Appendix B

SKM Proposed CBD Reservoir, Preliminary Investigation - 2004

[REF 1]

Greater Wellington Water
And
Wellington City Council

Proposed Central Business District Reservoir

REPORT ON PRELIMINARY INVESTIGATION

June 2004

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Greater Wellington Water and Wellington City Council

Proposed Central Business District Reservoir

REPORT ON PRELIMINARY INVESTIGATION

June 2004

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Contents

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Executive Summary

Greater Wellington Water and Wellington City Council propose to construct a new potable water reservoir in the vicinity of the existing Bell Road Reservoir in Brooklyn. The reservoir may fulfil three separate functions:

- As a terminal reservoir on the bulk water supply from the Wainuiomata Water Treatment Plant
- As a replacement for the existing Bell Road Reservoir
- As emergency storage for Wellington Hospital in the event of disruption to supply from the current Wellington City reticulation system

The proposed stored capacity is 35 megalitres with a top water level of RL 92 metres to New City Datum.

Sites close to the existing Bell Road Reservoir were included in the study with the nominated likely site being immediately north of the existing reservoir. After on-site investigation taking account of geotechnical, construction, servicing, and cost, an alternative site was identified south of the upper field of Prince of Wales Park with access from the end of Rolleston Street. Both sites are located on town belt and thus would need to be completely buried in order to improve their chances to be granted resource consent.

The estimated cost of the reservoir on the site north of the existing Bell Road reservoir is $10,950,000, and of the reservoir on the site south of the upper field of Prince of Wales Park is $7,600,000. The main differences in the cost for the more expensive option is the need to relocate a 33kV cable, more excavation, and tunnelling for the outlet pipe. Operational aspects of the site were not part of the study.

The investigation concludes that the site immediately south of the upper field of Prince of Wales Park to be the preferred option. It will be very significantly cheaper to construct, and access, both during construction and when the reservoir is in service, is superior to the site north of the existing Bell Road Reservoir.

A third site to the south-east of the existing Bell Road reservoir and to the south-west of the end of Rolleston Street was considered but was rejected because of engineering considerations, and because it would have destroyed an area of substantial regenerating native bush.

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1. Introduction

Greater Wellington Water and Wellington City Council have engaged Sinclair Knight Merz Ltd. to undertake preliminary investigations to determine a suitable site for the proposed 35 megalitre Central Business District Reservoir. The investigation includes determining the maximum volume of storage of up to 35 megalitres that could be placed on the site, along with resource consenting considerations, engineering feasibility, and minimisation of construction cost. The specification for the preliminary investigations, specification N° S2004/10, is attached as Appendix D to this report. Note that costing for reservoirs of less than 35 megalitres has not been included in this report as the desired maximum capacity can be accommodated on both of the sites investigated in detail.

The proposed reservoir may perform three functions:

- As a large terminal reservoir on the bulk water supply from the Wainuiomata Water Treatment Plant
- As a replacement for the existing Bell Road Reservoir
- As emergency storage for Wellington Hospital if the Wellington reticulation system is disrupted

The proposed site for the reservoir is in the vicinity of the existing Bell Road reservoir. The top water level for the reservoir is to be RL 92.00 to New City Datum. There are limited sites available in this area on which to locate such a large reservoir at the appropriate level.

This report identifies two such sites and estimates the likely cost of construction for such a reservoir on each of them. A third site was identified but detailed planning and estimates for that site were not undertaken as the site presents serious engineering restrictions. The report discusses the site selection and characteristics of the two individual sites. A preliminary design for the reservoirs on both sites is costed along with the bulk earthworks, reinstatement after construction, and landscaping. These costs are compared for both the sites and a recommendation is made for the preferred site.

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2. Scope of Preliminary Investigation

Initially Wellington City Council (WCC) proposed that the reservoir site immediately north of the existing Bell Road Reservoir be investigated as the preferred option. The brief was discussed with Greater Wellington Water (GWW) and WCC with a view to confining the investigation to this site but with the scope of shifting the reservoir around the site to optimise size and construction costs. The possibility of some realignment of Bell Road, and of demolishing part of the existing reservoir to optimise reservoir construction has been included as part of the optimisation scope.

Significant relocation of the proposed site was discussed at the initial briefing meeting but emphasis was to be placed on the site immediately north of the existing reservoir. This site is referred to in the remainder of this report as Option A, or Site A. A photomontage of the reservoir on the site is shown in Figure 1. Typical sections of the excavation profiles and completed fill profiles are shown in Figure 3.

During the initial walkover of the site by the project team it was considered that some investigation of the land immediately to the southeast of the existing reservoir should be undertaken. In a subsequent visit to the site for detailed geotechnical investigation the site to the south of the Prince of Wales Park upper field (at the end of Rolleston Street) was identified as possibly being suitable for the reservoir. Detailed investigation of this site has been carried out and is deemed to be a viable alternative to Site A. A photomontage of this site is shown in Figure 2 and is referred to in the remainder of this report as Option B, or Site B. Typical sections of the excavation profiles and completed fill profiles are shown in Figure 4. We note that this site had been considered by WCC in the past for a smaller capacity reservoir.

The site immediately to the south-east of the existing Bell Road Reservoir was discounted during detailed site walkovers for two reasons. The first of these was related to engineering considerations of the steeply sloping site and the prospect of poor foundation soils towards the bottom of the gully that runs up from the end of Rolleston Street. It was also considered that the advanced regenerating native bush would have made obtaining resource consent for this site as unlikely, particularly because burying the reservoir completely on this site would not have been particularly feasible.

Detailed site investigations undertaken on both Sites A and B consisted of:

- Site constraints such as inlet and outlet pipework, hydraulic characteristics, potential storage volume, and an existing electrical high voltage main crossing the site.
- Geotechnical considerations.
- Planning and resource consent considerations.

No	DATE	DRAWN	AMENDMENT
A	30/06/04	KWH	DESIGN REPORT

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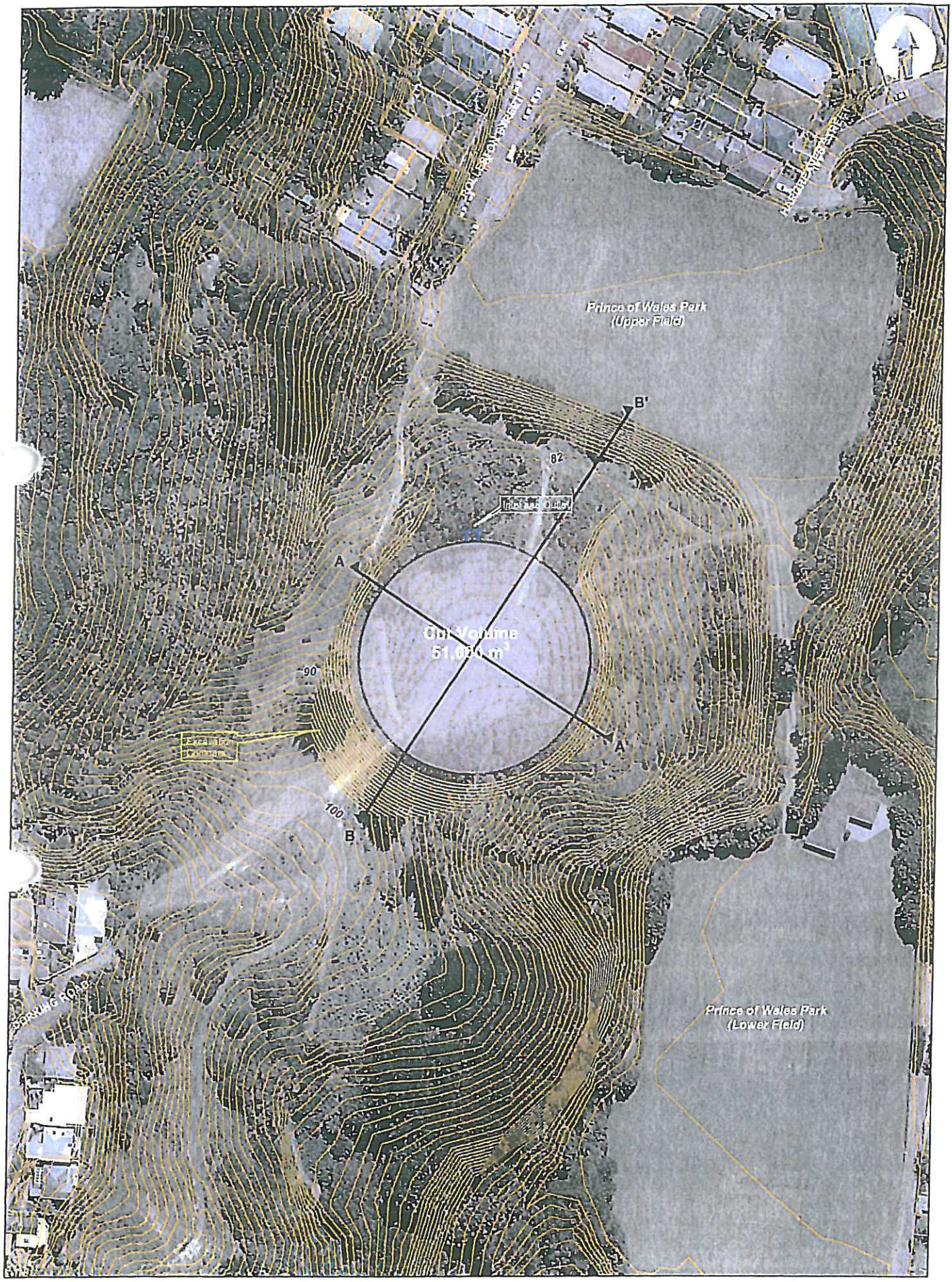
CLIENT: GREATER WELLINGTON WATER / WELLINGTON CITY COUNCIL
PROJECT: CBD RESERVOIR

