

Appendix C

## Structural Basis of Design

Basis of Structural Design

# Hospital Prince of Wales Reservoir Structural Basis of Design

**Prepared for Wellington City Council (WCC)**

**By CH2M Beca Limited (Beca)**

1 February 2013



## Revision History

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## 1 Introduction

This document describes the basis of structural design for **The Hospital Prince of Wales Reservoir Project** located in upper Prince of Wales Park at Mount Cook, Wellington City.

The project includes a reservoir and the associated earthworks and pipelines. The reservoir is fully buried below ground level and will store 35,000m<sup>3</sup> volume of water. It will supply water to Wellington Hospital and to the Central Business District (CBD). CH2M Beca (Beca) has been commissioned by Wellington City Council (WCC) to supply engineering services for the development of the new reservoir.

## 2 Objectives

The principal objective of this document is to establish a basis that shall be used for the structural design and documentation works of the reservoir and pipe tunnel and to:

- Comply with client requirements
- Comply with statutory requirements
- Adopt a sound design philosophy
- Utilise the relevant experience and skills of the design team members
- Adopt the latest engineering technology
- Enable close coordination with other design disciplines
- Permit construction sequencing to be undertaken in accordance with the client's agreed programme

## 3 Definitions

Unless the context requires otherwise the following abbreviations and their meanings are used within this document:

B2	Exposure Classification
CBD	Central Business District
Capacity	Capacity Infrastructure
Council	Wellington City Council
CCANZ	Cement and Concrete Association of New Zealand
CoG	Centre of Gravity
DL	Dead load
EL <sub>U</sub>	Ultimate limit state earthquake load
EL <sub>S</sub>	Serviceability limit state earthquake load
Eu	Ultimate limit state earthquake load.

$F_p$	Fluid pressure loading
$F_x$	Force in x direction
$F_y$	Force in y direction
$F_z$	Force in z direction
G	Dead load
GWRC	Greater Wellington Regional Council
HERA	NZ Heavy Engineering Research Association
HPOW	Hospital Prince of Wales
N.A.	Not applicable
NZBC	New Zealand Building Code
NBS	New Building Standard
LL	Live Load
POW	Prince of Wales Park
Q	Live Load
RFP	Request for Proposal
OSH	Occupational Health and Safety Department of Labour
Sh	Shrinkage effects loading
SLS1	Serviceability limit state for structures of Importance Levels 1, 2 or 3
SLS2	Serviceability limit state for Importance Level 4 – Operational Continuity
SW	Swelling effects loading
TBC	To Be Confirmed
TWL	Top Water Level
UDL	Uniformly Distributed Load
ULS	Ultimate limit state
WCC	Wellington City Council
WE	Wellington Electricity
$W_{L_u}$	Ultimate limit state wind load
$W_{L_s}$	Serviceability limit state wind load
$\gamma_c$	Live load combination factor
$\mu$	Ductility factor

$\varepsilon$  Damping factor

## 4 Scope of Structural Design

Beca will prepare structural design calculation, detailed drawings and specifications to demonstrate compliance with the relevant codes, standards and guidelines outlined in this brief. The scope of structural design work shall cover the reservoir and pipe tunnel including but not limited to the following:

- Foundations
- Floor slabs
- Walls
- Roof support columns
- Roof support beams
- Roof slabs
- Columns
- Reservoir pipe tunnel roof, walls and floor
- Access hatches into the reservoir (roof and floor)
- Pipe supports inside the reservoir and pipe tunnel
- Access stairs and landings
- Access ladders and platforms
- Guard rails and handrails

## 5 Reference Documents

The following documents are to be referred to in the design of the Hospital Prince of Wales Reservoir.

This document shall be read in conjunction with the following documents:

- Hospital Prince of Wales Reservoir Geotechnical Basis of Design (Beca, Rev B dated 1 February 2013)
- Hospital Prince of Wales Reservoir Mechanical Basis of Design (Beca, Rev 1 dated 1 February 2013)
- Hospital Prince of Wales Reservoir Geotechnical Report (Beca, Rev B 'Final' dated 3 October 2012)
- Hospital Prince of Wales Reservoir Geotechnical Report Addendum (Beca, Rev 1 dated 14 January 2013)
- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir (2012).

## 6 Specific WCC Requirements

The following WCC requirements are specified in the RFP document and are listed below for the purpose of outlining the general and structural requirements which are deemed critical for the structural design.

