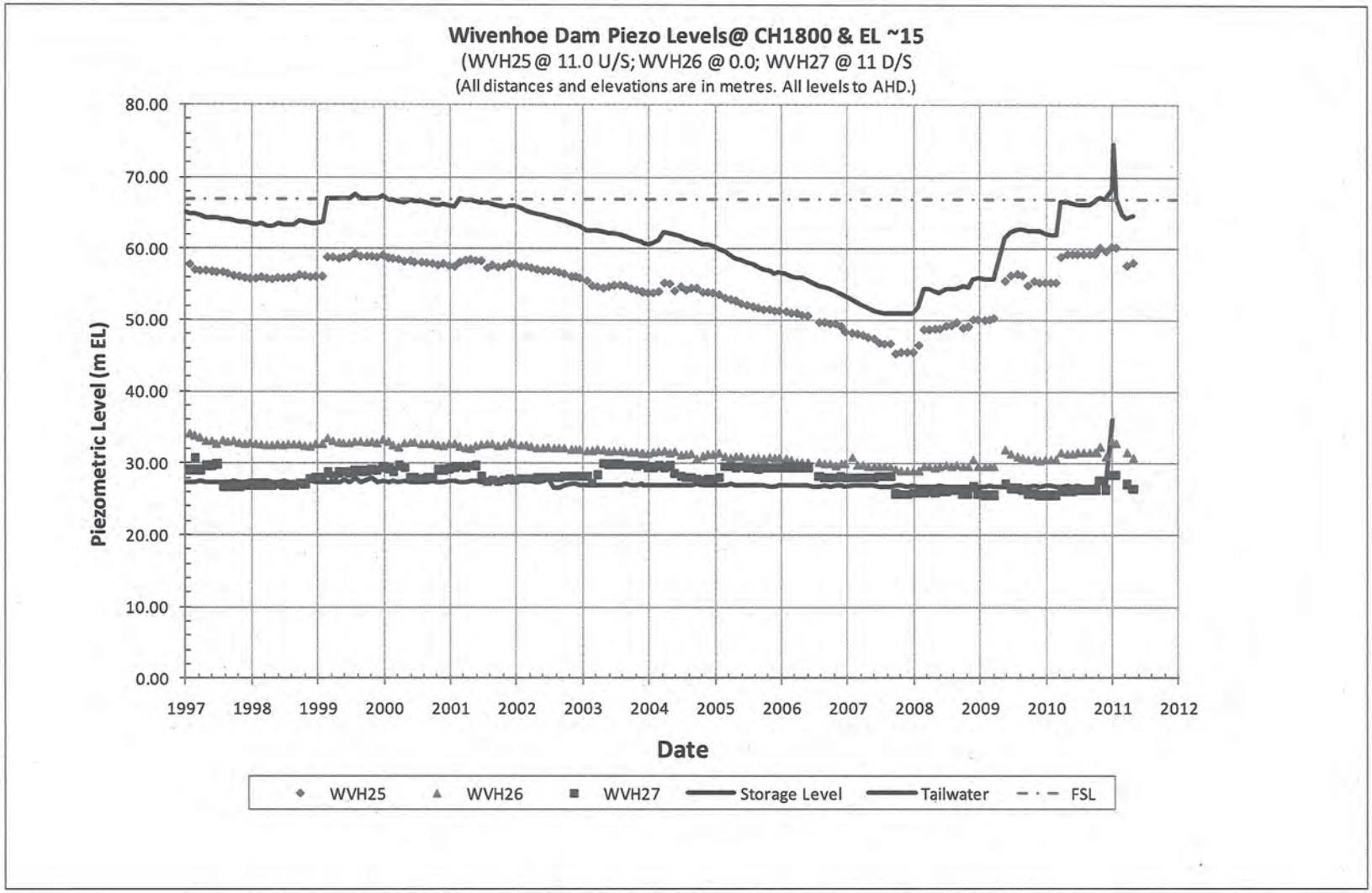

Wivenhoe Dam Piezo Levels@ CH1600 & EL ~25
(WVH04 @ 11.0 U/S; WVH05 @ 5 U/S; WVH06 @ 0.0; WVH07 @ 5.0 D/S; WVH08 @ 9.5 D/S; WVH09 @ 13.6 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH04
WVH05
WVH06
WVH07
WVH08
WVH09
Storage Level
Tailwater
FSL

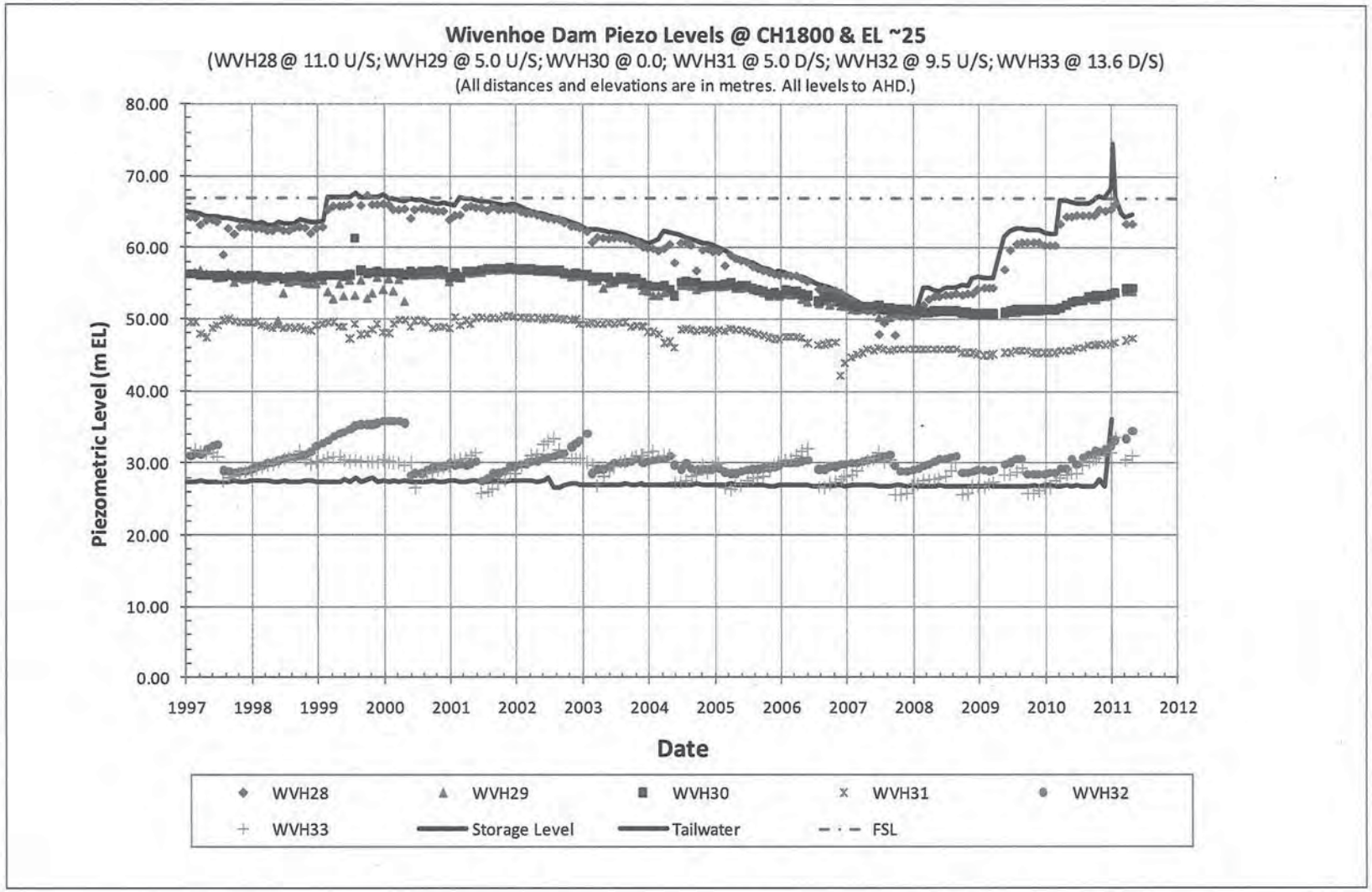

Wivenhoe Dam Piezo Levels@ CH1600 & EL ~35
(WVH10 @ 8.0 U/S; WVH11 @ 3 U/S; WVH12 @ 3 D/S; WVH13 @ 8.0 D/S; WVH23 @ 42 U/S; WVH24 @ 42 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH10
WVH11
WVH12
WVH13
WVH23
WVH24
Storage Level
Tailwater
FSL

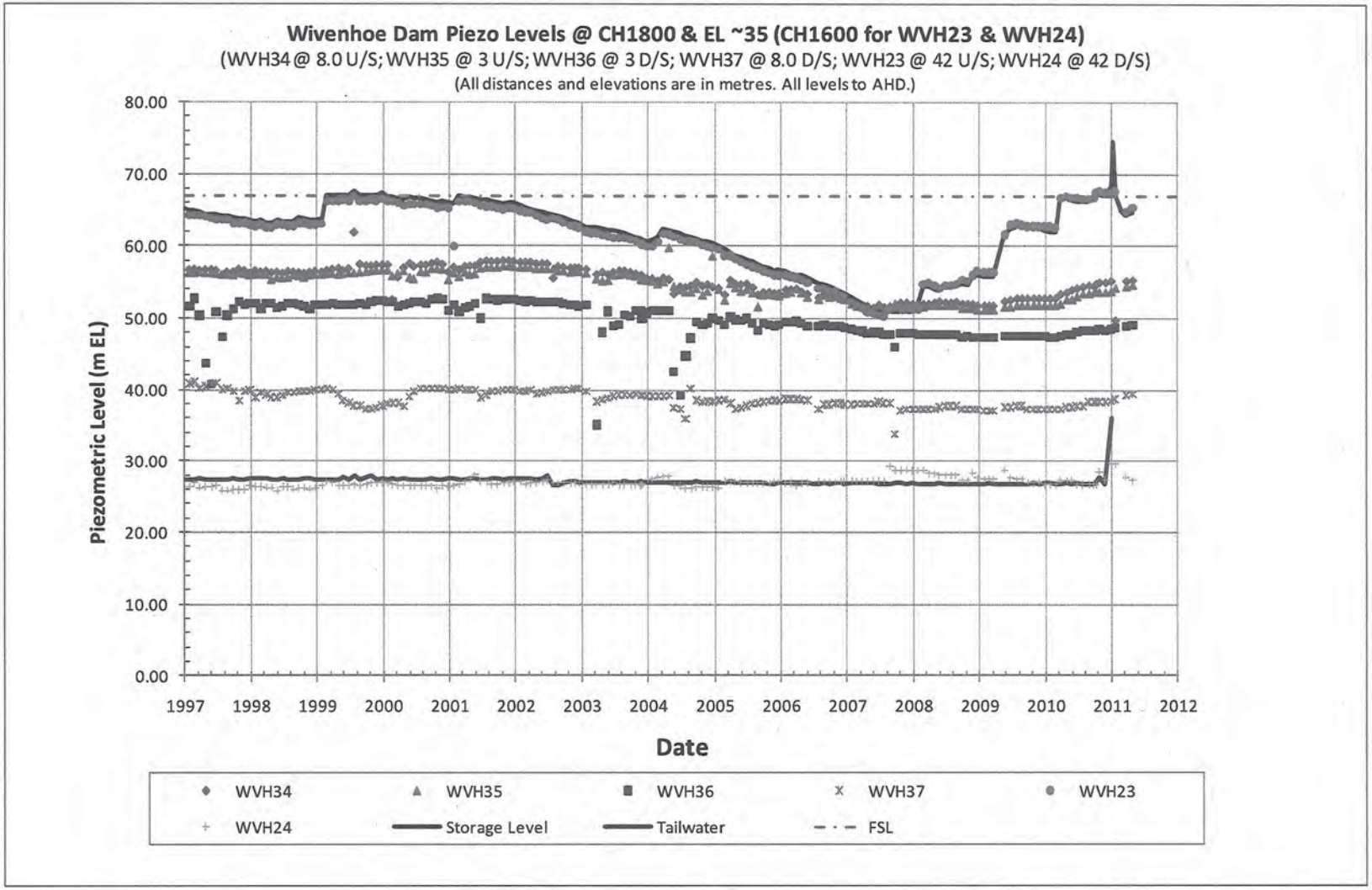

Wivenhoe Dam Piezo Levels@ CH1600 & EL ~45
(WVH14 @ 7.5 U/S; WVH15 @ 2.5 U/S; WVH16 @ 2.5 D/S; WVH17 @ 6.0 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH14
WVH15
WVH16
WVH17
Storage Level
Tailwater
FSL

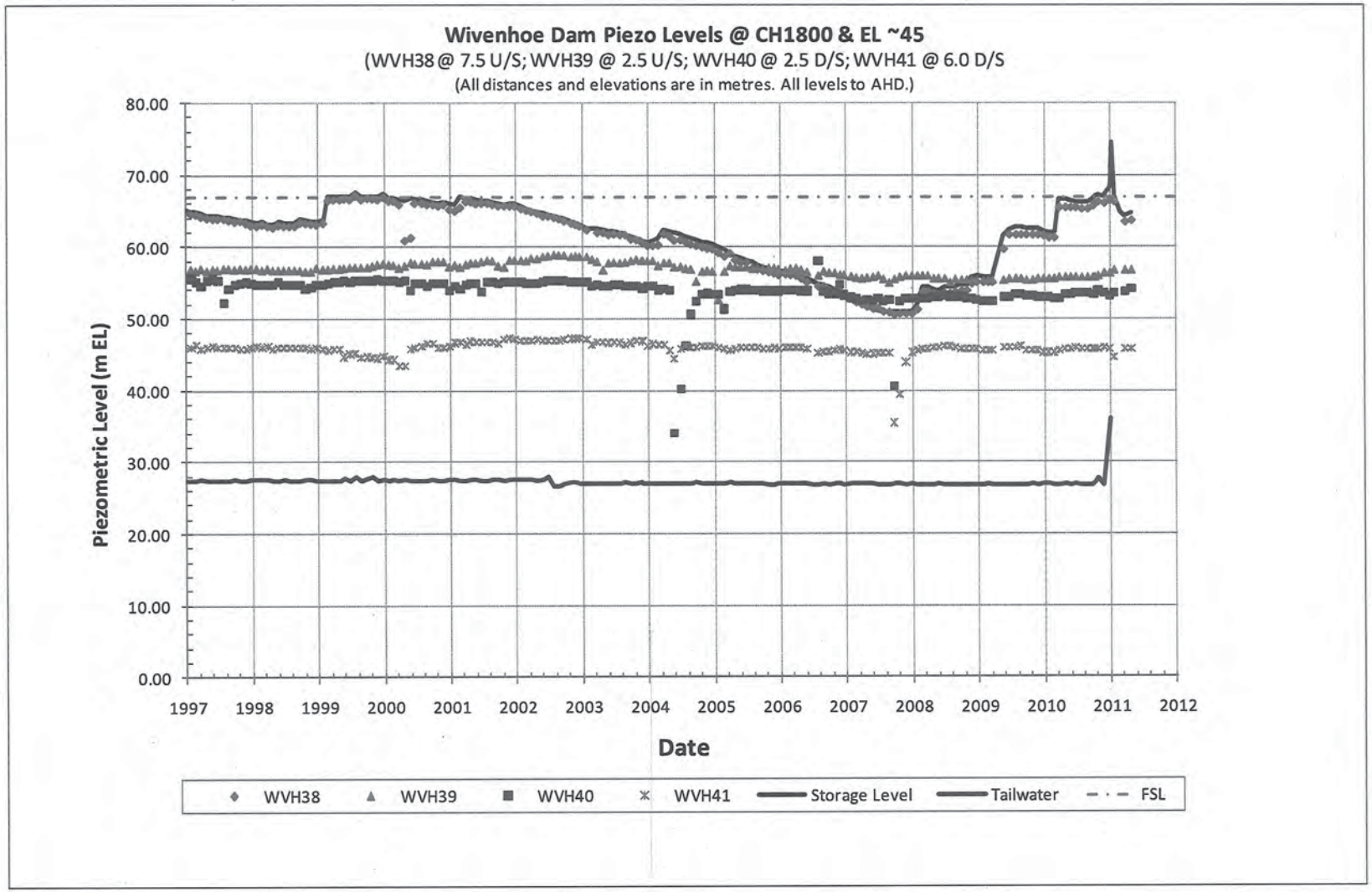

Wivenhoe Dam Piezo Levels@ CH1600 & EL ~55
(WVH18 @ 4.0 U/S; WVH19 @ 0.0; WVH20 @ 4 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH18
WVH19
WVH20
Storage Level
Tailwater
FSL

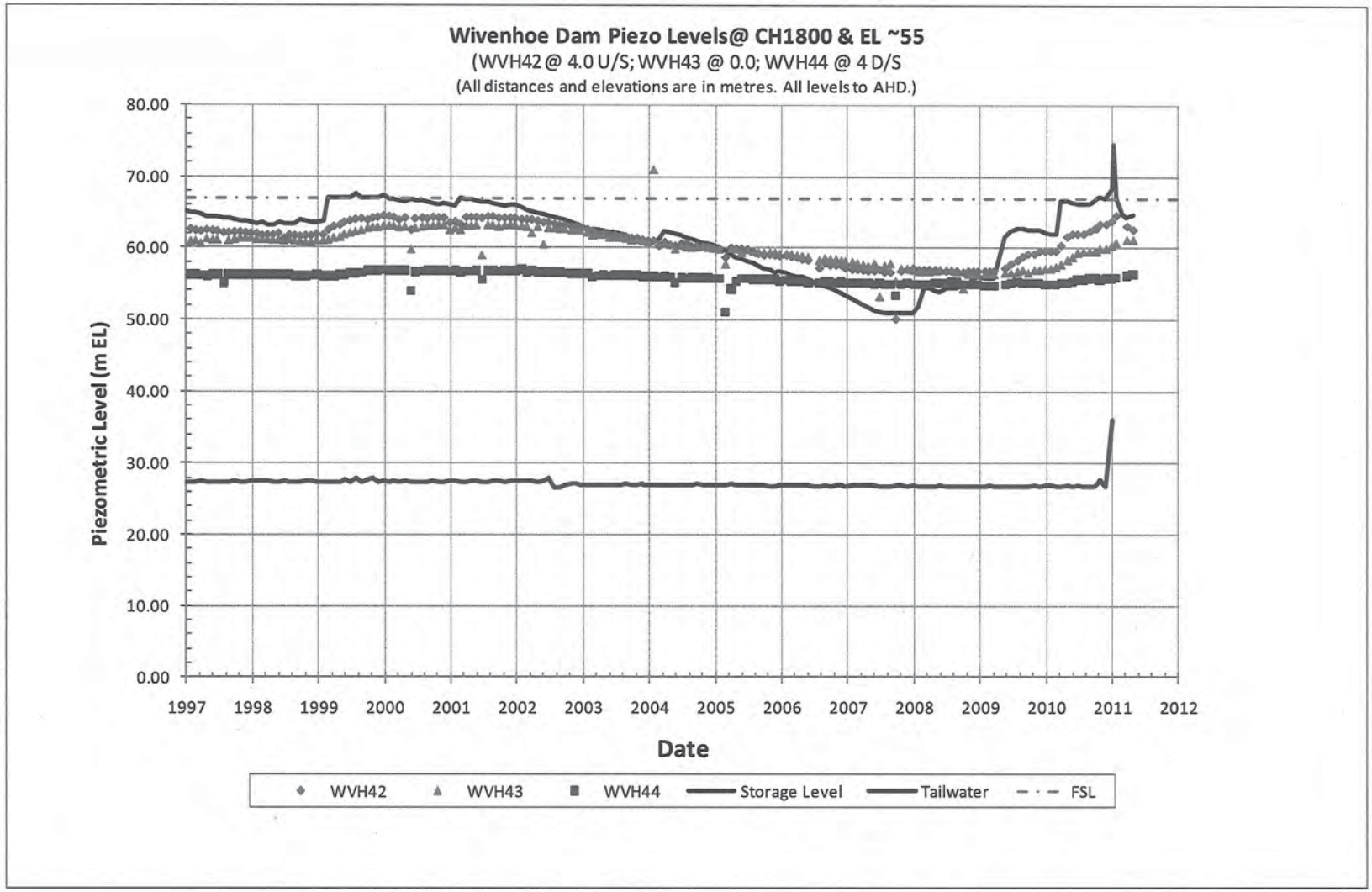

Wivenhoe Dam Piezo Levels@ CH1600 & EL ~65
(WVH21 @ 3.0 U/S; WVH22 @ 3 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH21
WVH22
Storage Level
Tailwater
FSL

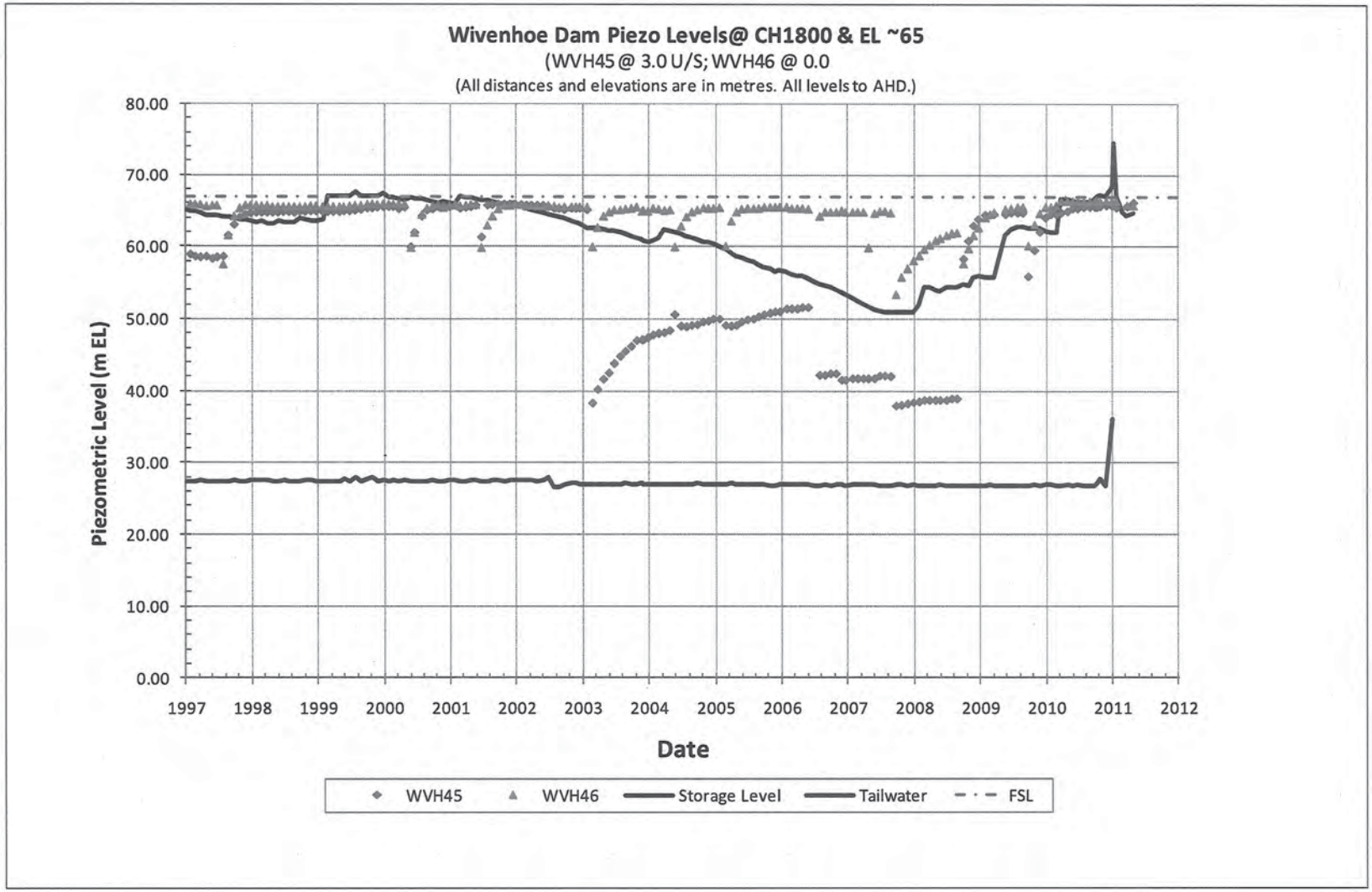

Wivenhoe Dam Piezo Levels@ CH1800 & EL ~15
(WVH25 @ 11.0 U/S; WVH26 @ 0.0; WVH27 @ 11 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH25
WVH26
WVH27
Storage Level
Tailwater
FSL

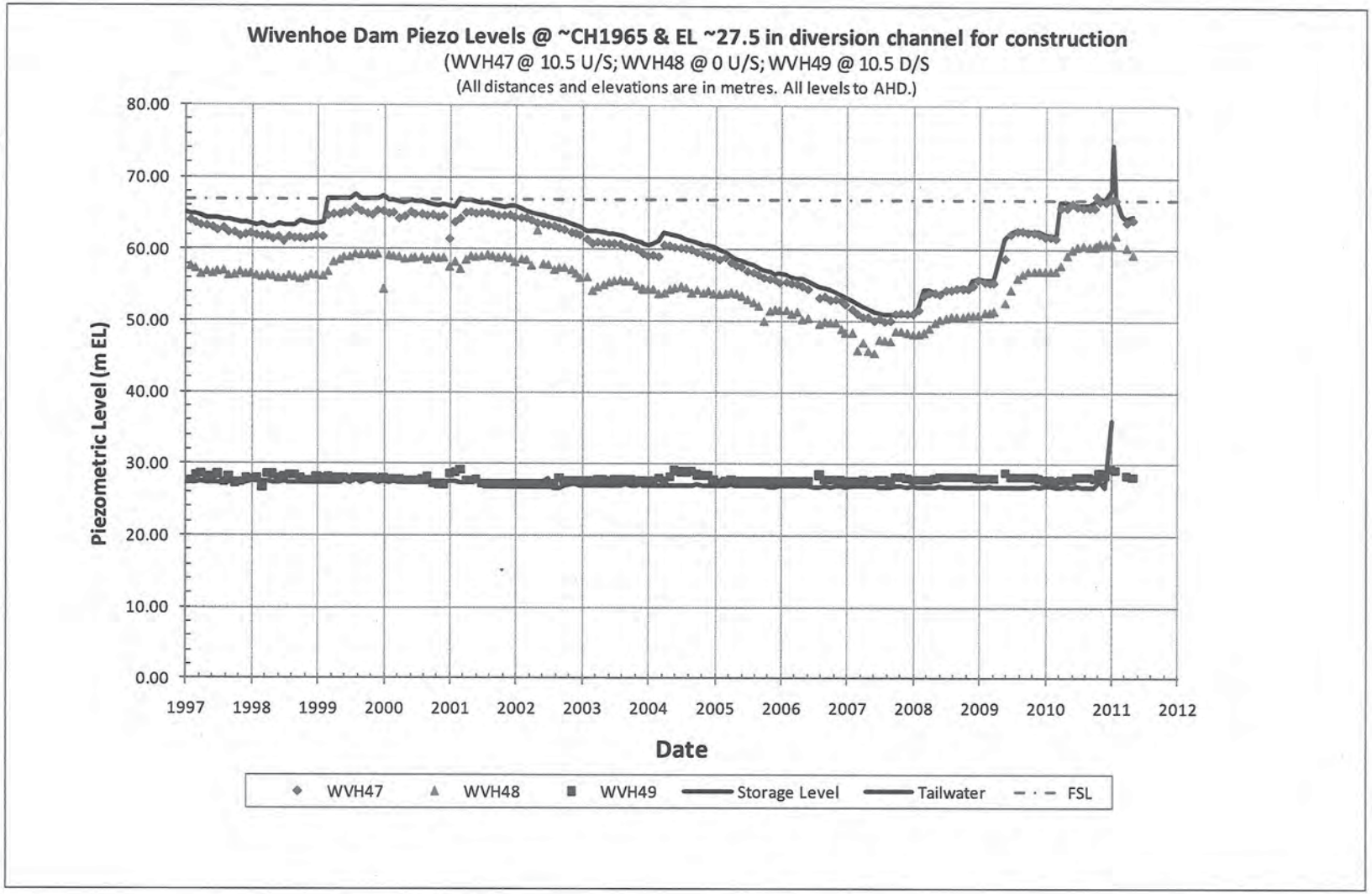

Wivenhoe Dam Piezo Levels @ CH1800 & EL ~25
(WVH28 @ 11.0 U/S; WVH29 @ 5.0 U/S; WVH30 @ 0.0; WVH31 @ 5.0 D/S; WVH32 @ 9.5 U/S; WVH33 @ 13.6 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH28
WVH29
WVH30
WVH31
WVH32
WVH33
Storage Level
Tailwater
FSL

