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Waltham Pool Tank

BU 1044-004 EQ2

Detailed Engineering Evaluation

Qualitative Report

FINAL

Waltham Park, 30-40 Waltham Road, Christchurch

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Waltham Pool Tank
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Detailed Engineering Evaluation
Qualitative Report
FINAL

Waltham Park, 30-40 Waltham Road, Christchurch

Christchurch City Council

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Date
07/12/12

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Qualitative Report Summary

Waltham Pool Tank

BU 1044-004 EQ2

Detailed Engineering Evaluation

Qualitative Report - SUMMARY

FINAL

Waltham Park, 30-40 Waltham Road

Corner of Fifield Tce & Waltham Road, Christchurch

Background

This is a summary of the Qualitative report for the building structure, and is based in general on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and visual inspections on 24 January 2012.

Key Damage Observed

The pool tank structure is largely undamaged. A large crack was noted in the mortar between concrete blocks at the top of the wall, above one of the tank wall control joints. A few small cracks were noted in the concrete tank walls that appear to be related to shrinkage and not seismic damage.

Critical Structural Weaknesses

The site liquefaction potential presents a critical structural weakness that affects the pool tank.

Indicative Building Strength (from IEP and CSW assessment)

The IEP assessment procedure is not directly applicable to the pool tank. Instead, a simple quantitative analysis of the tank walls was undertaken to determine the pool tank's seismic capacity, using the structural details available in the original construction drawings. The building's original capacity has been assessed to be in the order of 50% NBS. The building's capacity excluding critical structural weaknesses is in the order of 71% NBS. Therefore the building is an Earthquake Risk but is not potentially Earthquake Prone.

Recommendations

It is recommended that:

- Use of the pool tank should not be restricted based on this assessment; however, the occupancy status of the surrounding buildings may affect the pool tank.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of the Waltham Pool grounds. This report covers the pool tank.

This report includes a simple quantitative assessment of the building structure, and is based in general on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. The recommended IEP assessment is not applicable to the pool tank, and therefore a simple quantitative assessment of the pool tank walls was performed instead.

A simple quantitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information (including existing drawings and calculations, if available), and indicative calculations of the seismic strength of the structure.

The purpose of the assessment is to determine the likely building performance and damage patterns, to identify any potential critical structural weaknesses or collapse hazards, and to make an initial assessment of the likely building strength in terms of percentage of new building standard (%NBS).

At the time of this report, no intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. The building description is based on the visual inspection carried out on site and the building drawings made available.

2. Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.0 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee carry out a full structural survey before the building is re-occupied.

We understand that CERA will require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

2.1 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 – Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to any alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67% NBS however where practical achieving 100% NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67% NBS.

2.1.1 Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

- In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
- In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
- There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
- There is a risk that that other property could collapse or otherwise cause injury or death; or
- A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property. A moderate earthquake is defined by the building regulations as one that would generate ground shaking 33% of the shaking used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.2 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

We anticipate that any building with a capacity of less than 33% NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% NBS of new building standard as recommended by the Policy.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

2.3 Building Code

The building code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
- Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

3. Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 3.1 below.

Figure 1 NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

Table 3.1 compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance in the next year.

Table 1 %NBS compared to relative risk of failure

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

4. Building Description

4.1 General

The Waltham Pool Tank was constructed in 1965. The site is located at Waltham Park, which is located at 30-40 Waltham Road. The surrounding area consists of the park, which includes a pool, other staff grounds, and open space. The park is bordered to the South by Heathcote River, and on all other sides by residential dwellings.

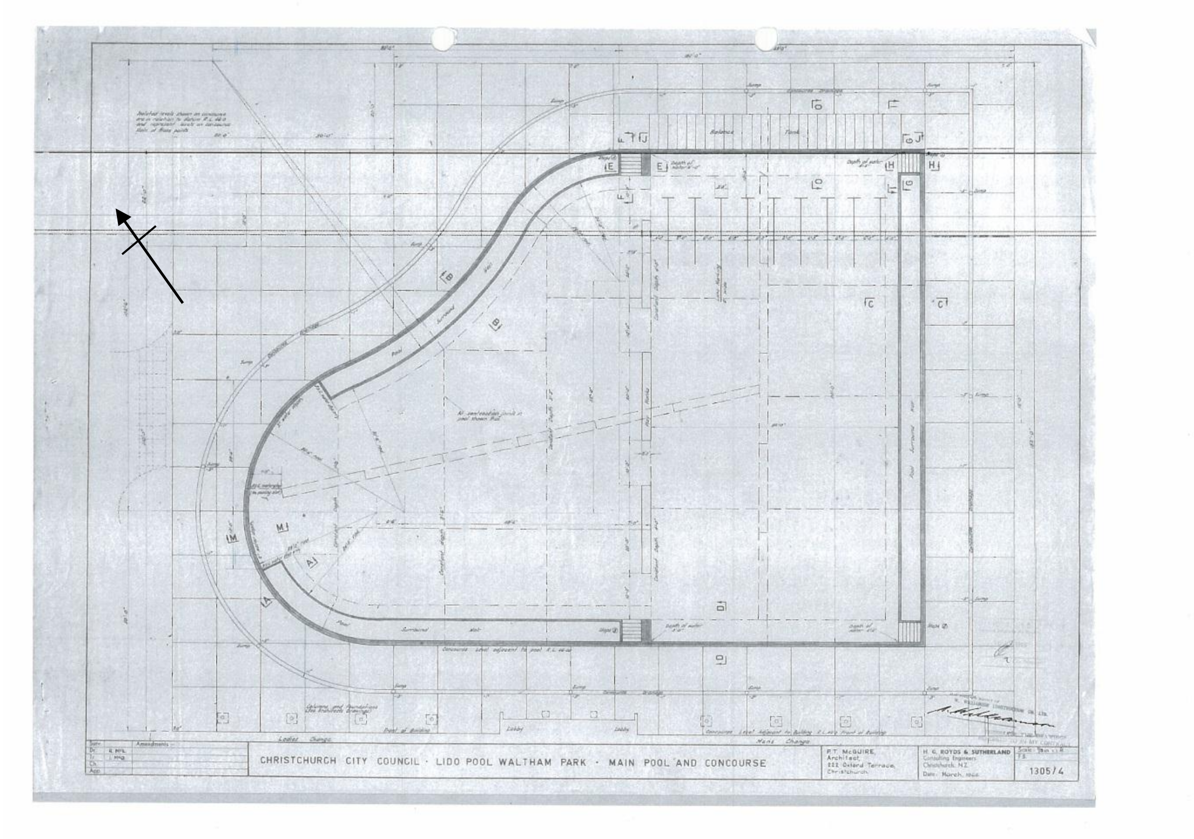
The site is situated on the outskirts of a recreational reserve, within the residential suburb of Waltham in southeast Christchurch. It is relatively flat at approximately 6m above mean sea level. It is approximately 80m northwest of the Heathcote River, 4.5km west of the estuary and 8.5km west of the coast (Pegasus Bay).

The dimensions of the pool tank are approximately 47m long by 34m wide, though it is irregularly shaped. In plan, the pool tank consists of an irregularly-shaped portion to the northwest and a rectangular portion with swimming lanes to the southeast. The pool floor slopes upward toward the narrow entry at the northwest end, and maintains a constant depth across the rectangular swimming lane area. The depth across the swimming lanes area is approximately 2m.

The pool tank is constructed of reinforced concrete walls and pool floor. The tank construction includes a bund of two rows of concrete block atop the reinforced concrete walls, which form a concourse level. A concrete slab footpath surrounds the pool and abuts the concourse level blockwork. The tank construction utilises contraction joints in the floor and walls. There is a concourse drain that surrounds the pool.