DRAWN	DATE	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
KWH	JUN 2004	AJOL	
DESIGNED	DESIGN REVIEW		
AJOL	NG		

TITLE: Fig. 1 Reservoir Option A

SCALE @ A3	SKM PROJECT No	DRAWING No	ISSUE
1:1,000	WB00959		A



A	30/06/04	KWH	DESIGN REPORT
No	DATE	DRAWN	AMENDMENT

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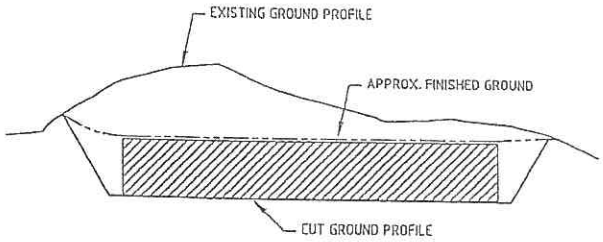
PROJECT	CBD RESERVOIR		
DRAWN: KWH	DATE: JUN 2004	REVIEWED PROJECT MANAGER: AJOL	APPROVED PROJECT DIRECTOR:
DESIGNED: AJOL	DESIGN REVIEW: NG		

TITLE: Fig. 2 Reservoir Option B

SCALE @ A3	SKM PROJECT No	DRAWING No	AMDT
1:1,000	WB00959		A



A-A

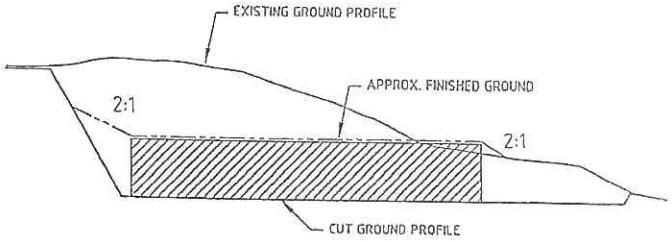


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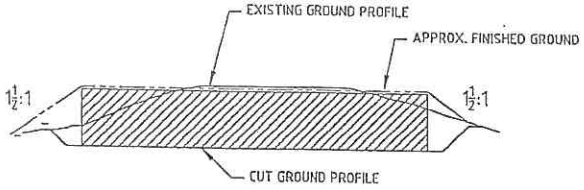
FIG. 3: OPTION A SECTIONS



A-A

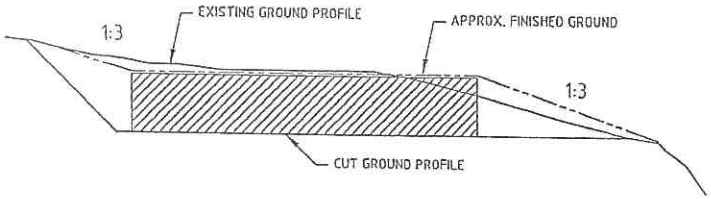


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FIG. 4: OPTION B SECTIONS

No	DATE	DRAFTING CHECK	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	AMENDMENT
A	30/06/04			AJOL		DESIGN REPORT

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CLIENT	GREATER WELLINGTON WATER/WELLINGTON COUNCIL			
PROJECT	CBD RESERVOIR			
DRAWN	DGN	DATE MAY04	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
DESIGNED		DESIGN REVIEW		

TITLE	FIGURES 3 AND 4		
SCALE	SKM PROJECT No	DRAWING No	AMDT
N.T.S.	WB00959		A

PLOT DATE: [1653 30JUN04]
NAME: OPTIONA AND B

- Temporary servicing during construction and permanent access when the reservoir is in service.
- Constructability.
- Costs of construction including costs associated with resource consents and re-routing other services (electrical).

In the next section of this report detailed consideration of each of the above constraints is presented.

In Section 4 of the report an overall comparison of the selected Sites A and B is presented and in Section 5 a recommendation is made on the preferred site.

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3. Identification of Suitable Sites

3.1 General

Brickell Moss carried out a Scheme Option Assessment for Wellington Low Level Zone Water Storage in 1988. Appendix I of that study is attached as Appendix B to this report.

3.2 Site A

Site A as shown in Figure 1 is located immediately north of the existing Bell Road Reservoir. This site was identified as being suitable for a 10 ML circular reservoir in the 1988 Scheme Option Assessment. The site is characterised by a knoll sloping upwards from north to south. The site falls away to Bell Road on the west and to private properties on the east. The existing Bell Road Reservoir roof is at a level of approximately RL 107, being approximately 20 metres higher than the intersection of the Bell Road and Bidwill Street intersection at the north of the site. The site is covered in matured pine trees plus some miscellaneous regenerating native bush.

3.2.1 Site Constraints

The site north of the existing reservoir is only just adequate in area for 35 megalitres of storage. Bidwill Street slopes up steeply from Brooklyn Road to the intersection with Bell Road and then equally steeply slopes down to private sections some 60 metres further on before turning north-east. Bell Road climbs steeply from the intersection with Bidwill Street to the existing Bell Road Reservoir. It is cut in to a steep slope down from the reservoir site to Brooklyn Road. The option of re-routing part of Bell Road to increase the size of the site was briefly investigated but that would require major earthworks and retaining structures. The grade of Bell Road could not get much steeper and to maintain the existing grade would mean it would have to be located closer to Brooklyn Road, hence raising the existing natural ground level considerably immediately to the west of the proposed site.

There are particular functional constraints related to the reservoir site as follows:

- The site must be reasonably accessible for the incoming water main and the outgoing main.
- The top water level is set at RL 92 metres.
- The storage volume requirement is 35 megalitres.
- There are two existing oil filled 33 kV electrical cables running approximately from north to south across Site A that would need to be re-routed if a reservoir was to be constructed.

Part of the existing Bell Road Reservoir could be demolished prior to construction of a new reservoir but the position and height of the existing reservoir add a complication to this site in relation to access. There would also be a disruption to the existing supply and storage during demolition of the existing reservoir.

3.2.2 Geotechnical

Refer to Appendix A for the geological assessment of the site resulting from a surface investigation plus reference to published information. Reference also Appendix B for Appendix I of the 1988 published investigation by Brickell Moss of various sites including Site A.

3.2.3 Resource Consent

The site is located in the town belt and thus it is highly likely that a fully notified resource consent application would be required. There is a commitment by Wellington City Council to fully bury the reservoir so it is not anticipated that obtaining a resource consent would be out of the question. There is some miscellaneous regenerating native bush on the site but not of great significance. The site is generally covered in mature pine trees. There is a walking track across the site but this could temporarily be re-routed during construction and reinstated after construction is completed.

There would be no permanent disruption to domestic neighbours but construction would be relatively noisy with a very significant amount of earthworks required. Dust suppression during construction will be required but dust should not have much effect on neighbours. It is likely that access to existing garages located on reserve land occupied by some of the neighbours would be curtailed which may encourage them to resist the granting of a resource consent.

3.2.4 Servicing and Access

The site is located in an area characterised by narrow winding steep streets. Bidwill Street is steep from Brooklyn Road and there is a restriction on heavy vehicles. Bell Road is narrow and winding although the corners are not excessively sharp. The intersection between Bidwill Street and Bell Road is difficult for long vehicles and would need to be at least temporarily regraded to allow access for long construction vehicles. Access to the site appears to be most appropriate from Brooklyn Road via Washington Avenue and down Bell Road, turning right into Bidwill Street and immediately right on to the site. Exit from the site would be via Bidwill Street directly to Brooklyn Road. There would be sufficient space allowed to the north of the reservoir for vehicle turning, site storage and site accommodation.

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Location of inlet and outlet mains is discussed in the Preliminary Investigation on Inlet and Outlet Pipelines attached as Appendix C. Scour and overflow would be piped to stormwater pipework via Bidwill street or Brooklyn Road. Overflow capacity in surrounding street stormwater systems will need to be investigated in detail during the design report stage of a reservoir on this site.

3.2.5 Construction

To optimise the volume of storage of up to 35 megalitres a reservoir of 67 metres internal diameter and working water depth of 10 metres has been chosen. These dimensions allow cut faces for the excavation for the reservoir construction to be formed without the necessity of soil nailing or rock bolting. The cut faces will extend effectively from the eastern to the western boundaries of the site. This gives the nominal base of the reservoir as RL 82. By excavating to the north-east of the reservoir site out to Bidwill Street a level access for construction can be achieved about half way between the Bell Road intersection and where Bidwill Street turns north-east to run parallel with the rear boundaries of the adjacent domestic properties. In this way reasonable, but certainly not ideal, access to the site for reasonably large vehicles can be achieved. An area for vehicle turning, site storage, and site accommodation is created north-east of the reservoir and level with the nominal base of the reservoir. Refer to Figure 1. Access around the outside of the reservoir during construction has been limited to a 1.5 metre strip which is the bare minimum which can be used for construction.