## 6.1 General Requirements

- Reservoir is to be located in the Upper Prince of Wales Park, Mt Cook, Wellington.
- The required reservoir capacity is 35,000m<sup>3</sup> to be stored below the TWL of 92.00m (New City Datum).
- Reservoir to be fully buried.
- Have roof hatches (non-venting) in all four quadrants of the reservoir adjacent pipework discharge points (overflow, primary inlet, high pressure inlet and the fourth quadrant) with an access ladder and platforms below at least one of the roof hatches.
- Incorporate a continuous membrane across the reservoir roof.
- Incorporate a bitumen emulsion or equivalent membrane product on the external face of the reservoir walls.
- Completed a successful reservoir water tightness test prior to backfilling the reservoir or sealing the external face of the reservoir walls.

## 6.2 Structural Requirements

- Reservoir Design Life to be either 100 or 150 years (WCC to advise selection at preliminary design stage).
- The reservoir shall be designed for SLS2 seismic loads equivalent to a 1000 year return period event (HOLD Capacity to confirm seismic design standard). This is to provide equivalence or exceed the seismic design standards for the Wellington Regional Hospital to provide operational continuity within six hours of a 1000 year return period earthquake.
- Allowance for excavation around any point of the perimeter of the reservoir in the future.
- A minimum of four sumps shall be positioned in the floor located opposite to inlets. Sumps to have grates and connect to the sewer pipe system.
- The reservoir structure shall be designed to withstand a water pressure of at least one meter above the top level of the reservoir walls.
- The roof shall be designed to take the required loading from landscaping activities, tractor mowing and use of an excavator (at least 10 tonnes) for future maintenance.
- A minimum of 300mm of turf including top soil shall be provided over the roof the reservoir on top of any site concrete layer protecting the waterproofing membrane layer below.
- The reservoir walls shall be either cast in-situ, pre-stressed or precast concrete panels.
- The lowest roof beam must be 300mm above TWL or 50mm above the maximum water level when the reservoir is discharging via the overflow system at a flow rate of 1200L/s (250mm above TWL).
- The minimum level of the roof slab shall be at least 450mm above the TWL.
- Pipe tunnel/gallery to have at least 2.2m clear internal height.

# 7 Reservoir Structural Description

## 7.1 Structural System

### 7.2 Roof

- Minimum reservoir floor and roof grades are to be 1 in 100.

Either an orthogonal column and beam layout or a circumferential column and beam layout depending on selected option. Reservoir Option R1.0 could have either an orthogonal or

circumferential roof structure layout. Reservoir Option R3.1 would dictate a circumferential roof structure layout.

### 7.3 Floor Slab

- Nominally 250 thick slab. Either conventionally reinforced or post tensioned construction.

### 7.4 Walls

Nominally 425 thick (based on SLS2 1000 year earthquake return period), prestressed vertically and post tensioned horizontally. 8 No. Pilasters; circumferential stressing in four overlapping tendons around reservoir.

### 7.5 Foundations

- Continuous strip foundations normally two metres wide below reservoir wall. Local slab thickenings 500mm deep at column positions.

## 8 Design Standards & Guidelines

The following standards (and manual) shall be used in the design of the structures stated in this document.

AS/NZS1170.0	General Principles
AS/NZS1170.1	Permanent, Imposed and other Actions
AS/NZS1170.2	Wind Actions
AS/NZS1170.3	Snow and Ice Actions
NZS1170.5	Earthquake Actions - New Zealand
NZS3106	Design of Liquid Retaining Structures
AS4678:2002	Earth-retaining Structures
NZS3101.1	Concrete Structures Standard
NZS3404.1	Steel Structures Standard
NZS 3109	Concrete Construction
NZS 3121	Water and aggregate for concrete
NZS 3114	Concrete surface finishes
NZS 3104	Specification for concrete production
NZS 3122	Specification for Portland and blended cements
AS/NZS 4671	Steel Reinforcing Material
AS/NZS 4672	Steel prestressing materials
AS 1310	Steel wire for tendons in prestressed concrete
AS1311	Steel tendons for prestressed concrete

AS 3678	Hot-rolled structural steel plates, floorplates and slabs
AS 3679.1	Hot-rolled structural steel bars and sections
AS 3679.2	Welded Sections
AS/NZS 1252	High Strength Bolts for Structural Engineering
AS/NZS 2451	Bolts, screws and nuts
AS/NZS 1553.1	Covered Electrodes for Welding
AS/NZS 1554.1	Welding of Steel Structures
AS/NZS 1554.2	Welding of Stainless Steel Structures
CCANZ Publication TM 34 Tilt-up Technical Manual	
Transit New Zealand (TNZ) Bridge Manual	
RRU 83 – Seismic Design of Bridge Abutments	
New Zealand Building Act 2004	
New Zealand Standard Act 1988	

## 9 Material Properties

The following material properties shall be used in the design of the structural elements including components and connections.