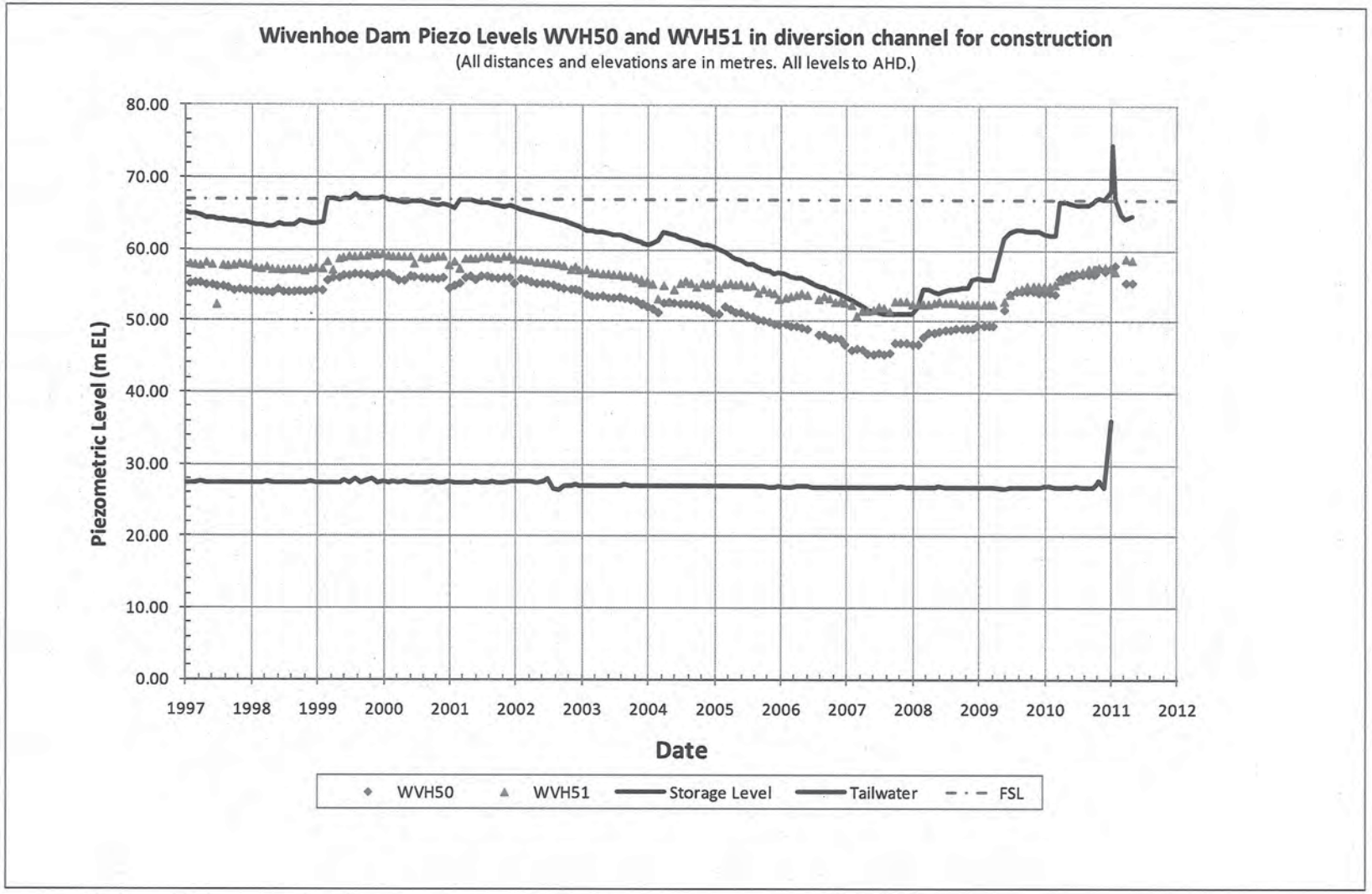

Wivenhoe Dam Piezo Levels @ CH1800 & EL ~35 (CH1600 for WVH23 & WVH24)
(WVH34 @ 8.0 U/S; WVH35 @ 3 U/S; WVH36 @ 3 D/S; WVH37 @ 8.0 D/S; WVH23 @ 42 U/S; WVH24 @ 42 D/S)
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH34
WVH35
WVH36
WVH37
WVH23
WVH24
Storage Level
Tailwater
FSL

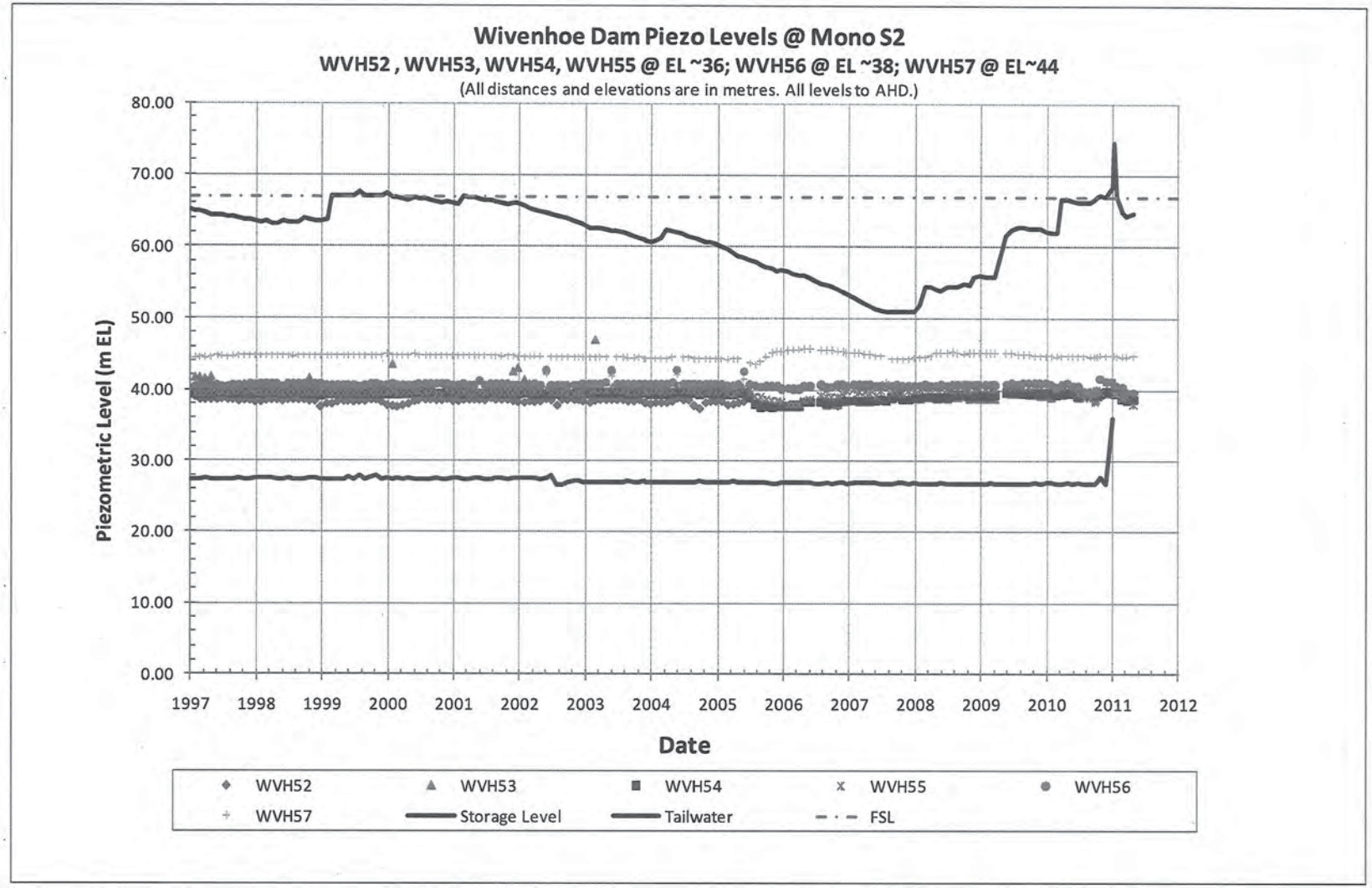

Wivenhoe Dam Piezo Levels @ CH1800 & EL ~45
(WVH38 @ 7.5 U/S; WVH39 @ 2.5 U/S; WVH40 @ 2.5 D/S; WVH41 @ 6.0 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH38
WVH39
WVH40
WVH41
Storage Level
Tailwater
FSL

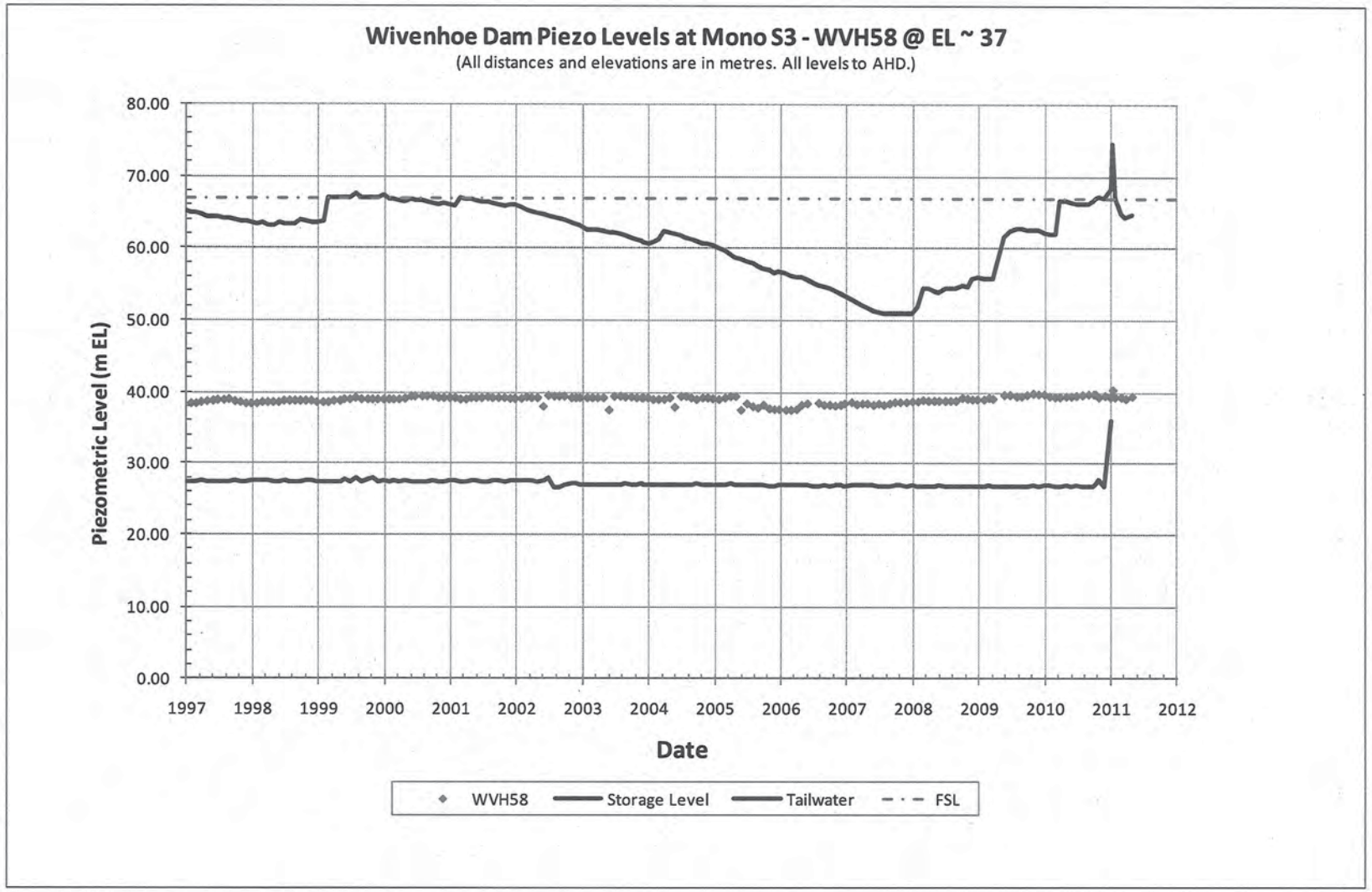

Wivenhoe Dam Piezo Levels@ CH1800 & EL ~55
(WVH42 @ 4.0 U/S; WVH43 @ 0.0; WVH44 @ 4 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH42
WVH43
WVH44
Storage Level
Tailwater
FSL

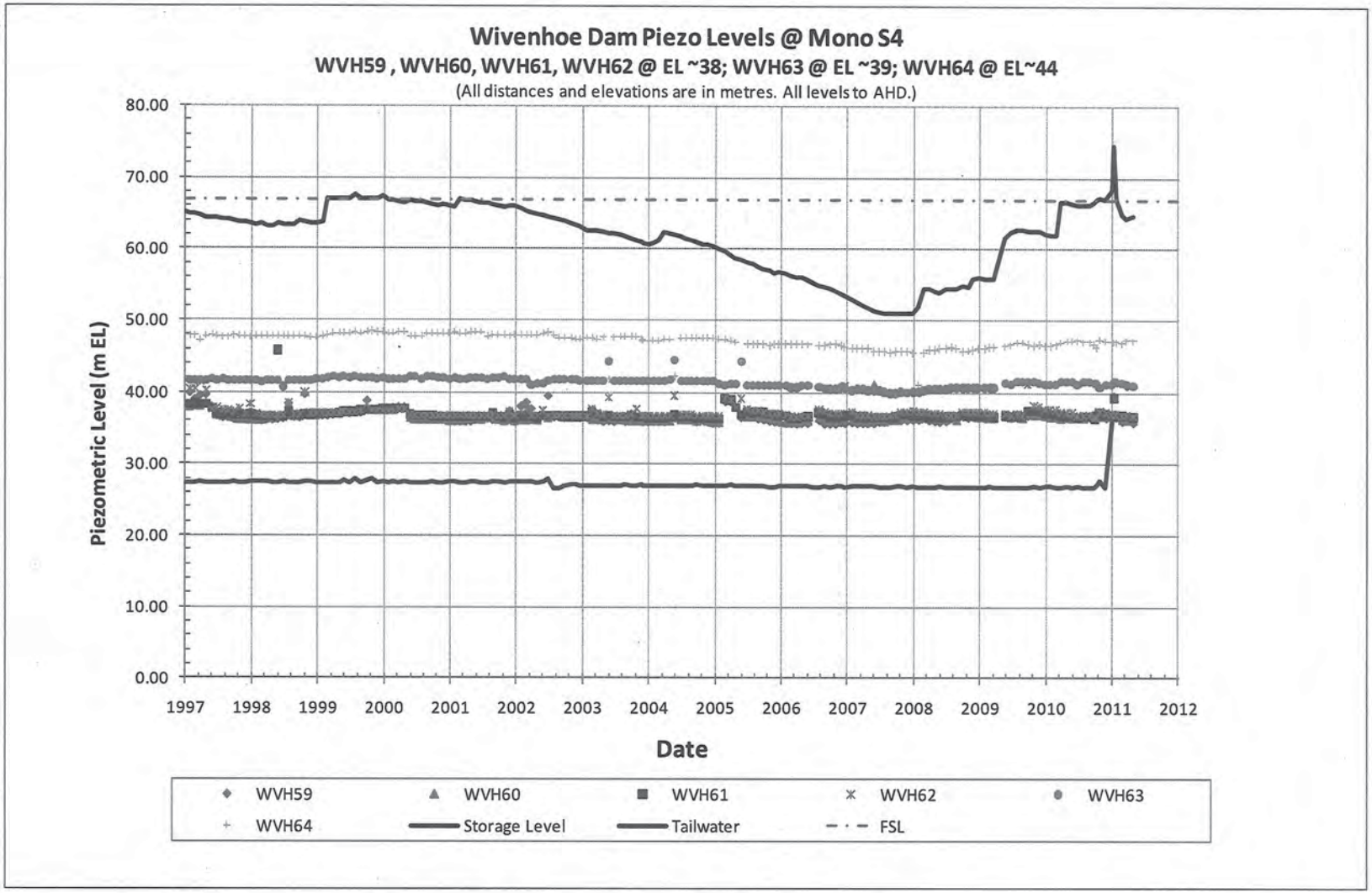

Wivenhoe Dam Piezo Levels@ CH1800 & EL ~65
(WVH45 @ 3.0 U/S; WVH46 @ 0.0
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH45
WVH46
Storage Level
Tailwater
FSL

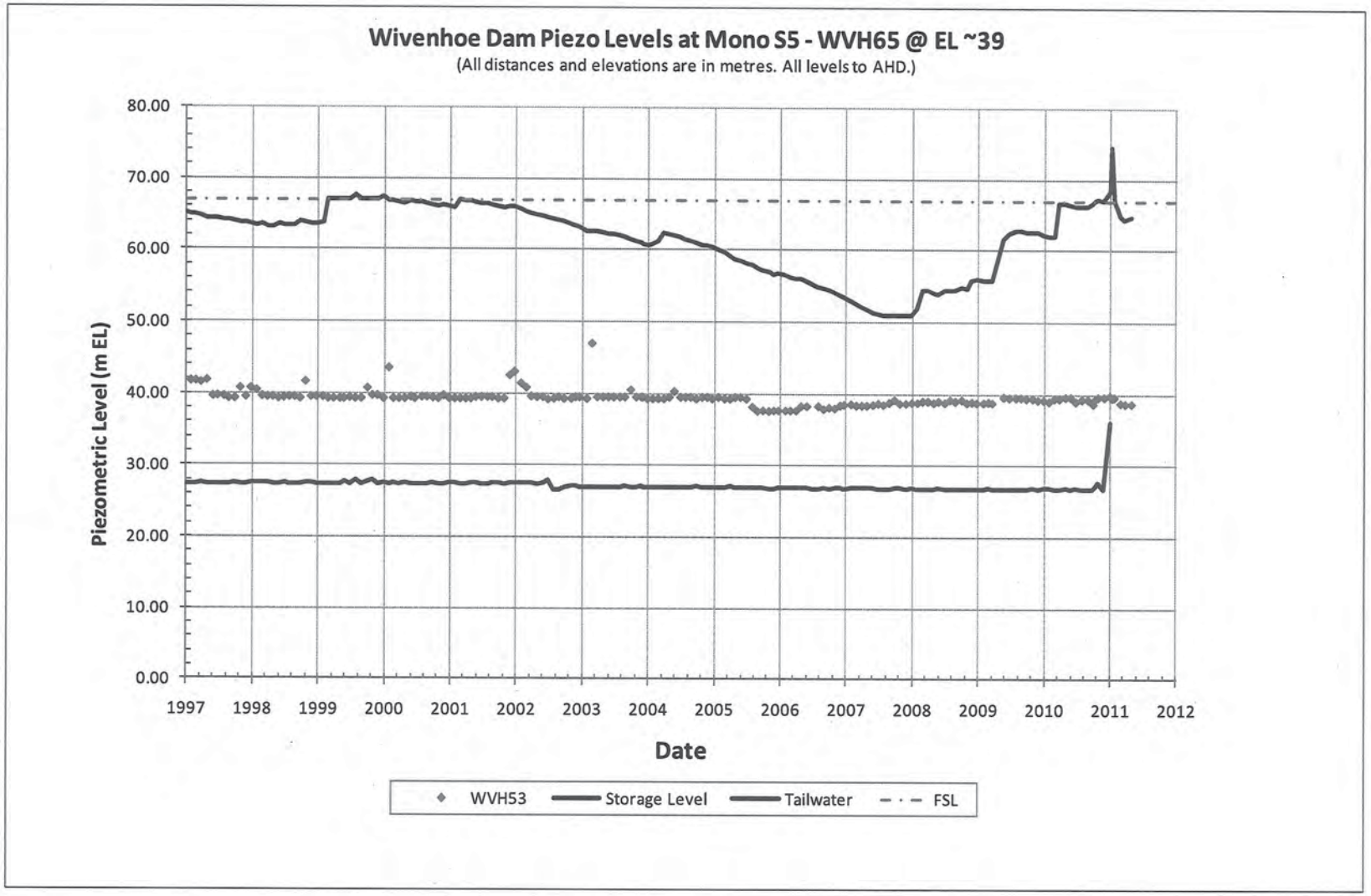

Wivenhoe Dam Piezo Levels @ ~CH1965 & EL ~27.5 in diversion channel for construction
(WVH47 @ 10.5 U/S; WVH48 @ 0 U/S; WVH49 @ 10.5 D/S
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH47
WVH48
WVH49
Storage Level
Tailwater
FSL


Wivenhoe Dam Piezo Levels WVH50 and WVH51 in diversion channel for construction
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH50
WVH51
Storage Level
Tailwater
FSL


Wivenhoe Dam Piezo Levels @ Mono S2
WVH52 , WVH53, WVH54, WVH55 @ EL ~36; WVH56 @ EL ~38; WVH57 @ EL~44
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH52
WVH53
WVH54
WVH55
WVH56
WVH57
Storage Level
Tailwater
FSL


Wivenhoe Dam Piezo Levels at Mono S3 - WVH58 @ EL ~ 37
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH58
Storage Level
Tailwater
FSL


Wivenhoe Dam Piezo Levels @ Mono S4
WVH59 , WVH60, WVH61, WVH62 @ EL ~38; WVH63 @ EL ~39; WVH64 @ EL~44
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH59
WVH60
WVH61
WVH62
WVH63
WVH64
Storage Level
Tailwater
FSL


Wivenhoe Dam Piezo Levels at Mono S5 - WVH65 @ EL ~39
(All distances and elevations are in metres. All levels to AHD.)
Piezometric Level (m EL)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date
WVH53
Storage Level
Tailwater
FSL

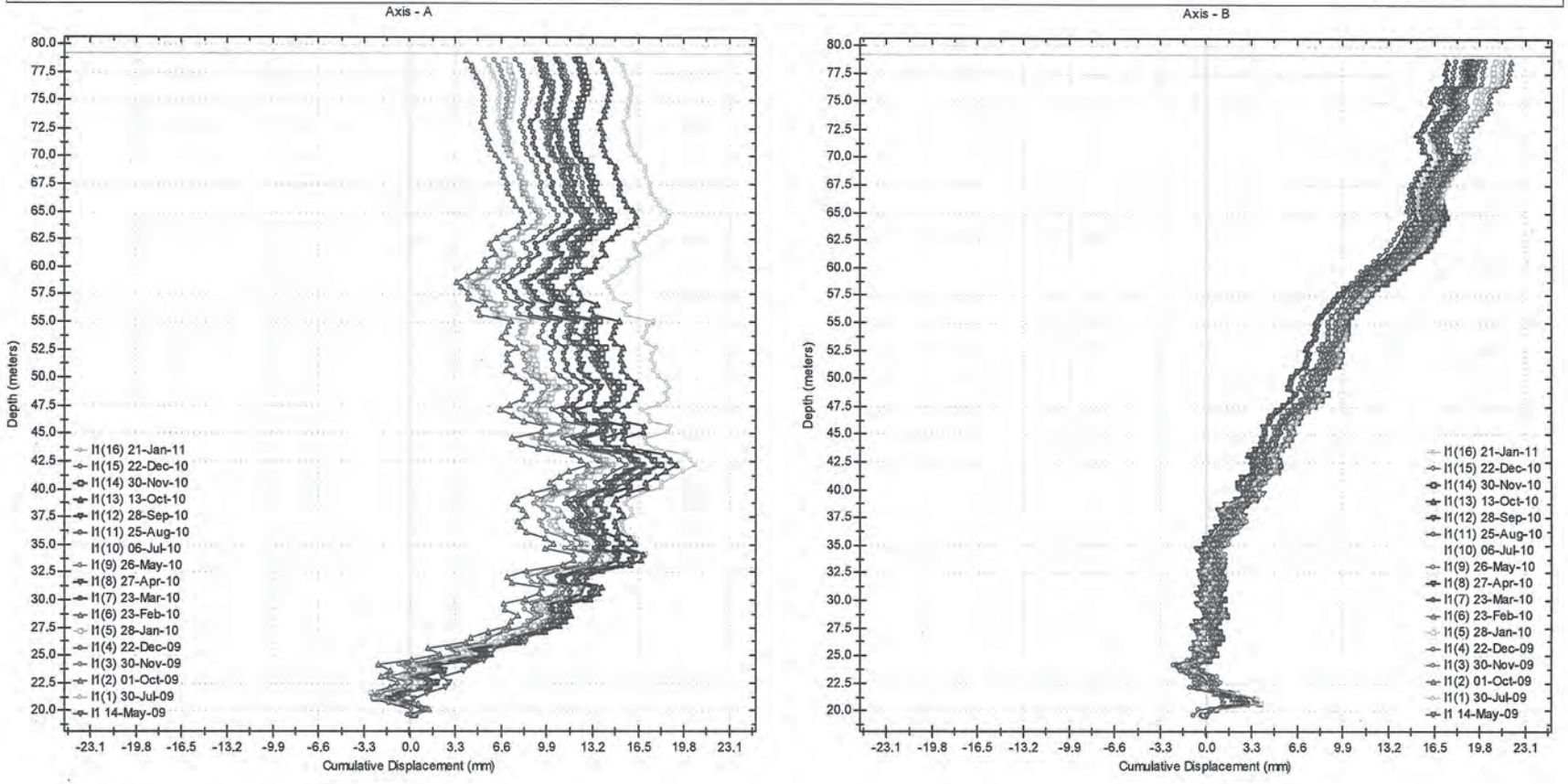
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

Borehole : I1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 79.1 meters
Borehole Total Depth : 59.5 meters
North Groove Azimuth :
Base Reading : 1989 Aug 30 11:01
Axis A Azimuth : 0.0 degrees



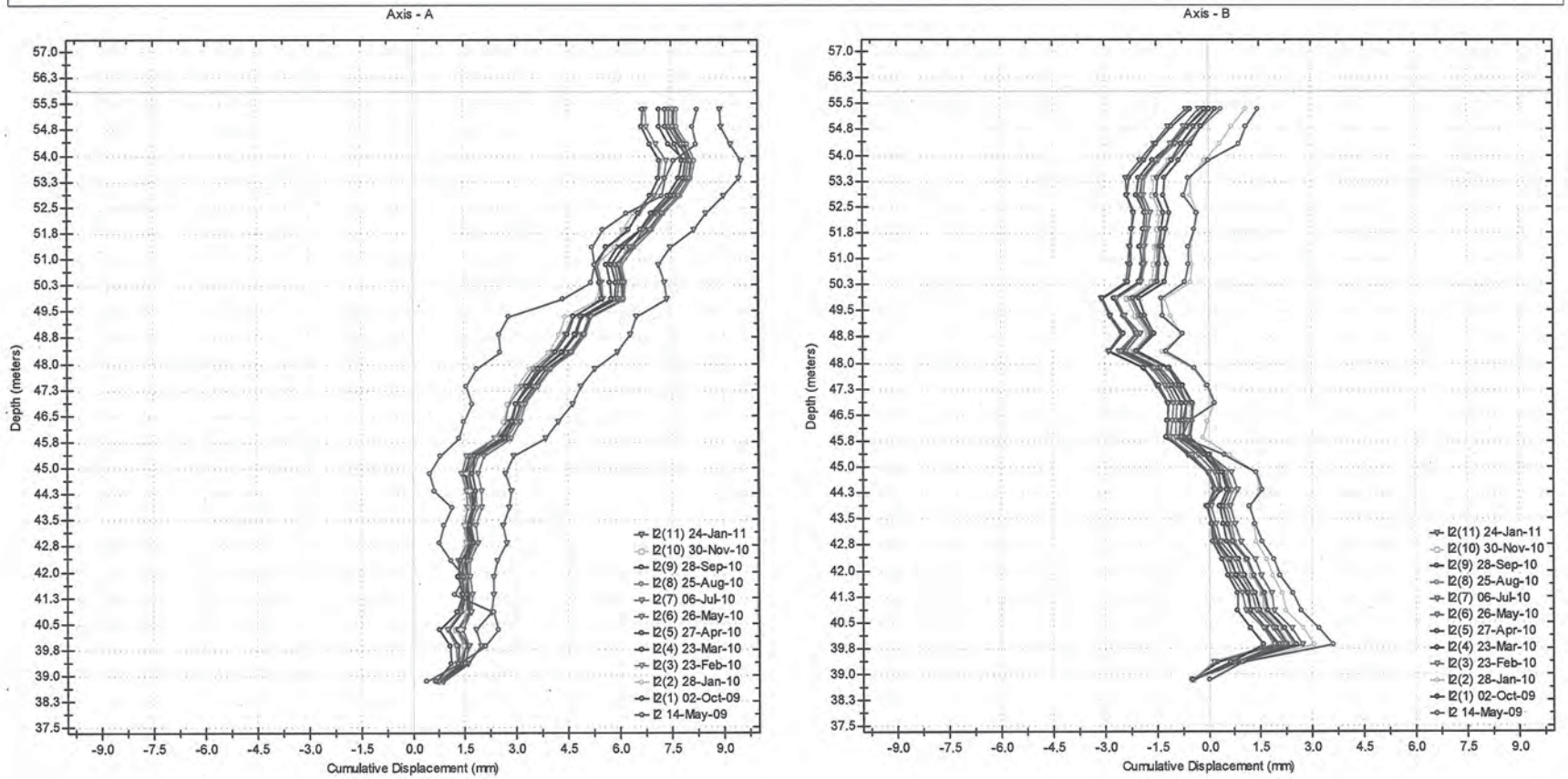
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