Access for construction is required for excavation material removal, premixed concrete, concrete pump, and for transport of general construction materials and precast concrete elements. The precast concrete elements required for a reservoir of this size and depth will be up to 11 metres in length. Thus, the access roads for the reservoir construction will be required to accommodate an articulated road transport vehicle. Thus access to the site for the fully laden construction vehicles will be up Brooklyn Road with a sharp left turn into Washington Avenue, a sharp left turn into Heaton Terrace, and down Heaton Terrace and Bell Road to Bidwill Street. There is a sharp right turn from Bell Road into Bidwill Street and from there a sharp right turn into the site. Exit from the site for trucks carrying excavated material, or empty trucks, will be a left turn into Bidwill Street and straight down Bidwill Street to Brooklyn Road with a left or right turn into Brooklyn Road.

All construction work for the reservoir will be from the inside of the reservoir walls. This has been used successfully on other large diameter reservoirs where a mobile crane is located inside the reservoir and works its way outwards as the reservoir is constructed. In this case the exit point for the crane will be to the site storage and access area to the north-east adjacent to Bidwill Street.

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The incorporation of a hopper bottom to reduce the reservoir diameter is not particularly feasible because a hopper bottom does not allow good internal access during construction. Further the outlet pipe and scour can become excessively deep.

Filling the site after the reservoir has been constructed will be initially with relatively small plant because of the narrow gap between the reservoir and the cut face. As this gap widens with increasing depth of fill heavier plant will be able to be used.

There does not appear to be anywhere immediately adjacent to this site where excavated material required for fill after the reservoir is constructed can be stockpiled. There is an open area of park on the other side of Brooklyn Road but there is a serious question whether using this area for some stockpiling would be allowed. Another area for potential stockpiling could be Prince of Wales Park but access to this is rather torturous being down Brooklyn Road to Webb Street and then up Taranaki Street and Wallace Street to Rolleston Street or Hargreaves Street. The distance as the crow flies is very short but the actual distance by road is several kilometres.

A very large amount of fill will be required to cover the reservoir at the end of construction thus a substantial site for stockpiling will be required. An even greater volume of excavated material will be required to be removed and dumped from the site. There are several options for this. One is to take the fill to the local landfill but tipping fees are quite high. Another is to find an area in the vicinity that requires clean fill. There may be some locations in the southern part of the city that require clean fill but this is a timing issue, when the excavation is undertaken the need for fill may not be appropriate for these sites. A further option is for land reclamation being undertaken by Centreport. We understand that Centreport may want clean fill for such a reclamation, as they have some possible reclamation projects but again there is a timing issue. A further option is to fill a gully to the southeast of the existing Bell Road Reservoir. This option is unlikely to be viable because the particular gully in question has substantial regenerated native bush which would make the granting of a resource consent for filling the gully unlikely.

About half of the excavated material will be required for burying the reservoir. For this particular site several million dollars of excavation and filling is likely. The estimated volumes of earthworks are tabulated below, please note that the disposal and backfill items represent bulked volumes, e.g. each 1m³ excavated becomes approx. 1.3m³ for carting away or disposal off site, also for backfilling a shrinkage factor of approx. 1.1 would be evident where for every 1.1m³ of material placed for backfilling a void of 1m³ would be filled due to the compaction of the materials.

Bulk Excavation	109,000m³
Disposal off-site	51,000m³
Backfill	75,000m³

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3.2.6 Costs

We have estimated the cost of constructing a reservoir on this site. The cost is broken down as follows:

▪ Re-routing the 33 kV cable	$ 500,000
▪ Excavation and filling including landscaping	$5,550,000
▪ Reservoir construction including pipework cast into reservoir structure (but excluding the tunnelled outlet main)	$3,300,000
▪ Resource consent application professional fees	$ 100,000
▪ Professional fees excluding resource consent application	$ 300,000
Reservoir construction sub-total	**$9,750.000**
▪ Inlet pipeline from Bidwill/Wallace Streets intersection (excluding connection to existing reticulation)	$ 350,000
▪ Tunnelled outlet pipeline	$ 450,000
▪ Outlet pipeline to Rolleston/Wallace Streets intersection (excluding connection to existing reticulation)	$ 400,000
Pipelines sub-total	**$1,200,000**
Reservoir Sub total brought forward	**$9,750.000**
Total	**$10,950,000**

The budget is based on an estimating accuracy of +25, - 15%.

This gives a cost per litre of storage for the reservoir at Site A of approximately 31 cents per litre. For reservoirs of this size such a unit cost is high, but it should be noted that the earthworks contribute about 16 cents per litre to the total cost. For the reservoir itself including professional fees the unit cost would be close to 11 cents per litre.

The cost of excavation and filling is based on carting the whole of the excavated material off site to stockpile or paying for disposal. Material to be used for filling after construction of the reservoir is assumed to be brought to site from a remote off site stockpile. If a reclamation or site that requires clean fill is available for disposal of excavated material then the excavation cost would be significantly reduced, but the availability of such cost effective disposal is a matter of timing.

The level of the potential saving through the removal of the need to dispose of excavated materials will depend on a number of factors such as the location of the destination and it's proximity to the

reservoir site. Where the distance is such that trucking the excavated materials is required the saving will be limited to the difference in cost between dumping fees and the cost of levelling and compacting the materials in the designated area.

3.3 Site B

The proposed Site B shown in Figure 2 is immediately south of the upper field of Prince of Wales Park at the end of Rolleston Street. This site is about 250 metres south-east of Site A. This site was identified for a 10 ML circular or 20 ML rectangular reservoir in the 1988 Scheme Option Assessment. The site is on elevated ground with a steep bank down to the upper field of Prince of Wales Park and to the south-east another relatively steep slope down to the lower field of Prince of Wales Park. The two fields are connected by a reasonably graded wide access that would be suitable with some minor strengthening for heavy vehicles. The site itself is a ridge running south-west from the upper field. The ridge falls away to the north-west and south-east, and also to the north-east but continues to rise beyond the reservoir site to the south-west. The ridge is currently covered in scrub and gorse with some minor native revegetation. The only significant trees on the site are pine and eucalypts. The site is crossed by at least two walking tracks. One of these tracks is the "City to Sea" track but during construction this track could be easily re-routed to avoid the construction site. Part of the track provides the basis of a relatively good access to the actual site.

The contours of the site mean that the reservoir can be constructed and covered reasonably cost effectively.

3.3.1 Site Constraints

This site presents some flexibility in the depth of the reservoir in relation to its diameter. For the purposes of this preliminary investigation the depth of 10 metres and diameter of 67 metres has been chosen as that is a cost effective proportion for a 35 megalitre reservoir. Within reasonable limits the water depth will not have significant effect on the cost estimate. An 8m water depth will be more difficult to fit on the site from a landscaping point of view because final fill slopes become much steeper. Generally, the site constraints for Site B are relatively minor. The general constraints related to accessibility, top water level, and storage volume are similar to Site A but there is no 33 kV electrical cable crossing the site. The site offers a reasonable excavation profile with a reasonable volume of fill material required to bury the reservoir at completion of construction. Access off Rolleston Street is adequate and wide enough for articulated vehicles. The final reservoir level will not produce excessive depth of pipelines. Further details are given in subsection 3.3.5.

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3.3.2 Geotechnical

Refer to Appendix A for the geological assessment of the site resulting from a surface investigation plus reference to published information. Reference also Appendix B for Appendix I of the 1988 published investigation by Brickell Moss of various sites including site B.

3.3.3 Resource Consent

This site, like Site A, is located in town belt and thus it is also likely that a fully notified resource consent application will be required. It is proposed that the reservoir be buried after construction. Thus it is not anticipated that obtaining a resource consent will be excessively protracted or difficult. The site is covered by scrub and gorse with a few matured trees of mostly pine and eucalypts. There is some regenerating native bush on the site but not of significance. There are several walking tracks crossing the site but these could be easily re-routed during construction and reinstated after completion.

There would be no permanent disruption to domestic neighbours but construction will be relatively noisy with a significant amount of earthworks. The earthworks will not encroach directly on the neighbours and the site is southeast of the nearest neighbours which means that dust should not be a problem to them. During construction dust suppression will be undertaken in the usual manner.

3.3.4 Servicing and Access

The site is located at the end of Rolleston Street which is reasonably wide for access of construction vehicles. A track already exists from the end of Rolleston Street to the site itself which will require some upgrading for construction traffic but the track does form a good starting point for access. Sufficient space will be provided during construction to the north of the site for vehicle turning, site storage, and site accommodation.

Location of inlet and outlet mains is discussed in the Preliminary Investigation on Inlet and Outlet Pipelines attached as Appendix C. Scour and overflow would be piped to stormwater pipework via Rolleston Street. Overflow capacity in surrounding street stormwater systems will need to be investigated in detail during the design report stage of a reservoir on this site.

3.3.5 Construction

Excavation for construction of the reservoir will require some significant batters to the southwest of the site but there is adequate land beyond the immediate reservoir location to allow these batters to be formed without the necessity for soil nailing or other costly retaining. The batters and size of the site are such that a 3 or 4 metre access around the reservoir can be excavated for construction which will aid construction although it is not necessary. Like the reservoir proposed for Site A all

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construction can be undertaken from inside the reservoir space. Like Site A disposal of the excavated material presents some problems.