Figure 2 shows a plan view of the structure, and the available drawings of the structure are located in Appendix B. Photographs which further exhibit the structure are contained in Appendix A of this report.

Figure 2 Plan of Pool Tank



4.2 Gravity Load Resisting System

The gravity loads in this simple structure are resisted by the reinforced concrete walls and floor, and are transferred directly into the ground.

4.3 Lateral Load Resisting System

The reinforced concrete pool tank walls act as retaining walls supporting the soil. The tank walls also support the water pressure from the filled tank in conjunction with the passive soil pressure behind the walls. The connection between the tank walls and floor transfers bending moment from the laterally-loaded walls into the tank floor and into the ground.

5. Assessment

A visual inspection of the empty pool tank was undertaken on 24 January 2012. Most reinforced concrete elements of the tank were therefore available for inspection. No intrusive investigation was undertaken, therefore the reinforcement in the concrete walls was not able to be verified. However, the original construction drawings detail the concrete reinforcement, and are likely to be accurate.

The visual inspection consisted of observing the tank to determine the structural systems and likely behaviour of the tank during an earthquake. The site was assessed for damage, including observing the ground conditions, checking for damage in areas where damage would be expected for the structure type observed and noting general damage observed throughout the tank. The reticulation and drainage of the tank were not inspected in detail, but general observations were noted.

The %NBS score was determined using a simple quantitative assessment, similar in complexity to the IEP qualitative assessment. The critical structural weaknesses which were evident from our inspection were considered and are reflected in the overall %NBS score. Further detail about the assessment can be found in section 10 of this report.

6. Damage Assessment

6.1 Surrounding Buildings

The Waltham Pool grounds are located in Waltham Park, which is surrounded on most sides by residential dwellings and to the south by Heathcote River. During the inspection there was no apparent damage to the surrounding properties.

Some of the pool grounds displayed signs of damage. The nearby Staff Building showed some minor cracking to its unfilled block external walls. The Plant Room showed significant seismic damage and differential settlement. The steel water slide ladder had several welded connection failures. The barbeque shelter suffered considerable damage to its unreinforced concrete members.

6.2 General Observations

The pool tank appears to be in good condition structurally. There were some minor shrinkage cracks observed, and one crack along the mortar between the top of the reinforced concrete tank wall and the concrete block, which could be due to previous seismic action. There was no other apparent damage that should be attributed to seismic action.

6.3 Ground Damage

There was no liquefaction or settlement noted in or around the pool tank proper.

Differential ground settlement in the order of 100mm to 200mm was noted at the northeast corner of the nearby plant room.

A slight ground settlement at the northeast corner of the adjacent barbeque shelter structure was noted on-site. It is noted that this settlement was very minor.

7. Critical Structural Weakness

7.1 Liquefaction

No liquefaction was observed at the site. However, the site soil conditions do provide potential for liquefaction to occur, as noted in Section 8 of this report. This has been incorporated into the IEP process as a “significant” critical structural weakness and is reflected in the overall %NBS score.

8. Geotechnical Consideration

8.1 Site Description

The site is situated on the outskirts of a recreational reserve, within the residential suburb of Waltham in southeast Christchurch. It is relatively flat at approximately 6m above mean sea level. It is approximately 80m northwest of the Heathcote River, 4.5km west of the estuary and 8.5km west of the coast (Pegasus Bay).

8.2 Published Information on Ground Conditions

8.1.1 Published Geology

The geological map of the area[1] indicates that the site is underlain by Holocene alluvial soils of the Yaldhurst Member, sub-group of the Springston Formation, comprising alluvial sand and silt overbank deposits.

The map also indicates that the site is situated on an old stream bed (Jacksons Creek).

8.1.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that seven boreholes are located within a 120m radius of the site with four >2m depth. Of these boreholes, one was drilled at the pool site and it has an adequate lithographic log. The site geology described in this log indicates the area is predominantly layers of sand and clay to a depth of ~23mbgl. Varying amounts of gravel and silt are also indicated to be present.

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M36/1194	~34.1m	~1.3m bgl	0m N/A
M36/9705	~3.5m	N/A	~23m S
M36/9334	~3.71m	N/A	~30m SE
M36/9335	~2.44m	N/A	~61m S

It should be noted that the purpose of the boreholes the well logs are associated with, were sunk for groundwater extraction and not for geotechnical purposes. Therefore, the amount of material recovered and available for interpretation and recording will have been variable at best and may not be representative. The logs have been written by the well driller and not a geotechnical professional or to a standard. In addition strength data is not recorded.

[1] Brown, L. J. and Weeber J.H. 1992: Geology of the Christchurch Urban Area. Institute of Geological and Nuclear Sciences 1:25,000 Geological Map 1. Lower Hutt. Institute of Geological and Nuclear Sciences Limited.

8.1.3 EQC Geotechnical Investigations

The Earthquake Commission has undertaken geotechnical testing in the area of the site. Information pertaining to this investigation is included in Tonkin and Taylor Report[2]. Two investigation points were undertaken within close proximity of the site, the results of which are summarised below in Table 3.

Table 3 EQC Geotechnical Investigation ECan Bore Log Summary Table

Bore Name	Grid Reference	Log Summary	
CPT-WTM-21 (WT at 3.0m bgl)	2481726 mE 5739636 mN	0 – 5.0m	SILT and SAND mixtures
		5.0 – 7.8m	Silty CLAY
		7.8 – 18.5m	Fine to coarse SAND; dense to very dense
		18.5 – 26.8m	SILT, sandy SILT and clayey SILT
CPT-STM-11 (WT at 0.5m bgl)	2481703 mE 5739201 mN	0 – 15.0m	Layers of clayey SILT, sandy SILT and silty SAND
		15.0 – 20.0m	Dense SAND and silty SAND

8.1.4 Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has published areas showing the Green Zone Technical Category in relation to the risk of future liquefaction and how these areas are expected to perform in future earthquakes. The site is classified as not applicable (N/A). This means the site is non-residential property that has not been given a technical category.

8.1.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake shows no signs of liquefaction outside the building footprint or adjacent to the site.

[2] Tonkin and Taylor . September 2011: Christchurch Earthquake Recovery, Geotechnical Factual Report, Waltham & St Martins

Figure 3 Post February 2011 Earthquake Aerial Photography [3]

8.1.6 Summary of Ground Conditions

From information on ECan borehole logs and EQC CPT data subsoils at the site are anticipated to be layers of sands (with some gravel) and silts (with some sand and clay). These soils are consistent with the Springston formation (Yaldhurst member), being stratified alluvial deposits of predominantly sand and silt overbank deposits.

It is anticipated that the site is situated on an old stream bed. Associated with this is an increased potential for subsoil liquefaction beneath the site.

8.3 Seismicity

8.3.1 Nearby Faults

There are many faults in the Christchurch region, however only those considered most likely to have an adverse effect on the site are detailed below.

[3] Aerial Photography Supplied by Koordinates sourced from http://koordinates.com/layer/3185-christchurch-post-earthquake-aerial-photos-24-feb-2011/

Table 4 Summary of Known Active Faults [4,5]

Known Active Fault	Distance from Site (km)	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	130	8.3	~300 years
Greendale (2010) Fault	24	7.1	~15,000 years
Hope Fault	110	7.2~7.5	120~200 years
Kelly Fault	110	7.2	~150 years
Porters Pass Fault	60	7.0	~1100 years

Recent earthquakes since 22 February 2011 have identified the presence of a new active fault system / zone underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available. Average recurrence intervals are yet to be estimated.