Borehole : I2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 55.8 meters
Borehole Total Depth : 17.0 meters
North Groove Azimuth :
Base Reading : 1989 Aug 30 11:01
Axis A Azimuth : 0.0 degrees



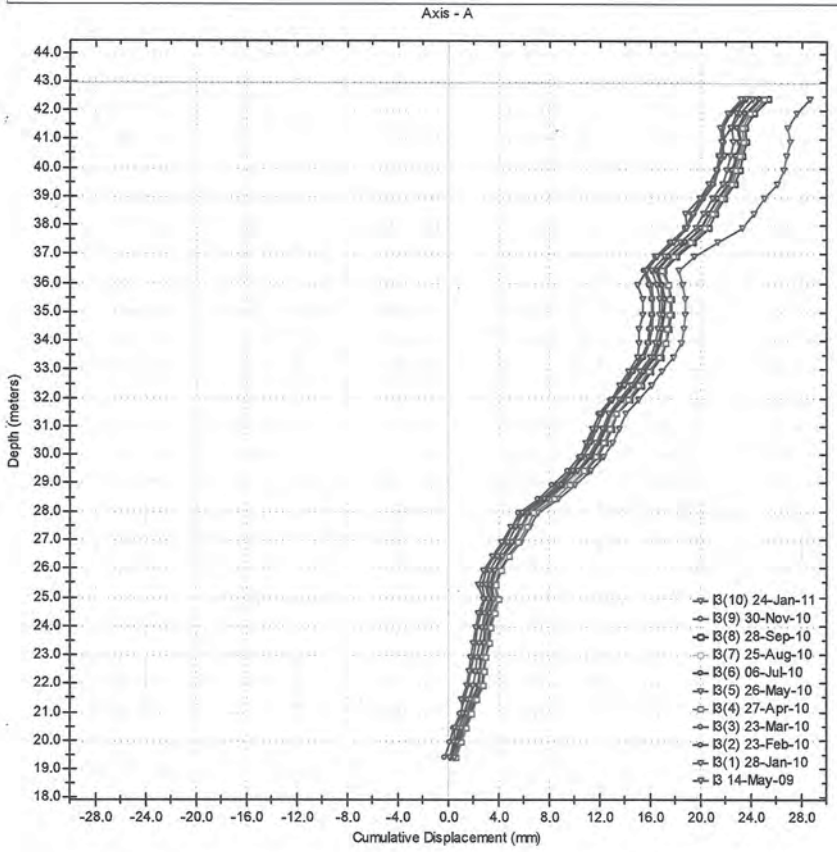
RST Instruments Ltd.

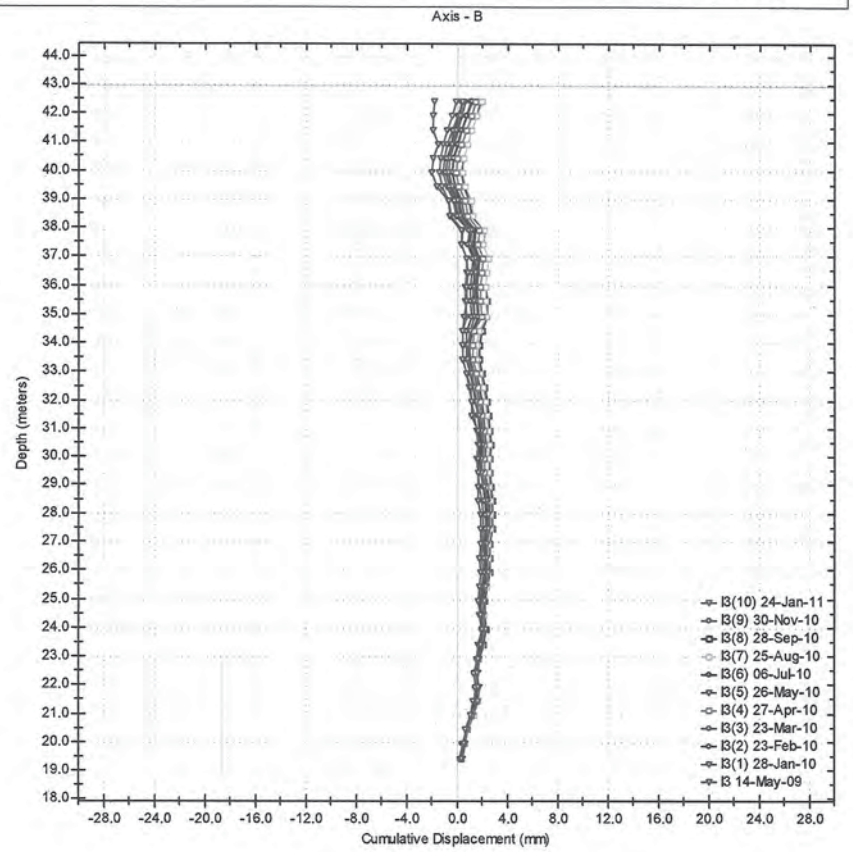
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

Borehole : I3
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 42.9 meters
Borehole Total Depth : 23.5 meters
North Groove Azimuth :
Base Reading : 1990 Jan 12 11:01
Axis A Azimuth : 0.0 degrees





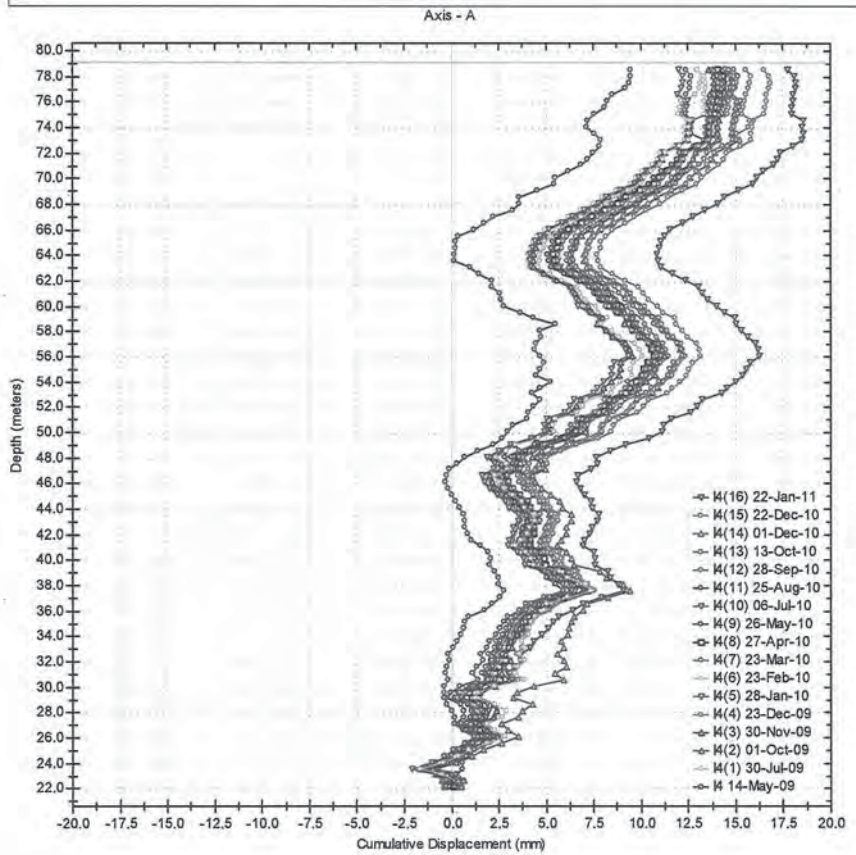
RST Instruments Ltd.

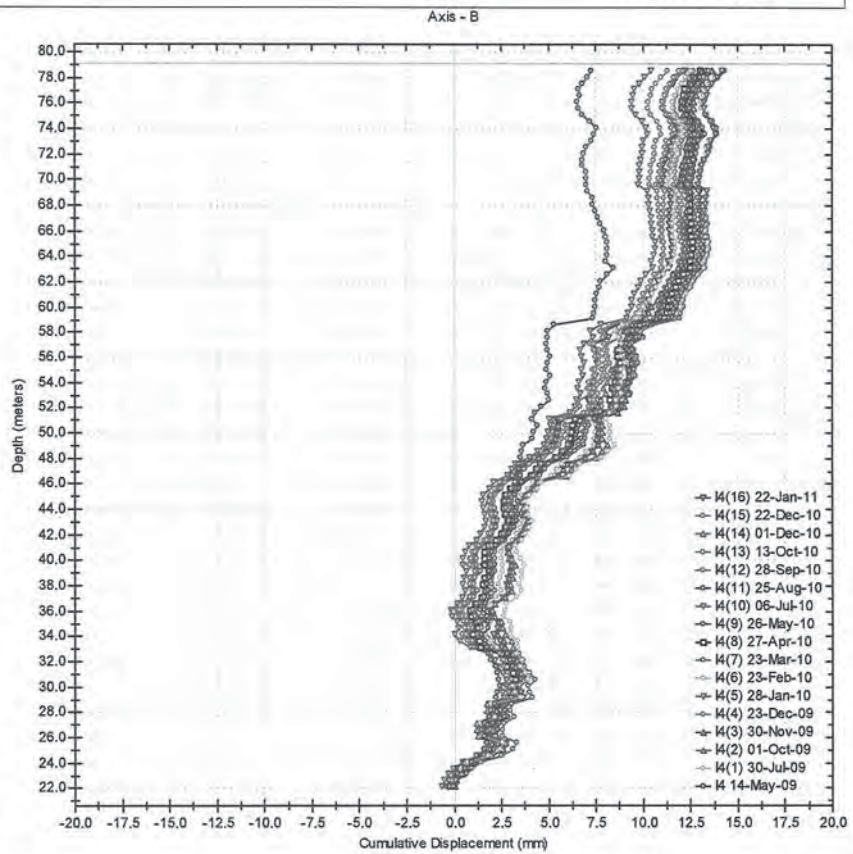
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

Borehole : I4
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 79.1 meters
Borehole Total Depth : 57.0 meters
North Groove Azimuth :
Base Reading : 1990 Jan 09 11:01
Axis A Azimuth : 0.0 degrees





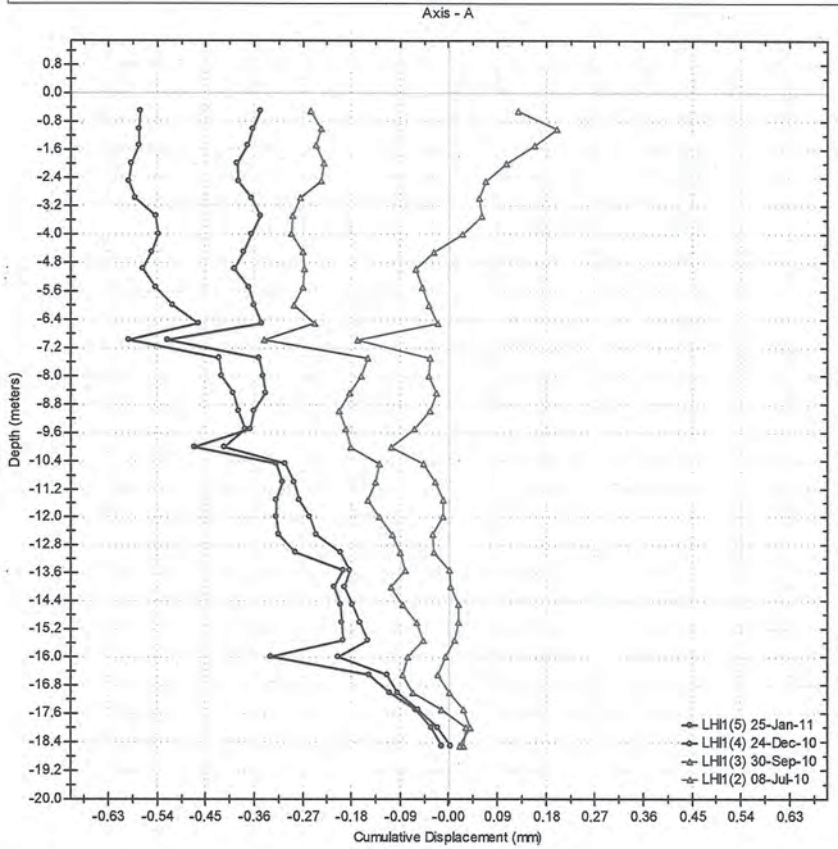
RST Instruments Ltd.

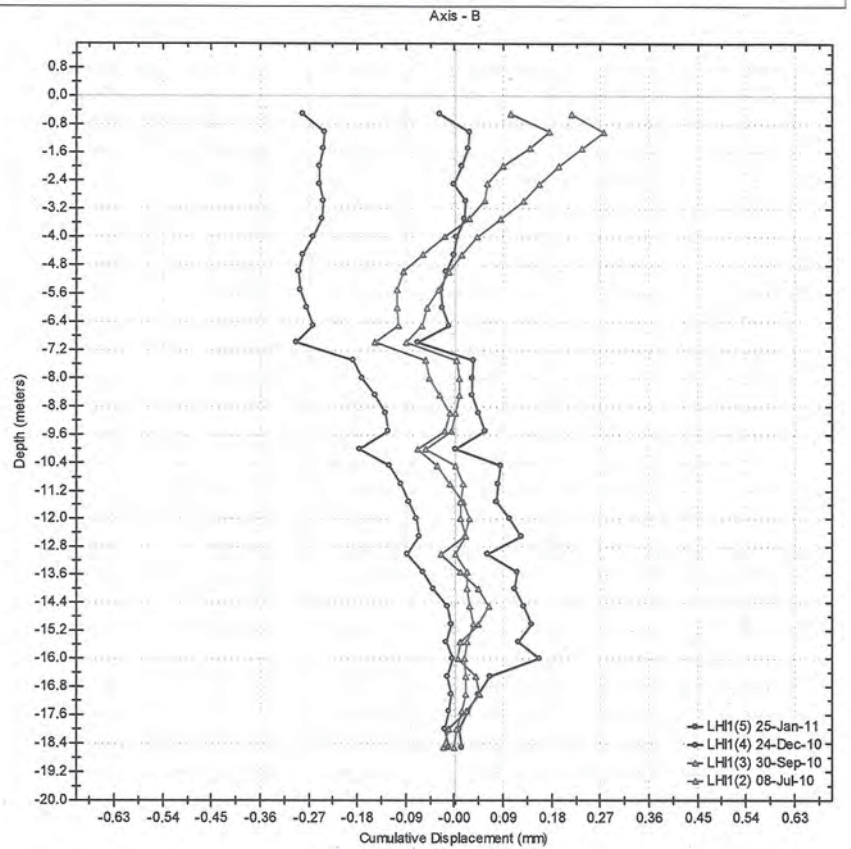
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

Borehole : LHI1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 18.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 30 10:50
Axis A Azimuth : 0.0 degrees





RST Instruments Ltd.

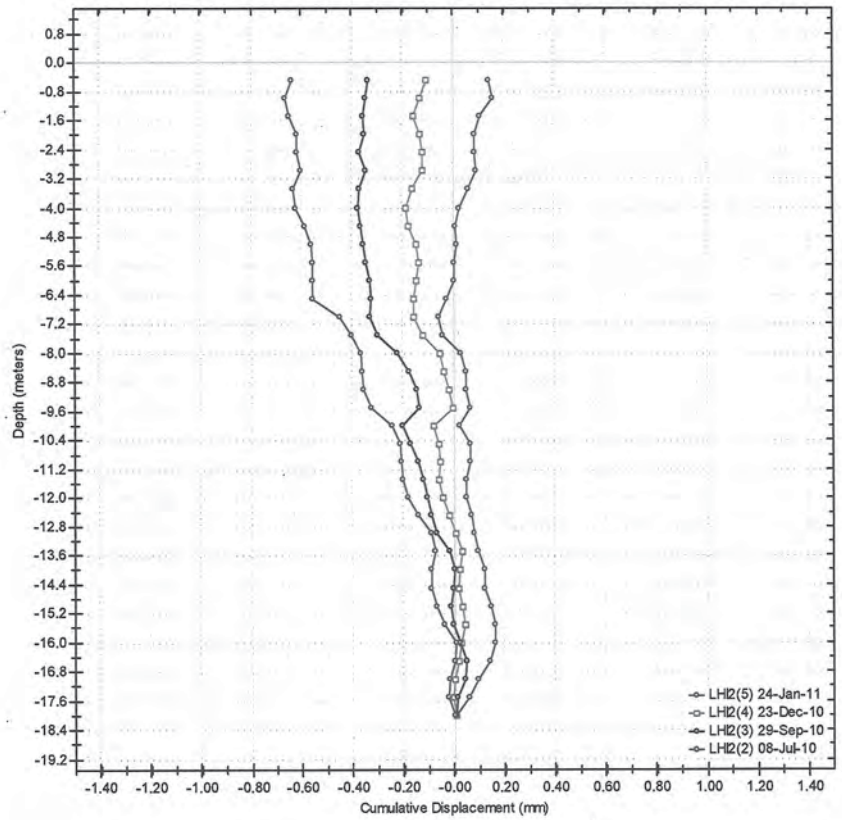
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

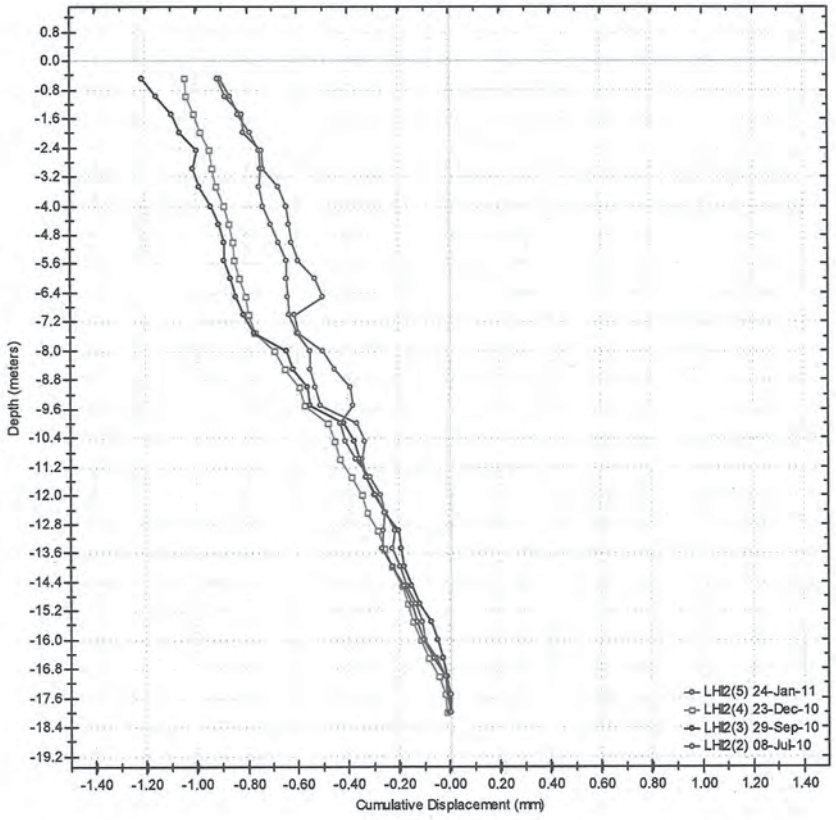
Borehole : LHI2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 18.0 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 13:30
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

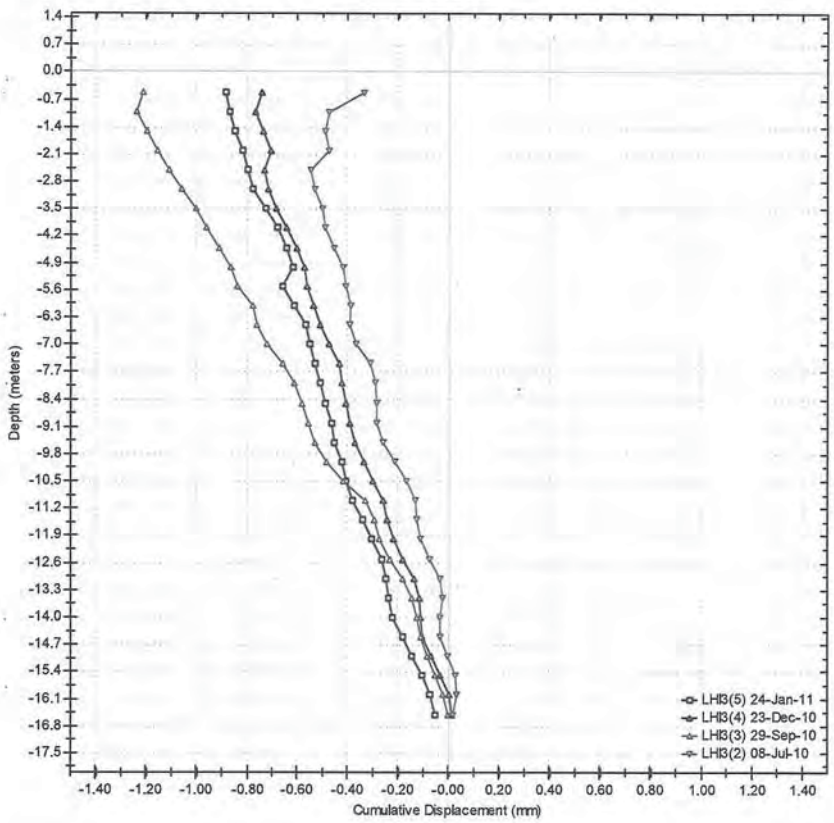
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

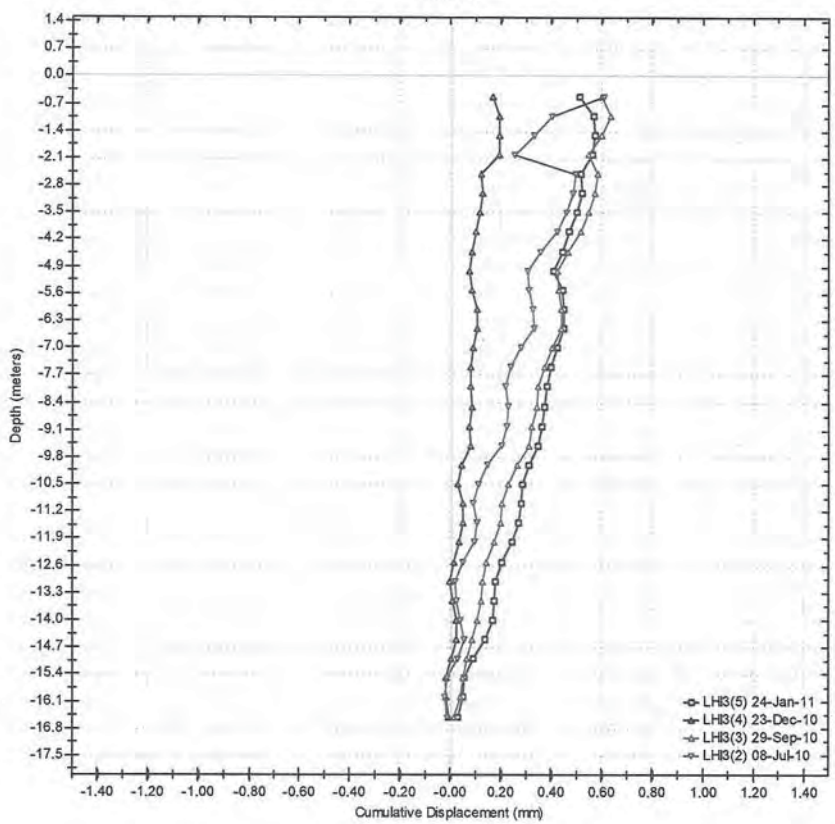
Borehole : LHI3
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 16.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 13:53
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

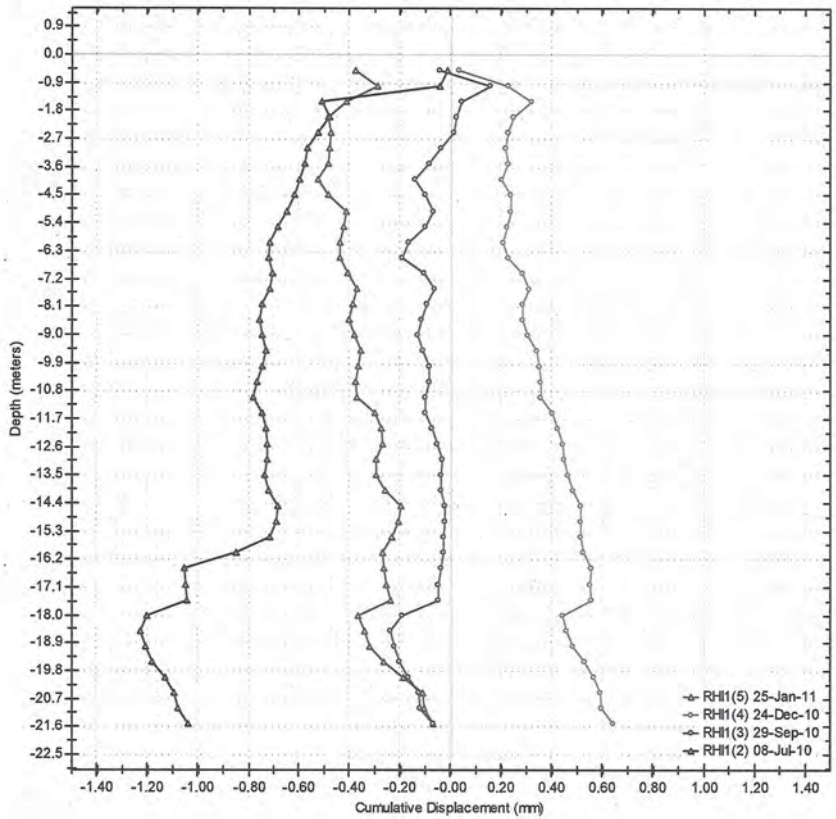
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