Again a hopper bottom is an option to reduce the diameter of the reservoir but it does restrict using the inside of the reservoir during construction. A more detailed analysis of the cost/benefit can be made at the design report stage.

The advantages of this site over Site A are that the total excavated volume is less than half of Site A, and access for excavation removal is adequate. The added possible advantage is that stockpiling could be done on the upper field of Prince of Wales Park immediately to the north of the site. Also excavated material could be used to raise the level of either the upper or lower fields of Prince of Wales Park. These parks can become very wet in the winter and the prospect of raising the level by a metre or so of well drained material may be attractive to the Wellington City Council Parks and Gardens. This needs to be investigated once a commitment to this site has been made. If stockpiling on the upper field is allowed this will significantly reduce the cost of construction at Site B. The estimated volumes of earthworks are tabulated below. The estimated volumes of earthworks are tabulated below, please note that the disposal and backfill items represent bulked volumes, e.g. each 1m³ excavated becomes approx. 1.3m³ for carting away or disposal off site, also for backfilling a shrinkage factor of approx. 1.1 would be evident where for every 1.1m³ of material placed for backfilling a void of 1m³ would be filled due to the compaction of the materials.

Bulk Excavation	51,000m³
Disposal off-site	51,000m³
Backfill	13,000m³

3.3.6 Costs

We have estimated the cost of constructing a reservoir on this site. The cost is broken down as follows:

▪ Excavation and filling including landscaping (estimated on the assumption that using Prince of Wales Park for stockpiling or permanent disposal is not an option)	$3,100,000
▪ Reservoir construction including pipework cast into reservoir structure	$3,400,000
▪ Resource consent application professional fees	$100,000
▪ Professional fees excluding resource consent application	$300,000
Reservoir Construction sub-total	**$6,900,000**

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▪ Inlet pipeline from Bidwill/Wallace Streets intersection (excluding connection to existing reticulation)	$350,000
▪ Outlet pipeline to Rolleston/Wallace Streets intersection (excluding connection to existing reticulation)	$350,000
Pipelines sub-total	**$700,000**
Reservoir Sub total brought forward	**$6,900,000**
Total	**$7,600,000**

The budget is based on an estimating accuracy of +25, - 15%.

Backfilling represents $260,000 of the $3.1 million figure in the above table for the excavation and filling of the earthworks. This includes the bulk works and an additional $10,000, over and above the $260,000 but within the $3.1 million is included as a specific allowance for landscaping requirements.

This gives a cost per litre of storage for the 35 ML reservoir at Site B of approximately 22 cents per litre. For a reservoir of this size such a unit cost is relatively high as a consequence of the major excavation and filling requirement. For the reservoir itself including professional fees the unit cost would be close to 11 cents per litre.

The cost of excavation and filling is based on carting the whole of the excavated material off site to stockpile or paying for disposal. Material to be used for filling after construction of the reservoir is assumed to be brought to site from a remote off site stockpile. If a reclamation or site that requires clean fill is available for disposal of excavated material then the excavation cost would be significantly reduced, but the availability of such cost effective disposal is a matter of timing. If the option to fill either one or both fields of Prince of Wales Park, and to use these fields for temporary stockpiles, were available, then the excavation cost would be reduced by approximately $1,100,000. Motor scrapers could be used for the excavation and haul distances would be very short for excavation and filling.

The level of the potential saving through using the excavated materials to regrade areas in close proximity to the site will depend on a number of factors, primarily the location of the area designated to receive the materials. This is likely to come down to the difference between the costs of loading materials from local spoil heaps to trucks and carting away to dump sites, including dump fees and the cost of regrading the designated area.

3.3.7 Amenity Value

The top of the reservoir could be used as an informal play area but it is not big enough for a rugby or similar field. Access hatches also restrict formal sporting activity.

It is understood that a car park in the area is part of the Town Belt Management Plan objectives. The area to the north of the reservoir to be used for construction lay down space could be converted into parking spaces for approximately 15 or so cars but it is some 13 meters above the upper field level. Resource consent to fill the gully to the west of the site for car parking is likely to be difficult to obtain.

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4. Comparison of the two Selected Sites

Table 4.1 below gives a quick reference comparison of the selected sites, being Site A and Site B.

Table 4-1 : Comparison of Site A and Site B

	Site A	Site B
Project Cost	$10,950,000	$7,600,000
Size that can be accommodated on site	35 ML	35 ML
Resource Consent	Notified. Should be obtainable.	Notified. Should be obtainable.
Buried	Fully	Fully
Geotechnical	Good	Good
Difficulty of Construction	Difficult	Less difficult
Site access during construction	Difficult	Straightforward
Site access in service	Restricted	Straightforward
Inlet/Outlet pipelines	Poor access	Reasonable access
Construction restrictions	Noise/dust	Noise/dust
Earthworks	Major	Major but half of Site A
Landscaping	Reasonable	Reasonable
Construction time	21 months	17 months
Specific comparative advantages	None	Likely easier disposal of fill
Specific impediments	Reroute 33kV cable Tunnelling outlet main	None

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5. Recommendation

There are no advantages in construction of a 35 megalitre reservoir on Site A over Site B. Site B is:

- Cheaper
- Has better long-term access
- Will have a reduced construction time.
- May have some spin off advantages to the City related to filling Prince of Wales Park

We therefore recommend Site B as the preferred site for the provision of 35 megalitres of potable water storage for the following three possible functions:

- A terminal reservoir on the bulk water supply from the Wainuiomata Water Treatment Plant.
- A replacement for the existing Bell Road Reservoir.
- Emergency storage for Wellington Hospital.

We recommend that a sum of $7.60M plus contingency be budgeted for construction of the reservoir on Site B. The budget is based on an estimating accuracy of +25, - 15%.

This recommendation excludes consideration of operational issues of the water supply system.

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Appendix A CBD Reservoir – Preliminary Engineering Geological Assessment

SKM

Date 19/05/2004

Author Jon Sickling Project No WB00959

Subject **CBD Reservoir - Preliminary Engineering Geological Assessment**

1. INTRODUCTION

This memorandum presents the findings of a site inspection and engineering geological assessment undertaken on 17 May 2004 for pre-feasibility investigations of a proposed buried concrete reservoir. The reservoir is proposed to have 35Ml storage capacity, and initially is expected to comprise a circular footprint of about 70m diameter and bottom water level of +82m. Three possible sites were initially considered, one of which was deemed unsuitable (the gully site immediately south east of existing Bell Rd Reservoir). The two sites that are considered to have potential are Sites A and B, defined on the attached figure. The inspection comprised a walkover appraisal and field logging of rock exposures.

2. SITE DESCRIPTION

2.1 Site A

Site A is located immediately north east of the existing Bell Road Reservoir, in the Brooklyn Town Belt. The site is on the top of a north-east trending ridge, rising approximately 20-25m above Brooklyn Road to the West and 40-50m above Rolleston Street to the east. The site elevations range between +90 and +109m. The site is vegetated in pine trees and low scrub, and is dissected by a sealed access track. Residential properties form the eastern boundary, while Bidwill Street and Bell Road form the northern and western boundaries respectively. A 33kV cable runs through the eastern portion of the site, presumably coincident with the sealed track. The following photograph shows the site, located with the pine trees above the houses.

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2.2 Site B

Site B is located in the order of 250m to the south east of Site A. The site is located on the hill forming the southern boundary of the Rolleston Street playing fields, part of the Prince of Wales Park. The site is located on a knob-shaped north-east trending ridge spur, truncated to the north by cut and fill earthworks that have formed the playing field. The crest of the knob is located 20-25m above the playing fields, with the range in elevation beneath the possible reservoir footprint between +82 and +94m. The site is vegetated by a line of Pohutukawa Trees on the crest of the cut slope, a few pines and generally gorse scrub and grass. The site is located above the cut slope at the left of the following photograph.

Another view of the site looking from the south-west towards the north-east is provided in the following photograph.

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3. ENGINEERING GEOLOGY

3.1 Regional

The 1:50,000 map 'Geology of the Wellington Area' bublished by GNS (1996) shows the site to be underlain by sandstone dominated lithofacies of the Torlesse Complex, known as Wellington Greywacke. The map shows that the inactive Terrace Fault may cross Site A, and the inactive Lambton Fault may cross Site B. The active Wellington Fault is located 2-2.3km to the north-west. The map indicates several bedding measurements near the general site area. In the vicinity of Site A these are (dip direction / dip) 272/77 and 290/63, and near Site B 318/83.

3.2 Site A

Site mapping of the road and track cut exposures revealed topsoil, slopewash and completely weathered greywacke overlying massive jointed sandstone with several beds of argillite, although the bedding planes were generally indistinguishable.

In the vicinity of the track that crosses the site, it was observed that the soil overburden thickness was usually less than 0.5-1m. In some places a thickness greater than 1m of colluvium was observed, presumably where ancient landslips had filled small gullies. Beneath the soil overburden the rock was observed to be generally highly weathered massive greywacke sandstone, with very close to closely spaced defects and is classed as very weak rock/very stiff soil. Argillite appears to comprise less than 20% of the total material. A predominant defect set, possibly bedding-parallel, was recognised at 140-145/65-90°. The track sides were presumably cut between 60° and vertical, but have been subject to some slumping. The elevations of this exposure are approximately +95 to +102m.