### 9.1 Reinforced Concrete

#### 9.1.1 Concrete

The minimum compressive strength of concrete to be used in design of ordinary reinforced concrete element shall be:

- Reservoir (roof, beam, wall, base-slab, column & foundation)  $f_c' = 40\text{MPa}$
- Reservoir access hatch upstands  $f_c' = 40\text{MPa}$
- Pipe tunnel  $f_c' = 40\text{MPa}$
- Valve chambers  $f_c' = 30\text{MPa}$
- Pipe encasement  $f_c' = 30\text{MPa}$
- Stair and platform foundation  $f_c' = 30\text{MPa}$
- Pipe supports and thrust blocks  $f_c' = 30\text{MPa}$
- Retaining walls around entrance to pipe tunnel  $f_c' = 30\text{MPa}$

#### 9.1.2 Reinforcing Steel

The minimum yield strength of reinforcing bar to be used in the design shall be:

- Deformed bar designated 'DH' shall be grade 500E  $f_y = 500\text{MPa}$
- Plain round bar designated 'RH' shall be grade 500E  $f_y = 500\text{MPa}$
- Plain round bar designated "R" shall be grade 300E  $f_y = 300\text{MPa}$

## 9.2 Prestressed Concrete

If prestressed concrete shall be used in the design of reservoir the following material properties shall be used.

### 9.2.1 Concrete

The maximum compressive strength of prestressed concrete shall be determined in conjunction with the concrete supplier and precaster but is likely to be no more than 55 MPa. The minimum compressive strength of concrete to be used in design of prestressed concrete element shall be:

- Roof slab, floor slab, roof support beams, walls  $f_c' = 40\text{MPa}$

### 9.2.2 Prestressing Strands

The minimum tensile strength of prestressing strand (tendons) to be used in the design of prestressed concrete shall be:

- VSL Super Grade (or equivalent)  $F_{p_u} = 1840\text{MPa}$
- Strand diameters shall be either 12.7mm or 15.9mm with appropriate proprietary wedge anchorage systems.

## 9.3 Structural Steel

The minimum yield strength of steel (mild and stainless) structures, components and connections to be used in the designed shall be:

### 9.3.1 Steel Sections

- Hot rolled plates  $f_y = 250\text{MPa}$
- Hot rolled structural sections (UB, UC, PFC, EA)  $f_y = 300\text{MPa}$
- Hot rolled structural sections (RHS, SHS & CHS)  $f_y = 350\text{MPa}$

### 9.3.2 Stainless Steel Sections

- Plates (TBC)
- Sections (TBC)

### 9.3.3 Bolts & Nuts & Washers

- High strength bolts grade 8.8  $f_u = 830\text{MPa}$
- Mild steel bolts grade 4.6  $f_u = 460\text{MPa}$
- Stainless steel bolts grade 316 (TBC)

### 9.3.4 Welding Consumables

- E48XX electrodes shall be specified for all welds  $f_{uw} = 410\text{MPa}$

## 10 Design Criteria and Loads

The following criteria and loadings shall be used in the design of the reservoir structure and the associated structures stated in this brief.



permanently submerged roof design is adopted then the maximum height of retained water above the top of the walls will be used.

## 10.6 Ground Water, Gw

Hydrostatic pressure due to ground water shall be considered in the design of the reservoir including associated underground structures. The water table gradient shall be based on the highest piezometer water level recorded on site reducing to an effective residual pressure at the reservoir wall. This is based on the assumption that a drainage system is installed around the external perimeter of the reservoir.

## 10.7 Earthquake Loads, E

The following seismic parameters shall be used for the calculation of earthquake loads. The height of retained water to be used in the designed shall be one meter above the top of reservoir wall. Refer Clause 6.2 of this brief for the specific client requirements.

■ Hazard factor	Z = 0.4 For Wellington City
■ Site sub-soil class	Soil Class A/B (Refer SSSHA)
■ Annual probability of exceedance	P = 1/2500; 1/5000 or 1/7500 for ULS (TBC)
■ Annual probability of exceedance	P = 1/1000 for SLS <sub>2</sub> (Operational continuity) (HOLD TBC)
■ Annual probability of exceedance	P = 1/500 for SLS <sub>2</sub> (Code requirement)
■ Return period factor	R <sub>u</sub> for ULS (Refer SSSHA recommendations)
■ Return period factor	R <sub>s</sub> = 1.3 For SLS <sub>2</sub> (Operational continuity)
■ Return period factor	R <sub>s</sub> = 1.0 For SLS <sub>2</sub> (Code requirement)
■ Near fault factor	N(Ti,D) = (Refer SSSHA recommendations)
■ Structural performance factor	S <sub>p</sub> = 1.0 for ULS & SLS <sub>2</sub> (for reservoir)
■ Structural performance factor	S <sub>p</sub> = 0.925 for ULS (for pipe tunnel structure)
■ Structural performance factor	S <sub>p</sub> = 0.7 for SLS (for pipe tunnel structure)
■ Ductility factor	μ = 1.25 for ULS
■ Ductility factor	μ = 1.0 for SLS
■ Damping factor	ε = 5% for ULS
■ Damping factor	ε = 0.5% for SLS

The increase in liquid pressure (hydrodynamic) due to seismic accelerations shall be calculated as per Appendix A of NZS3106:2009.