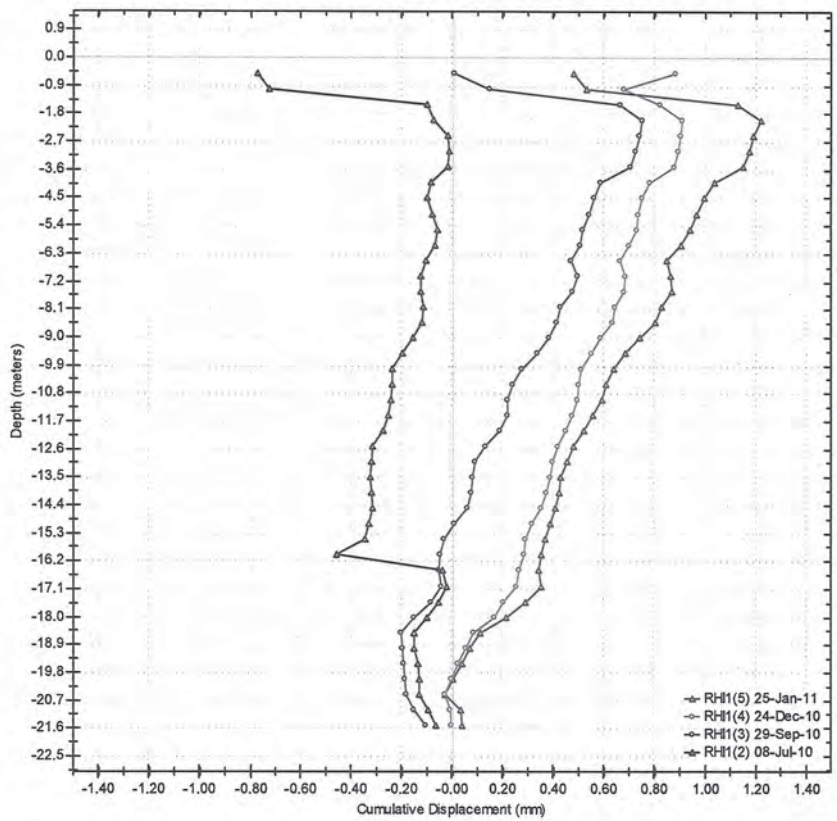
Borehole : RHI1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 21.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 30 10:09
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

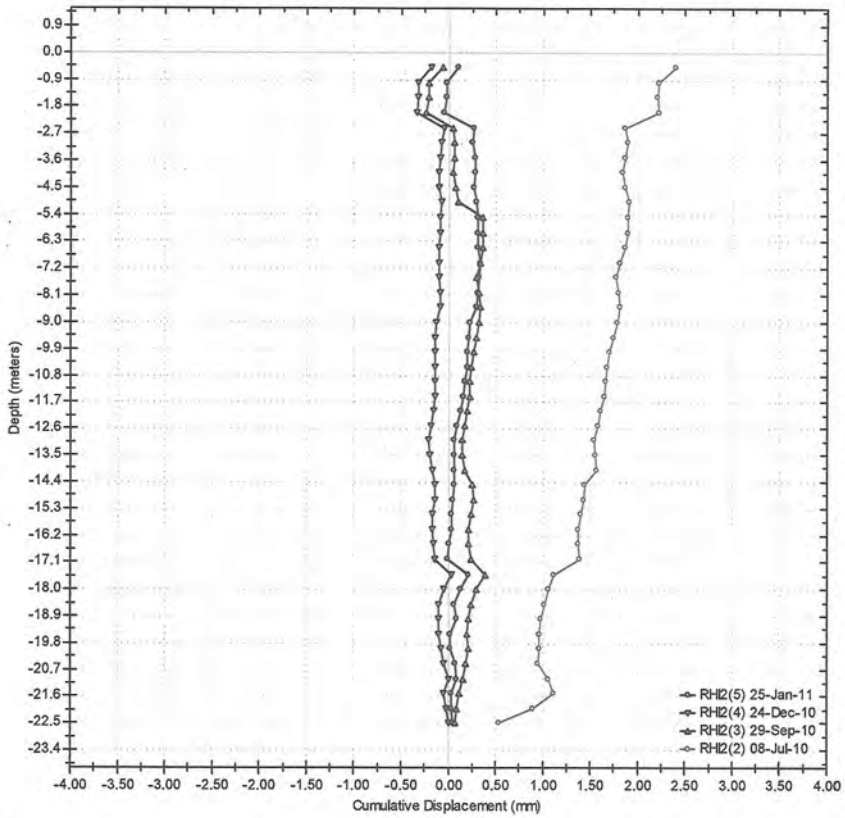
CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

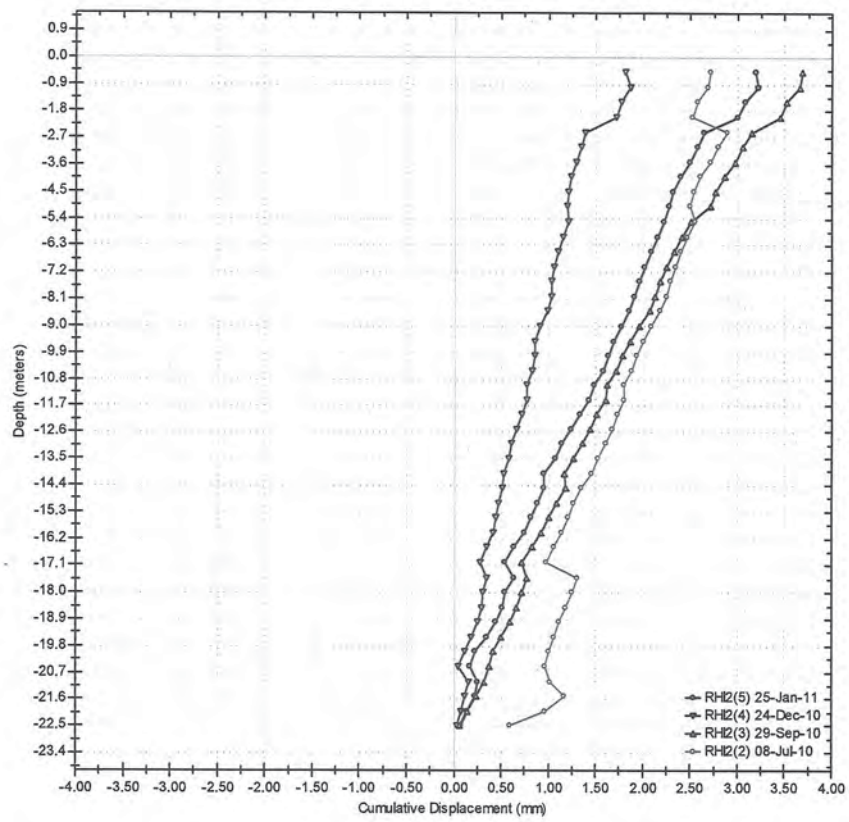
Borehole : RHI2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 22.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 14:37
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

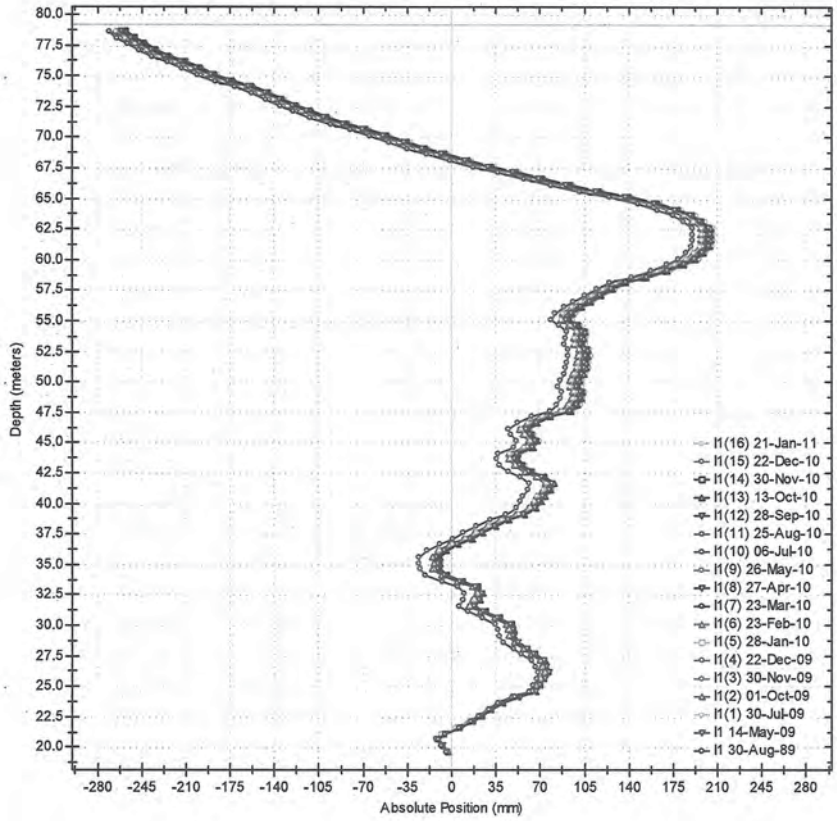
ABSOLUTE POSITION

Inclinalysis v.2.35

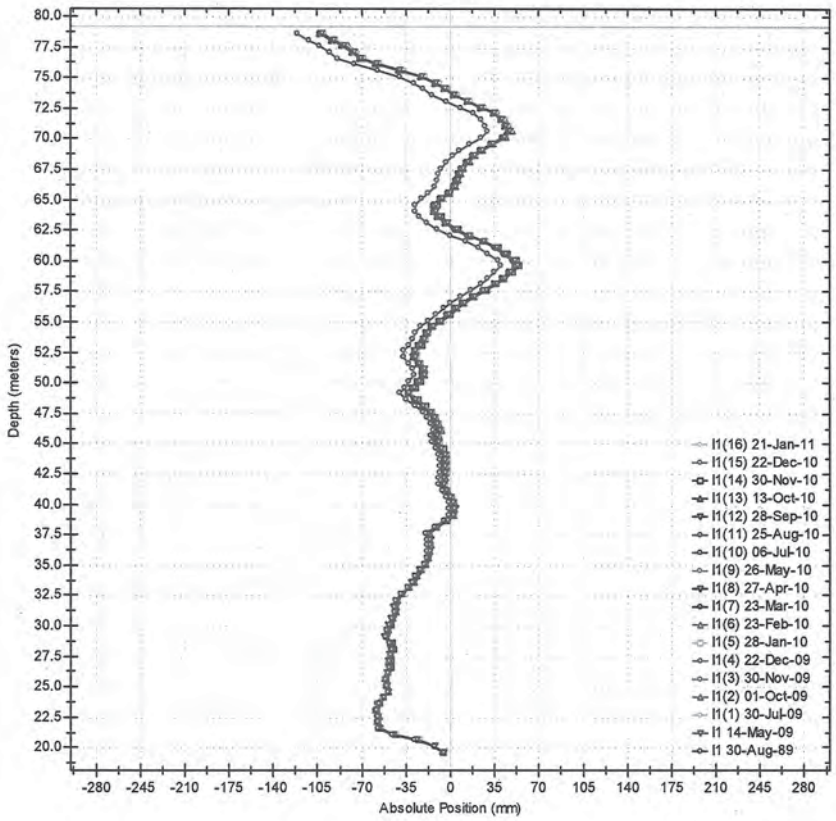
Borehole : I1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 79.1 meters
Borehole Total Depth : 59.5 meters
North Groove Azimuth :
Base Reading : 1989 Aug 30 11:01
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



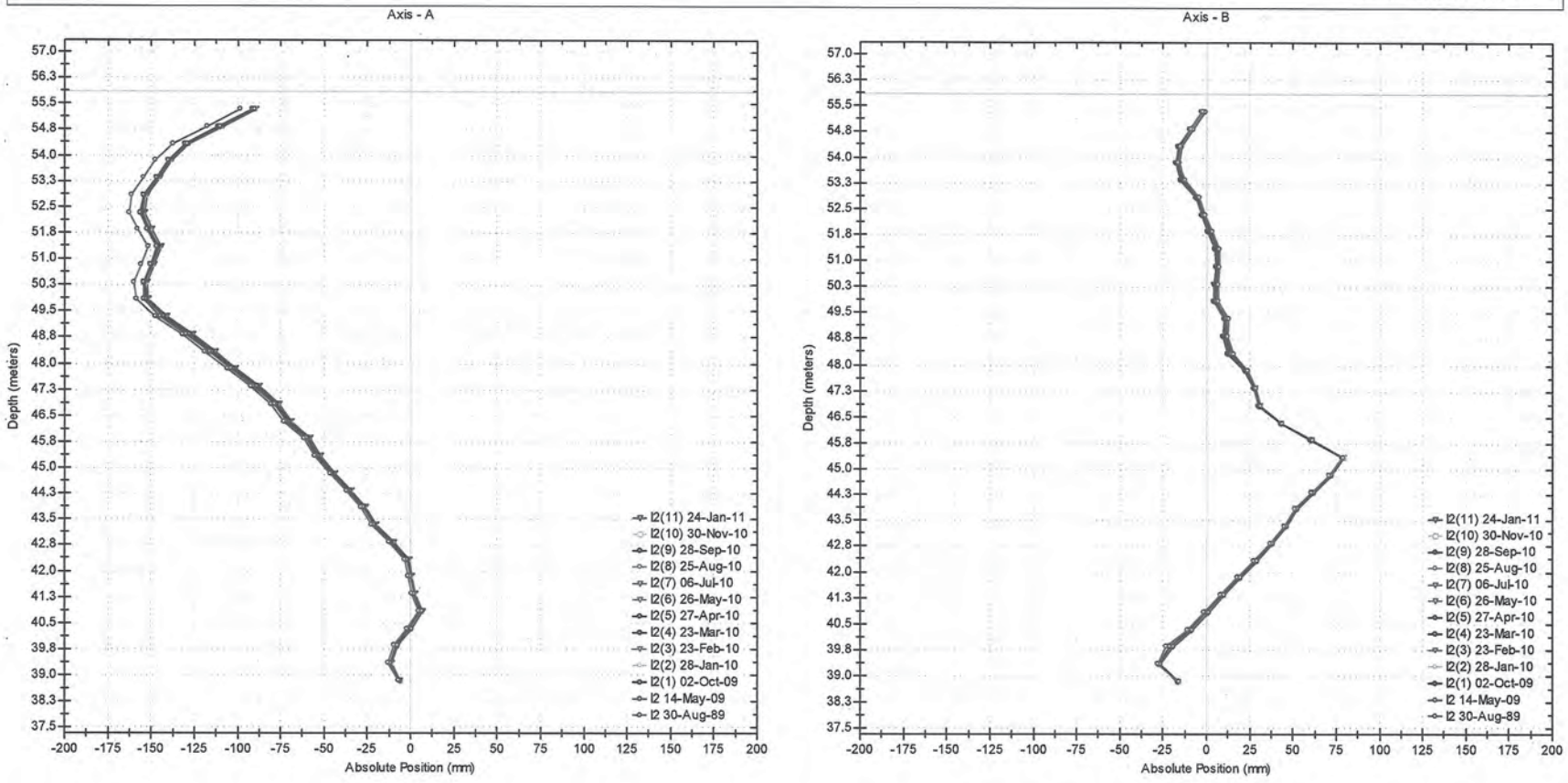
RST Instruments Ltd.

ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : I2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 55.8 meters
Borehole Total Depth : 17.0 meters
North Groove Azimuth :
Base Reading : 1989 Aug 30 11:01
Axis A Azimuth : 0.0 degrees



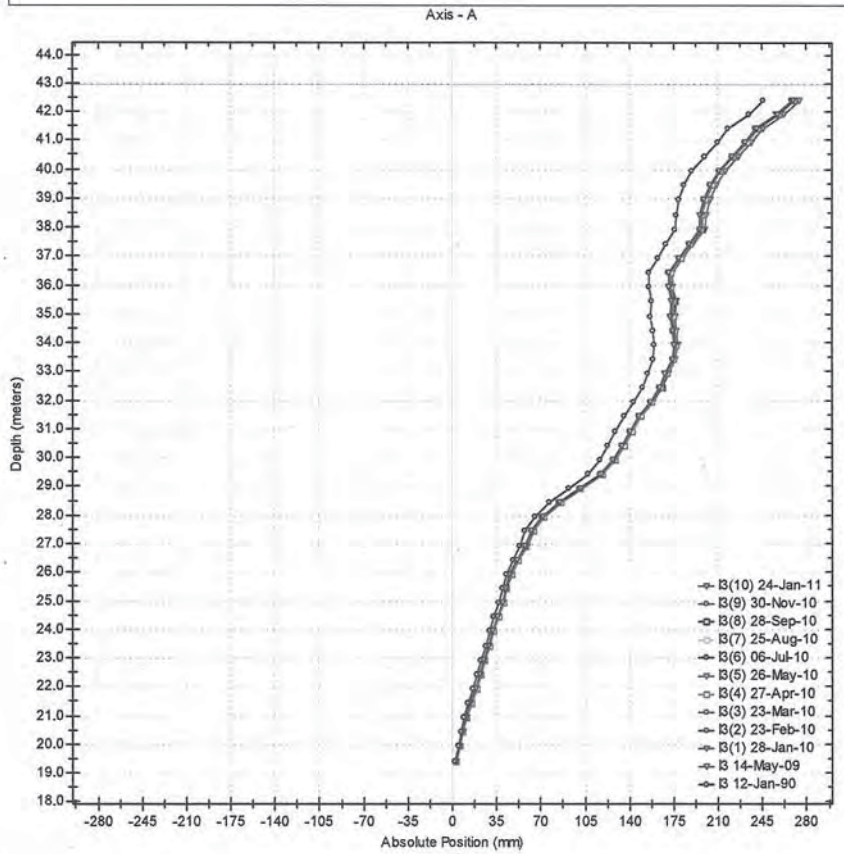
RST Instruments Ltd.

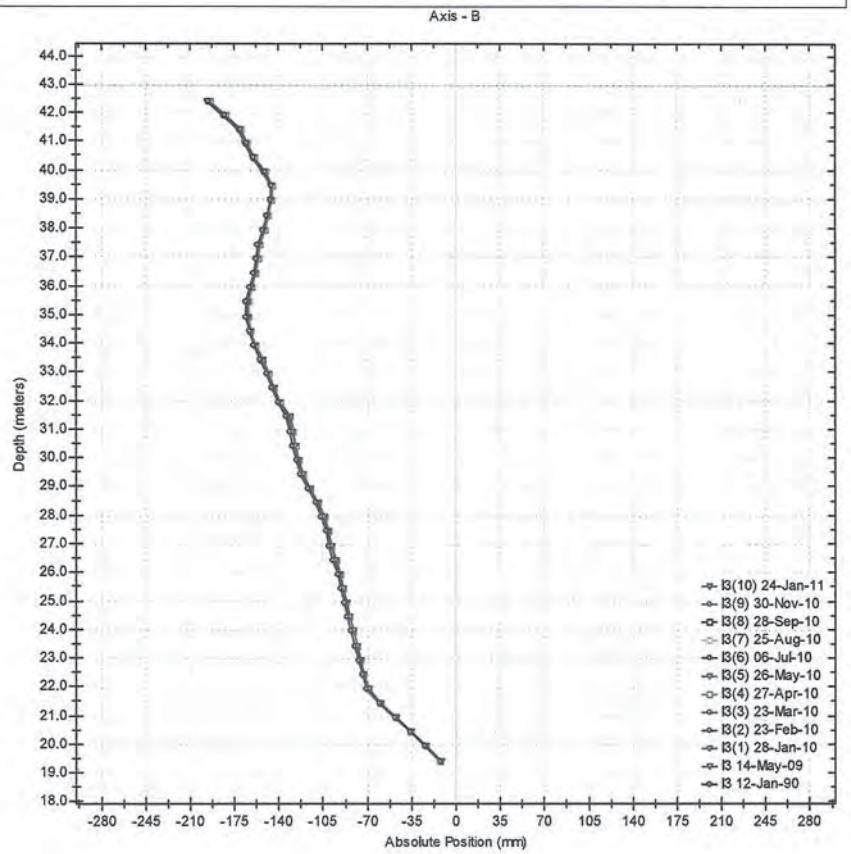
ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : I3
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 42.9 meters
Borehole Total Depth : 23.5 meters
North Groove Azimuth :
Base Reading : 1990 Jan 12 11:01
Axis A Azimuth : 0.0 degrees





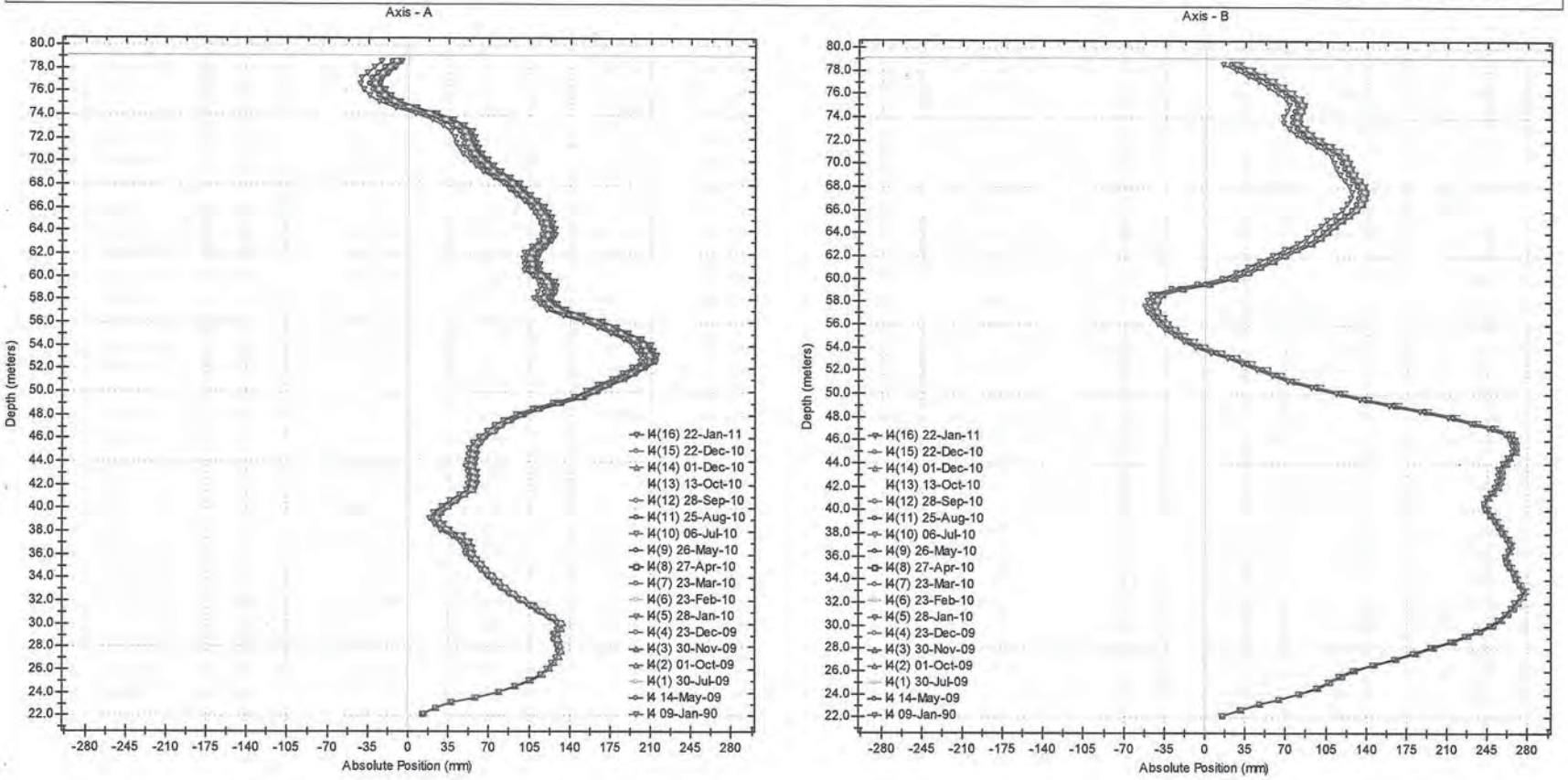
RST Instruments Ltd.

ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : I4
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 79.1 meters
Borehole Total Depth : 57.0 meters
North Groove Azimuth :
Base Reading : 1990 Jan 09 11:01
Axis A Azimuth : 0.0 degrees



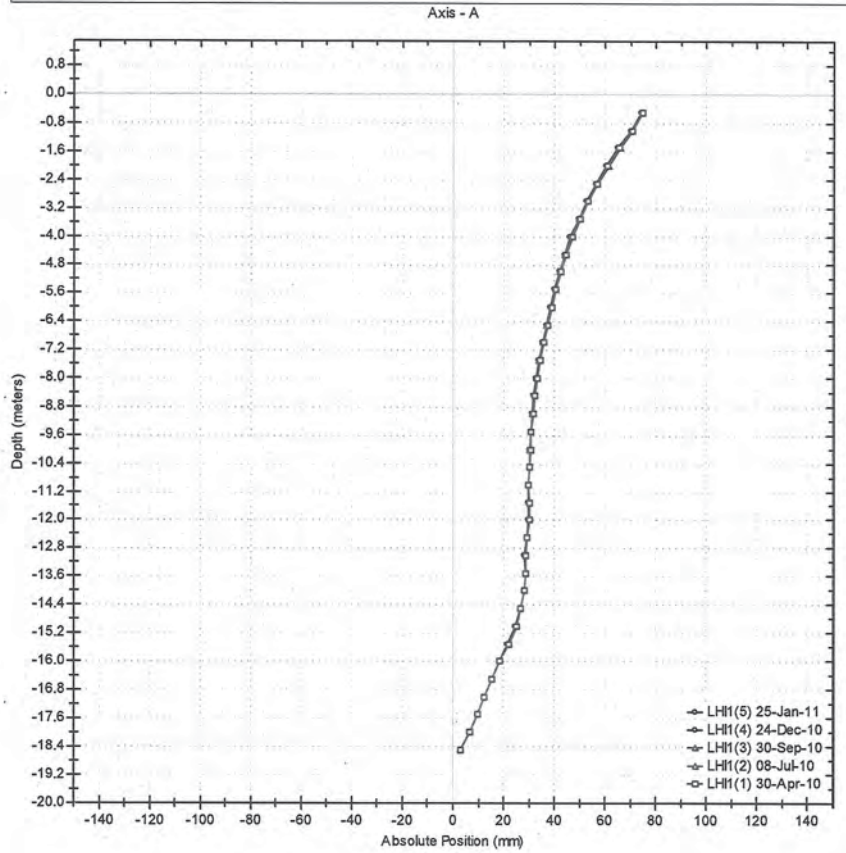
RST Instruments Ltd.

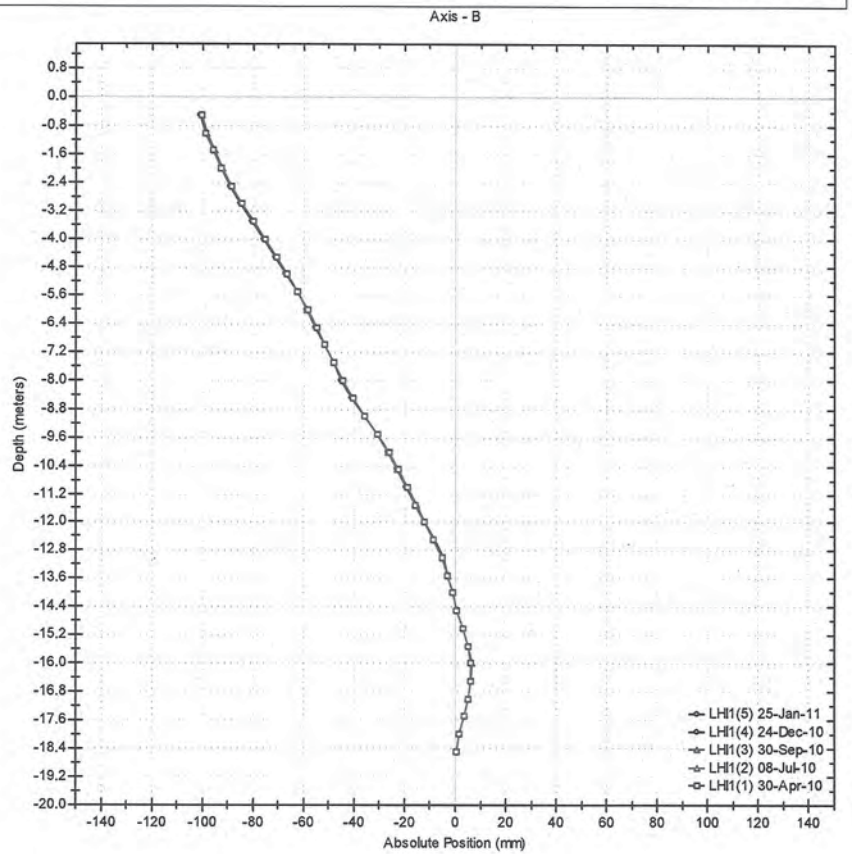
ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : LHI1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 18.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 30 10:50
Axis A Azimuth : 0.0 degrees





RST Instruments Ltd.