8.3.2 Ground Shaking Hazard

This seismic activity has produced earthquakes of Magnitude-6.3 with peak ground accelerations (PGA) up to twice the acceleration due to gravity (2g) in some parts of the city. This has resulted in widespread liquefaction throughout Christchurch.

New Zealand Standard NZS 1170.5:2004 quantifies the Seismic Hazard factor for Christchurch as 0.30, being in a moderate to high earthquake zone. This value has been provisionally upgraded recently (from 0.22) to reflect the seismicity hazard observed in the earthquakes since 4 September 2010.

In addition, anticipation of Holocene alluvial soils of the Yaldhurst Member, sub-group of the Springston Formation, comprising alluvial gravel, sand, and silt of historic river flood channels, and a 475-year PGA (peak ground acceleration) of ~0.4 (Stirling et al, 2002). However, bedrock is anticipated to be in excess of 500m deep, and hence ground shaking is expected to be moderate to high.

8.4 Slope Failure and/or Rockfall Potential

The site is located within Waltham, a flat suburb in southeast Christchurch. Global slope instability risk is considered negligible. However, any localised retaining structures and/or embankments should be further investigated to determine the site-specific slope instability potential.

8.5 Liquefaction Potential

Due to the presence of alluvial sand and silt deposits, it is considered possible that liquefaction will occur where sands and silts are present. However, there is no evidence of liquefaction from the post-earthquake aerial photography. Given the site's proximity to the Heathcote River, it is considered likely that lateral spreading has occurred within or adjacent to the site. In future seismic events the site is

[4] Stirling, M.W.; McVerry, G.H.; and Berryman K.R. (2002) *A New Seismic Hazard Model for New Zealand*, Bulletin of the Seismological Society of America, Vol. 92 No. 5, June 2002, pp 1878-1903.

[5] GNS Active Faults Database, http://maps.gns.cri.nz/website/af/viewer.htm

considered at risk of lateral spreading. Therefore, until intrusive testing suitable for liquefaction analysis is carried out the overall liquefaction potential should be considered to be moderate.

8.6 Recommendations

If a more detailed assessment is required, intrusive investigation comprising one piezocone CPT test to 20m bgl should be undertaken. This will allow a numerical liquefaction analysis to be carried out.

8.7 Conclusions & Summary

This assessment is based on a review of the geology and existing ground investigation information, and observations from the Christchurch earthquakes since 4 September 2010.

The site appears to be situated on stratified alluvial deposits, predominantly comprising sand and silt. Associated with this the site also has a moderate potential for liquefaction including the potential for lateral spreading.

Should a more comprehensive liquefaction and/or ground condition assessment be required, it is recommended that an intrusive investigation comprising of one piezocone CPT be conducted. From this, a numerical liquefaction analysis may be undertaken.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

9. Survey

No level or verticality surveys have been undertaken for this building at this stage.

10. Initial Capacity Assessment

10.1 % NBS Assessment

The Waltham Pool Tank is not a building and does not qualify as the type of structure for which an Initial Evaluation Procedure assessment is applicable. Therefore, an alternate method of assessment was employed.

In lieu of a qualitative IEP assessment, a simple quantitative assessment was performed in calculations to assess the seismic strength of the tank. The tank walls and floor were considered as a retaining wall. The critical case for the tank occurs when the tank is empty, and the tank walls must retain the ground outside the tank. While the tank is filled, the retained water acts against the tank walls in the opposite direction, and the demands on the tank walls are much lesser. The critical case of an unfilled tank is less likely to occur during a seismic event than a filled tank; however, we have calculated the seismic strength of the tank while unfilled as a conservative assumption.

The tank has been assessed as achieving in the order of 50% New Building Standard (NBS) in terms of seismic strength. Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the tank is not considered potentially Earthquake Prone as it achieves above 33% NBS. The critical structural weaknesses in the structure lowered the IEP assessment score from 71% to 50% NBS. This score has not been adjusted when considering damage to the structure as all damage observed was relatively minor and considered unlikely to adversely affect the load carrying capacity of the structural systems below their current value.

10.2 Seismic Parameters

The seismic design parameters based on current design requirements from NZS1170:2002 and the NZBC clause B1 for this building are:

- Site soil class: D, NZS 1170.5:2004, Clause 3.1.3, Soft Soil
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011 (in accordance with recommendations from the Department of Building and Housing recommendations)
- Return period factor R_u = 1.0, NZS 1170.5:2004, Table 3.5, Importance Level 2 structure with a 50 year design life.

10.3 Expected Structural Ductility Factor

A structural ductility factor of 1.25 has been assumed based on the reinforced concrete structure type and date of construction.

10.4 Discussion of Results

The results obtained from the simple quantitative assessment are consistent with those expected for a pool tank of this age and construction type founded on Class D soils with a potential for liquefaction. This tank would have been designed to the loading standards at the time, namely Chapter 8 of NZS1900 (1965). The design loads used in this code will have been less than those required by the current loading standard and detailing requirements. When combined with the increase in the hazard factor for Christchurch to 0.3 it is reasonable to expect the building to be classified as a potential Earthquake Risk.

10.5 Occupancy

The tank poses no immediate risk to users and occupants of the tank or other nearby structures. Occupancy or use of the pool tank should not be restricted in accordance with Christchurch City Council policy. The tank should be inspected following any further seismic events for leaks or other signs of damage.

11. Initial Conclusions

The tank has been assessed to have a seismic capacity in the order of 50% NBS and is therefore a potential Earthquake Risk.

12. Recommendations

The Waltham Pool Tank structure achieves 50% NBS due to its design, critical structural weaknesses and date of construction. The building should be classified as a potential Earthquake Risk but not as potentially Earthquake Prone.

The damage to the Waltham Pool Tank during recent seismic activity in Christchurch is minor and has not affected the structural capacity of the retaining wall structure.

A water level survey should be carried out to determine if the water-retaining capacity of the tank has been affected. A pool specialist should be consulted to analyse the water-tightness of the tank.

Occupancy of the tank should not be restricted in accordance with Christchurch City Council policy.

13. Limitations

This report has been prepared subject to the following limitations:

- No inspection of the bracing in in the timber framed walls could be undertaken.
- No intrusive structural investigations have been undertaken.
- No intrusive geotechnical investigations have been undertaken.
- No level or verticality surveys have been undertaken.
- No material testing has been undertaken.
- No calculations, other than those included as part of the IEP in the CERA Building Evaluation Report, have been undertaken. No modelling of the building for structural analysis purposes has been performed.

13.0 Geotechnical Limitations

This report presents the results of a geotechnical appraisal prepared for the purpose of this commission, and for prepared solely for the use of Christchurch City Council and their advisors. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. GHD Limited (GHD) accepts no responsibility for other use of the data.

The advice tendered in this report is based on a visual geotechnical appraisal. No subsurface investigations have been conducted. An assessment of the topographical land features have been made based on this information. It is emphasised that Geotechnical conditions may vary substantially across the site from where observations have been made. Subsurface conditions, including groundwater levels can change in a limited distance or time. In evaluation of this report cognisance should be taken of the limitations of this type of investigation.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of the report, which have been modified in any way as outlined above.

Appendix A
Photographs

Photograph 1: Unfilled Pool Tank looking Northwest.

Photograph 2: Unfilled Pool Tank looking Southeast.

Photograph 3: Unfilled Pool Tank looking South. Note concrete block bund.

Photograph 4: Damage to tile at top of tank wall.