## 10.8 Swelling, Sw

The effect due to swelling shall be considered in the design of the reservoir structure. In the absence of a rational analysis, the minimum effects due to moisture variation shall be determined considering the swelling strains specified in Table 2, Clause 4.2.4 of NZS 3106:2009

## 10.9 Shrinkage, Sh

The effect due to shrinkage shall be considered in the design of the reservoir structure. In the absence of a rational analysis, the minimum effects due to moisture variation shall be determined considering the shrinkage strains specified in Table 2, Clause 4.2.4 of NZS 3106:2009

## 10.10 Temperature, T

The effect due to increase or decrease in temperature and due to differential temperature gradient shall be considered in the design of the reservoir for the walls for load cases prior to backfilling. The following changes in temperature and temperature gradient as per Clause 4.2.3 of NZS 3106:2009 shall be used in the design:

- Roof  $\pm 20^\circ$  Celsius
- Roof temperature gradient is  $5^\circ$  Celsius per 100mm
- Wall  $\pm 30^\circ$  Celsius
- Wall temperature gradient as per in NZS 3106:2009

The coefficient of thermal expansion of concrete used in design was  $11 \times 10^{-6} / ^\circ$  Celsius

## 10.11 Construction Load

Allowance for load during construction shall be considered in the design. The roof and its immediate supports shall be designed assuming a minimum construction live load of 2.0kPa (TBC).

# 11 Load Combinations

In general, the load combinations specified in NZS3106:2009 shall be used in the design of reservoir structure. The load combinations specified in AS/NZS 1170.1 shall be used in the design of the associated structures (pipe tunnel). The following load combinations shall be used:

## 11.1 Roof slab, beams and columns

The roof slab of the reservoir including its immediate support shall be designed considering the load combinations specified Transit New Zealand (TNZ) Bridge Manual.

### 11.1.1 Maintenance Condition

#### Design Standard: TNZ Bridge Design Manual

- $1.35G + 1.35(1.67LLxI)$  At ULS      Where:  $I = 1.3$  Dynamic amplification factor
- $1.0G + 1.35LLxI$  At SLS

### 11.1.2 Operating Condition

#### Design Standard: NZS 3106:2009

- $1.35G$  At ULS
- $1.2G + 1.5Q$  At ULS
- $G + Flp + Sh$  SLS – Group A
- $G + T + 0.7Sh$  SLS – Group B1
- $G + Flp + Es_1$  SLS – Group B2

## 11.2 Floor slab, Wall and Wall Joints

The following load combinations shall be used in the design of floor slabs, walls and wall joints.

### 11.2.1 Serviceability

- $G + Flp + 0.5Sw$  Group A

- G + Flp + T                      Group B
- G + Flp + Es1                    Group B
- G + T + 0.7Sh                    Group B

#### 11.2.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

### 11.3 Foundation

The following load combinations shall be used in the design of foundations.

#### 11.3.1 Serviceability

- G + Flp + 0.5Sw
- G + Flp + T
- G + Flp + Es1
- G + T + 0.7Sh
- G + Q +  $\gamma_c Q$

#### 11.3.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

### 11.4 Associated Structures

The following load combinations shall be used in the design of other structures.

#### 11.4.1 Serviceability

- G + Q
- G + Ws +  $\gamma_c Q$
- G + Es

#### 11.4.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

### 11.5 Stability

The load combinations specified in AS/NZS 1170.1 shall be used for the global stability checked against overturning and sliding of the reservoir.

- 0.9G + 1.0Eu

## 12 Allowable Deflections

The following deflection criteria shall be used in the design of structural elements:

■ Roof slab	L/360
■ Roof beams	L/360
■ Cantilever retaining wall	H/150
■ Column lateral deflection	H/400

## 13 Durability Requirements

The following design criteria for concrete durability shall be used in the design of reservoir.