To the west of the site, good rock exposure is available in a cut on Bell Road. Less than 1m of topsoil and slopewash overlie moderately weathered greywacke with some highly weathered zones. Argillite appears to comprise less than 10% of the total material. The exposed rock is fractured with very close to closely spaced defects, and is classed as very weak to weak. A predominant defect set, possibly bedding-parallel, was recognised at 120-140/50-60°. The cut is 3-5m high and is standing at a stable angle of 65-70°. The elevations of this exposure are approximately +96 to +103m.

A rock outcrop exposed on the cut for Brooklyn Road about 30m west of the reservoir indicated slightly to moderately weathered greywacke sandstone, with close to moderately widely spaced defects and is classed as strong to very strong. The elevations of this exposure are approximately +83 to +84m.

3.3 Site B

Poorer quality exposures were available for Site B, due to the absence of road cuts. A cut slope forms the southern boundary of the playing field and this was inspected. The in-situ material was partially obscured by vegetation and slopewash debris. The material was observed to comprise mainly highly weathered greywacke sandstone and argillite in about equal portions. The cut is up to 10m high and appeared to be semi-stable at 55-60°, with instability confined to minor rockfall and falling of undermined overburden.

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No other rock exposures were observed, although the soils exposed in a track on the west side of the site appeared to be residually weathered greywacke soils. An incised north-east trending gully about 30-40m to the west of the site was not inspected in detail, but is likely to contain recent soft alluvium in the floor. This would not impact the proposed site.

4. ENGINEERING IMPLICATIONS FOR DEVELOPMENT

4.1 Summary of Expected Geological Conditions

The general impression gained from the rock exposures is that Sites A is underlain by massive greywacke sandstone, with less than 20% argillite. The rock mass is closely fractured, but distinct bedding plane defects were not observed. It is likely that material to be excavated for the proposed reservoir will comprise highly weathered greywacke at the top grading down to slightly weathered greywacke at founding level.

4.2 Stability of Permanent Slopes

At this stage of investigation there is no reason to consider that either of the proposed sites would have significant long term slope stability issues, assuming that the reservoirs are founded at +82m or similar in weathered greywacke. Small cut slopes (eg road cuts) may fail during extreme storm or earthquake events, but these are likely to be minor in extent and should not affect a buried reservoir.

4.3 Foundation conditions

Ground conditions are likely to be very satisfactory at the proposed reservoir founding levels for either site, and no issues with bearing capacity or excessive settlement are expected.

The possible presence of the inactive faults identified in Section 3.1 should be allowed for during construction. Crush zones or soft gouge may be associated with these faults, which may require partial excavation and concreting.

4.4 Access

Access for siteworks has not been considered in any detail, but it appears that access and associated haulage routes for removal of excess spoil are better for Site B.

4.5 Excavation

Excavation should be relatively straightforward at both sites. There is a higher chance of encountering stronger less fractured material in the lower excavation for Site A, which may require rock breaking equipment. The upper excavation of Site A and most of Site B are expected to be easily rippable with standard equipment.

It is expected that groundwater levels will be low for both sites, and dewatering of excavations due to ground and surface water will be easily managed. Site B may be more preferable in this regard, as a 'pit' excavation may not be required.

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4.6 Stability of Temporary Cut Slopes

There does not appear to be any significant potential for daylighting bedding and associated planar failure mechanisms in the excavation walls.

There may be issues associated with the faults (see Section 3.1), although it is unlikely that these issues could be determined until the excavation is opened up. Depending on the location and orientation of any such faults, local battering and stabilisation may be required.

The following slope batters are recommended for preliminary design of excavations, and reservoir siting. Slope stability will have to be specifically assessed for temporary excavations following detailed geotechnical investigations.

- Overburden Soils: Completely weathered greywacke, colluvium, and loess – 45° (assume 0-1.5m depth)
- Highly weathered greywacke – 50° (assume 1.5-10m depth)
- Moderately weathered greywacke – 60° (assume 10-15m depth)
- Slightly weathered to unweathered greywacke – 75° (assume >20m depth)

In all cases excavation profiles should be benched. Recommended bench profiles are 1.5m wide benches at 6m vertical intervals.

The overburden soils and highly weathered greywacke could be excavated at 80° if shotcrete and soil nailing stabilisation is used. The moderately weathered to unweathered rock may be excavated at 80° if shotcrete or mesh is used in conjunction with rock bolts as required.

While Site A will require either steep and high batters or extensive slope stabilisation/retaining, Site B is likely to require only a benched and battered cut on the upslope side. There is likely to be considerably less risk of temporary cut slope failure at Site B due to the excavation profile.

4.7 Options for Disposal of Excess Spoil

The following might be considered as options for off-site disposal of excess spoil from the excavations:

1) Spread and raise level of playing fields on Prince of Wales Park
2) Airport runway extension works
3) Centreport reclamation works
4) Haulage to landfill

We recommend the first three options be investigated in that order for viability.

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5. PREFERRED SITE

From a geotechnical and construction perspective, the preferred site is clearly Site B. Geologically there is little to distinguish the two sites, except that Site A is likely to encounter less weathered rock and Site B rock comprises a greater portion of argillite.

6. RECOMMENDATIONS

It is recommended that when a decision is made on a preferred site, detailed geotechnical investigations should be undertaken to determine the opportunities and constraints on the development, particularly with respect to excavation stability.

Such an investigation should comprise:

- Minimum of 3 No cored boreholes, to depths of at least 5m below foundation level.
- Laboratory testing on core samples to determine rippability and strength parameters.
- Installation of at least one piezometer, and monitoring of any groundwater levels.
- Exploratory trenching to locate and determine the extent and nature of fault traces.
- Geotechnical interpretative report, including assessment of geotechnical risks and risk control measures.

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Appendix B Appendix I from Wellington Regional Council - Wellington Low Level Zone Water Storage, Scheme Option Assessment, - Preliminary Geological Investigation

APPENDIX I

WELLINGTON REGIONAL COUNCIL

WELLINGTON LOW LEVEL ZONE WATER STORAGE

SCHEME OPTION ASSESSMENT

PRELIMINARY GEOLOGICAL INVESTIGATION

The aim of the preliminary geological investigation is to make an initial assessment of probable foundation conditions and slope stability aspects of each potential site.

1. Salamanca Road

This site is generally located on the west facing slope immediately adjacent to Salamanca Road, and south of the top end of Bolton Street. Presently, the ground surface comprises relatively smooth grassed slopes with a walking track at its base leading down to the Rose Gardens below.

Geologically, this site will be underlain by weathered, insitu rock beneath a variably thick layer of natural soil. The soils have been classified as comprising Paremata silt loam generally formed on partially weathered loess, colluvium or greywacke.

There are no known active faults cutting through this site.

Cut slopes around the north and east of the structure will be required. These cuts presumably will be relatively close to Salamanca Road and, hence, reasonable margins of safety from instability problems will be required. We recommend that for free standing permanent cuts, a slope of 40o (or 1¼ horizontal to 1 vertical) projected up from the toe of the cut face to the outer edge of the road reserve be used as a guide towards maximum cut slopes.

A conventional shallow founded reservoir structure sited upon cut natural ground at this location will, in our opinion, perform satisfactorily.

On fundamental geotechnical grounds, we do not see any major problems associated with siting a reservoir at this location.

2. Charles Plimmer Park

This site is located upon the western slope of Mt Victoria, above and parallel to Shannon Street, off Muellar Street and Palliser Road.

The site comprises sloping ground which is somewhat stepped in profile, with the gently sloping "tread" immediately back in from the private property boundaries off Shannon Street, then rises in a steep slope, the "riser", to another less steep but sloping tread above. This general hill profile is mapped on the 1:50,000 scale late Quartenary Tectonic Map of Wellington as possibly comprising the remnant of a Quartenary stranded shore line.

In "Microzoning for Earthquake Effects, Wellington", D.S.I.R. Bull.213, the site is mapped as comprising indifferentiated insitu rock, i.e. the typical weathered rock condition found around so much of Wellington. A small tongue of Trentham Gravel formation occupies the westernmost corner of the park, extending downslope into the Stafford Street area. West of and downslope from the site, the natural terrain has been mapped as "Rockfall". "Rockfall" describes an area mapped because of its irregular topography where irregularities are not clearly related to regular erosional valley forms. Low angled slopes with near surface rock or highly irregular slopes over short distances may be related to rockfalls.

Generally, "rockfall" areas have been mapped on evidence particularly within excavations where glide planes dipping at low angles (often with a curved form) are encountered. The glide planes usually have fine pug layers. In large rock slides, single masses of "intact" rock may exceed tens of metres across. Adjacent rock masses within such "rockfall" zones often have different rock types and different structural orientation. Surface examination of small rock exposures will seldom yield criteria specifically demonstrating instability and drilling may only furnish very limited useful data.

There appears to be no evidence for the presence of active faulting through or close to this particular site.