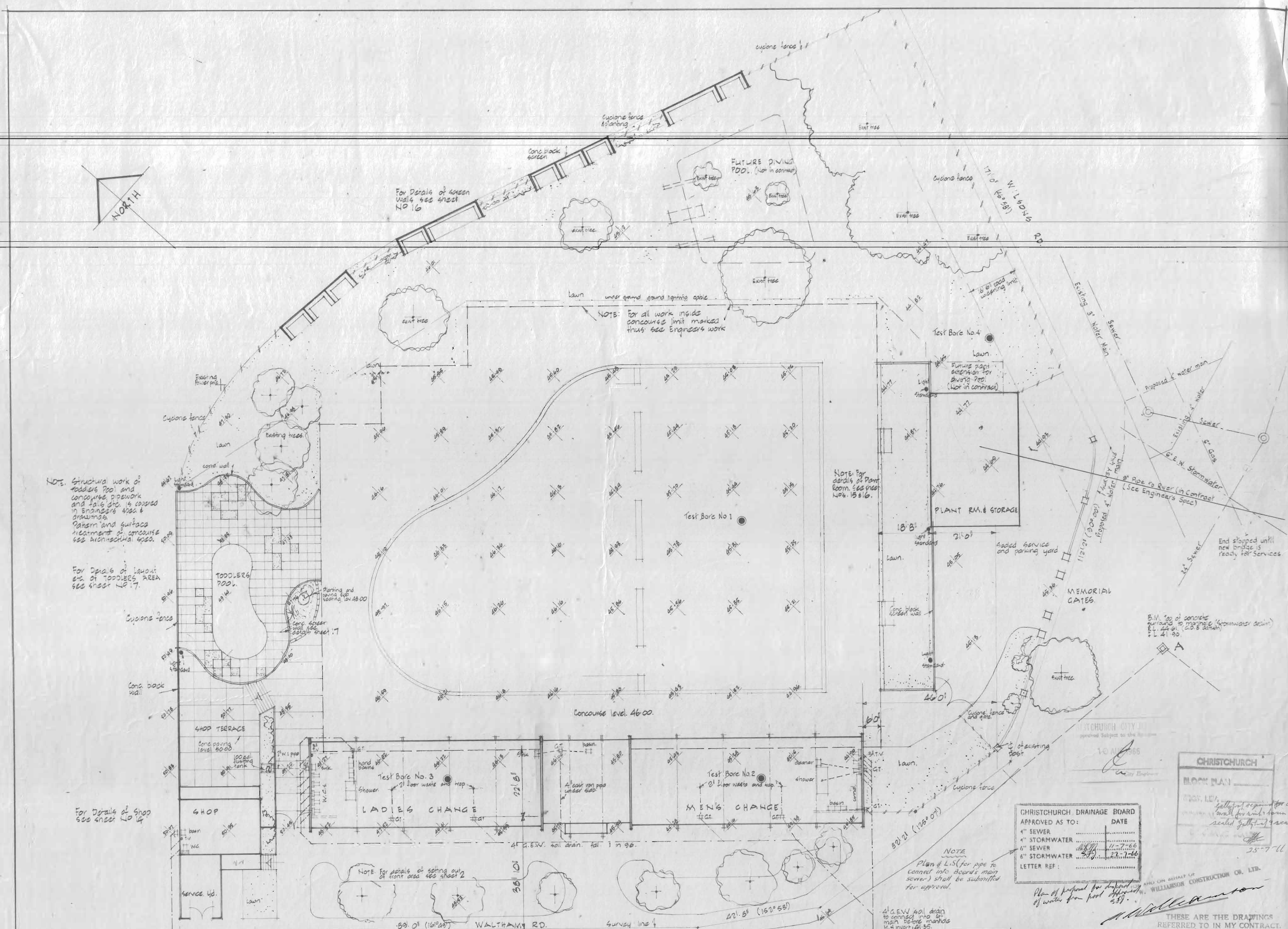
Photograph 5: Damage at top of tank wall.

Photograph 6: Damage to mortar surrounding concrete block bund at top of tank wall.

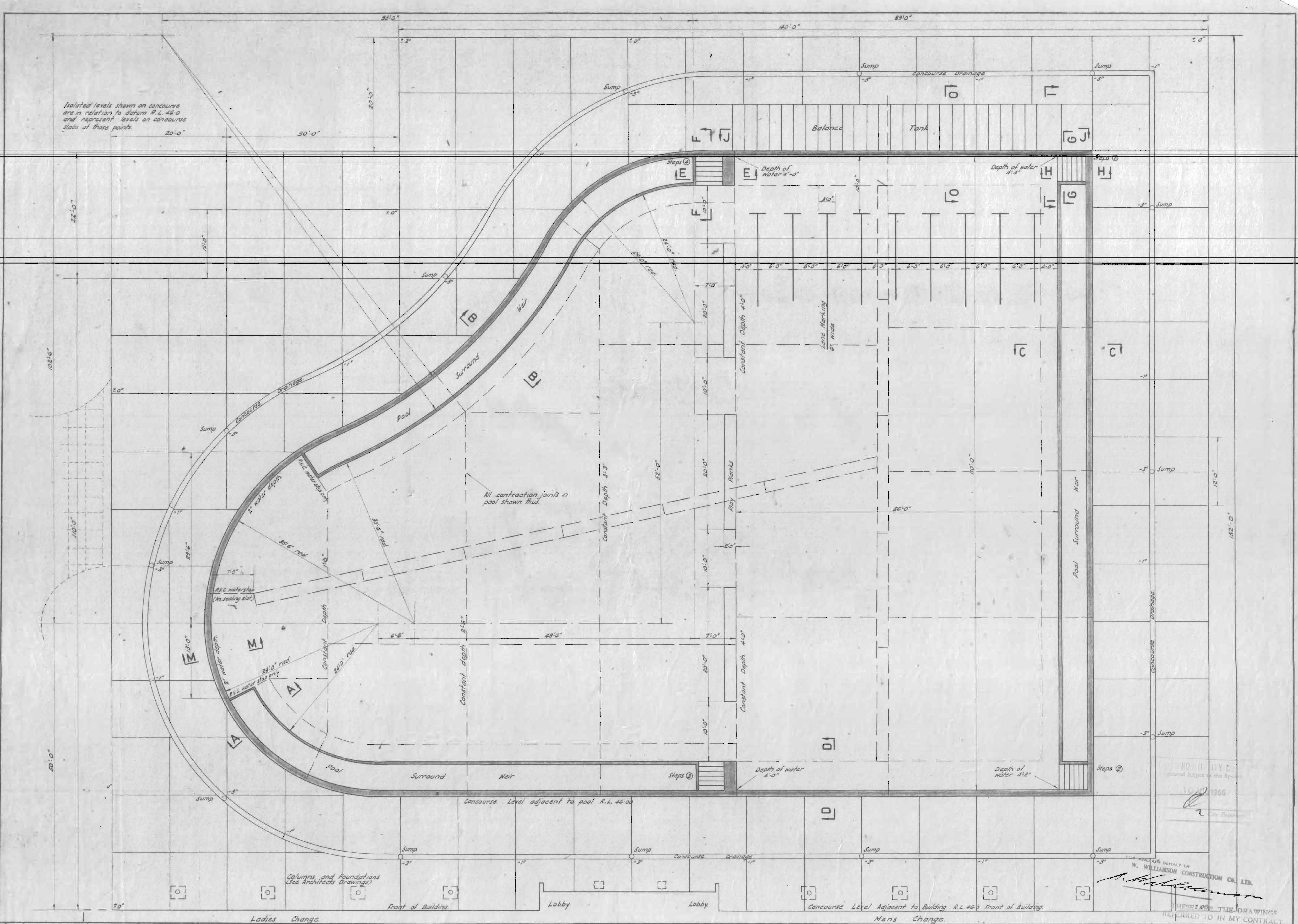
Photograph 7: Shrinkage crack in reinforced concrete tank wall.