■ Minimum intended life span	100 or 150 years (HOLD – TBC by Capacity)
■ External exposure classification	B2
■ Internal exposure classification	B2
■ Minimum concrete cover for walls	50mm for outside surface
■ Minimum concrete cover for walls	50mm for inside surface
■ Minimum concrete cover for roof slab	40mm for top bars (covered by membrane)
■ Minimum concrete cover for roof slab	25mm for bottom bars
■ Minimum concrete cover for ground slab	50mm for top bars
■ Minimum concrete cover for ground slab	40mm for bottom bars (with site concrete)
■ Minimum concrete cover for foundation	40mm for bottom bars (with site concrete)
■ Minimum concrete cover for foundation	50mm for bottom bars
■ Other structure not part of reservoir	50mm

Note the above specification is applicable for a 100 year durability in accordance with NZS3101:2006. For a design life greater than 100 years specific design and assessment will be required for concrete mix design and cover requirements.

## 14 Water Tightness Requirements

The reservoir walls shall be classified as water-tight liquid retaining structure having a Tightness Class 3 as per Table 3 Clause 5.1.1 of NZS3106:2009. The reservoir floor shall be classified as having a Tightness Class or 1 or 2 (HOLD - TBC)

Post-tensioning of the concrete water retaining elements of the reservoir shall be used to achieve this Tightness Class as required for the selected reservoir form.

The floor slab shall be designed to either; limit the width of cracks due to combined flexural stresses and secondary stresses (temperature, swelling and shrinkage) by limiting the tensile stress of the reinforcing steel to 240 MPa. This requirement is as per clause 5.2.5 of NZS3106:2009 or by the application of post tensioning to the slab in segments and between segments to resist combined tensile flexural and secondary stresses by the application of compression stress across the full concrete section.

## 14.1 Floor Slab Waterstops

At specified locations joints in the floor slab will be constructed. These will be to limit concrete pour size and optimise the geometry of slab segments. Waterstops to be provided at floor slab joints include synthetic rubber hydrophilic waterstops within the depth of the slab section and PVC external waterstops at the underside of the slab. Formed recesses will be provided for the hydrophilic sealants in the surface of the precast panels. A bullnose finish to the slab edge at each side of the joint is proposed to provide a cleanable surface finish. In general surface applied polyurethane sealants are not proposed for floor joints but will be provided around pipe penetrations, floor access hatches and at the junction of the wall to the floor slab.

Column foundations are to be constructed integrally with the floor slab with floor slab joints located away from column positions. Reinforcing starter bars will be provided through the floor for columns above. Waterstops are not proposed at the construction joint positions between the top of floor slab and base of column sections.

## 14.2 Wall Section Waterstops

Only vertical construction joints shall be used for the reservoir walls. Waterstops at the wall infill sections between precast concrete panels will be synthetic rubber hydrophilic waterstops within the depth of the wall section. Formed recesses will be provided for the hydrophilic waterstops in the surface of the precast panels. Roughened concrete surface finish will be provided for the balance of the precast panel construction joint surface.

Continuity will be provided between the vertical wall hydrophilic waterstops in the wall joints and the horizontal hydrophilic waterstops between the wall and floor slab.

## 14.3 Roof Slab Waterstops

TBC. The roof slab shall be covered with a waterproof membrane.

## 15 Geotechnical Information

Applicable geotechnical information for the structural design of the reservoir is included in the Beca document Hospital Prince of Wales Reservoir – Geotechnical Basis of Design (Beca 2012).

Appendix D

## Mechanical Basis of Design

Basis of Design

# Hospital Prince of Wales Reservoir Mechanical Basis of Design

**Prepared for Wellington City Council (Client)**

**By CH2M Beca Limited**

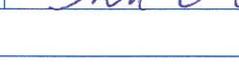
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Prepared by	Mike Yarrall		01/02/2013
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Approved by	Simon Edmonds		01/02/2013
on behalf of	CH2M Beca Limited		

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## Appendices

### Appendix A - Process and Instrumentation Diagram and Legend Sheet

## 1 Introduction

This document describes the basis of design for the mechanical components for the **Hospital Prince of Wales Reservoir Project** located in upper Prince of Wales Park at Mount Cook, Wellington City.

The project includes a reservoir and the associated earthworks and pipelines. The reservoir is fully buried below ground level and will store 35,000m<sup>3</sup> volume of fresh water. It will supply water to Wellington Hospital and to the Central Business District (CBD). CH2M Beca (Beca) has been commissioned by Wellington City Council (WCC) to supply engineering services for the development of the new reservoir.