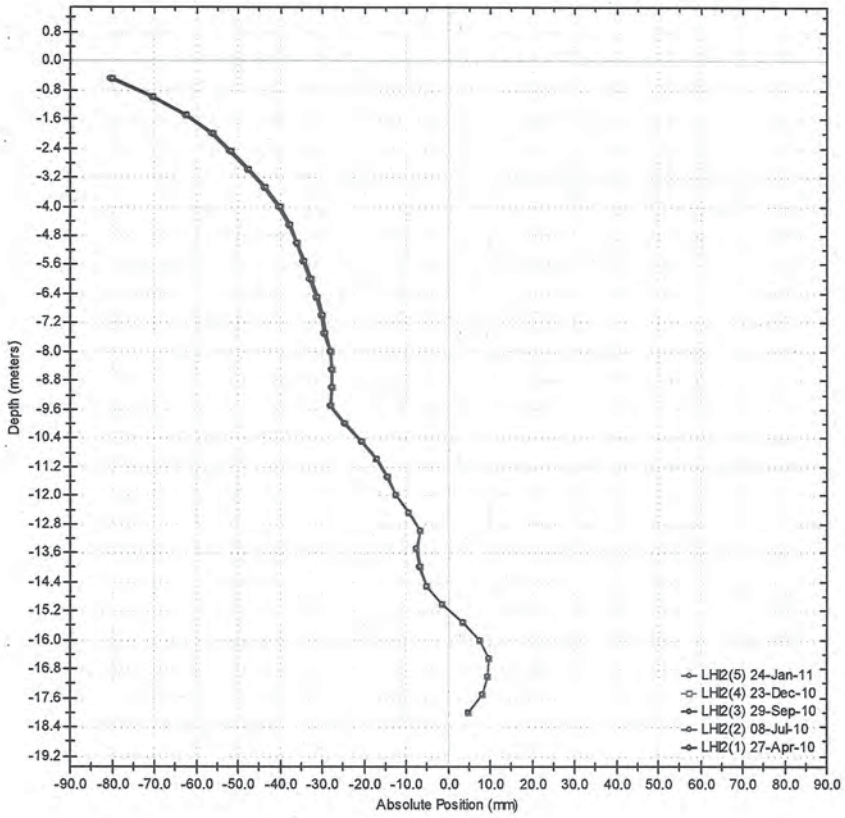
ABSOLUTE POSITION

Inclinalysis v.2.35

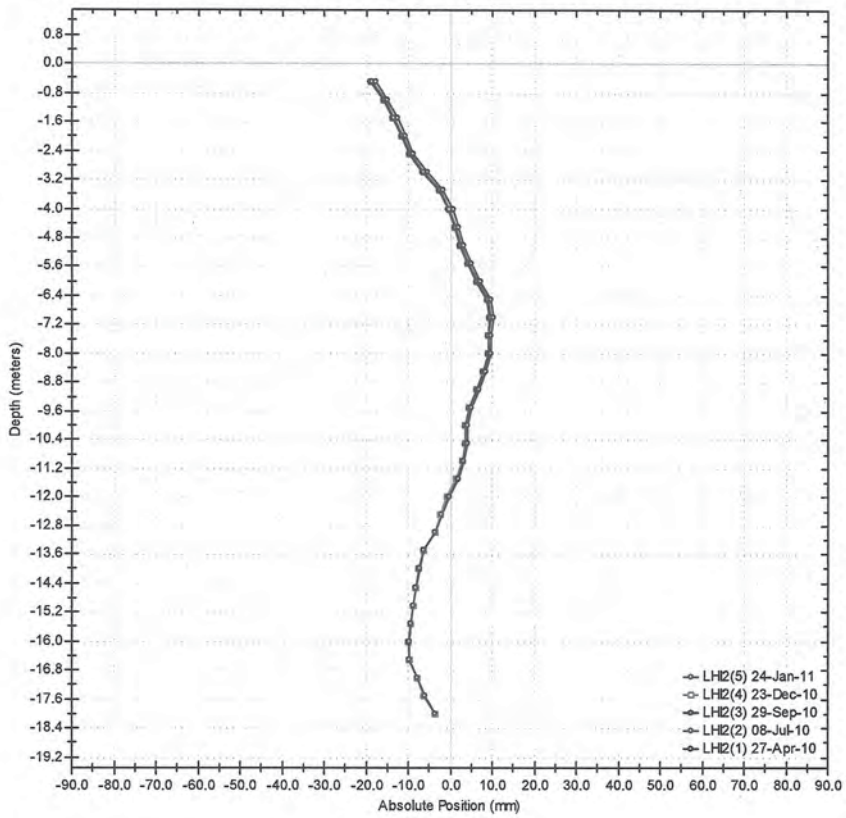
Borehole : LHI2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 18.0 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 13:30
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



RST Instruments Ltd.

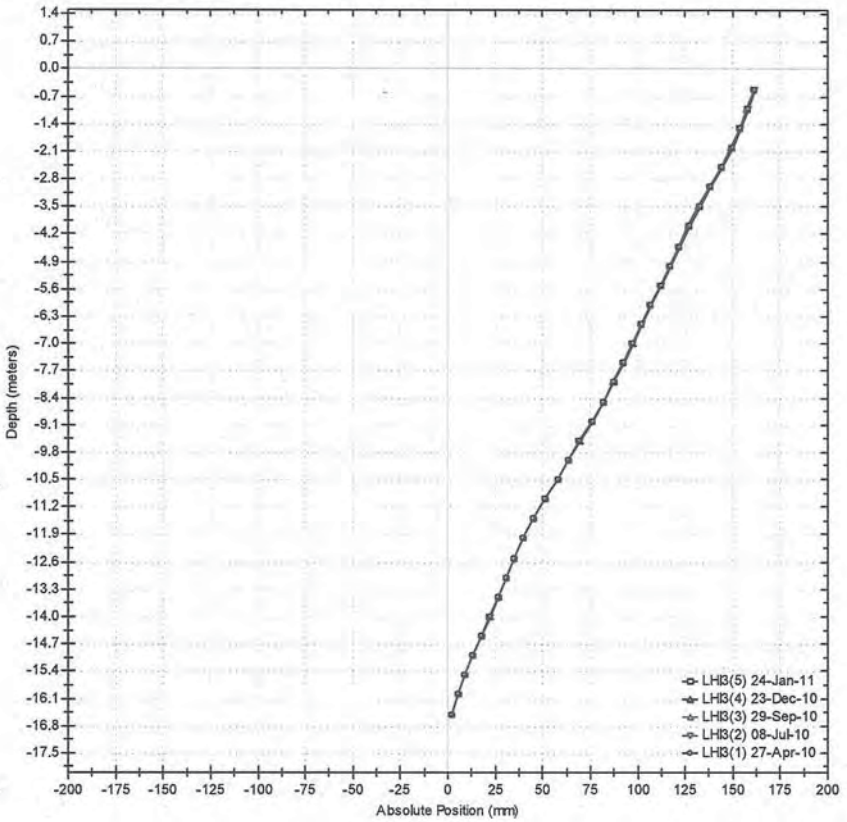
ABSOLUTE POSITION

Inclinalysis v.2.35

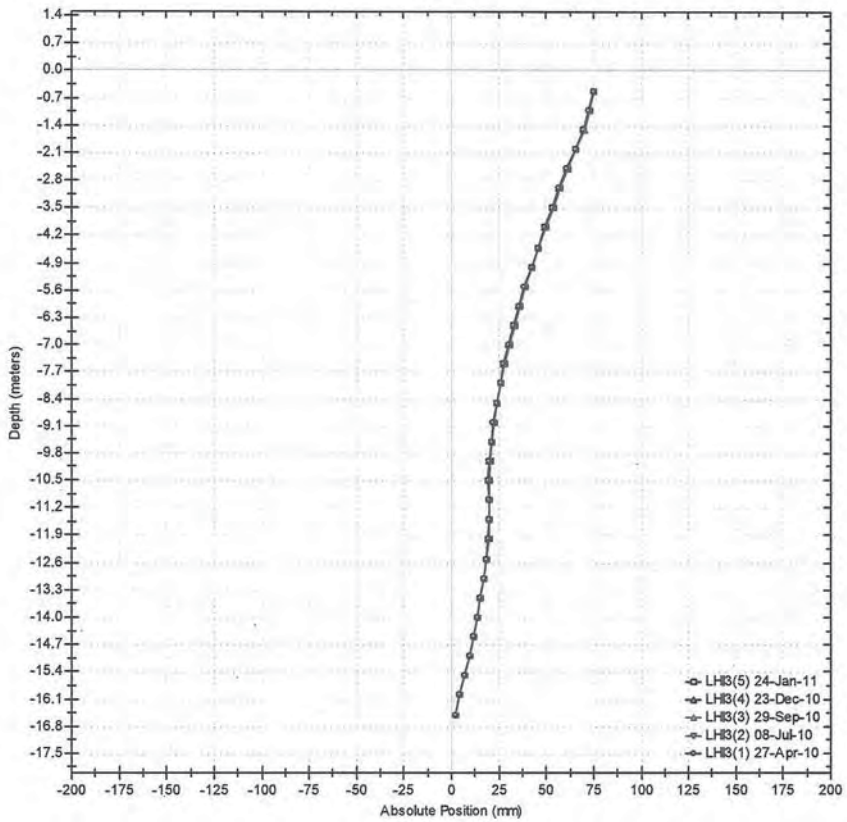
Borehole : LHI3
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 16.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 13:53
Axis A Azimuth : 0.0 degrees

Axis - A



Axis - B



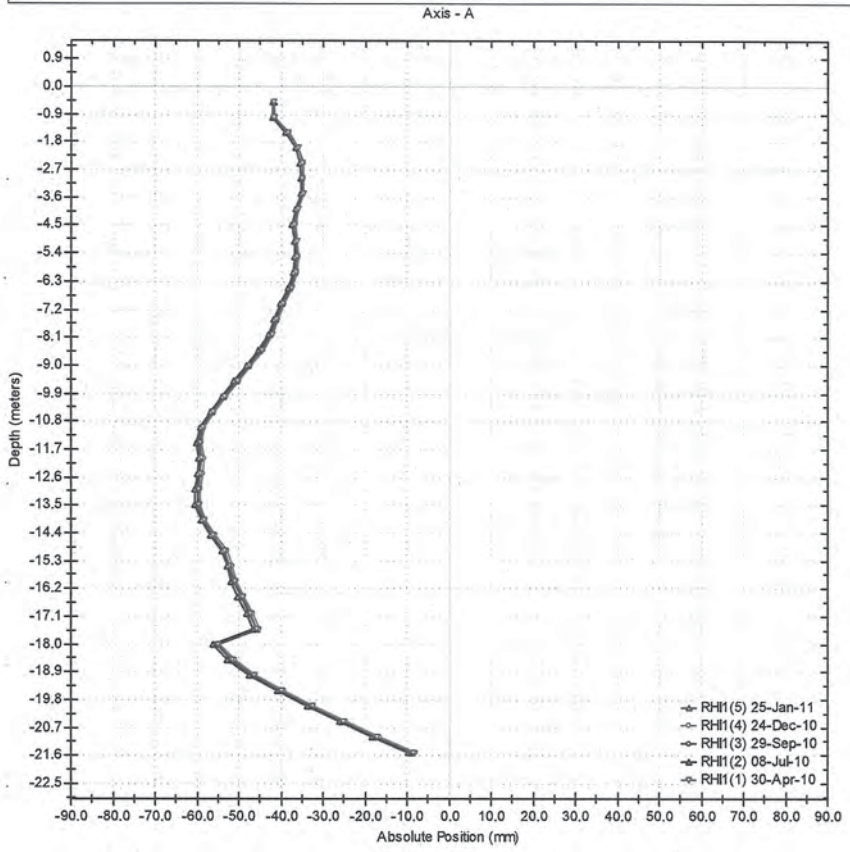
RST Instruments Ltd.

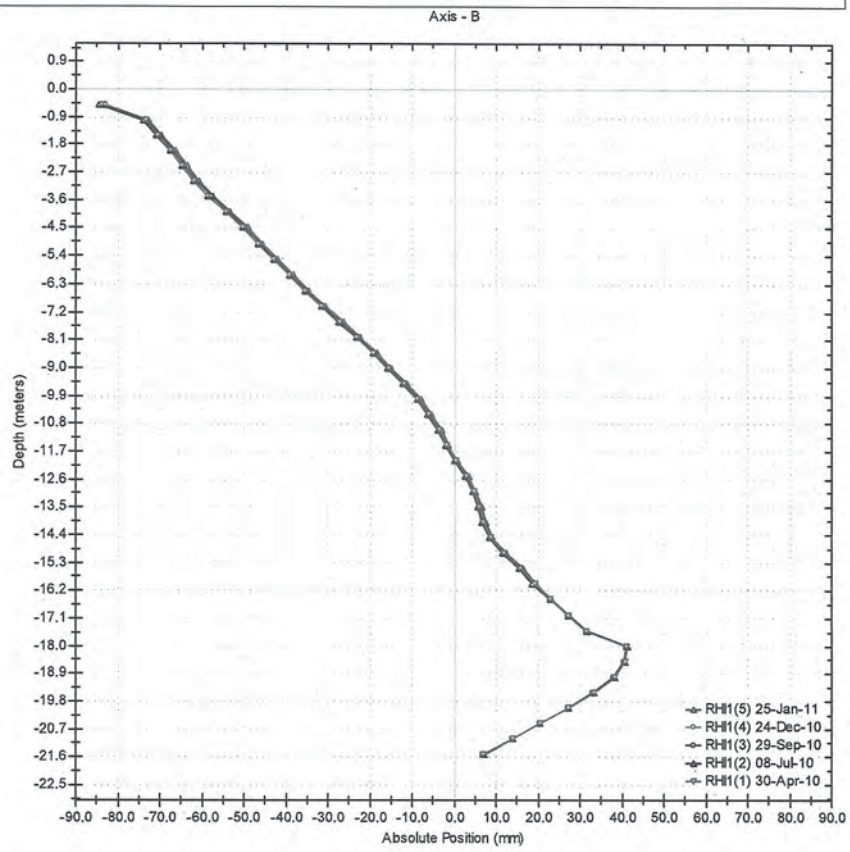
ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : RHI1
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 21.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 30 10:09
Axis A Azimuth : 0.0 degrees





RST Instruments Ltd.

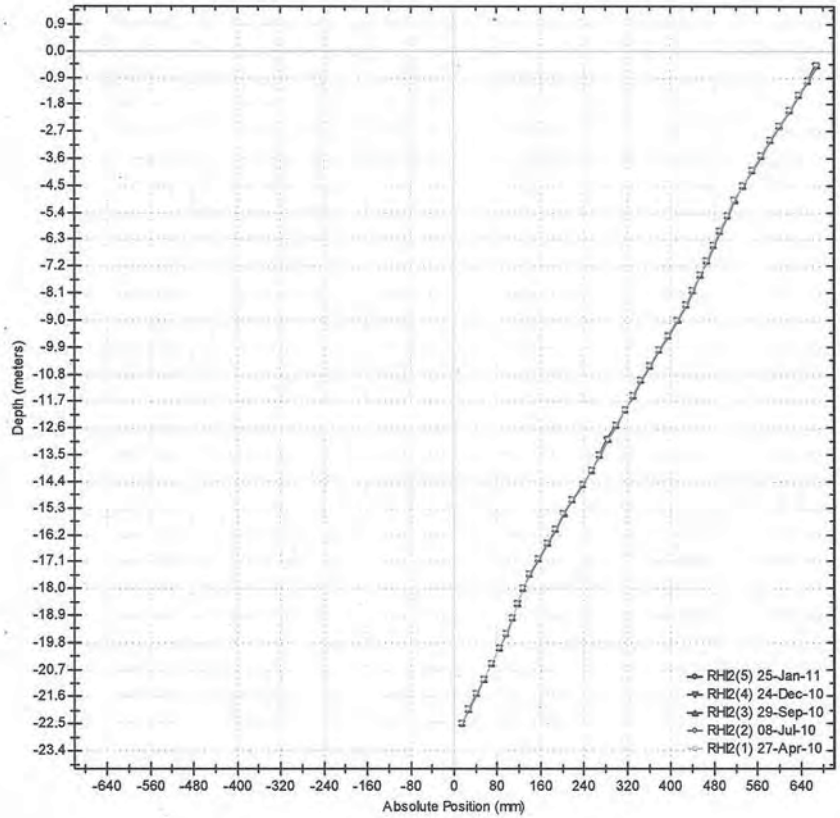
ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : RHI2
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 22.5 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 14:37
Axis A Azimuth : 0.0 degrees

Axis - A



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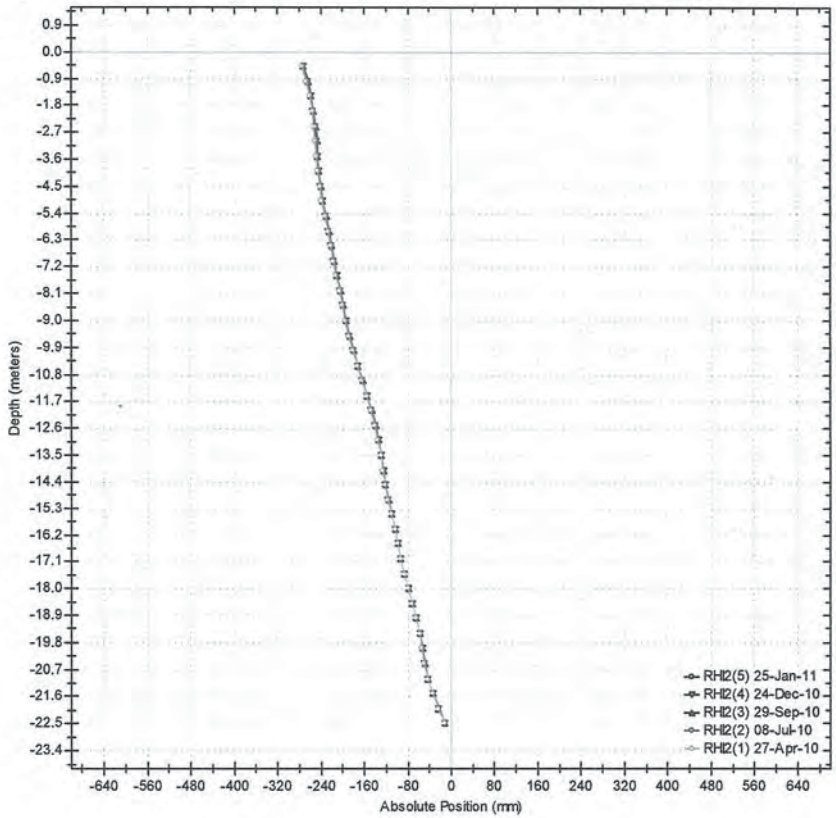


RST Instruments Ltd.

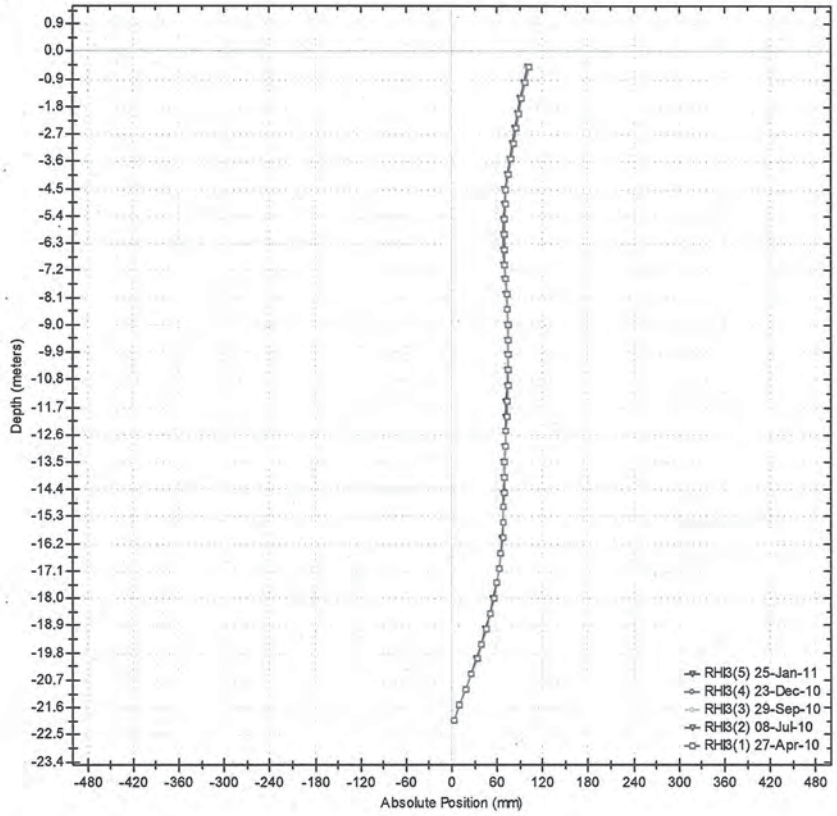
ABSOLUTE POSITION

Inclinalysis v.2.35

Borehole : RHI3
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 22.0 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 15:08
Axis A Azimuth : 0.0 degrees

Axis - A



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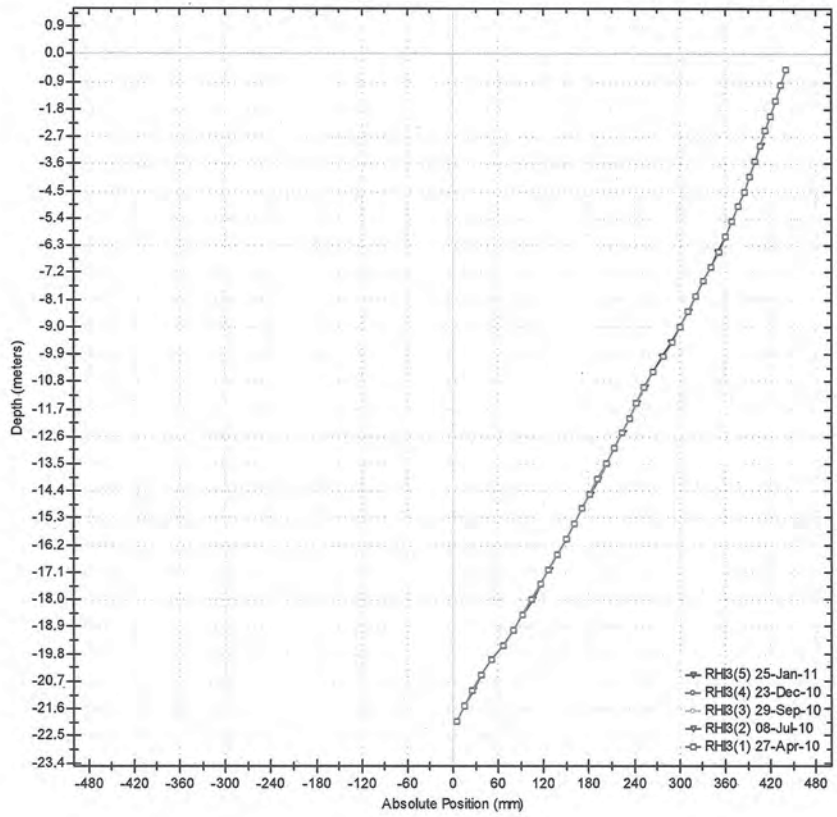

RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v.2.35

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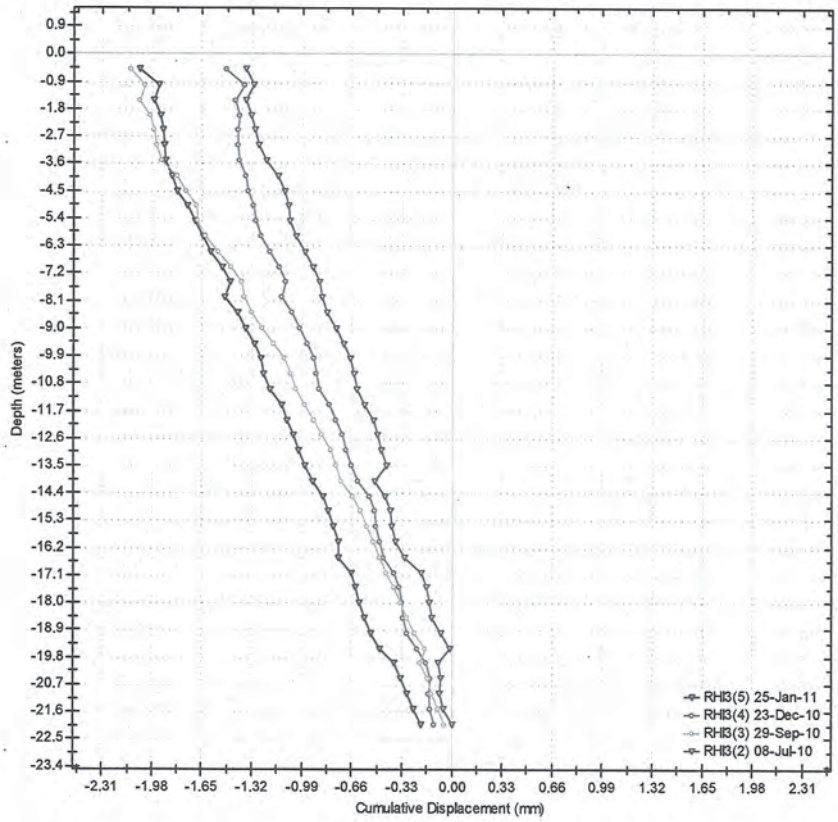
Project : Wivenhoe
Location :
Northing :
Easting :
Collar :

Spiral Correction : N/A
Collar Elevation : 0.0 meters
Borehole Total Depth : 22.0 meters
North Groove Azimuth :
Base Reading : 2010 Apr 27 15:08
Axis A Azimuth : 0.0 degrees

Axis - A



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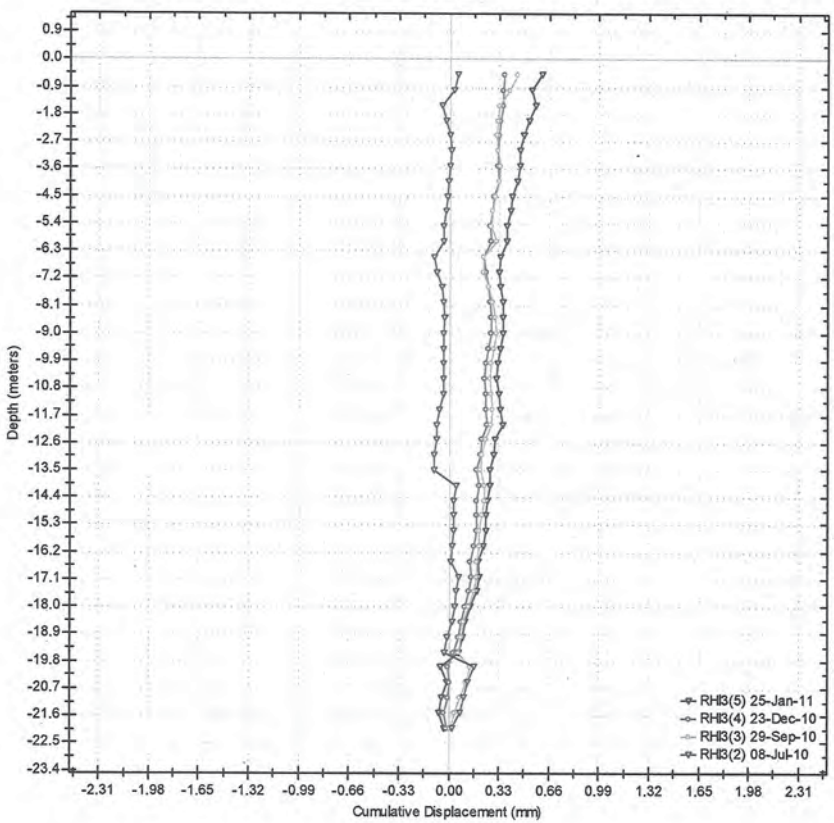