Appendix B

Existing Drawings



LIDO POOL WALTHAM PARK FOR THE CHRISTCHURCH CITY COUNCIL	H.G. ROYDS & SUTHERLAND Consulting Engineers CHRISTCHURCH	SCALES 1/16" to 1'0" SITE LAYOUT & SEWER PLAN	P.T. Mc GUIRE ARCHITECT 222 OXFORD TCE CHRISTCHURCH	SHEET No 1 17 SHEETS DATE February 1965



Surv.	
Dr.	R. McL.
Tr.	I. McQ.
Ch.	
App.	

Amendments :-

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · MAIN POOL AND CONCOURSE

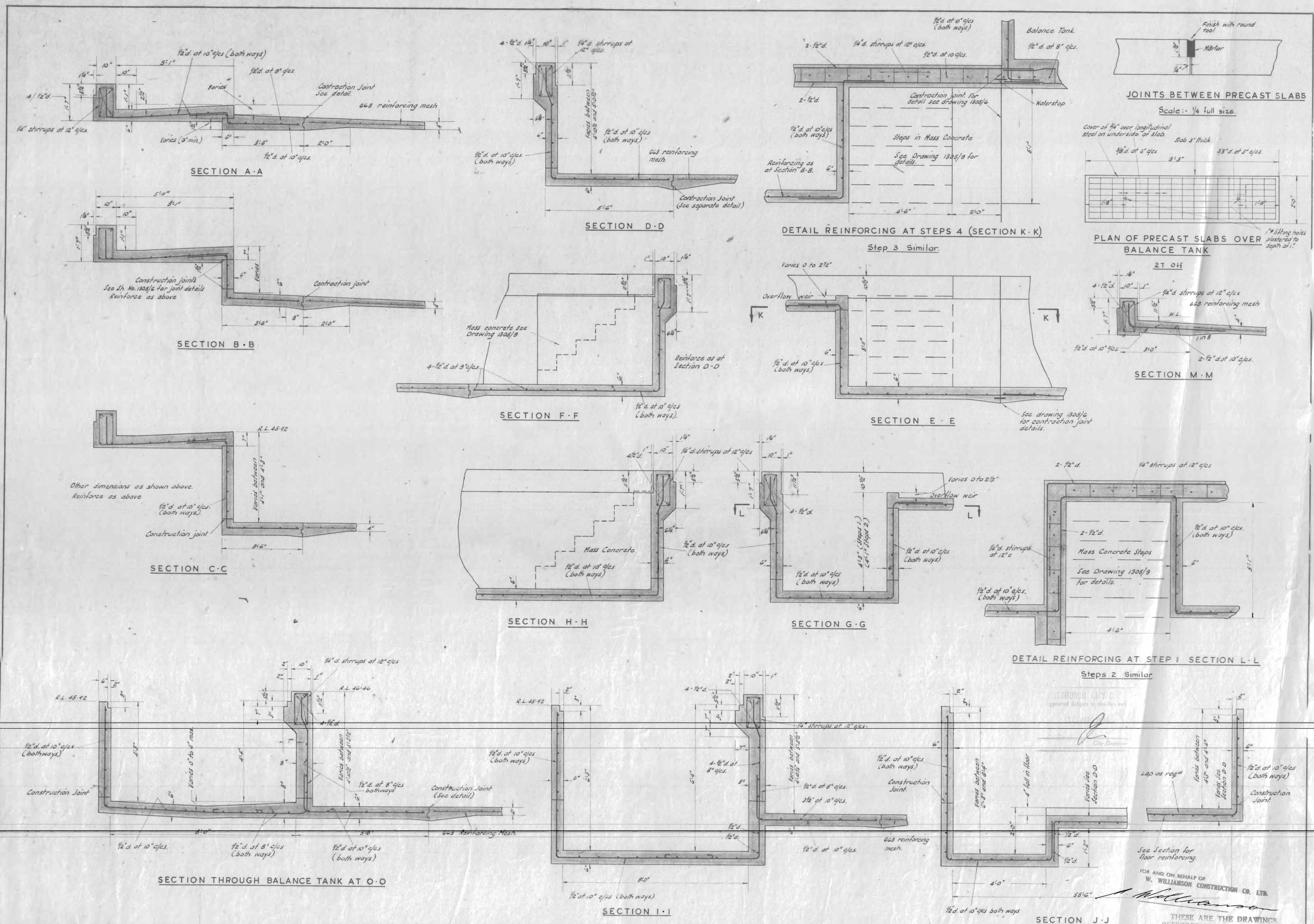
P.T. McGUIRE,
Architect,
222 Oxford Terrace,
Christchurch.

H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1965

Scale: 1/8in. = 1 ft.
F.B.
1305/4

FOR AND ON BEHALF OF W. WILLIAMSON CONSTRUCTION CO. LTD.

THESE ARE THE DRAWINGS REFERRED TO IN MY CONTRACT



Surv.	Amendments :-
Dr. R. McL.	
Tr. I. McQ.	
Ch.	
App.	

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · POOL & BALANCE TANK DETAILS

P. T. McGUIRE
Architect
222 Oxford Terrace,
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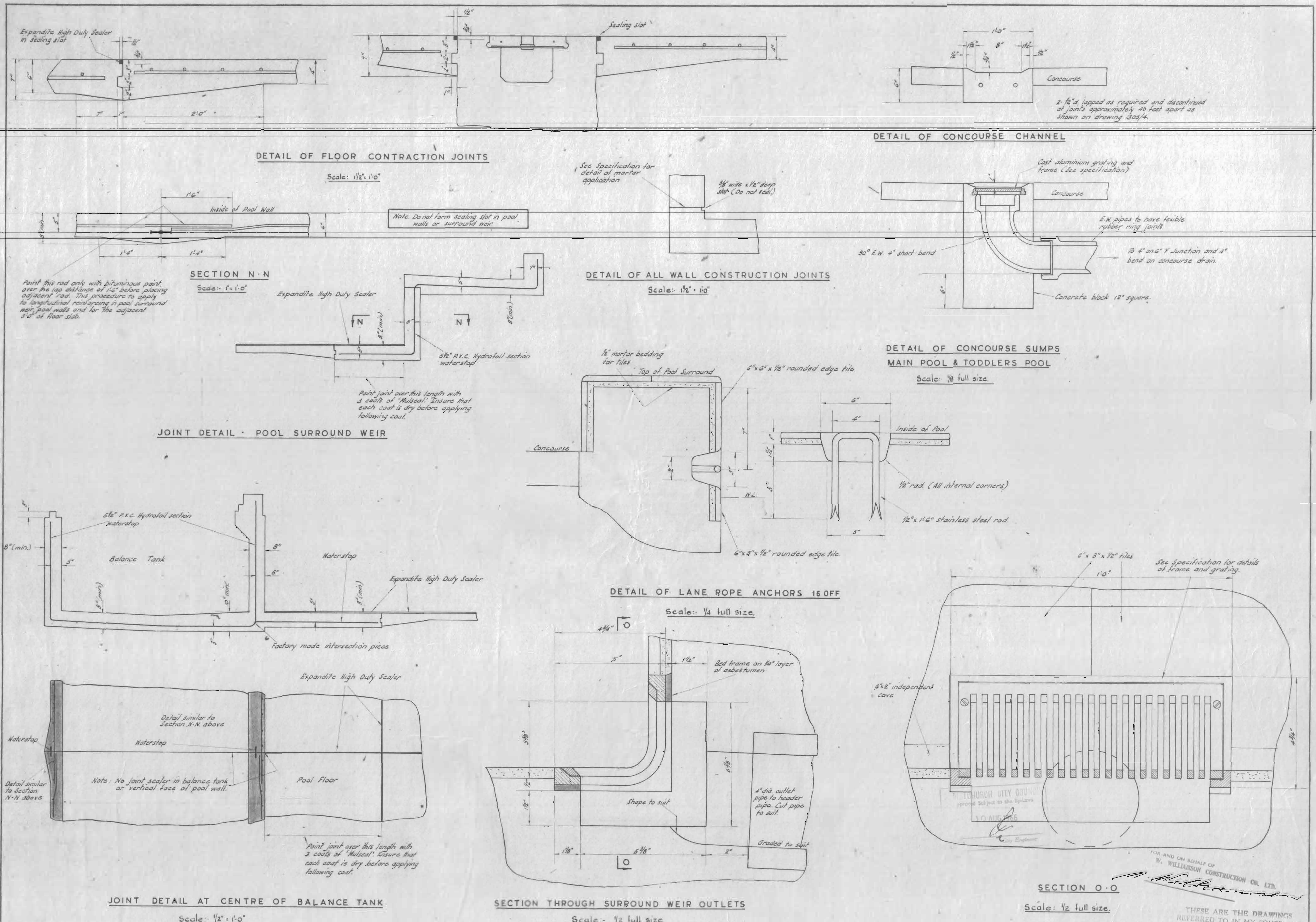
H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1965.