## 2 Objectives

The principal objective of this document is to establish a basis that shall be used for the design and documentation works of all aspects of the reservoir mechanical and piping components and to:

- Comply with client requirements
- Comply with statutory requirements
- Address whole of life operation, inspection and component replacement requirements
- Utilise the relevant experience and skills of the design team members
- Incorporate consideration of recent engineering technology developments
- Enable close coordination with other design disciplines
- Permit construction sequencing to be undertaken in accordance with the client's agreed programme

## 3 Definitions

Unless the context requires otherwise the following abbreviations and their meanings are used within this document:

CBD	Central Business District
Capacity	Capacity Infrastructure
Council	Wellington City Council
GW	Greater Wellington regional Council
HPOW	Hospital Prince of Wales
RFT	Request for Tender
TBC	To Be Confirmed
TWL	Top Water Level
WCC	Wellington City Council
WE	Wellington Electricity

## 4 Process Description

The HPOW reservoir will be part of the 'Low Level Zone'. This includes the following reservoirs: Macalister, Carmichael and Mt Albert. The reservoirs in this zone are hydraulically connected through the reticulation system with the larger reservoirs having a Top Water Level (TWL) of 92m. The HPOW reservoir is filled from the new 800 NB inlet main on Hargreaves St and the Bell Rd Reservoir. The outlets are both to the Carmichael Reservoir and the new 900 NB outlet main on Hargreaves St.

In a seismic event the reservoir will automatically be isolated from the reticulation network. Flow control valves also serve to allow control over the filling rate of the reservoir as well as controlling the flow out of the reservoir.

## 5 Scope of Mechanical Design

The following areas are covered by the mechanical design:

- Above ground pipework, valves and fittings inside the tunnel and reservoir.
- Underground pipelines, valves and fittings from the tunnel to the connection to the new streetworks pipelines.
- Underground pipework, valves and fittings from the tunnel to the existing mains.
- Underground overflow and scour pipework, valves and fittings from the tunnel to the stormwater system.

Pipelines associated with the reservoir:

- Outlet pipeline 900 NB to Hargreaves Street.
- Primary inlet pipeline 800 NB from Hargreaves Street.
- Scour and overflow pipeline.
- Secondary inlet pipeline 300NB that connects to the existing high pressure inlet pipeline, 450 NB existing installed in 1954 from Bell Road reservoir
- Secondary outlet pipeline 300 NB that feeds the existing 375 NB that supplies Carmichael Reservoir.

Pipeline design will include, where necessary: manual valves, automated actuated valves, air valves, scour valves and pressure reducing valves.

## 6 Reference Documents

The following documents are to be referred to in the design of the Hospital Prince of Wales Reservoir:

- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir 1 February 2012
- Capacity Infrastructure Services Approved Products Register 2011.04.01 (2011)
- Regional Standard for Water Services. Capacity Infrastructure Services. Rev A [DRAFT] – May 2012.
- Wellington City Council Pipe Networks requirements checklist for as-built drawings (2011)
- Wellington City Council Water Supply Specification 7th Edition (2004)

The following standards shall be used in the design of the Hospital Prince of Wales Reservoir:

- AS/NZS2280:2004 Ductile iron pipes and fittings
- AS/NZS2451:1998 Bolts, screws and nuts with British Standard Whitworth threads (rationalized series)
- AS/NZS2566.1:1998 Buried flexible pipelines Part 1: Structural Design
- AS/NZS2566.2:2002 Buried flexible pipelines Part 2: Installation
- AS/NZS2638.2:2003 Gate valves for waterworks purposes – Resilient seated
- AS/NZS4020:2005 Testing of products for use in contact with drinking water
- AS/NZS4058:2007 Precast concrete pipes (pressure and non-pressure)
- AS/NZS4087:2011 Metallic flanges for waterworks purposes
- AS/NZS4130:2009 Polyethylene (PE) Pipes for Pressure Applications
- AS/NZS4158:2003 Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
- AS/NZS4331:1995 Metallic Flanges (HOLD)
- AS/NZS4442:1998 Welded steel pipes and fittings for water, sewage, and medium pressure gas
- AS/NZS:4998:2009 Bolted unrestrained mechanical couplings for waterworks purposes
- AS2129:2000 Flanges for pipes, valve and fittings
- AS3897.3:2002 Site Testing of Protective Coatings
- AS4041:2006 Pressure Piping
- BS EN 1092-1:2007 Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1: steel flanges
- NZS1170.5:2004 Earthquake Actions - New Zealand
- Seismic Hazard Assessment for the Hospital Prince of Wales Park Reservoir (Beca, 2012)

## 7 Mechanical Design Criteria

The pipework arrangement will be designed to allow the same functionality as shown in the “Proposed Pipe Work and Fittings” drawing (approved 13/10/2011) issued by Capacity Infrastructure Services. This functionality is to be confirmed by preparation of a P&ID by Beca and subsequent review by Capacity and amendment by Beca to an agreed process flow.