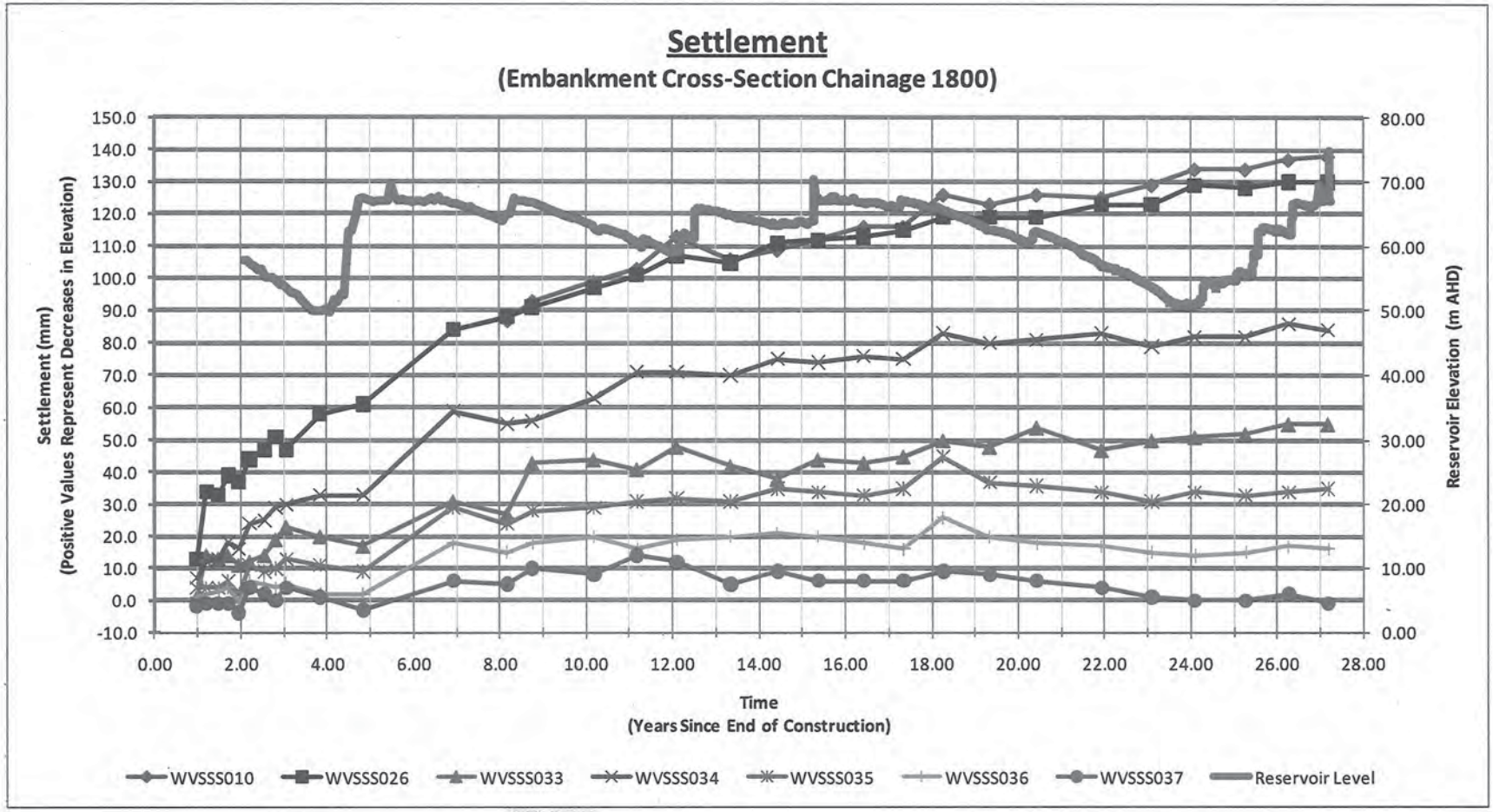
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(Embankment Cross-Section Chainage 1800)
Settlement (mm)
(Positive Values Represent Decreases in Elevation)
Reservoir Elevation (m AHD)
Time
(Years Since End of Construction)
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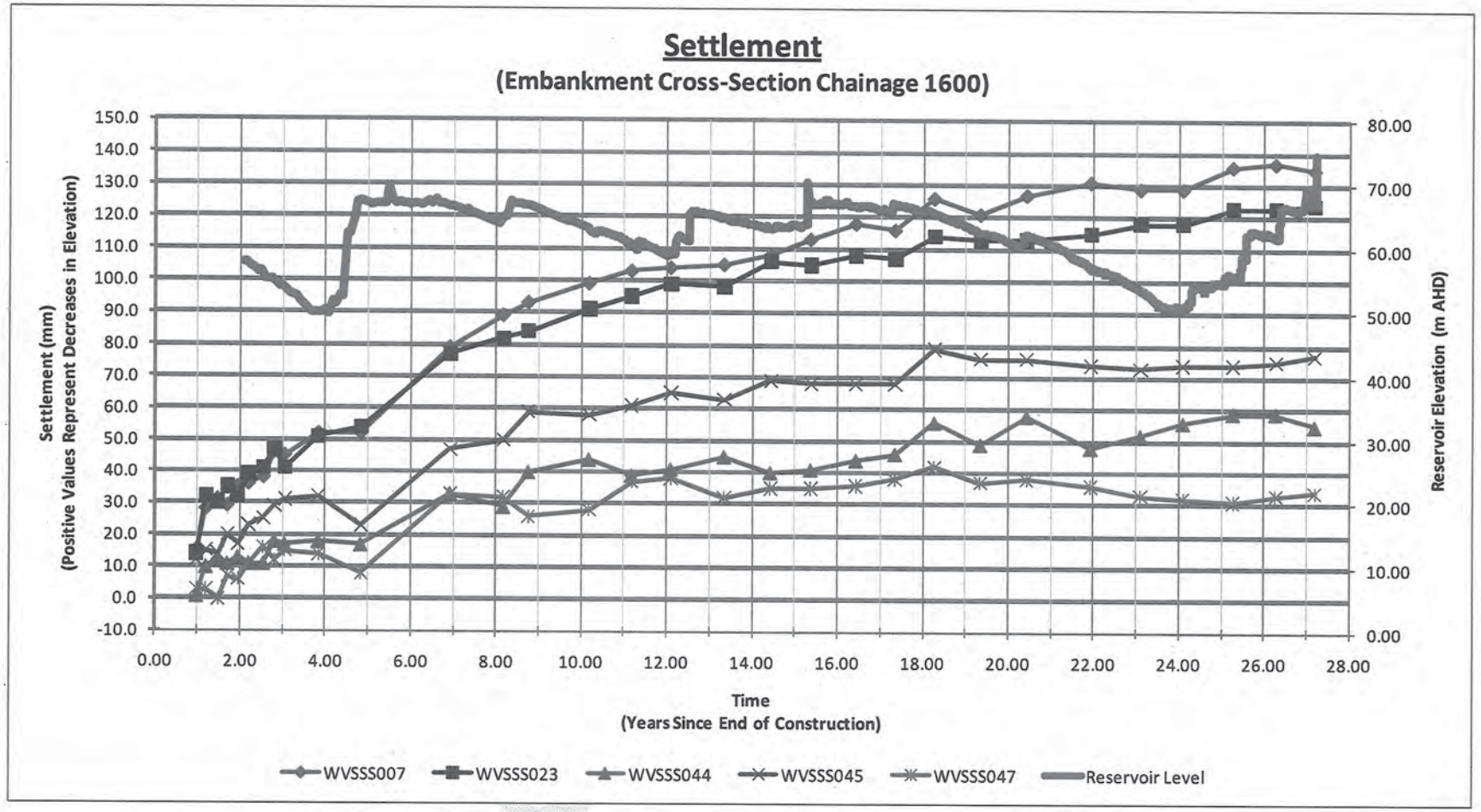
WVSSS026
WVSSS033
WVSSS034
WVSSS035
WVSSS036
WVSSS037
Reservoir Level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Settlement (mm)
(Positive Values Represent Decreases in Elevation)
Reservoir Elevation (m AHD)
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(Years Since End of Construction)
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100.0
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50.0
40.0
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0.0
-10.0
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70.00
60.00
50.00
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30.00
20.00
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12.00
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16.00
18.00
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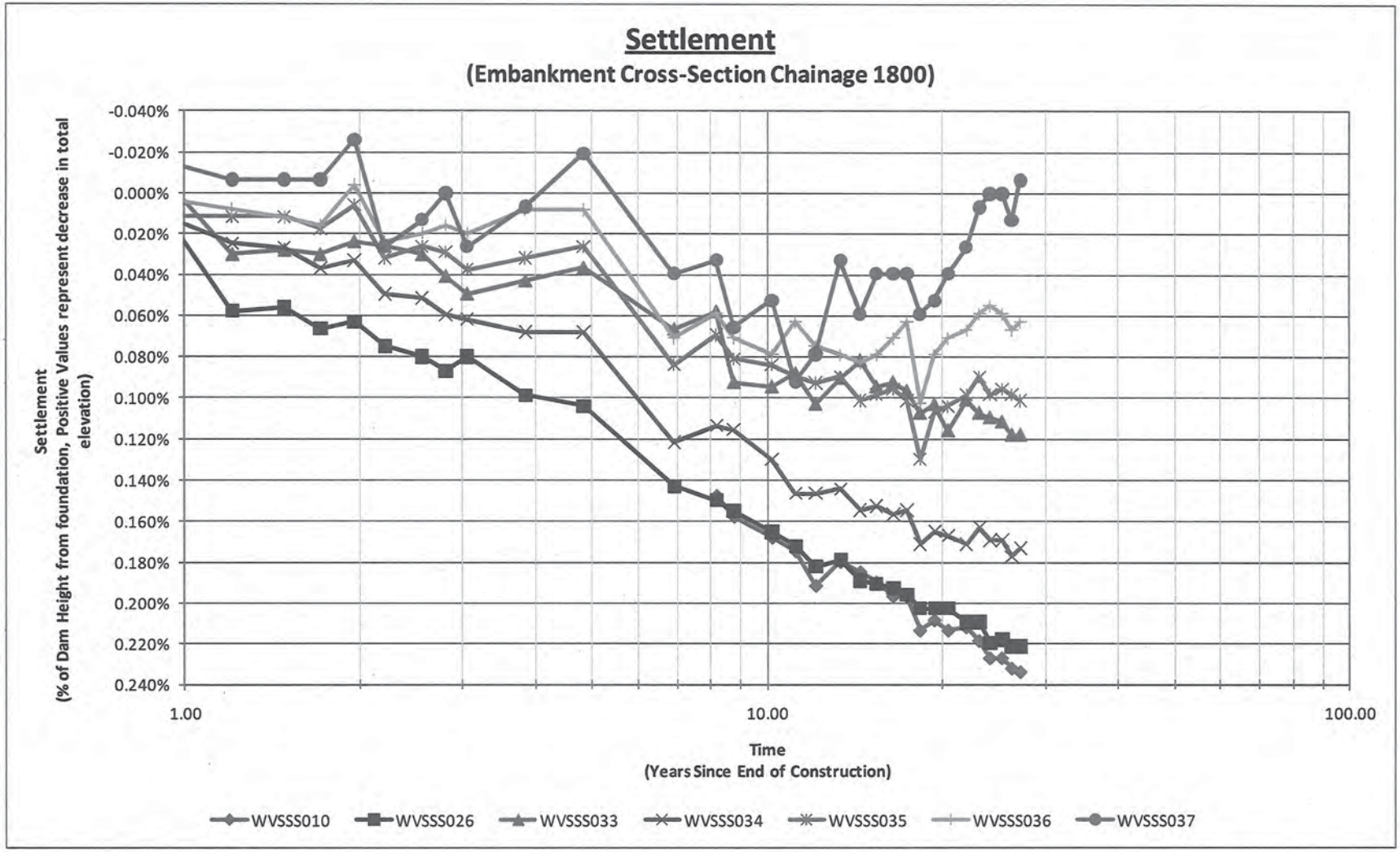
WVSSS044
WVSSS045
WVSSS047
Reservoir Level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(Embankment Cross-Section Chainage 1800)
Settlement
(% of Dam Height from foundation, Positive Values represent decrease in total elevation)
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-0.020%
0.000%
0.020%
0.040%
0.060%
0.080%
0.100%
0.120%
0.140%
0.160%
0.180%
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0.220%
0.240%
1.00
10.00
100.00
Time
(Years Since End of Construction)
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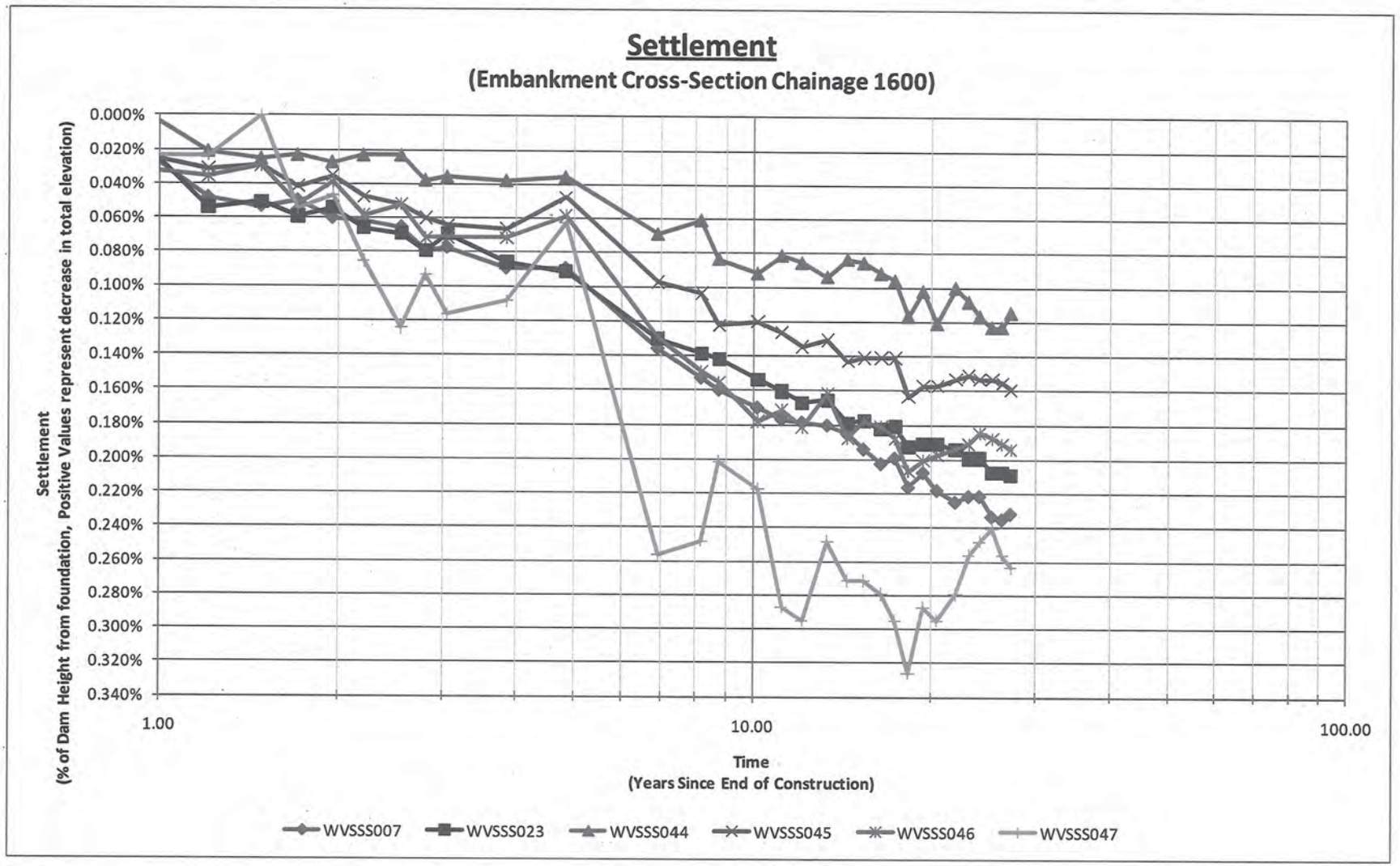
WVSSS037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1.00
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Time
(Years Since End of Construction)
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WVSSS044
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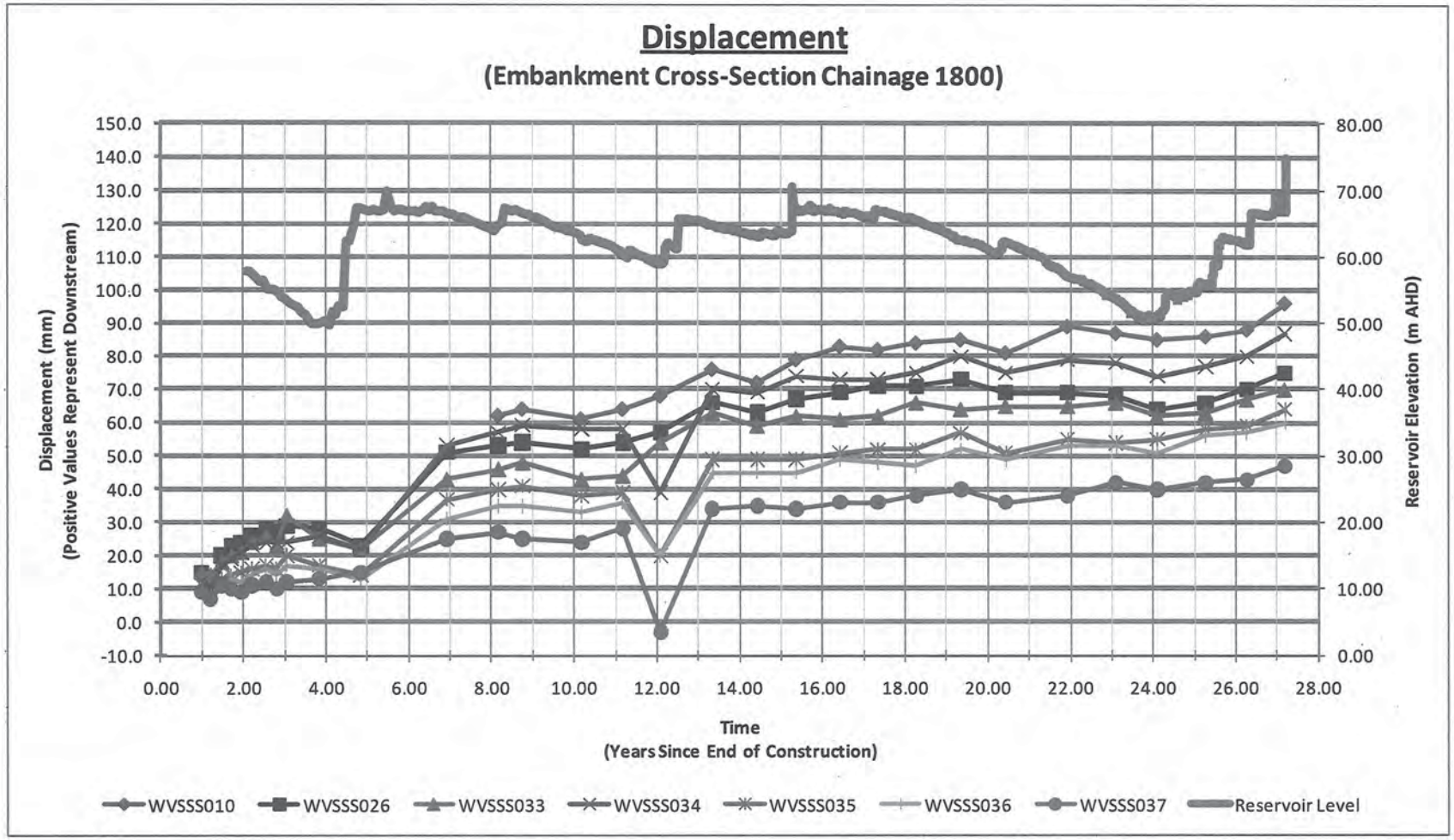
WVSSS047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(Embankment Cross-Section Chainage 1800)
Displacement (mm)
(Positive Values Represent Downstream)
Reservoir Elevation (m AHD)
Time
(Years Since End of Construction)
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140.0
130.0
120.0
110.0
100.0
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60.0
50.0
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18.00
20.00
22.00
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26.00
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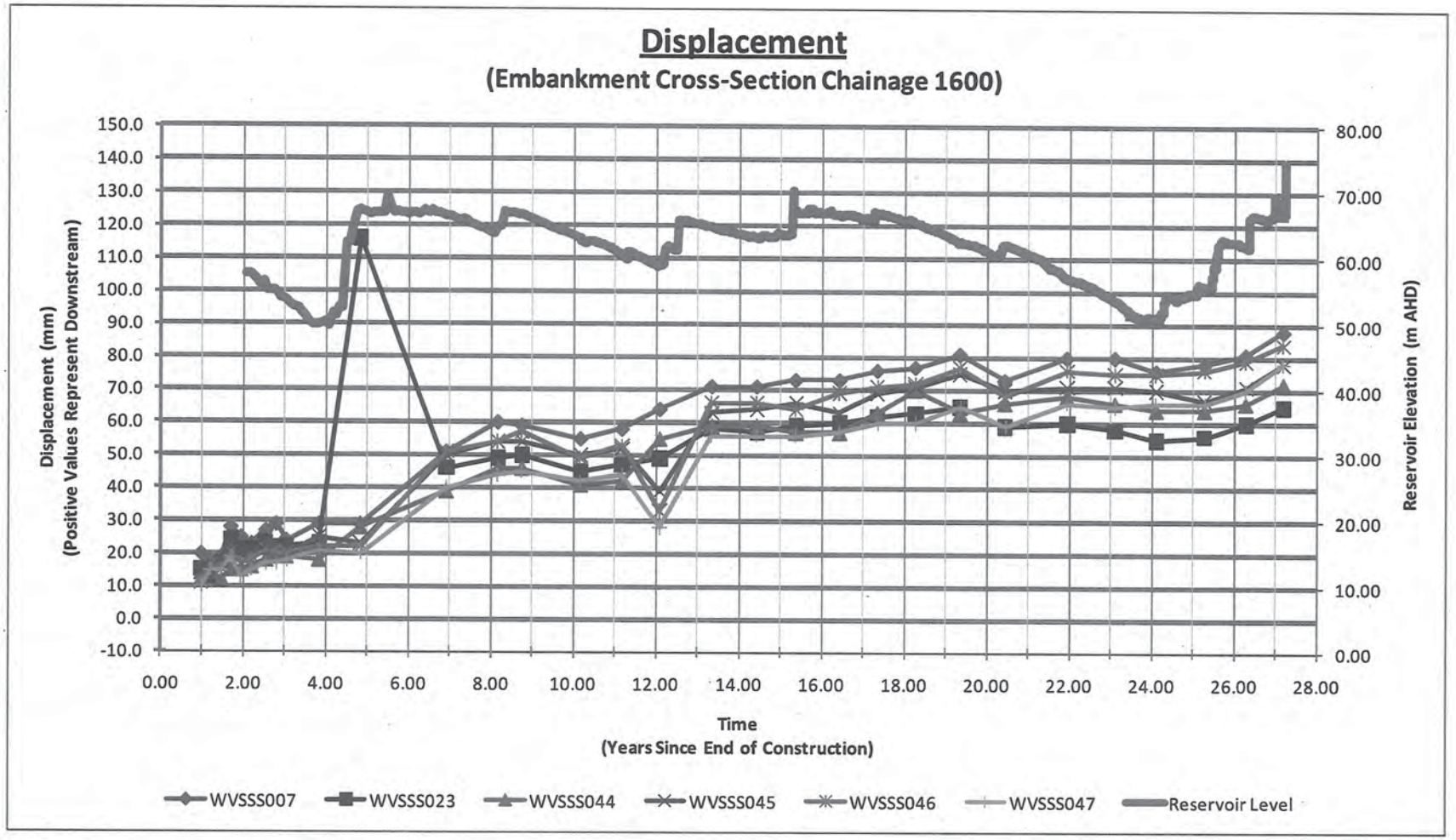
WVSSS026
WVSSS033
WVSSS034
WVSSS035
WVSSS036
WVSSS037
Reservoir Level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(Embankment Cross-Section Chainage 1600)
Displacement (mm)
(Positive Values Represent Downstream)
Reservoir Elevation (m AHD)
Time
(Years Since End of Construction)
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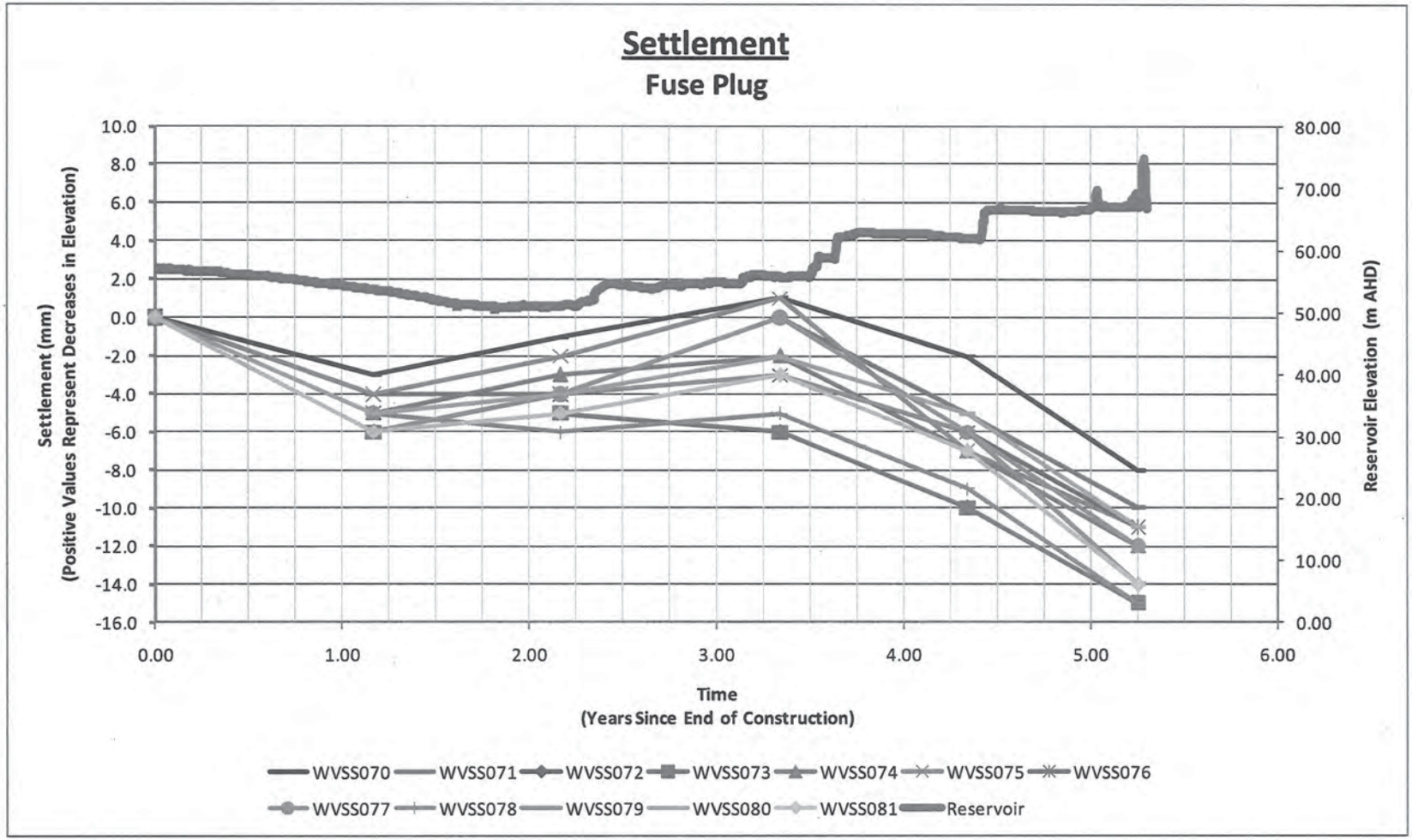
WVSSS044
WVSSS045
WVSSS046
WVSSS047
Reservoir Level