1305/5



Surv.		Amendments :-
Dr.	R. McL.	
Tr.	I. McQ.	
Ch.		
App.		

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · JOINTS & VARIOUS OTHER DETAILS

P. T. McGUIRE
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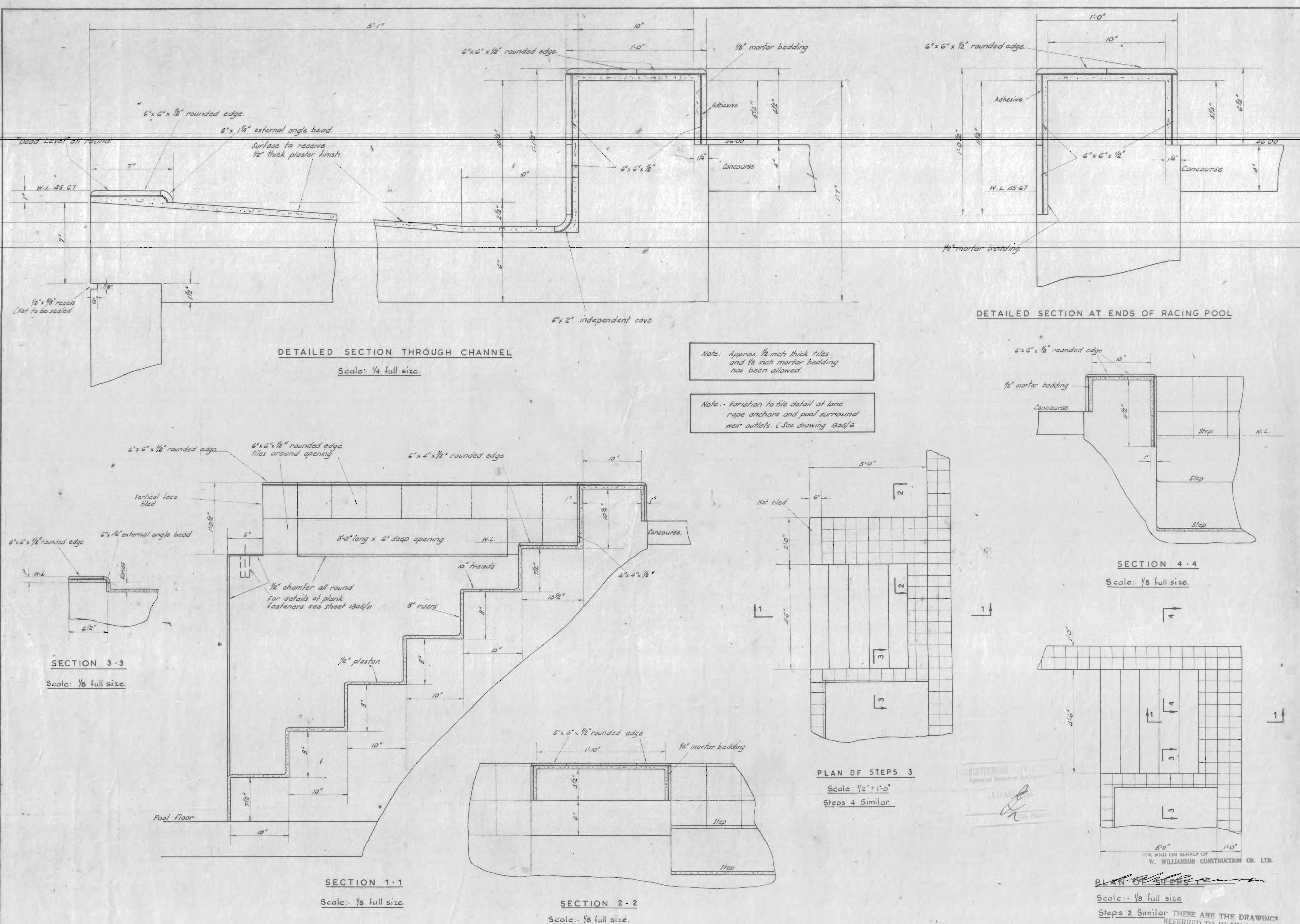
222 Oxford Terrace
Christchurch

H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1965.