Pipework and valves within the pipe tunnel are to be configured to allow the inspection (internal and external) and removal and replacement of pipe spools and fittings.

The design life for the pipelines is to be at least 100 years with maintenance.

### 7.1 Flows and Hydraulics

The inlet and outlet pipework will separately connect the reservoir to the Central Zone via the streetworks pipelines (primary connection) and to the Kaitoke main via Bell Road reservoir (secondary connection). There will be two separate inlets into the reservoir, and one outlet that will split to the two lines. A cross connection will link the secondary inlet to the outlets via a PRV. An overflow and scour will also be provided.

#### 7.1.1 Primary Inlet

Design Flowrate: 700 L/s (maximum peak value)

Proposed diameter: 600 NB inside tunnel, 800 NB below ground

Nominal velocity: 2.5 m/s (at maximum peak flowrate)

Level of rim: 90.000 NCD

### 7.1.2 Secondary Inlet

Design Flowrate: 120 L/s (maximum peak value)

Proposed diameter: 300 NB inside tunnel and below ground

Nominal velocity: 1.7 m/s (at maximum peak flowrate)

Level of rim: Bent down to below normal water level; inlet pipe high point at 92.000 NCD

### 7.1.3 Outlet

Design Flowrate: 800 L/s (maximum peak value)

Proposed diameter: 600 NB inside tunnel, 900 NB below ground

Nominal velocity: 2.8 m/s (at maximum peak flowrate)

Below floor level at 45°, with grill (stainless steel handrailing to be considered in subsequent design stages) and vortex preventer.

### 7.1.4 Secondary Outlet

Design Flowrate: Not provided

Proposed diameter: 300 NB inside tunnel and below ground

Branches from primary outlet in tunnel.

### 7.1.5 Overflow Pipework

Design Flowrate: 1,200 L/s (maximum peak value)

Level of rim: 92.075 NCD

Allowable head: 250mm above rim (92.325 NCD)

Pipe provided to be 600 NB, this would give a velocity of 4.2 m/s at the maximum peak design flowrate. Although this velocity is high the discharge at this rate would be for short periods only hence CLMS could be considered suitable. As an alternative epoxy lined pipe could be used subject to agreement from Capacity. The headloss in the overflow pipe is expected to be about 5m. As the overflow is expected to be more than 20m above the discharge point, there is plenty of head available. A vortex inhibitor is to be provided at the bellmouth to prevent vortices in the event that the overflow inlet becomes submerged.

### 7.1.6 Scour Pipework

Design Flowrate: 400 L/s (nominal over a period of 24 hours)

The minimum pipe diameter will be approximately 500mm prior to connection into the overflow line.

### **7.1.7 Test Pressure**

The test pressure for all pipework shall be 100m, which is the minimum specified in the RFT. This will be significantly in excess of the expected operating pressure. However, it will be less than the 1.3 x minimum pipe pressure rating as specified in the WCC Water Supply Specification.

## **7.2 Valves**

### **7.2.1 Below Ground Valves**

Below ground valves up to and including 300mm diameter will be flanged resilient seated gate valves.

Below ground valves larger than 300mm diameter will be resilient seated double flanged butterfly valves. Although the WCC Code of Practice for Land Development requires butterfly valves to be approved by the Council, the RFT indicates that most valves will be butterfly valves. For larger diameters, butterfly valves will offer a significant space, weight and cost saving over gate valves.

### **7.2.2 Above Ground Valves**

#### **Isolating:**

All valves isolating lines of 50mm diameter or less will be ball valves.

All above-ground manual valves isolating lines of greater than 50mm diameter will be butterfly valves. These valves will be double flanged which enables them to still isolate when pipework on one side is removed.

Although the RFT shows bypass valves on large diameter valves Capacity has advised that no bypass valves should be provided as there is no requirement to maintain water supply while operating valves (e.g. for testing purposes).

#### **Control:**

As specified in the RFT, all control valves will be plug valves and the type is to be agreed with Capacity. Manufacturers such as Valmatic and Dezurik will be considered. Rotork actuators with battery backup will be used for the shut-off valves. Limit switches will be required.

Flow control on the reservoir inlet and outlet valves is required to balance operation of the reservoir with the other low level zone reservoirs and ensure turnover of the reservoir contents.

The valves will be specified to be controlled so that the final part of the closure happens slowly enough to mitigate the risk of problematic surge pressures in the pipeline.

#### **Pressure Reducing Valve:**

A hydraulically actuated control valve is proposed. This will be sourced from Capacity approved suppliers Claval or Bermad. These valves generally require at least 10m upstream pressure to operate, but we understand this will be available from the Kaitoke main.