Settlement
Fuse Plug
Settlement (mm)
(Positive Values Represent Decreases in Elevation)
Reservoir Elevation (m AHD)
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(Years Since End of Construction)
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0.00
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1.00
2.00
3.00
4.00
5.00
6.00
WVSS070
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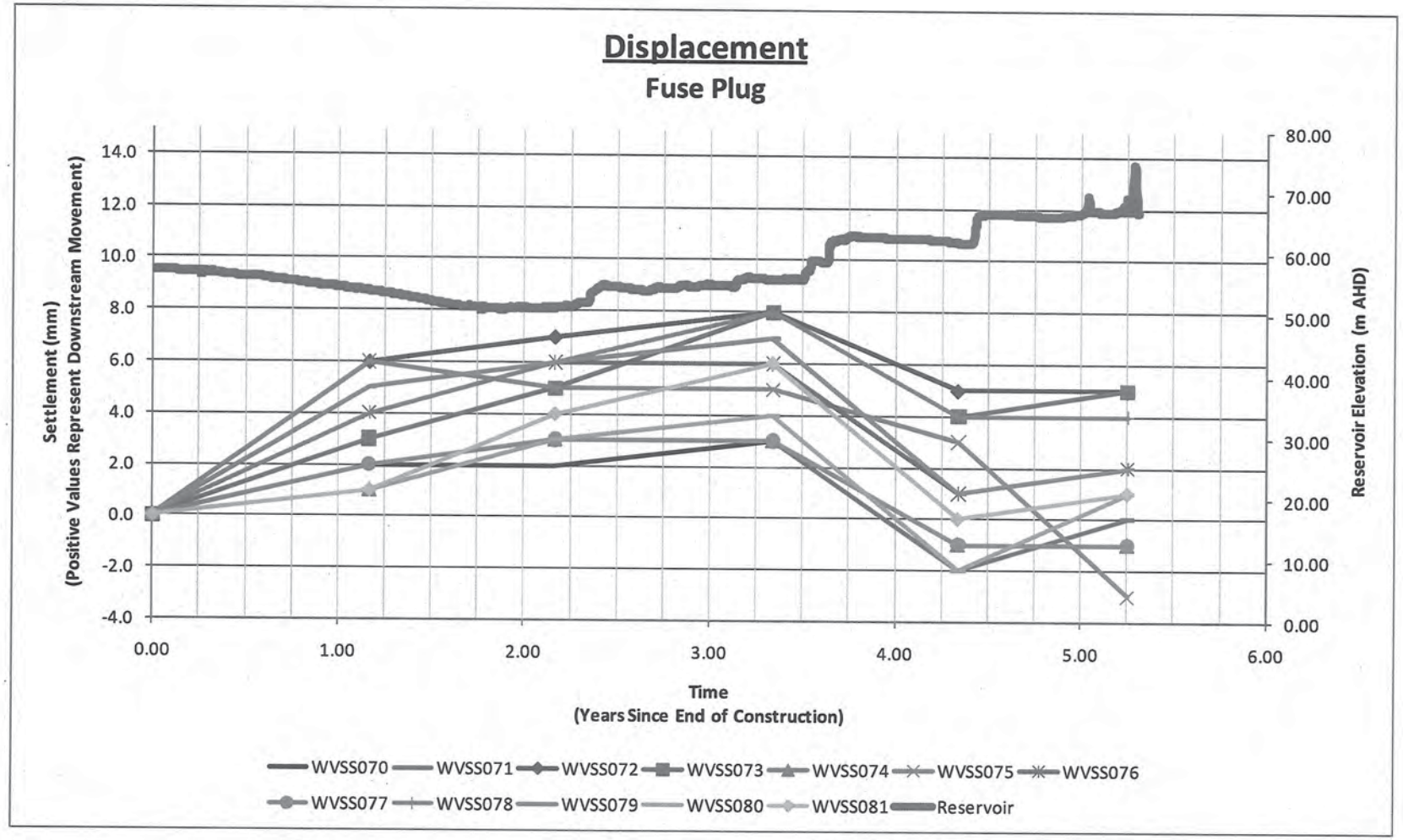
Reservoir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(Positive Values Represent Downstream Movement)
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30.00
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10.00
0.00
Reservoir Elevation (m AHD)
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2.00
3.00
4.00
5.00
6.00
Time
(Years Since End of Construction)
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WVSS074
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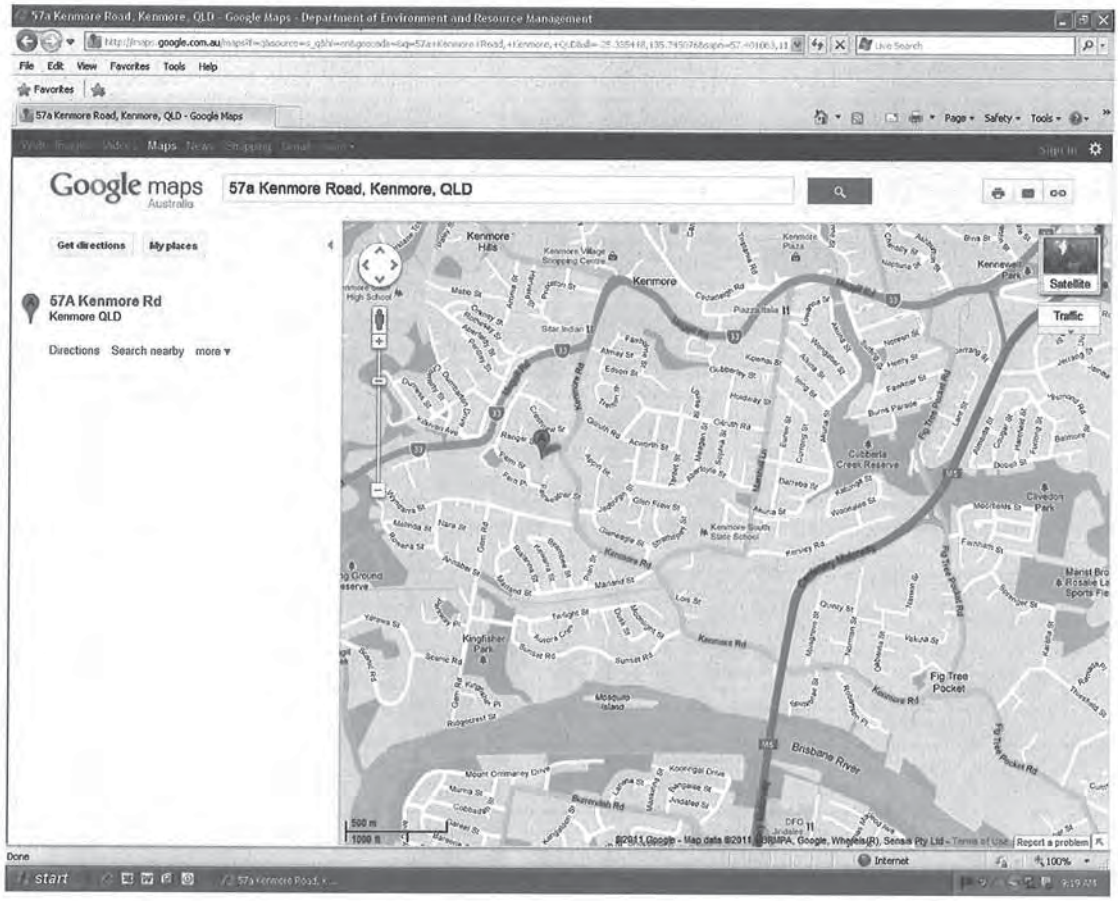
Reservoir


57a Kenmore Road, Kenmore, QLD - Google Maps - Department of Environment and Resource Management
File Edit View Favorites Tools Help
Favorites
57a Kenmore Road, Kenmore, QLD - Google Maps
Google maps
Australia
57a Kenmore Road, Kenmore, QLD
Get directions
My places
57A Kenmore Rd
Kenmore QLD
Directions Search nearby more
Satellite
Traffic
Kenmore
Kenmore Hills
Fig Tree Pocket
Brisbane River
Kenmore South State School
Kenmore Village Shopping Centre
Mosquito Island
Kingfisher Park
Clivedon Park
Gubberla Creek Reserve
500 m
1000 ft
©2011 Google - Map data ©2011 SIMPA, Google, Wheels(R), Sensis Pty Ltd - Terms of Use
Report a problem
Done
Internet
100%
start

This plan is based on Survey Map BBQ11732 but scaled as follows:
– lengths x 0.2 to convert to metres
– angles –4° to convert to T
Location of mast & buildings are approximate to fit the site.

ISS	ORIGIN	BY	DATE	DESIGN CHK	DRG CHK	REVISION DETAILS
5		rp	18.10.06			Proposed and Future Commercial DTV Installations Updated
7	BAPL	jcb	26.05.08			INTEGRATED JJJ SATELLITE DISH REPOINTING PROPOSAL
8	BAPL	A.H.	04.06.09			ABC JJJ SATELLITE DISH REPOINTING AS BUILT
9		jcb	19.03.10			ERGON ENERGY EQUIPMENT SHELTER PROPOSAL
10		jcb	14.09.10			ERGON ENERGY EQUIPMENT SHELTER AS BUILT

TITLE

BROADCASTAUSTRALIA

PASSCHENDAELE RIDGE, QLD
SITE NO 4114

SITE LAYOUT

ORIGIN:	
DRAWN:	
DESIGN CHK:	
DRG CHK:	
APPROVED FOR ISSUE:	

DRAWING No

BA4114.5

Wivenhoe Dam
Spillway Development

Design Philosophy

Wivenhoe Dam contains a gate controlled flip bucket spillway which throws discharging water away from the dam into a plunge pool for energy dissipation. The plunge pool is a cavity in the sandstone rock downstream and away from the dam. It was recognised at the time of the design that discharges from the dam will enlarge the plunge pool with time. Eventually the plunge pool will enlarge itself to the extent that it becomes stable, with all the discharge energy being dissipated in the cavity by the interaction of the upward flowing water leaving the plunge pool and the water being flipped off the spillway.

Background

The initial arrangement of the spillway was developed by the application of Engineering Principles. The arrangement was then validated by physical modelling in a hydraulic laboratory. The 1 in 200 modelling used erodible material in the plunge pool area. It showed that a plunge pool cavity would form, however erodability cannot be reliably modelled. The final extent of the erosion was however not dependent on the initial size or shape of the plunge pool cavity. On this basis an initial plunge pool was provided in the spillway during the construction of the dam. The constructed bed level of the plunge pool was at RL 17. The discharges of the 1999 flood event lowered the bed level to RL 16.

During the January flood of 2011, the maximum discharge through the spillway of Wivenhoe Dam was 7450 m^3/s, which is considerably larger than any previous discharges.

Observation

The flood surcharge in Wivenhoe Dam was progressively discharged through the spillway at progressively decreasing rates culminating in the final closure of all gates at 12 noon on the 19th January 2011.

As the tail water receded, a bank (Figure 1) of large blocks of sandstone rock emerged just downstream of the plunge pool. The bank was causing an afflux of about 4 meters.

Figure 1 Plunge Pool 10 am 19/1/2011

The plunge pool drained quickly following final closure exposing more blocks. Immediately before the commencement of operational releases through a crest gate, the full extent of the bank was visible (Figure 2). The sandstone blocks were across the whole width of the spillway, including the low flow channel on the left hand side of the spillway.

Expectations

With the record discharge through the spillway, additional enlargement of the plunge pool cavity was expected. The previous erosion episodes of earlier discharges have resulted in the deposition of moderate sandstone boulders downstream. The higher energy situation has obviously raised and displaced much larger sandstone blocks, which have been deposited in a bank once out of the high energy zone of the plunge pool (Figures 3 & 4).

The expectation is that the sandstone blocks in the bank have come from the floor of the plunge pool cavity, with a substantial lowering of the plunge pool floor.

SEQWater were arranging for diving contractors to examine the plunge pool erosion on the 20th January. The contractors arrived on the site whilst I was there and arranged with SEQWater to undertake the underwater inspection and a bathymetric survey on the 20th.

Issues

The issues are that the sandstone blocks in the bank could have come from elsewhere in the spillway channel, namely:

1. by lateral expansion of the plunge pool cavity at depth to beneath the walls of the spillway, thus decreasing their stability; or
2. by head ward erosion of the plunge pool cavity upstream towards or to beneath the apron and flip of the spillway structure.

Actions

To establish certainty, SEQWater are to:

1. Undertake a bathymetric survey of the plunge pool floor by a depth gauge attached to a boat starting on 20th January 2011; and
2. Investigate lateral expansion extent (if any) by professional divers in the spillway walls and the spillway toe starting 20th January 2011.

OWSR will continue to liaise with SEQWater on the outcomes of the investigations.

Figure 2 Plunge Poole 1 pm 19/1/2011

Figure 3 Sandstone Block Bank from downstream

Figure 4 Sandstone Block Bank just Upstream

Inspection and Report by

Russ McConnell
Manager Containment System, OWSR
Department of Environment and Resource Management.

Allen Peter

From: Allen Peter
Sent: Friday, 18 March 2011 2:19 PM
To: 'Jim Pruss'
Cc: Tibaldi, John (Business Fax); T.Malone [redacted] Rob Ayre (Rob.Ayre [redacted]; Guppy Ron; Reilly Bob
Subject: Outcomes of North Pine Dam Meeting 18th March 2011

Jim,

Just to confirm the outcomes of our meeting this morning in relation to North Pine Dam ...

The principal outcome was that Seqwater will prepare a program of activities that they intend to undertake to determine the following issues (which have arisen out of the January flood event) and provide DERM Dam Safety a copy of this program.

- Essentially what is required is a review of the spillway adequacy of North Pine Dam given the experiences during this recent event
  This will probably include assessments of:
  - A review of the AEP of the rainfall events (some idea of the representativeness of the gauged rainfalls might be good [from my perspective] and this might be obtained from a review of the weather radar imagery?)
  - A review of the hydrological models used to estimate historical and design flood inflows – recalibration for major floods using updated flood and dam characteristics
  - A review of the accuracy of the gate rating curves (especially at major gate openings) ... Do they adequately take into account: the bridge deck, the instability at major gate openings, the 3D effects of the 5 gate openings etc.?
  - A review of the storage capacity curve (again especially at higher storage levels)
  - A review of the structural adequacy of the gates, piers etc. in terms of whether they can support the higher loads associated with major floods which are in excess of the original design floods.
  - What is the maximum headwater level able to be accommodated within the dam?
  - Are there any operational restrictions that need to be applied to flood operations at the dam?
- A review of the operational procedures ... such as number of gate openings achievable in peak periods, the impact of loss of ability to control gates e.g. when water levels reach switch gear etc., what happens when gates are overtopped, reliability of gate winching mechanisms?
- Whether there should be changes to the Manual in the short term before the outcomes of these studies are known? I am especially thinking of the rapidity of gate movements (e.g. should we reduce the number of opening segments), reliability of gate lifting mechanisms etc.
- The benefit/cost of lowering FSL ... either permanently or temporarily??

Ultimately, I would be looking for some relatively simple short term actions that could provide some benefit and then when the other studies are undertaken, I would be looking for a longer term resolution. I see the short term as 'in the next month or so' and the longer term as 'before the next wet season'. One of the issues that I am particularly keen to obtain is an estimate of the AEP of the flood event that the dam can currently safely pass. This assist in the briefing of Ministers etc.

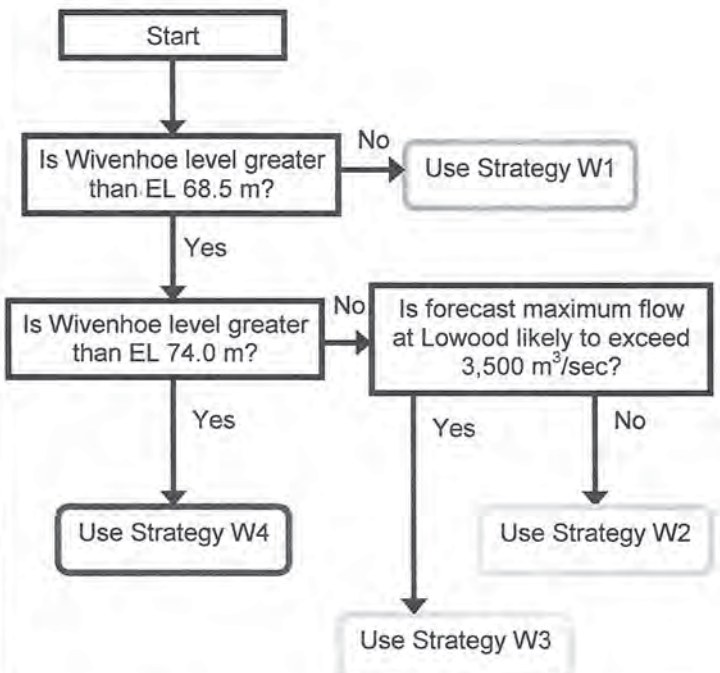
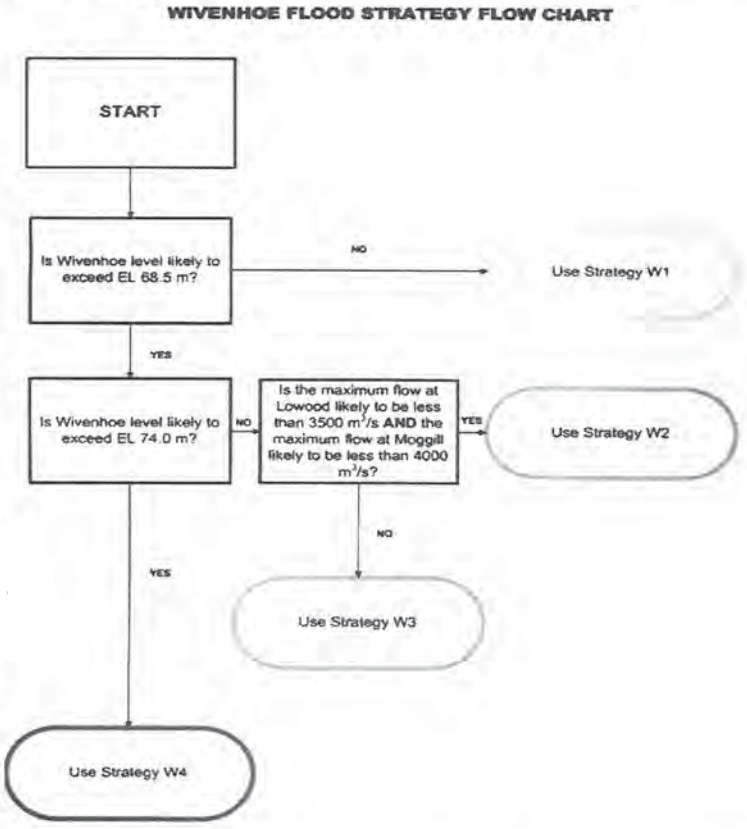
I am happy for the program to reflect uncertainty in that it may need to be adjusted depending on what is found.

Let me know if you are happy with the above. If not, I am prepared to negotiate a consensus but I look forward to hearing from next week.

Peter Allen
Director Dam Safety (Water Supply)
Office of the Water Supply Regulator
Telephone [redacted]
Email peter.allen[redacted]
www.derm.qld.gov.au
Department of Environment and Resource Management
3rd Floor 41 George Street, Brisbane Q 4000
GPO Box 2454, Brisbane Q 4001

Table comparing comments made by DERM and sent to Seqwater by email 13 October 2009 (Annexure 18 and 19 to Statement of Ronald Guppy) that were not incorporated into final version of Seventh Revision of Wivenhoe Flood Mitigation Manual
Prepared by Queensland Floods Commission staff

No. in Annexure 19	Suggestion by DERM (Annexure 18 and 19 to Statement of Ronald Guppy)	Final version of Seventh Revision of Wivenhoe Flood Mitigation Manual (Exhibit 21)
3	Section 8.4 talks about the strategy being chosen based on predictions, maximums and peaks as below: *The strategy chosen at any point in time will depend on the following predictions which are to be made using the best forecast rainfall and stream flow information available at the time:* • *Maximum storage levels in Wivenhoe and Somerset Dams.* • *Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases).* • *Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).* Our understanding is that the actual values are used to select W1 to W4 with some variations allowed for based on forecasts. e.g. You transition form W1 to W2 or W3 once the water level in Wivenhoe exceeds EL 68.5m. The choice between W2 and W3 is made on the forecast of the peaks depending on whether the Lowood or the Moggill flows control.	Section 8.4 states: The strategy chosen at any point in time will depend on the actual levels in the dams and the following predictions, which are to be made using the best forecast rainfall and stream flow information available at the time: • Maximum storage levels in Wivenhoe and Somerset Dams. • Peak flow rate at the Lowood Gauge (excluding Wivenhoe Dam releases). • Peak flow rate at the Moggill Gauge (excluding Wivenhoe Dam releases).
Response	As the event proceeds, the forecast maximum storage levels are revised using the actual storage levels as the 'starting' point. Therefore it is appropriate that the 'actual dam levels' are referred to.	

No. in Annexure 19	Suggestion by DERM (Annexure 18 and 19 to Statement of Ronald Guppy)	Final version of Seventh Revision of Wivenhoe Flood Mitigation Manual (Exhibit 21)
4	From this perspective, it may be better to change the figure on page 27 to something along the following lines. Wivenhoe Flood Strategy Flow Chart 	Flow chart on page 23: 
Response	This was a flowchart that I produced to put the Wivenhoe strategies into one flowchart. As indicated in my Submission, this was the first attempt to introduce 'predictions' into the selection of the Wivenhoe release strategies. The 'suggestion by DERM' was an attempt to clarify what was intended. There was no such flowchart in Revision 6. I had also realised that some flexibility was needed in the strategy selection in order to pass extreme floods. Once it was discussed more fully with Seqwater, it was agreed that the use of predictions should be accepted.	

No. in Annexure 19	Suggestion by DERM (Annexure 18 and 19 to Statement of Ronald Guppy)	Final version of Seventh Revision of Wivenhoe Flood Mitigation Manual (Exhibit 21)
5	All W strategies should refer to actual levels and flows and not the predicted levels and flows. Then W4A and W4B can be differentiated based on Predicted Maximum Lake Level.	Conditions for Strategy W1, p24: Wivenhoe Storage Level predicted to be less than 68.50 m AHD Conditions for Strategy W2, p27: Wivenhoe Storage Level predicted to be between 68.50 and 74.00 m AHD Conditions for Strategy W3, p28: Wivenhoe Storage Level predicted to be between 68.50 and 74.00 m AHD Conditions for Strategy W4, p29: Wivenhoe Storage Level predicted to exceed 74.00 m AHD Strategy W4A, p29: Lake Level between 74.0 and 75.5 m AHD Strategy W4B, p30: Lake Level greater than 75.5 m AHD
Response	The same comment as in Item 4 applies.	

No. in Annexure 19	Suggestion by DERM (Annexure 18 and 19 to Statement of Ronald Guppy)	Final version of Seventh Revision of Wivenhoe Flood Mitigation Manual (Exhibit 21)
5	I think there needs to be another criterion under Procedures W2 and W3 of not less than 1900 m^3/s given for the target maximum flows. Otherwise if for example the natural peak flow at Lowood excluding Wivenhoe releases was only 1000 m^3/s that becomes the target maximum flow there.	No minimum flow rate under Strategy W2 or Strategy W3: p27, 28.
Response	I think this comment has been misconstrued as suggesting that there should be a minimum discharge required under Strategies W2 and W3. It would have been an error to limit discharges under Strategies W2 and W3 because there needs to be flexibility in order to limit downstream damage. E.g. If there is 3000 m^3/sec coming from the Lockyer and the Bremer, it would be necessary to limit discharges from Wivenhoe to less than 1000 m^3/sec in order to reduce damages in Brisbane. If the minimum flow was nominated as 1900 m^3/sec (say) then the flow through Brisbane would be of the order of 4900 m^3/sec which would cause significant damage. It <u>needs</u> to be a decision of the Flood Operations Engineers who will select the actual discharge depending on what situation is developing. It will be different for each flood event.. The decision to not specify a minimum flow rate was therefore supported.	
5	It may also be useful to specify that the peak outflow should not exceed the peak inflow (i.e the total inflow into Wivenhoe including Somerset outflows).	Not specified in Strategy W2 or Strategy W3: p27, 28. However it is explicitly stated on Page 22.
Response	It is a widely held principal that outflows from a dam should not exceed inflows so that damages are not aggravated by dam operations. It is a principal nearly all dam operators would follow and Seqwater took the view that it did not have to be said. It will be reconsidered for inclusion in Revision 8 of the manual.	

No. in Annexure 19	Suggestion by DERM (Annexure 18 and 19 to Statement of Ronald Guppy)	Final version of Seventh Revision of Wivenhoe Flood Mitigation Manual (Exhibit 21)
7	The inclusion of the large Table in section 8.6 is not necessarily helpful and likely to be confusing. It is only really applicable for the loss of communications strategies. I am happy with the target of getting all the gates open before the first fuse plug triggers but while there are communications with the Flood Operations Centre, the gate opening rates are set by the Flood Operations Engineer. Under normal circumstances, gate operation is not dependent on storage level until EL 74 is exceeded. It is solely based on a discharge. The Table suggests otherwise. Even after EL 74 is reached the strategy is to open gates at minimum intervals until the water level begins to fall. That also is inconsistent with the Table. All that is needed in Section 8.6 is the order of gate operation.	Large table still present in section 8.6, p33, 34, 35.
Response	I believe the Table in the draft version that Mr Guppy was commenting on was different to the one incorporated in the approved version of Revision 7. The version commented on by Mr Guppy nominated headwaters for different gate openings in the left hand column and resultant discharges in column 7. This was obviously an error and Mr Guppy's comment was incorporated by removing these columns from the approved version. The Table is all about the sequencing of gate openings to ensure that the flow in the flip buck is symmetrical and the potential to damage the side walls is limited.	
Two dot points from bottom of document	In the title of the figure on page 40 'Strategy S2' should be removed - it applies to S3 as well.	Title of figure on p40: Strategy S2 – Wivenhoe / Somerset Operating Target Line
Response	Agreed it does apply equally to S3. However, the wording of Strategy S3 does specifically indicate that the requirements for S3 are 'In addition to the operating protocols used in Strategy S2'. It will be reconsidered in Revision 8.	

CTS No. 19928/10

Department of Environment and Resource Management
MINISTERIAL BRIEFING NOTE

Advisor ..... OK
Dated 17/11/10
Approved Not Approved Noted
Further information required
Minister [redacted]
Dated 22/11/10

TO: **Minister for Natural Resources, Mines and Energy and Minister for Trade**

SUBJECT: Dam Emergency Action Plans

RECEIVED
MINISTERIAL OFFICE
15 NOV 2010

☑ MINISTER
☐ POL ADV
☐ MEDIA ADV
☐ PARL SEC
☐ ADMIN
☐ .....

REQUESTED BY
- The Minister's Office requested this brief as soon as possible.

TIMEFRAME
- Noting of this brief is required by 10 November 2010 to meet the Minister's request.

RECOMMENDATION
It is recommended that the Minister **note** that in accordance with his request of 25 October 2010, owners of referable water supply dams have been asked to provide written confirmation that the Emergency Action Plan (EAP) for their dam is current.

BACKGROUND
- This briefing note should be read in conjunction with CTS No. 19311/10 – Managing Flood Impacts Downstream of Large Water Supply Dams approved by the Minister on 25 October 2010 (copy attached).
- A significant number of large water supply dams in Queensland are at, or near, their full capacity. Many catchments are in a 'wetted' condition likely to cause runoff quite readily resulting in water releases from these dams during the coming wet season which runs to about April 2011.
- DERM requires owners of referable water supply dams to have current EAPs.
- The owners of referable water supply dams are required by virtue of the EAPs for their dams to notify local governments responsible for communities downstream of such dams about the volumes of floodwater passing through their dams.