Scale: 1½", 1", ½", = 1'-0"
F.B.
1305/6



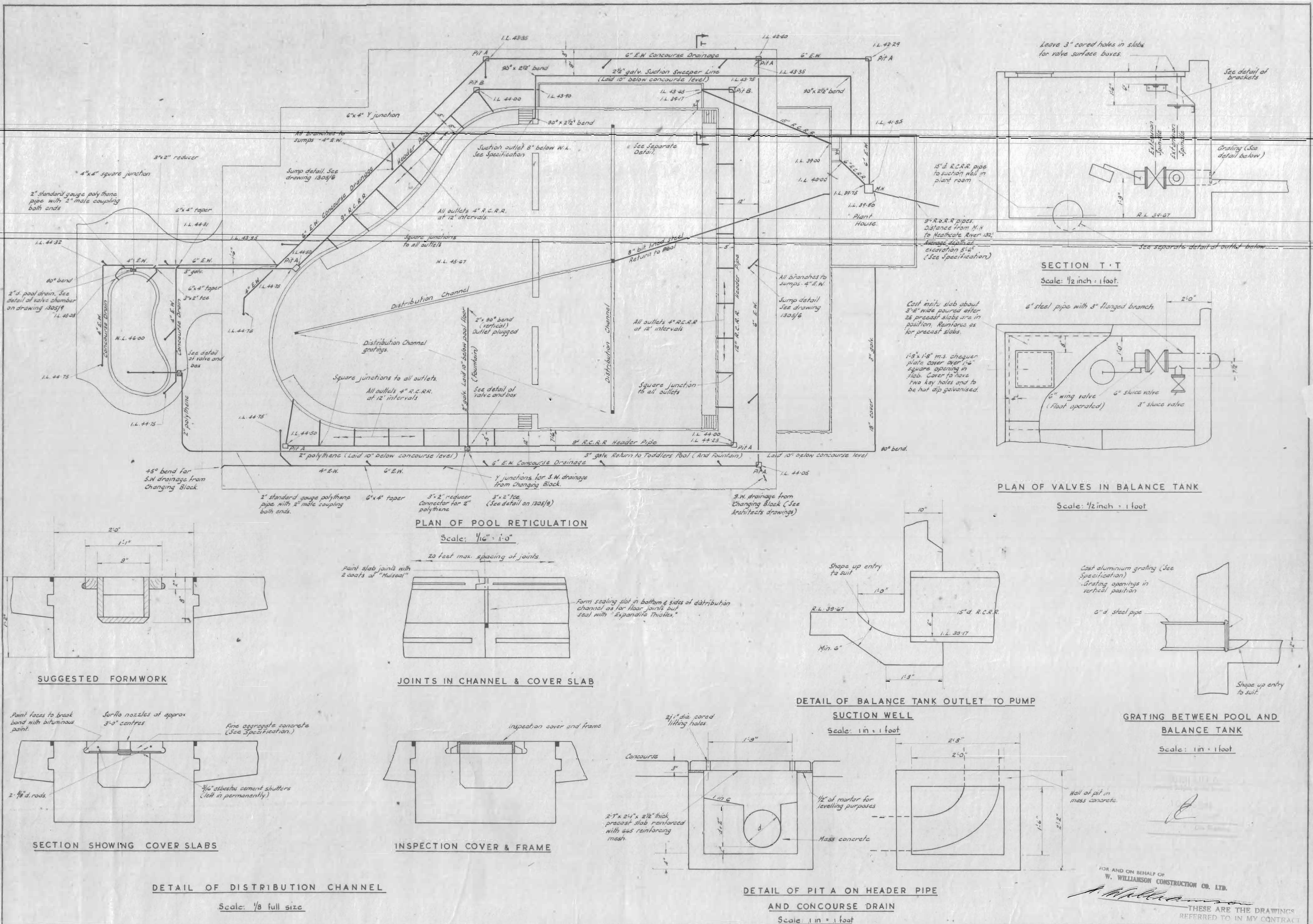
Surv.	Amendments :-
Dr. R. McL.	
Tr. I. McQ.	
Ch.	
App.	

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · DETAILS OF TILING

P. T. McGUIRE
Architect
222 Oxford Terrace
Christchurch.

H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1965

Scale: As shown.
F.B.
1305/7



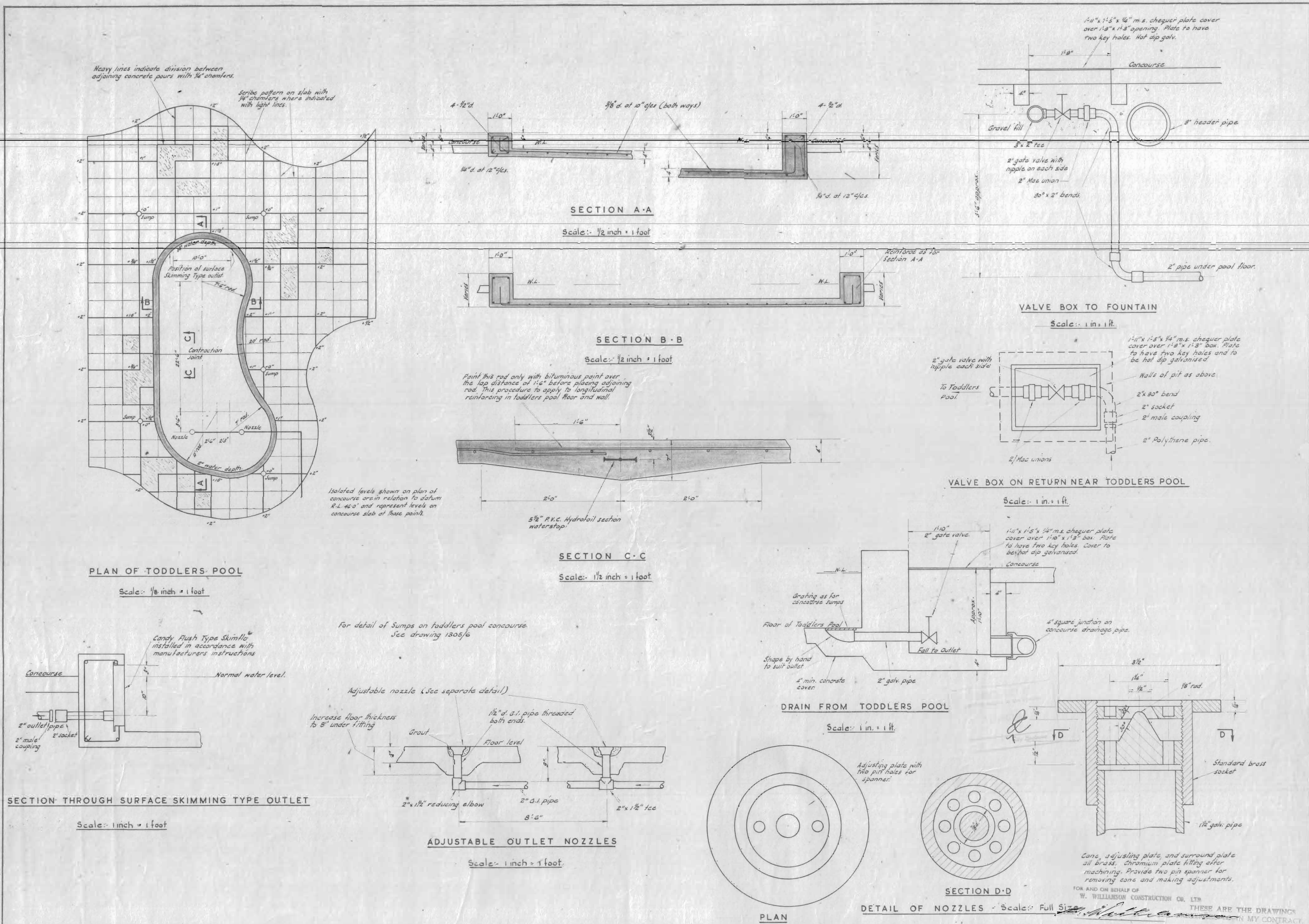
Surv.	Amendments:-
Dr.	R. McL.
Tr.	L. McQ.
Ch.	
App.	

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · POOL RETICULATION

P. T. McGUIRE
Architect,
222 Oxford Terrace,
Christchurch.

H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1955.

Scale: As shown
F.B.
1305/8



Surv.		Amendments :-
Dr.	R. McL.	
Tr.	I. McQ.	
Ch.		
App.		

CHRISTCHURCH CITY COUNCIL · LIDO POOL WALTHAM PARK · TODDLERS POOL DETAILS

P.T. McGUIRE
Architect,
222 Oxford Terrace,
Christchurch.