## **Non Return Valves:**

A non-return valve will be installed on the 300mm diameter outlet. This could be a swing-check type of valve or a wafer type twin plate sprung non-return valve. Capacity to confirm their preference.

Flap valves will be provided where the open channel tunnel drain discharges to the stormwater manhole.

## **Air Valves:**

Air valves will be required to vent air that accumulates at high points and bends in the pipeline, and to assist when filling the pipe. They will also be required to let air in to the pipe to prevent negative pressure from occurring in the event of sudden valve closure.

The exact location of air valves will be confirmed once the pipework arrangement is finalised.

The recommended air valve type is the Vent-O-Mat RBX. Capacity to confirm their preference.

Standpipes will not be considered as they are not preferred by Capacity.

## **7.3 Flexible Couplings**

Bellows will be provided as the first flexible coupling outside of the reservoir after the isolation valves hard piped to the reservoir structure. A flexible coupling will also be provided at the end of the tunnel arrangement. Where the pipework exits the tunnel the pipe penetration will be configured to allow a degree of movement to accommodate seismic movement and differential settlement.

All pipework in the tunnel will be restrained, with thrust taken up outside the tunnel. However pipe supports could also provide thrust restraint if required. Flexible couplings/bellows may need to have tie bolts installed to allow partial dismantling of piping which is in service to deal with thrust.

Viking Johnson dismantling joints or tied gibaults/flange adaptors will be used to provide the ability to dismantle valves and fittings and to correct alignments during construction.

Earthquake loads on the pipes will be determined as detailed in NZS 1170.5:2004 modified in accordance with the Site Specific Seismic Hazard Assessment (Beca, 2012). The design acceleration recommended by the site specific assessment is 1.56g horizontal.

## **7.4 Pipe**

### **7.4.1 Below Ground Pipework**

Pipe will be installed with a minimum of 1m cover. The design will aim to maintain a maximum cover of 2m. However, the raising of the existing park level will mean the cover for existing pipework may exceed this with agreement from Capacity. A minimum of 0.5m clearance needs to be provided between the 33kV cable and the pipeline, but the design will aim for a larger clearance.

The large diameter below ground pipework (i.e. the 800mm and 900mm diameter pipes) will be concrete lined mild steel to NZS 4442. The pipe wall thickness will be as detailed in column (b) of Table 2 in NZS 4442:1988. The pipe outside diameters will be 345, 426, 508, 610, 813 or 914 mm.

Depending on the pipe supplier, the pipes will be coated with either a Polyken Synergy or Sintakote coating. Hemispherical slip-in joints are proposed.

The structural pipeline design shall allow for HN-HO-72 external loading in areas where heavy traffic loads are expected.

The material for smaller diameter below ground pipework will be determined during subsequent design stages, but could be steel or ductile iron.

Pipework 600mm diameter and above will have 500mm diameter access hatches to provide personnel access to the interior of the pipe. These will be spaced at 200m intervals. We understand Capacity have preferred details for these access points.

#### **7.4.2 Above Ground Pipework**

Concrete lined, epoxy coated steel pipework to NZS 4442:1988 is preferred for all pipework in the tunnel. Epoxy lined pipe may be used for short pipe lengths with agreement from Capacity.

All pipework will either be welded, flanged or use gibault/flange adaptor flexible couplings.

#### **7.5 Flanges**

All flanges will be tested to a minimum of 10 bar. Subject to suitable valves, bellows and other fittings, the flange drilling will be to AS2129 Table E (which complies with the WCC Water Supply Specification, this is the metric equivalent of BS10 specified in the RFT). Table D meets the test and operation pressure requirements but is thinner and lighter than Table E but will only be used with approval from Capacity.

Other flange patterns will be considered if a preferred valve or other fitting cannot be obtained in a Table E drilling. AS/NZS 4331:1995 (HOLD to be determined by Capacity at detail design stage) / BS EN 1092 PN10 or PN16 drilling would be the next choice. This drilling pattern is not the first choice as it would not be consistent with most of the fittings in Capacity's network (HOLD to be determined by Capacity at detail design stage). The design will aim to have a consistent flange drilling for the same size of flange throughout the tunnel pipework.

An insulated flanged joint is required on the inlet pipe immediately outside the structure to allow cathodic protection to be applied to the inlet pipe without loss of the impressed current into the structure.

#### **7.6 Instrumentation**

##### **7.6.1 Flowmeters**

All flowmeters will be ABB Watermaster 24 V DC as specified in the RFT.

Flowmeters will be full bore as the pipework in the tunnel is already a reduced diameter.

As bidirectional flow could occur, at least 5 x diameter straight length will be provided upstream and downstream of the flowmeters.

##### **7.6.2 Other Instrumentation**

Tappings for pressure indicators and transmitters will be provided.