CURRENT ISSUES
- Currently there are 105 referable dams in Queensland.
- By letter dated 25 October 2010, the Minister requested the dam safety regulator, DERM, to seek an assurance from the owners of referable water supply dams that EAPs for their dams are current.
- Wivenhoe Dam, Somerset Dam and North Pine Dam are to be excluded because they are subject to special flood management arrangements.

Rec'd - ODG
10 NOV 2010

RESOURCE/IMPLEMENTATION IMPLICATIONS
- There are no resource issues for DERM.

PROPOSED ACTION
- In response to the Minister's request, letters have been sent requiring written confirmation that the EAPs for a total of ~~99~~ 98 referable water supply dams are current. This assurance is to be provided to DERM by 30 November 2010.
- The dam owner groups comprise: SunWater – 23 dams; Queensland Bulk Water Supply Authority – 24 dams; DERM owned dams – 5; other owners dams – 18.

Author	Cleared by	Cleared by	Recommended:
Name: John McKenna Position: Manager, DS(FD) Tel No: [redacted] Date: 5 November 2010	Name: Peter Allen Position: Director, Dam Safety Tel No: [redacted] Name: Bob Reilly Position: GM OWSR Tel No: [redacted] 7/11/10	Name: Chris Robson Position: A/DDG Water & Ecosystem Qu[redacted] Tel No: [redacted] Date: 9/11/10	Name: John Bradley Director-General, DERM Tel No: [redacted] Date: [redacted]

File Ref:

- No letter is to be sent to the following referable dam owners because:
  - for nine dams, the population at risk is confined to property owned by the dam owner and there is no downstream community that needs to be notified by the relevant local government or emergency management agency in an emergency situation; or
  - the owners of a further 16 dams have informed DERM within the last four months that they have produced/updated or reviewed their EAPs.
- There are 10 referable dams that have no EAPs because:
  - safety condition DS 13 requires an EAP to be prepared by 30 November 2010 for Crystal Waters Estate (Upper and Lower) Dams;
  - construction of Gillens Dam owned by Kupapipi Pastroal Pty Ltd has not yet commenced;
  - Town Dam Lakeland owned by Cook Shire Council is to be modified so that it no longer has a population at risk and therefore will not require an EAP;
  - in the case of the seven referable dams listed in Attachment 1, compliance action has been initiated as the dam owners have failed to produce their EAP by the date required.
- The dam safety regulator, DERM, will monitor compliance with the requirement to supply this information during the first week of December and will implement appropriate follow-up action with any non-compliant dam owner, as necessary.
- A progress report will be provided to the Minister by 15 December 2010.

OTHER INFORMATION

- *Consultation:* N/A
- *Legislation: N/A*
- *Key Communication Messages*: N/A

MINISTER'S COMMENTS

ATTACHMENTS

- Attachment 1 - CTS No. 19311/10

Author	Cleared by	Cleared by	Recommended:
Name: John McKenna Position: Manager, DS(ED) Tel No [redacted] Date: 5 November 2010	Name: Peter Allen Position: Director, Dam Safety [redacted] Name: Bob Reilly Position: GM OWSR Tel No: [redacted]	Name: Chris Robson Position: A/DDG Water & Ecosystem Outcomes Tel No [redacted] Date:	Name: John Bradley Director-General, DERM Tel No [redacted] Date:

File Ref:

Attachment 1

Dam Name	Local Government Area	Dam Owner	Population at Risk
Environmental Dam	Isaac Regional Council	Blair Athol Coal Pty Ltd	3
Forest Lake Dam	Brisbane City Council	Brisbane City Council	218
Gordonbrook Dam	South Burnett Regional Council	South Burnett Regional Council	10
Lake Mitchell Dam	Tablelands Regional Council	Southedge Daintree Pastoral Co Pty Ltd	10
Moody Creek Detention Basin Dam	Cairns Regional council	Cairns Regional Council	73
Springfield Lakes – High Level Dam	Ipswich City Council	Delfin Lend Lease Ltd	70
Springfield Lakes – Low Level Dam	Ipswich City Council	Delfin Lend Lease Ltd	70

File/RefDAM/130/000(096)

2 November 2010

Mr William Steen
Department of Environment and Resource Management
PO Box 1762
ROCKHAMPTON, QLD 4701

Dear William

Re: Notification of EAPs review and update

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams

Ibis Dam
Copperfield River Gorge Dam
Corella Dam
Crooks Dam
Wyndham Dam

can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone [redacted]
Facsimile

Website www.derm.qld.gov.au

ABN 46 640 294 485

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

File/Ref CBD/024067

Chief Executive Officer
Toowoomba Regional Council
PO Box 302
TOOWOOMBA, QLD, 4350

Attention Laurie Ashe, Manager Water Infrastructure Assets

Dear Laurie

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam(s)
Cooby Creek Dam
Cressbrook Creek Dam
Perseverance Creek Dam
can you please provide confirmation by 30 November 2010 that the EAP(s) has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me or [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone [redacted]
Facsimile

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024079

Chief Executive Officer
Townsville City Council
PO Box 1268
TOWNSVILLE, QLD, 4810

Attention Rob Hunt

Dear Rob

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam(s)
Ross River Dam
Paluma Dam
can you please provide confirmation by 30 November 2010 that the EAP(s) has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me or [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone + [redacted]
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024217

Chief Executive Officer
Ipswich City Council
PO Box 191
IPSWICH, QLD, 4305

Attention Quentin Underwood

Dear Quentin

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams
Marburg Detention Basin
Rosewood Detention Basin
can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me o[redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone +[redacted]
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024117

Chief Executive Officer
Wide Bay Water Corporation
PO Box 5499
HERVEY BAY, QLD, 4655

Attention Denis Heron

Dear Denis

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams
Eli Creek Effluent Re-use Dam
can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me or [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

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ABN 46 640 294 485

File/Ref CBD/024117

Chief Executive Officer
Cairns Regional Council
PO Box 359
CAIRNS, QLD, 4870

Attention Simon Page

Dear Simon

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Copperlode Falls Dam
can you please provide confirmation by 30 November 2010 that the EAP has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

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Facsimile

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024042

Chief Executive Officer
Gold Coast City Council
PO Box 5042
GOLD COAST MIAL CENTRE, QLD, 5042

Attention Edwin Salazar

Dear Edwin

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams
Tallebudgera Creek Dam
Biggera Creek Flood Detention Basin
Loders Creek Flood Detention Basin
can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone +[redacted]
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024159

Chief Executive Officer
Tablelands Regional Council
PO Box 154
MAREEBA, QLD, 4880

Attention Bill Cuthbertson, Manager – Water and Wastewater

Dear Bill

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Wild River Dam
can you please provide confirmation by 30 November 2010 that the EAP has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

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ABN 46 640 294 485

File/Ref CBD/024091

Chief Executive Officer
Isaac Regional Council
PO Box 229
CLERMONT, QLD, 4721

Attention Andrew McGregor

Dear Andrew

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Theresa Creek Dam
can you please provide confirmation by 30 November 2010 that the EAP has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

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Telephone +[redacted]
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024060

Chief Executive Officer
Southern Downs Regional Council
PO Box 26
WARWICK, QLD, 4370

Attention Jim Llewellyn

Dear Jim

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Connolly Dam
can you please provide confirmation by 30 November 2010 that the EAP has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone + [redacted]
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref DAM/130/000(036)

2 November 2010

Mr Mal Halwala
SunWater Limited
PO Box 15536, City East
BRISBANE, QLD 4002

Dear Mal

Re: Notification of EAPs review and update

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams
Leslie Dam
Bjelke-Petersen Dam
Boondooma Dam
Burdekin Falls Dam
Callide Dam
Cania Dam
Claude Wharton Weir
Coolmunda Dam
Eungella Dam
EJ Beardmore Dam
Fairbairn Dam
Fred Haigh Dam
Julius Dam
Kinchant Dam
Peter Faust Dam
Tinaroo Falls Dam

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone [redacted]
Facsimile

Website www.derm.qld.gov.au

ABN 46 640 294 485

Wuruma Dam
Kroombit Dam
Teemburra Dam
Paradise Dam
Woongarra Balancing Storage
Moura Offstream Storage
Isis Balancing Storage
can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

File/Ref DAM/130/000(044)

2 November 2010

Mr Peter Borrows
Queensland Bulk Water Supply Authority
PO Box 16146, City East
BRISBANE, QLD 4002

Dear Peter

Re: Notification of EAPs review and update

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dams

Lake MacDonald Dam

Atkinson Dam

Baroon Pocket Dam

Bill Gunn Dam

Borumba Dam

Cedar Pocket Dam

Clarendon Dam

Cooloolabin Dam

Enoggera Dam

Ewen Maddock Dam

Little Nerang Dam

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
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Telephone +
Facsimile +

Website www.derm.qld.gov.au

ABN 46 640 294 485

Maroon Dam

Moogerah Dam

Sideling Creek Dam

Gold Creek Dam

Hinze Dam

Lake Manchester Dam

Leslie Harrison Dam

Poona Dam

Wappa Dam

Bromelton Off-Stream Storage

Can you please provide confirmation by 30 November 2010 that the EAPs have been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

File/RefCBD/024176

Site Manager
Kareeya Power Station
Stanwell Corporation
c/- GPO Box 773
BRISBANE, QLD, 4001

Kevin Ramm

Dear Kevin

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Koombooloomba Dam
can you please provide confirmation that the EAP has been updated as necessary.

While the safety conditions require the update advice by the end January I would appreciate if you provide the confirmation by 30 November 2010. There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
Director (Dam Safety)
Office of the Water Supply Regulator

Street Address
Floor 3 Mineral House, 41 George Street, Brisbane Qld 4000

Postal Address
GPO Box 2454, Brisbane Qld 4001

Telephone [redacted]
Facsimile [redacted]

Website www.derm.qld.gov.au

ABN 46 640 294 485

File/Ref CBD/024171

Wivenhoe Power Station
Tarong Energy Corporation
PO Box 38
FERNVALE, QLD, 4306

Attention Sorin Lupelescu

Dear Sorin

It is important that emergency response agencies responsible for communities downstream of dams are aware of significant flood events that might pass through the dams or result from events/incidents at the dams so they can mitigate any adverse consequences.

The owners of referable dams are required by the safety conditions applying at their dams to prepare an Emergency Action Plan (EAP) for their dam that will provide such information to those agencies. To be effective this EAP needs to be kept up to date. DS 13 in most instances is the condition relating to EAPs and it contains a requirement to annually advise of the status of the EAP, in particular that it has been reviewed and updated as necessary.

Now as the wet season approaches I am writing to the owners of large dams seeking confirmation that their EAPs have been reviewed and updated as required by the safety conditions to contain current information so that they can be smoothly implemented if necessary.

As the owner of the following dam
Splityard Creek Dam
can you please provide confirmation by 30 November 2010 that the EAP has been updated as necessary in line with the safety conditions.

There are various other notification requirements within the safety conditions. If you have not already done so it would be an opportune time to also provide those required advices.

Please contact me on [redacted] if you have any queries.

Yours sincerely

[redacted]

Peter Allen
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Office of the Water Supply Regulator

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CTS No 22106/10

Advisor	OK
Dated	/ /
Approved Not Approved Noted	
Further Information required	
Minister.....	
Dated	/ /

Department of Environment and Resource Management
MINISTERIAL BRIEFING NOTE

TO: **Minister for Natural Resources, Mines and Energy and Minister for Trade**

SUBJECT: **Dam Emergency Action Plans / Somerset/Wivenhoe Dam Floodwater Release Protocol**

REQUESTED BY

- The Minister's Office requested an update on previous briefing note CTS 19928/10 (copy attached) along with an update on the status of Somerset/Wivenhoe Dam floodwater release protocol

TIMEFRAME

- The MECS due date is 20 December 2010

RECOMMENDATION

It is recommended that the Minister:

- **note** the status of the Emergency Action Plans for referable dams in Queensland
- **note** the status of Somerset/Wivenhoe Dam floodwater release protocol

Status of Emergency Action Plans:

BACKGROUND

- This briefing note has been prepared as a follow up to CTS No. 19982/10 – Dam Emergency Action Plans, noted by the Minister on 23 November 2010 (copy attached).
- In accordance with the Minister's request, DERM wrote to referable dam owners seeking confirmation that the Emergency Action Plans for their dams were up to date. This was done so that the potentially impacted local governments responsible for community safety downstream of the dams would be reliably informed of flood situations at the referable dams.
- Currently there are 105 referable dams in Queensland.
- The owners of 80 referable dams were contacted in early November. No letter was sent to the owners of the other 25 dams because:
  - for nine dams, the population at risk is confined to property owned by the dam owner and there is no downstream community that needs to be notified by the relevant local government or emergency management agency in an emergency situation; or
  - the owners of a further 16 dams had informed DERM within the previous four months that they had prepared/updated their EAPs.

CURRENT ISSUES

- Responses have been obtained from the owners of the 80 dams.
- For 65 dams, revised EAPs (or advice that no revision is required) have been received.
- For 1 dam, the due date for provision of an EAP has not yet passed (Environmental Dam at Blair Athol Mine)
- For 1 dam (Town Dam at Lakeland Downs) modification to the works, to make it non-referable, has been completed.
- For the remaining 13 dams the owners have advised of progress in producing or updating

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	Name: Bob Reilly ✓ 17/12/10 Position: GM OWSR Tel No: [redacted]	Name: Dean Ellwood [redacted] Position: Assistant DG, ENRR Tel No: 3330 5628	Name: John Bradley [redacted] Position: DG, DERM Tel No: [redacted]

File Ref:

the EAPs. They have all advised dates by which these actions will be completed. Most of the thirteen EAPs should be substantially complete by 31 December 2010 with the others expected to be finalised in January. These dams are listed in Attachment 1.

PROPOSED ACTIONS

- DERM will write to the owners of the remaining 13 dams to confirm the dam owner's nominated date for supply of the EAP. It will state that, unless the EAP is received by the nominated date, compliance action will be initiated, given the issue's importance.
- Initially, compliance action would involve issuing a Show Cause Notice under the *Sustainable Planning Act 2009*, which gives the dam owner 20 business days to respond.
- Issuing the notice now would mean a response would not be required prior to 24 January 2011, by which date, all owners have advised their EAPs will be in place. Therefore, it is not proposed to initiate compliance action now.

Status of Somerset/Wivenhoe Dam floodwater release protocol:

BACKGROUND

- A copy of the draft Protocol was emailed to Brisbane, Ipswich and Somerset Councils on 21 October 2010
- Somerset dam has been included in the draft Protocol because Wivenhoe and Somerset dams are operated on an integrated basis for flood management purposes and Somerset Council would be specifically interested in the operation of Somerset dam.
- A meeting was held on 28 October 2010 between senior staff from Queensland Government agencies and officers from Brisbane and Ipswich City Councils to discuss the draft protocol.
- A positive response has been received from Brisbane City Council
- Somerset and Ipswich Councils have some reservations about wording that they consider may expose council to liability. They continue to consider their position and have yet to reply formally on the issue.
- Department of Community Safety (Emergency Management Queensland), is the lead agency for preparing/finalising the protocol.

CURRENT ISSUES

- The draft protocol was trialled on Sunday 12 December 2010, when advice was received that Wivenhoe would commence releasing water from Monday 13 December.
- The SEQ Water Grid Manager (who leads Queensland Government communications around floodwater releases for these dams) has advised that the draft protocol worked well from a communication and operations perspective.

RESOURCE/IMPLEMENTATION IMPLICATIONS

- There are no resource issues for DERM.

OTHER INFORMATION

- *Consultation:* N/A
- *Legislation:* N/A
- *Key Communication Messages: N/A*

MINISTER'S COMMENTS

Author	Cleared by	Cleared by	Cleared by
Name: Ron Guppy Position: Project Manager, Dam Safety) Tel No [redacted] Date: 17 December 2010	Name: Peter Allen Position: Director, Dam Safety Tel No [redacted]	Name: Debbie Best Position: DDG WEO Tel No [redacted]	Name: Terry Wall Position: Assoc DG, OER
	Name: Bob Reilly Position: GM OWSR Tel No: [redacted]	Name: Dean Ellwood Position: Assistant DG, ENRR Tel No [redacted]	Name: John Bradley Position: DG, DERM

ATTACHMENT 1

	Dam Name	PAR (1)	Dam Owner	Progress with EAP
1 2 3	Tallebudgera Creek Dam Biggera Creek Detention Basin (2) Loder's Creek Detention Basin	93 2780 255	Gold Coast City Council	EAPs exist for all dams but should be updated. Major changes in council staff responsibilities has resulted in staff inexperienced with dams managing the referable dams. DERM is working closely with newly responsible officers to acquaint them with their responsibilities. This included participation in a trial EAP exercise. The results from the exercises are to be incorporated into the existing EAPs as part of the update now occurring. The owner has advised updated EAPs will be provided by 21 January 2011
4 5	Marburg Detention Basin Rosewod Detention Basin	173 143	Ipswich City Council	Consultant engaged to address various dam safety matters including update of EAP. Update of EAP to receive priority and should be received before the end of January 2011
6	Gordonbrook Dam	10	South Burnett Regional Council	Council advised consultant has been engaged to complete draft EAP by end of December 2010
7 8	Springfield Lakes, Upper Dam Springfield Lakes, Lower Dam	70 82	Delfin Lend Lease (dams located in Ipswich City local government area)	DERM provided comments on a draft EAP provided by owner's consultants. Awaiting formal submission from owner and expected to be received by 20 January 2011
9	Lake Mitchell Dam	9	Southedge Daintree Pastoral Co (dam located in Tablelands local government area)	Owners consultants advised EAP would be provided by 17/12/2010
10	Moody Creek Detention Basin	73	Cairns City Council	Preparation of EAP has commenced but unlikely to be submitted until the end of January 2011
11	Wild River Dam	35	Tablelands Regional Council	Dams manager advised up to date EAP would be provided by 24 December 2010
12	Theresa Creek Dam	12	Isaac Regional Council	Dams manager is updating an existing EAP. Formal response has to go through council processes and is expected by 21/1/11.
13	Crystal Waters Dams	6	Redlands City Council	EAP became due on 30th November 2010. Expected completion before end of January 2011

(1) Population at Risk (PAR) if the dam fails
(2) Detention Basin temporarily store flood waters during major rainfall events. This reduces downstream flooding.

PHA – 29 Current Status of Emergency Action Plans

Dam ID	Dam name	Owner Name	EAP Update requested	EAP Received
22	Middle Creek Dam	Mackay Regional Council	email on 13/10/2010 advising EAP may need to be updated following removal of low wall	7/03/2011
36	Leslie Dam	SunWater Limited	2/11/2010	6/12/2010
43	Tallebudgera Creek Dam	Gold Coast City Council	1/11/2010 Compliance letter sent 10/11/2010	28/05/2008
44	Lake MacDonald Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
96	Ibis Dam	The State of Queensland - Department of Environment & Resource Management	2/11/2010	14/12/2010
174	Leichhardt River Dam	Mount Isa Mines Limited	already submitted	27/05/2010 20/05/2011
210	Atkinson Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
211	Awoonga High Dam	Gladstone Area Water Board		21/02/2011
214	Baroon Pocket Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
217	Bill Gunn Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
219	Bjelke-Petersen Dam	SunWater Limited	2/11/2010	17/12/2010
222	Environmental Dam	Blair Athol Coal Pty Ltd	Compliance action	
227	Boondooma Dam	SunWater Limited	2/11/2010	17/12/2010
228	Borumba Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
235	Bundoora Dam	Anglo Coal (Capcoal Management) P/L	Single PAR	1/06/2011
236	Burdekin Falls Dam	SunWater Limited	2/11/2010	17/12/2010
239	Callide Dam	SunWater Limited	2/11/2010	20/12/2010
242	Cania Dam	SunWater Limited	2/11/2010	20/12/2010
244	Cedar Pocket Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
249	Clarendon Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
252	Connolly Dam	Southern Downs Regional Council	1/11/2010	1/12/2010
253	Cooby Creek Dam	Toowoomba Regional Council	1/11/2010	26/11/2010
254	Coolmunda Dam	SunWater Limited	2/11/2010	17/12/2010
255	Cooloolabin Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
256	Copperfield River Gorge Dam	The State of Queensland - Department of Environment & Resource Management	2/11/2010	10/11/2010

Dam ID	Dam name	Owner Name	EAP Update requested	EAP Received
257	Copperlode Falls Dam	Cairns Regional Council	1/11/2010	Draft by email 22/08/2011
258	Corella Dam	The State of Queensland - Department of Environment & Resource Management	2/11/2010	8/11/2010
259	Cressbrook Creek Dam	Toowoomba Regional Council	1/11/2010	26/11/2010
264	Enoggera Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
266	Eungella Dam	SunWater Limited	2/11/2010	17/12/2010
267	Ewen Maddock Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
268	EJ Beardmore Dam	SunWater Limited	2/11/2010	17/12/2010
269	Fairbairn Dam	SunWater Limited	2/11/2010	6/12/2011
272	Fred Haigh Dam	SunWater Limited	2/11/2010	17/12/2010
278	Glenlyon Dam	Dumaresq-Barwon Border Rivers Commission	August dated letter from Sunwater advising EAP to be reviewed by 22-23 September 2010	13/01/2009
297	Julius Dam	SunWater Limited	2/11/2010	17/12/2010
301	Kinchant Dam	SunWater Limited	2/11/2010	17/12/2010
309	Lenthalls Dam	Wide Bay Water Corporation	Incorrect letter saved in Keeper - unable to locate file to confirm letter was sent on 1/11/2010	15/12/2010
312	Little Nerang Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
318	Maroon Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
323	Moogerah Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
334	North Pine Dam	Queensland Bulk Water Supply Authority	FMM in place	10/11/2010
337	Paluma Dam	Townsville City Council	1/11/2010	15/12/2010
339	Perseverance Creek Dam	Toowoomba Regional Council	1/11/2010	26/11/2010
340	Peter Faust Dam	SunWater Limited	2/11/2010	17/12/2010
344	Ross River Dam	Townsville City Council	1/11/2010	15/12/2010
349	Sideling Creek Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
354	Somerset Dam	Queensland Bulk Water Supply Authority	FMM in place	10/11/2010
356	Storm King Dam	Southern Downs Regional Council	DERM commented on draft EAP on 22/10/2010	1/12/2010
366	Theresa Creek Dam	Isaac Regional Council	1/11/2010	20/01/2011
370	Tinaroo Falls Dam	SunWater Limited	2/11/2010	2/11/2010
377	Wivenhoe Dam	Queensland Bulk Water Supply Authority	FMM in place	10/11/2010
378	Wuruma Dam	SunWater Limited	2/11/2010	17/12/2010

Dam ID	Dam name	Owner Name	EAP Update requested	EAP Received
384	Chinaman Creek Dam	Cloncurry Shire Council	letter from owner on 13/10/2010 advising EAP delay due to other documentation - email requesting update by 30/11/2010 sent on 12/11/2010	28/01/2011
389	Dalrymple Bay Coal Terminal - Quarry Dam	Prime Infrastructure (DBCT) Management Pty Ltd	Single PAR - Dam Safety audit requested update of Crisis & Emergency Mgt Manual to comply with EAP on 8/8/2011	
401	Crooks Dam	The State of Queensland - Department of Environment & Resource Management	2/11/2010	8/11/2010
406	Blackwater Coal Mine - Rockland Creek Dam	South Blackwater Coal Limited (BMA Blackwater Mine)		20/04/2011
416	Perry River Dam	LGL Services Australia Pty Ltd	No DS conditions applied until 2011	Not due yet
476	Gold Creek Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
520	McKinnon Creek Flood Detention Dam	Cairns Regional Council	2003 document received 21-9-2010 - email requesting update by 30/11/2010 sent on 11/11/2010	1/12/2003
521	Lake Mitchell Dam	Southedge Daintree Pastoral Company Pty Ltd	Compliance action	4/01/2011
527	Kroombit Dam	SunWater Limited	2/11/2010	20/12/2010
535	Biggera Creek Flood Detention Basin	Gold Coast City Council	1/11/2010	28/01/2011
634	Eli Creek Effluent Reuse Storage Dam	Wide Bay Water Corporation	1/11/2010	2/12/2010
651	Forest Lake Dam	Brisbane City Council	Compliance action	23/12/2011
654	Gap Creek Dam	Holiday Villages (Aust) Pty Ltd	Single PAR	
657	Gordonbrook Dam	South Burnett Regional Council	Compliance action	Draft 22/12/2010
701	Rifle Creek Dam	Mount Isa Mines Limited	already submitted	27/05/2010 20/05/2011
706	Hinze Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
713	Lake Manchester Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
715	Leslie Harrison Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
730	Poona Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010

Dam ID	Dam name	Owner Name	EAP Update requested	EAP Received
731	Wappa Dam	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
766	Newlands Coal Mine - Cerito Creek Dam	Xstrata Coal Queensland Pty Ltd	Single PAR	7/12/2009
850	Stanwell Power Station - Water Supply Dam	Stanwell Corporation Limited	already submitted	30/06/2010
874	Teemburra Dam	SunWater Limited	2/11/2010	17/12/2010
883	Wyndham Dam	The State of Queensland - Department of Environment & Resource Management	2/11/2010	8/11/2010
1007	Dashwood Property Dam	RP & JC Dashwood	Single PAR	
1198	Wild River Dam	Tablelands Regional Council	1/11/2010	17/12/2007
1350	Russell Property Irrigation Dam	CT, JM, CT & SK Russell	Single PAR	
1450	Splityard Creek Dam	Tarong Energy Corporation Limited	1/11/2010	9/12/2010
1487	Cubbie Station - Top Shed Dam	Cubbie Dirranbandi 1 Pty Ltd	Single PAR	29/04/2011
1491	Tarong Power Station - Cooling Water Dam	Tarong Energy Corporation Limited	Advice of review completed 25/10/2010	24/05/2011
1493	Meandu Creek Dam	Tarong Energy Corporation Limited	Advice of review completed 25/10/2010	24/05/2011
1510	Koombooloomba Dam	Stanwell Corporation Limited	1/11/2010	1/12/2011 Update 22/08/2011
1643	Swanbank Power Station - Cooling Water Dam	CS Energy Ltd	already submitted	03/08/2010 New 08/07/2011
1648	Loders Creek Flood Detention Basin	Gold Coast City Council	1/11/2010	28/01/2011
1755	Andrew Deguara Holdings Pty Ltd Dam	Andrew Deguara Holdings Pty Ltd	Single PAR	
1785	Town Dam - Lakeland	Gary W McClelland	being modified to have no population at risk	Updated FIA being considered
1822	South Walker Mine - Down Dip Dam	BHP Mitsui Coal Pty Ltd	Single PAR	10/01/2011
1826	Kelly's Offstream Storage	Rockhampton Regional Council	already submitted	30/09/2010
1839	Mount Morgan Water Supply - No. 7 Dam	Rockhampton Regional Council	already submitted	30/07/2010
1945	Rosewood Detention Basin	Ipswich City Council	1/11/2010	10/10/2007
1946	Moody Creek Detention Basin Dam	Cairns Regional Council	Compliance action - Compliance notice issued 18/3/2011	22/06/2011
1952	Suhr's Creek Dam	Charters Towers Regional Council	submitted August 2010	4/10/2010
1981	Marburg Detention Basin	Ipswich City Council	1/11/2010	10/10/2007
1997	Paradise Dam	SunWater Limited	2/11/2010	17/12/2010

Dam ID	Dam name	Owner Name	EAP Update requested	EAP Received
2002	Crystal Waters Upper and Lower Dams	Queensland Bulk Water Supply Authority	not requested - EAP not required until 30/11/2010	Draft 31/1/2011
2016	Springfield Lakes - High Level Lake	Delfin Lend Lease	Compliance action	8/04/2011
2031	Woongarra Balancing Storage	SunWater Limited	2/11/2010	17/12/2010
2033	Moura Offstream Storage	SunWater Limited	2/11/2010	17/12/2010
2233	Isis Balancing Storage	SunWater Limited	2/11/2010	17/12/2010
2259	Wyaralong Dam	Queensland Bulk Water Supply Authority	Construction version received April 2010	7/12/2010
2263	Bromelton Off-Stream Storage	Queensland Bulk Water Supply Authority	2/11/2010	10/11/2010
2277	Springfield Lakes - Low Level Lake	Delfin Lend Lease	Compliance action	8/04/2011
2278	Gillens Dam	Kunapipi Pastoral Pty Ltd	Not commenced	