Although Charles Plimmer Park is not specifically mapped as within a rockfall area (rather, it is in undifferentiated insitu rock), nevertheless probably its relative closeness to such an area is the reason for Dr B. Riddolls' reference in his report dated 20 December 1980, that the site might require intensive investigation. In reality, the presence of a precise boundary between undifferentiated rock conditions (assumed for general geological purposes as stable) and "rockfall" (which for geological purposes assumed to be of potentially suspect stability) cannot be accurately established.

Substantial subsurface investigation at this site will be required to further examine the site's nature. Appropriate investigation would probably involve both some deep trench excavations aligned at right angles to the contour at the proposed tank location and a number of deep fully cored borings. As a result of such investigation, there is unlikely to be fully conclusive proof that the site is satisfactory. It is possible that a decision to either proceed or otherwise with the site will have to be made on the basis of a lack of specifically identifiable evidence for the site's subsurface rock condition being definitely unsuitable rather than positive and conclusive evidence that it is suitable.

In summary therefore, geologically, the site we suggest can be classified as most probably being acceptable for the engineering purposes of a large storage reservoir, but there does and probably even with the aid of intensive subsurface investigation always will remain a residual element of doubt of its long-term stability, hence its acceptability in the engineering sense.

The use of a siding fill to disguise the western face of a 20 Ml reservoir was considered but is not recommended because:

(a) The concept of a very substantial sized sidling fill (i.e a fill largely constructed parallel to the underlying natural contour) on sloping ground in close proximity to residential development does contain some elements of inherent stability risk. This particularly is

the case in the short term, i.e. during construction and immediate post construction phase, where such large scale earthworks are and always (to a greater or lesser degree) will be vulnerable to stormwater runoff problems. Where, for other reasons (i.e. environmental, etc), topsoil coverage on fill faces is necessary, this material is extremely vulnerable to sheet erosion during storm conditions.

In addition to the above, in the event of a problem of sheet erosion from the fill face forming debris flows down on the adjacent properties, downslope vehicle/machine access for clearance operations is generally poor and in many cases unavailable.

(b) The proposed construction of a substantial filling on the lower, less steep portion of this site will apply a substantial loading on the ground beneath. In the event that the underlying rock comprises undifferentiated insitu rock, then the additional loading is unlikely to have any effect upon the bulk stability of the slope below. In the event however that the lower slopes comprise the upper extension of an ancient "rockfall" mass, then it is possible that the surcharge effect of the fill mass will lower the overall stability of the slopes below.

Conclusion:

From both the geological and engineering aspects, the development of a reservoir at this location is not straightforward. Geologically, there is and may well always remain a residual element of doubt regarding its suitability, and in the engineering sense the scheme has definite unsatisfactory aspects.

Because of the above, the 20 Ml reservoir considered assumed no filling on the western side.

The 10 Ml reservoir, because of its smaller size and the fact that such filling is not proposed, appears feasible although still subject to the required foundation investigation as covered earlier.

3. Prince of Wales Park

Both 10 Ml and 20 Ml reservoir options have been considered on this site.

The site for the reservoir is on top of a ridge which descends in a northeasterly direction from Brooklyn, down towards Hargreaves and Wright Streets below. Presently, the upper playing field on the park (with access onto Rolleston Street) has been constructed by a major cutting across the line of the ridge along the park's southwestern margin and by filling on its outer north and east sides. The base of the proposed cut for the reservoir platform is approximately elevation 85 metres, while the level of the upper playing field is approximately elevation 70.

The reservoir site has been mapped on the 1:25,000 scale Microzoning Report map as comprising undifferentiated rock overlain by Korokoro and Makara Hill soils. Exposed in the cut face forming the southern margin of the playing field below, the natural ground comprises deeply weathered insitu rock. The insitu rock comprises typical alternating beds of siltstone and sandstone sequences, with the former being relatively prominent. The predominent rock structure appears to be near vertical bedding striking SSW into the face. Overlying the insitu rock is a mantle of natural colluvial soils which varies markedly in thickness from 1 metre to nearer 3 metres at the east end of the cut. This colluvial soil comprises gravelly silts and clays.

Since the cut face has been constructed (presumed to have been in the mid-1930s), a number of locallised failures have occurred. This has in effect left the present face at an overall slope of approximately 45° or 1 horizontal on 1 vertical, as an irregular surface. There was, however, no indication of gross or large scale failure apparent.

Some localised failures also appear to have occurred on the high very steep cut batter originally constructed in the northwest corner of the lower playing field, the head of which is situated approximately 45 metres horizontally out from the base of the proposed reservoir. Again, however, this old cutting with its past local failures does not appear to have evidence suggesting larger scale movement.

As judged from surface perusal on site and a study of 1938 vintage aerial photographs over the area, the hillside upon which the tanks are proposed appears to have had a history of relative stability. Some irregular surface features on the slopes suggest the possibility of past relatively shallow surface soil movement (possibly induced by original clearing of bush cover). There was no evidence to suggest deep and/or large scale instability had occurred in the past.

The head of a steep, bush clad local valley is situated close to the southeast quarter of the proposed reservoir site. This valley may contain some surface soils prone to slipping, however the base level and plan position of the reservoir in respect to this feature appears adequate to found well below such soils.

Published maps of the area suggest that there are no known active faults traversing through or in close proximity to the site.

Based upon our assessment of the site, we conclude that the proposed cut platform will be satisfactory for shallow founding the proposed structures. The positioning of the alternative reservoirs are such that they are at an adequate distance from potential instability problems arising from existing cut faces to the north and east of the site. The proposed reservoirs will not surcharge the site beyond its existing state due to the extensive excavations required.

The cut faces proposed at the southwest end of the larger reservoir option may require some flattening over its upper third.

Both reservoir options show a limited amount of fill to limit the visual impact of the structures. We consider the fills to present no real problems provided good engineering practice is followed, namely:

(i) adequate stripping of topsoil and benching of the underlying subsoils

(ii) stormwater control above the fill batters particularly until growth on the fill face is well established.

Our conclusion is that in both geological and foundations engineering aspects, we anticipate no major difficulties associated with this site development. In addition, some small scale modification to the outer perimeter of the upper playing field could feasibly be constructed i.e. a raised earth bund, in order to form an emergency pond in the unlikely event of a significant leakage problem from the reservoir.

4. Government House Vicinity

This site is located on the hillslopes immediately north of Ewart Hospital, Newtown. Two schemes have been proposed, a 10 megalitre round reservoir located more or less on a saddle separating north and south trending drainage paths, close to the Government House grounds, and a 20 megalitre rectangular reservoir located on a platform cut into the west facing hillside.

The locality has been mapped as comprising undifferentiated insitu rock overlain by Makara and Korokoro Hill soils. The valley immediately to the south of the site is mapped as Paremata silt loam overlying insitu rock. Outcrops of weathered rock are exposed in the existing track leading up to the saddle.

There is no known active faulting in the immediate vicinity of the site.

Dr Riddolls in his report dated 20 December 1980, mentions the possibility of an old fault existing within the proposed reservoir site. He suggests that, in the event that it is present on site, it is unlikely to be active but could affect foundation conditions.

In our opinion, if such a fault was encountered on site, it is likely to occur through the prominent saddle upon which the 10 megalitre circular reservoir is proposed to be sited. In our considerable foundation experience around the city, the bearing capacity of even severely faulted rock materials is such that no major obstacles to conventional shallow foundations over such material are anticipated.

It could be argued that, in the event of a major earthquake affecting the city (presumably generated by displacement on nearby Class I Active Faults), that the weaker ground formed by old fault zones could be vulnerable to some sympathetic movement. The probability of such movement response is, at this time, unknown and, hence, the risk of such can only be described as a possibility and, for any one particular site, relatively remote.

The positioning of the 20 megalitre rectangular reservoir completely within cut ground on the hillside will, in our opinion, ensure that the structure is founded on sound ground. No significant difficulties regarding conventional shallow foundations at this site are anticipated.

The proposed cut faces behind both reservoirs appear to be a satisfactorily stable proposition in respect to the proposed slopes as initially designed.

The relatively small volumes of filling proposed for both reservoir options suggests that no significant problem should be encountered. Normal sound earthworks practice regarding stripping topsoil and vegetation prior to cutting horizontal steps into sound underlying subsoils will be required.

In summary, therefore, we see no fundamental reason why this site should not be considered on geotechnical grounds as other than generally suitable for the proposed reservoir siting. Further site investigation however is warranted at this site.

5. Bell Road Site

This proposal involves the construction of a 10 megalitre cylindrical reservoir on the site located at the bottom east side of Bell Road, where

it intersects Bidwell Street, Brooklyn. An existing rectangular low profile storage reservoir is located immediately upslope (south of) this location.

Presently the site comprises a pine covered hillside which slopes gently down to the north.

This area has been geologically mapped as undifferentiated insitu rock overlain by Korokoro Hill soils and Paremata silt loam. As judged from outcrops exposed in roadside cuttings on both the east and west sides of the site, insitu rock (principally greywacke) occur underlying a variably thick layer of natural colluvial soils. These later soils generally comprise firm to stiff gravelly silts and clays. The underlying insitu rock varies markedly in degree of weathering. On the western upslope side, the rock generally appears to be moderately weathered while northward the rock grades highly weathered. On the east side of the site, weathering grades from completely weathered rock over the centre of the site to highly weathered at its north eastern extremity. Over the lower, northern portion of the site, where the cut bank is only of low height, colluvial soil only is exposed.