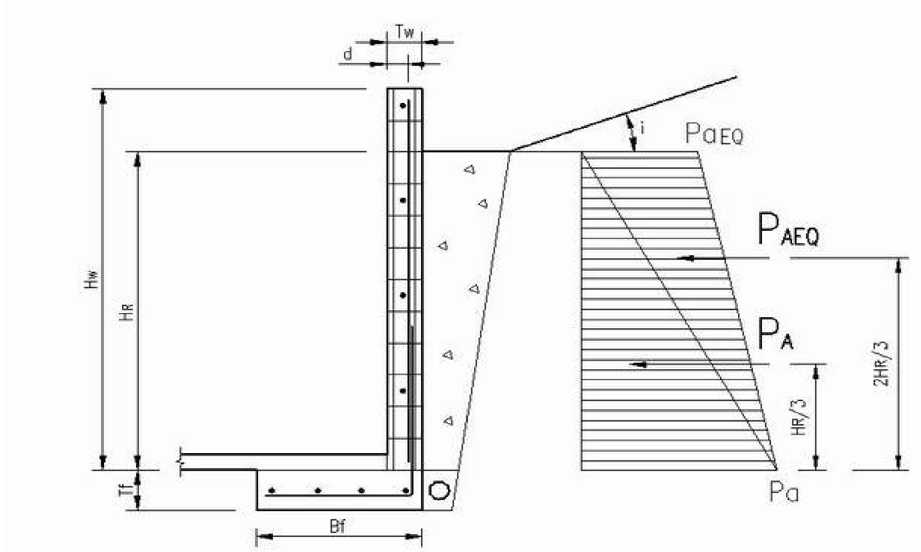
H. G. ROYDS & SUTHERLAND
Consulting Engineers
Christchurch, N.Z.
Date: March, 1965.

Scale: As shown
F.B.
1305/9

Appendix C

CERA Building Evaluation Form

Note: IEP assessment not used – simple quantitative assessment performed in lieu of an IEP assessment – therefore CERA Form page 2 has been omitted.



$$\theta = \tan^{-1}\left(\frac{k_h}{1-k_v}\right)$$

Kh (ZR)= 0.30
Kv= 0.00

Kh/1-Kv = 0.30

Gives θ = 0.291

$$K_a(\phi,\delta) := \frac{\cos(\phi-\alpha)^2}{\cos(\alpha)^2\cdot\cos(\delta+\alpha)\cdot\left(1+\sqrt{\frac{\sin(\delta+\phi)\cdot\sin(\phi-i)}{\cos(\delta+\alpha)\cdot\cos(i-\alpha)}}\right)^2}$$

$$K_{aEQ}(\phi,\delta,\theta) := \frac{\cos(\phi-\alpha-\theta)^2}{\cos(\alpha)^2\cdot\cos(\theta)\cdot\cos(\delta+\alpha+\theta)\cdot\left(1+\sqrt{\frac{\sin(\delta+\phi)\cdot\sin(\phi-i-\theta)}{\cos(\delta+\alpha+\theta)\cdot\cos(i-\alpha)}}\right)^2}$$

H_R =	2	m
H_w =	2	m
γ =	18	kN/m3
φ =	30	degrees
δ =	15	degrees
α =	0	degrees
i =	0	degrees

(Mononobe-Okabe Theory)

Gives K_a = 0.301
Gives K_{aEQ} = 0.563

Ultimate Limit State

(kN/meter length)

$P_A = K_a\gamma H^2/2$ = **10.85 kN**
$P_a = P_A/0.5H_R$ = 10.85 kPa

$P^* = P_{AEQ}/2 = K_{aEQ}\gamma H^2/4$ = 10.13 kN
$\triangle P_{AEQ} = P_{AEQ} - P_A$ = **-0.72 kN**
$P_{aEQ} = \triangle P_{AEQ}/0.5H_R$ = -0.72 kPa

Static case = 1.6P_A

M^*_{static} = $1.6\times P_A\times H_R/3$ = **11.57 kNm**

Seismic case = $P_A + \triangle P_{AEQ}$

$M^*_{seismic} = P_A\times H_R/3 + \triangle P_{AEQ}\times 2H_R/3$ = **6.27 kNm**

Wall Capacity

M^* = 11.57 kNm

Restoring Moment

B_f = 2.80 m
T_f = 0.15 m

Weights
$W_w = 22\text{kN/m}^3 \times T_w \times H_w$ = 6.6 kN/m
$W_f = 24\text{kN/m}^3 \times T_f \times B_f$ = 10.08 kN/m
Wt = 16.68 kN/m

Flexural Capacity

f'_c =	20	MPa
d =	75	mm
Tw (wall thickness) =	150	mm
f_y =	300	MPa
Bar Diameter	12	mm
Bar Spacing	250	mm
Gives As =	452	mm^2/m
Compressive Block Centroid Depth a =	8.0	mm

ϕM_R = $0.9[W_w \times (b_f - T_w/2) + W_f \times Bf/2]$ = 28.89 kNm
>M* - OK Restoring Moment

ϕM_b = $0.85A_s f_y(d-a/2)$ = 8.19 kNm
<M* - Flexural Fails !

% NBS = ΦM_R / M* = > 100%

% NBS = ΦM_B / M* = 71%

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Waltham Pool Tank		Reviewer:	Stephen Lee
	Unit / No: / Street		CPEng No:	1006840
Building Address:	Waltham Park - 30 Waltham Road		Company:	GHD
Legal Description:			Company project number:	5130596/08
			Company phone number:	04 472 0799
	Degrees / Min / Sec			
GPS south:			Date of submission:	
GPS east:			Inspection Date:	24-Jan-12
			Revision:	0
Building Unique Identifier (CCC):			Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	2
Soil type:	mixed	Soil Profile (if available):	
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	

Building

No. of storeys above ground:		single storey = 1	Ground floor elevation (Absolute) (m):	6.00
Ground floor split?	no		Ground floor elevation above ground (m):	0.00
Storeys below ground	1			
Foundation type:	strip footings		if Foundation type is other, describe:	Retaining Wall structure
Building height (m):	0.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	650			
Age of Building (years):	47		Date of design:	1965-1976
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	public		Brief strengthening description:	
Use (upper floors):	public			
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	other (note)	describe system	N/A
Floors:	concrete flat slab	slab thickness (mm)	150
Beams:	none	overall depth x width (mm x mm)	N/A
Columns:	other (note)	typical dimensions (mm x mm)	N/A
Walls:			

Lateral load resisting structure

Lateral system along:	other (note)	Note: Define along and across in detailed report!	describe system	Retaining Wall structure
Ductility assumed, μ:	1.25			
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	other (note)		describe system	Retaining Wall structure
Ductility assumed, μ:	1.25			
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

north (mm):		leave blank if not relevant
east (mm):		
south (mm):		
west (mm):		

Non-structural elements

Stairs:	cast insitu	notes	Pool steps in tank
Wall cladding:			none
Roof Cladding:			none
Glazing:			none
Ceilings:			none
Services(list):			

Available documentation

Architectural	full	original designer name/date	P.T. McGuire/March 1965
Structural	full	original designer name/date	P.T. McGuire/March 1965
Mechanical		original designer name/date	none available
Electrical		original designer name/date	none available
Geotech report		original designer name/date	none available

Damage

Site: (refer DEE Table 4-2)

Site performance:		Describe damage:	Non-structural cracks
Settlement:	none observed	notes (if applicable):	NE corner - very minor
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:			
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):	Minor, not structural		
Across	Damage ratio:	0%		
	Describe (summary):	Minor, not structural		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	Damage to front masonry wall
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	very minor settlement at NE corner

$$Damage\_Ratio = \frac{(\%NBS(before) - \%NBS(after))}{\%NBS(before)}$$

Recommendations

	Level of repair/strengthening required:	minor non-structural	Describe:	Repair minor cracks
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before:	50%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: Simple calculations
	Assessed %NBS after:	50%		
Across	Assessed %NBS before:	50%	##### %NBS from IEP below	
	Assessed %NBS after:	50%		

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
FINAL	Nate Oakes	Rob Collins	[signature]	Stephen Lee	[signature]	7/12/12