There is no known active faulting through or in the immediate vicinity of this site.

The proposed scheme involves an initial excavation down to El.85 metres for the reservoir base and backfilling up to El.92 metres and the reservoir then on permanent exposed cut on three sides reaching a maximum height of 16 metres over its southern quadrant. The proposed cut slopes are 1/2 horizontal to 1 vertical with benches leaving an average slope of approximately 50 deg. from the horizontal.

Both from the view of conventional shallow foundations and site stability, we are of the opinion that the proposed scheme is geotechnically satisfactory. There will, however, be some short term risks associated with excavation down to 85 metres (or lower) particularly on the west side where the cut face will be sited right up to the Bell Road carriageway. The temporary cut slope is indicated as being at approximately 1/2 horizontal to 1 vertical. While such a slope in typical Wellington weathered rock conditions is not at all unreasonable for a temporary condition, it may be necessary due to local failures (or risk of same) to anticipate some temporary retention capacity along this road margin. If road closure during the construction phase is possible, then this problem will be largely overcome.

The two variations for the Bell Road option only vary in that one is closer to the NZED cable (eastern side) and the other closer to Bell Road (western side). Thus the above comments apply to either the roadway or to the track beneath which the cables are laid.

Stormwater control during construction should not be a significant problem if normal sound measures are anticipated and taken during construction. The excavation should have no affect on the existing natural side slopes (both east and west) of the site.

In summary, we consider this site to be suitable geotechnically for the proposed reservoir construction.

6. Carmichael Site

A 10 Ml reservoir is proposed for this site located on a cut platform immediately south of an existing 7.5 Ml reservoir. Both circular and

rectangular options are shown on the drawings. The proposed site is on the northern end of a very narrow, steep sided natural ridge line located above the southern termination of Coromandel Street and Crawford Road. The land surface is in pines.

This area of the city is mapped as comprising undifferentiated insitu rock with an overlying of Paremata Silt Loam and Korokoro Hill soils. There are no known active faults through or very close to this site.

The natural ground conditions likely to be encountered beneath the new reservoir site is variably weathered insitu rock with a colluvial soil overlay. Exposed in the substantial cut face at the southern margin of the existing reservoir, massive beds of partially weathered siltstone along with sandstones are exposed. The principal structure within the rock appears to be a strongly developed lineation probably closely parallel with bedding, striking more or less along the line of the ridge, i.e. north/south and dipping at a very steep angle.

We anticipate that sound, hard ground is likely to be encountered beneath the bulk of the site at the proposed base level of the new reservoir and will be suitable for conventional shallow founding. Although the side slopes on this ridge (particularly on the east side) are very steep, providing tight control of stormwater disposal is maintained both during construction and in the longer term of the structure's working life, specific stability problems on the side slopes are considered unlikely under normal working conditions.

We are however not entirely convinced that some potential stability problems will not occur on the east side of the ridge in the event of a major earthquake affecting the city. Providing however that the new reservoir is founded in sound insitu rock around its full perimeter, stability problems on the slopes below are likely to be confined largely to the slopes soil overlay, hence leaving the reservoir unaffected. The rectangular reservoir option enables the eastern edge to be pulled back further from the eastern slopes, thereby maximising the likelihood of sound foundations along that side and minimising any future risk to the reservoir.

The proposed main cut faces on the south side of the new reservoir should present no significant stability problems. Due to the limited fill involved with the alternatives, this is unlikely to present stability problems.

In summary, we see this site as geotechnically being generally suitable for the proposed structure. However, we are conscious of the very steep side slopes to the east which could feasibly be anticipated to undergo some superficial instability in a major seismic event. Founding into sound insitu rock on the eastern side of the reservoir will be necessary. It should be feasible with the rectangular option but some geotechnical investigation should be carried out prior to final detailed design.

7. Alexandra Park

A 20 Ml rectangular reservoir is proposed for this site, fully backfilled and covered with approximately one half metre of soil.

The site of Alexandra Park is immediately north of and above the former Fever Hospital, with access off Alexandra Road. The park has been constructed by part cut - part fill construction forming the present near level playing field. Old aerial photographs of the city indicate that at 1938 the area comprised a relatively wide based but shallow natural valley

extending from the Fever Hospital northward to the top of the ridge. Examination of the park indicates cut faces on its east, north and west sides, with the south end comprising virtually all filling. The fill mass is likely to wedge out towards the northeast corner of the park. Based upon current levels and limited available old contour information, the inferred extent of fill has been shown on the drawing cross sections.

We understand that, in order to obtain the necessary elevation, cutting in excess of 15 metres depth at this site will be required. Excavation to such a depth is likely to bottom out through the deeper portion of the filling and expose natural ground in its base. (Refer the cross sections.) Generally the natural ground exposed should be satisfactory for founding a reservoir with conventional shallow foundations. Insitu rock will form the natural underlying ground, probably with a moderately thick (in the order of 1 to 3 metres) overlay of colluvial soils. No founding problems would be anticipated providing all the old filling and any weak residual underlying soils are removed beneath the reservoir base.

Investigation drilling to determine the above details will be required if this scheme should proceed further.

There are no known active faults in this locality.

8. Scottish Harriers Site

A 10 Ml rectangular reservoir has been suggested on this site. The site is located on a northward decending narrow ridge located immediately above Hutchison Road - approximately opposite (west of) the Winter Show Grounds main car parking area. The site is within town belt and is covered in mature pines and macrocarpa trees.

Geologically, this area is mapped as comprising undifferentiated greywacke rock which will be overlain by varying thickness of natural soils, i.e. Makara Hill soils and Korokoro Hill soils.

A relatively steep cut batter on the west side of Hutchison Road forms the eastern margin of the site.

There appears to be no known active faults in the vicinity of this site.

The narrowness of the ridge and the necessary minimum width of a 10 Ml reservoir means that fill would be required in some areas to provide a level site. This would mean that the reservoir would be founded partly on cut and partly on fill. Although feasible, this method of founding is not normal for reservoirs of this size. Such "hybrid" foundation conditions can lead to marked differences in settlement performance of the structure above. For this reason, we consider that this site is less desirable than most of the others from founding aspects.

9. Torquay Terrace site

A 10 Ml reservoir has been suggested on this site. The site is located on that relatively irregular shaped rising ground situated immediately behind and to the west of Torquay Tce, Newtown. The landform at this location comprises the partially eroded former saddle which forms the main watershed between northward sloping land draining towards Newtown and Te Aro and that land draining south through Berhampore to Island Bay.

The natural ground at this location is mapped as undifferentiated greywacke overlain by Paremata Silt loam and Korokoro Hill soils over its lower eastern portion, and Makara Hill soils over its steeper western margin. Considerable landscaping earthworks appear to have been carried out on portions of these slopes, and this has in part removed much of the soil overlay.

There appears to be no active faulting intersecting this particular site.

Published data does indicate the presence of an inactive fault, possibly striking north north west in the vicinity of the site's westernmost margins. As such, in the event of such a fault being intersected within cut faces for the reservoir site, this is likely only to locally affect cut batter stability and have no other significant detrimental effect on the site's utilisation.

The site does not require major excavation but, as for the Scottish Harriers site, founding levels would necessitate the building up with fill over part of the site. Relocation of the reservoir site slightly to the north-northwest could eliminate the need for founding partially on filling.

10. Macalister Park

Both 20 Ml and 10 Ml reservoir options have been considered for this site. This proposed reservoir site comprises a conical hill located on the southernmost end of the main ridge line comprising Town Belt extending northward parallel with Finnmore Street and Hutchison Road.

The hill, bounded by near level playing fields on its west and south margins, comprises undifferentiated insitu greywacke. The surface of the hill will have a veneer of residual hill soils of the Korokoro - Makara varieties.

Presently, the surface vegetation of the hill comprises a few young trees amidst regenerating gorse and grass. The top of the hill is joined to the main pine covered ridge line northward by a spur with a well defined local gully on its western side and a more regular landform sloping down to the lower playing fields of Macalister Park on the east.

There appears to be no recorded active faulting through or in the general vicinity of this site.

From a geological perspective, this site appears to be suitable for adequately founding a water storage facility. At a probable founding elevation of some 84 metres N.C.D., the cut platform is likely to comprise relatively hard insitu rock over the majority of its area. Natural colluvial soils are likely over the westernmost edge of the platform where it coincides with the main valley. Overexcavation of these subsoils down to underlying insitu rock may be required. As such, we see such modification to the site as being relatively minor, and is not an aspect which significantly affects the site's general geotechnical suitability for siting the various reservoir options.

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Appendix C Central Business District Reservoir – Preliminary Investigation Inlet and Outlet Pipelines

SKM

		Date	29 June 2004
Author	Neil Gillon	Project No	WB00959

Subject **Central Business District Reservoir - Preliminary Investigations**

Inlet & Outlet Pipelines

1. Introduction

In accordance with the brief (Specification No. S2004/10) received from Greater Wellington Water, dated 23 April 2004, I have reviewed the pipeline routes associated with the two possible options for positioning of the proposed reservoir.

The two options considered are as follows:

- North of existing Bell Road Reservoir bounded to the north by Bidwill Street and the west by Bell Road (Site A).
- South east of the existing Bell Road Reservoir immediately to the south of the northern playing field of Prince of Wales Park (Site B).

The review carried out consisted of discussions with Greater Wellington Water staff and examination of pipeline drawings available from Wellington Water Management Limited (Capacity) and Greater Wellington Water.

2. Pipeline Options

The brief requires that the inlet pipeline be fed from the 800 mm main in Wallace Street, which feeds the Macalister Park Reservoir. Outlet mains are required to Rolleston Street, to utilise the Bell Road Reservoir outlet mains, and, additionally, a link is required to the 525 mm cast iron main in Nairn Street. It is expected that the inlet and outlet mains would be approximately 600 mm diameter.

2.1 Site A

Existing Bell Road Reservoir Pipelines:

According to available as-built records, construction of a reservoir at Site A would not interfere with the existing inlet pipelines to the Bell Road Reservoir and therefore this pipework would not need to be diverted during reservoir construction.

Inlet Pipeline:

The preferred route of the pipeline would be from the 800 mm diameter main in Wallace Street via Bidwill Street and Nairn Street Park. As Anderson Terrace is not as busy as Bidwill Street, it would be possible to lay the main in this road. However, the roadway is very narrow and the work would make access to the properties difficult.

Outlet Pipeline:

The bottom of the reservoir will be at approximately 82 m MSL assuming a reservoir depth of 10 m and a diameter of 67 m. The outlet pipeline must not rise above the floor level of the

reservoir. The distance from the reservoir to the 82 m contour line on the route of the Bell Road outlet pipelines is approximately 100 m.

As an alternative to a very deep excavation to lay the outlet pipe, it could be inserted in a pipe sleeve that would be bored from the reservoir site to the 82 m contour. The outlet pipe would then be inserted in the sleeve and the annular space filled with foam concrete with a compressive strength of 1 MPa. The outlet pipe material would be polyethylene PE 100. The maximum working pressure would be 11 m. The pipe should be able to withstand a pressure of 17 m. The minimum SDR (standard dimension ratio) for PE 100 polyethylene pipe is 41 which gives a pressure rating of 4 Bar (approximately 40 m head of water).

It is normal practice to flange the isolating outlet valve to the outlet fitting cast into the reservoir structure. There should not be a coupling between the reservoir and this valve. The reason for this is to ensure that the reservoir can be isolated in the event of the pipeline or coupling failing. This could be achieved by constructing a valve access chamber/shaft forming part of the reservoir structure.

Relative Positions of Inlet and Outlet Pipelines:

The inlet and outlet pipelines would be on opposite sides of the reservoir thus avoiding short-circuiting of the water within the reservoir.

2.2 Site B

Existing Bell Road Reservoir Pipelines:

Construction of the reservoir and pipelines at Site B will not effect the operation of the Bell Road Reservoir or its associated pipelines.

Inlet Pipeline:

The preferred route for the inlet pipeline would be from the 800 mm main in Wallace Street via Rolleston Street.

Outlet Pipeline:

The top end of Rolleston Street is at 70 m MSL, below the bottom level of the reservoir. The outlet pipeline would follow the route of the inlet pipeline from the reservoir to the existing Bell Road Reservoir outlets at the end of Rolleston Street.

Relative Positions of Inlet and Outlet Pipelines:

The inlet and outlet pipelines would connect to the reservoir at the same location. A combined valve chamber could be provided for both pipelines. To avoid short-circuiting of water between these two pipelines, the inlet would extend across the floor of the reservoir as a concrete pipe.

The inlet and outlet pipelines would be laid at standard cover to the edge of Prince of Wales Park and from there they would be installed in a pipe gallery to the reservoir. The length of the pipe gallery would be dependent upon the finished ground levels above the pipelines. A valve chamber would form part of this pipe gallery.

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2.3 Connection to Existing Reticulation

The outlet pipes from the existing Bell Road Reservoir now serve the Bell Road Zone. Details of how the proposed reservoir outlet pipeline will connect to existing reticulation have yet to be determined. A requirement is that it will connect to the Low Level Zone in accordance with the City Council's overall log-term strategy.

Connection to the 525 mm main in Nairn Street could be via a new main from the reservoir outlet pipeline. For both possible reservoir site locations, a possible route for this connection would be via Rolleston Street, Wallace Street, Bidwill Street, Anderson Terrace and Nairn Street Park. As stated previously, work in Anderson Terrace would limit access. An alternative route for the pipeline is via Hankey Street to Nairn Street. This alternative is the shortest route but would require the main to be laid up two very steep inclines.

3. Recommendation

The preferred reservoir site with respect to the pipelines would be Site B. With this option the pipes will not be as deep as for Site A and the lengths of pipelines to connection points would be shorter. The inlet and outlet valves can be installed within a single chamber, forming part of a pipe gallery, and would thus provide better accessibility. This option also provides a shorter pipeline route if a direct connection to the hospital is required.

Neil Gillon
Senior Water Engineer

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Appendix D Specification N° S2004/1D : Proposed Central Business District Reservoir – Preliminary Investigations, Stage 1 – Brief to Consultants

greater WELLINGTON
THE REGIONAL COUNCIL

SPECIFICATION NO. **S2004/10**

TITLE **Proposed Central Business District Reservoir - Preliminary Investigations, Stage 1 - Brief to Consultants**

DATE **21 April 2004**

FILE NO. **B/19/04/05**

1. Background

Wellington City Council (WCC) owns and operates the Bell Road Reservoir, with a capacity of 9 ML. It is scheduled for replacement in the next few years.

As part of the emergency preparedness and response of water supply authorities following a major earthquake, it has been identified that the supply of water to Wellington Hospital to meet its needs after an earthquake would be almost impossible.

Greater Wellington Water (GWW) has in its programme the construction of a large terminal reservoir on the supply from Wainuiomata to Wellington.

The common needs of these three authorities suggest that a combined reservoir project could be advantage to all parties.

2. Objective

This brief is for a preliminary assessment of the preferred site, along with an assessment of the maximum amount of water that could be economically stored and expected costs.

3. Liaison

Although both WCC and GWW will fund this investigation, the engagement will be with GWW.

Liaison during the period of the commission will be with John L Morrison of GWW and Mike Prasad on behalf of WCC.

4. Site Location

The proposed site is on Town Belt, just north of the existing Bell Road Reservoir. The site is bounded by Bell Road on the west, Bidwill Street on the north, and properties fronting on Rolleston Street on the east. The existing Bell Road Reservoir (Top Water Level 105.8 m) could be demolished prior to

construction of the new reservoir and replaced with a small tank. If demolished, the existing reservoir site would be available as part of the construction area.

A contour plan of the site is attached and this plan is available in PDF format.

Access to the site is expected to be from Bidwill Street and Bell Road. Note that it may be possible to close Bell Road for the duration of the construction and, if necessary, relocate it on a permanent basis.

5. Reservoir Size and Function

The preferred volume for the reservoir is 35 ML, which at an 8 m water depth gives a diameter of about 75 m. The water depth could be made greater if it is economically feasible. Ideally the reservoir should be fully buried, with reinstated landforms and planting to the requirements of WCC Parks and Gardens. Any part of the reservoir that is not buried must be able to be adequately screened by planting. The Top Water Level will be 92 m NCD.

The reservoir will be filled by connection from the 800 mm main in Wallace Street, which feeds to the Macalister Park Reservoir. The inlet main route will be either up Bidwill Street, Anderson Terrace, and Naim Street Park parallel to Bidwill Street, or via Rolleston Street. This latter route may require a very long tunnel to the reservoir. Outlet mains will be required to Rolleston Street, to utilise the Bell Road Reservoir outlets, as well as a link to the Brooklyn Road 525 mm main. There may also be a possible dedicated outlet main to the hospital. The routes of these pipelines will require further investigations and would be carried out as a separate exercise.

6. Form of Structure

It is envisaged that the structure will incorporate precast walls but be based on pseudo *in situ* construction and be post tensioned. Because there may be a significant amount of fill on the roof, larger vertical loads are expected. Precast beams, wall columns and roof structure are expected. In addition, there will be a valve chamber with controls. Because the associated pipework will be at least 600 mm diameter, sufficient space must be provided.

7. Scope of Commission

This commission is for carrying out the following tasks:

- Preliminary geotechnical assessment of the site but not including any subsurface investigation.
- Determination of the optimum location for the reservoir, taking into

account site constraints, such as but not limited to:

- Realigning the roads
- Purchasing additional land
- Decommissioning the Bell Road Reservoir, so as to increase the available land
- Reshaping the whole area to WCC Parks and Gardens' requirements

- Determination of the maximum capacity, determined by site conditions, if the desired 35 ML is not achievable.

- Estimate of construction costs for a range of capacities. Note that the disposal of surplus material will impact on this item. Options should be given for local disposal on an adjacent park and to move all totally off-site, less amounts required for backfilling. Where the optimum location involves realigning the roads, these costs should be given separately.

8. Programme

Three copies of the draft report are required by 28 May 2004 and three final copies by 11 June 2004.

9. Terms of Engagement

The terms of engagement will be in accordance with the *Conditions of Contract for Consultancy Services (CCS)*, February 2002.

10. Basis of Fees

Because the scope of the work is not clearly defined, the commission will be carried out on a hourly rate basis.

The submission must include an estimate of the total fee, including disbursements, as well as chargeout rates for staff who will be engaged on this project. Details of relevant experience of your staff should also be included.