IPENZ Engineering Heritage Register Report

Morton Dam, Wainuiomata

Written by: Karen Astwood and Helena Botes
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Morton Dam, *circa* 1924. Wellington City Archives, Lantern Slides of the Wellington Water Works, 00125:0:15.

Contents

A. General information

Name: Morton Dam

Alternative names: Morton's Dam, Morton Buttress Dam, Solomon's Knob Dam, Wainui Dam, Wainui-o-mata Dam, Wainuiomata Dam.

Location:

Reservoir Road

Wainuiomata

Lower Hutt

Geo-reference: -41.2629, 174.9956.

Legal description: Unknown

Map courtesy of GoogleMaps

Access information:

Access is restricted – permission to enter this area must be obtained from Greater Wellington Regional Council.

City/District Council: Hutt City Council

IPENZ category: Civil (Civil)

Date registered: 30 August 2016

Other IPENZ recognition: N/A

Other heritage recognition:

- *Heritage New Zealand, New Zealand Heritage List/Rārangi Kōrero*: N/A
- *Local Authority District Plan*: N/A
- *Other:* New Zealand Archaeological Association Site Recording Scheme, R27/416.

B. Description

Summary

Constructed between 1908 and 1911, the Morton Dam is located in the Wainuiomata River water catchment. Upon completion it was named after William Hobbard Morton (1866–1923), the Wellington City Engineer who designed this reinforced concrete flat slab buttress dam.

In 1878 Wellington became the first municipality in New Zealand to have a public water supply dam. However, by the early 20th century the existing Karori and Wainuiomata supplies were insufficient. The Karori supply was expanded when Morton's Upper Karori Dam was completed in 1908. While this was being built, further Wainuiomata extensions were getting underway with the Morton Dam's design during 1907 and 1908. This well-publicised construction project at Solomon's Knob was undertaken by local contractors Martin, Hurrell and Snaddon, beginning in late 1908. They finished work in September 1911 and at the celebration of the structure's completion it was named the Morton Dam in recognition of Morton's achievements. The Morton Dam was eventually decommissioned in 1988 because of concerns about its seismic performance, spillway capacity and reservoir silt levels.

The Morton Dam is 128 metres (m) long and 17 m high, ranking it among New Zealand's largest early concrete dams. Its buttresses form a line of open-fronted cells, interrupted by a spillway towards the west end. The upstream side of the dam features an inclining wall. There seems to have been little alteration to the structure until it was decommissioned. The Morton Dam's engineering heritage value was considered in the decision to retain the majority of the structure and only remove a western section to allow the Wainuiomata River to revert to a pre-dam flow position. This structure forms an impressive monument to Morton's distinguished career.

Morton was an important early 20th century engineer and the Morton Dam has special engineering heritage significance because it was the first and largest of only two reinforced concrete buttress dams to be built in New Zealand. An Ambursen-type dam was a bold choice for the Morton Dam and it was one of the largest of this type in the world at the time of its completion.

Historical narrative

Wellington became New Zealand's capital in 1865, prompting population growth and the need for increased infrastructure, such as water supply and waste water systems essential for maintaining public health. During this period Wellington was characterised by timber buildings and a good water supply was also important for firefighting purposes.[1]

The completion of the Lower Karori Dam and associated works in early 1878 created Wellington's first public water supply scheme. However, demand for water quickly outstripped supply, due to some dry summers, the capital city's population growth and greater usage than anticipated. This resulted in citywide water shortages.[2] James Daniel Baird (1840–1908), Wellington's City Surveyor and Engineer from 1878, investigated and recommended the Wainuiomata River catchment, in the hills on the opposite side of Wellington harbour, as a good option. The catchment's main advantage was average rainfall 700 millimetres more than those already supplying the city. Baird suggested building a dam across the Wainuiomata River, creating about 1.5 kilometres (km) of tunnels and installing over 20 kms of pipeline around the harbour to carry the water to Wellington. Wellington City Corporation then initiated the process of obtaining the necessary 3,400 hectares of land.[3] As per Baird's recommendations, construction on this first Wainuiomata dam began in 1880 and was completed in January 1884. A week later the dam sustained damage during a flood, meaning that regular supply began in mid-1884.[4]

By the late 1890s Wellington's water supply was overtaxed and restrictions were imposed.[5] The water supply question was also topical within the wider region. During this period, councils at proximity to the Wainuiomata catchment were also trying to source water. For example, in the early 20th century the Petone Borough Council

[1] Chris Maclean, 'Wellington region - From town to city: 1865–1899,' *Te Ara - the Encyclopedia of New Zealand*, updated 21 August 2014, http://www.TeAra.govt.nz/en/wellington-region/page-8.

[2] P. Cooke, *Our Water History on Tap: Water Supply in the Wellington Region, 1867–2006* (Wellington: Greater Wellington Regional Council, 2007), 8–9. URL: http://www.gw.govt.nz/assets/Our-Environment/Water-Supply/PDFs/Our-water-history-on-tap-complete-document.pdf (accessed 27 August 2015). S. Morrison, *History of Water Supply in the Wellington Region, 1872–1985* (Wellington: Wellington Regional Council, 1986), 1.

[3] Frederick Furkert, *Early New Zealand Engineers* (Wellington: Reed, 1953), 102. Cooke, *Our Water History on Tap*, 9. 'Water supply extension,' *Evening Post*, 18 May 1878, 2.

[4] 'The damage to the Wainui Waterworks,' *Evening Post*, 24 January 1884, 2. *Evening Post*, 24 June 1884, 2.

[5] Cooke, *Our Water History on Tap*, 13.

constructed the upper Korokoro Stream Dam (1903) and Lower Hutt Borough did the same on the Belmont Stream.[6]

In 1900 Richard Septimus Rounthwaite (1854–1932), Wellington's newly appointed City Engineer, was asked to investigate a way to rectify the water supply problem. He was scathing of Wellingtonians' over-indulgence when it came to water, describing usage as "enormous as compared with that of any other city or town within my knowledge."[7] In addition to metering usage, he proposed building new dams on the Wainuiomata River and also at Karori.[8] The dams and associated works had an estimated cost of £230,000. Ratepayers ultimately rejected the proposal to raise the necessary loan – a main reason being the cost of the improvements.[9]

William Hobbard Morton (1866–1923) succeeded Rounthwaite as City Engineer in 1904. He recognised the benefits of Rounthwaite's proposal for the Wainuiomata River and wider waterworks extension plans. However, he was arguably more strategic in his approach to getting the requisite ratepayer support. Morton recommended the water be piped as far as Melrose, one of the new hilltop suburbs in the western borough of Wellington. With residents along the route backing the scheme, ratepayers were now prepared to support the council's moves to obtain a significant loan for the project. Morton's plan included dams at Karori and Wainuiomata, new mains, as well as the instalment of pumping stations to serve hilltop suburbs such as Brooklyn, Kelburn, Melrose, Roseneath and Wadestown.[10]

Morton had a strong grounding in municipal activities, working as Assistant City Engineer in his hometown of Melbourne, Australia before getting the Wellington position. His achievements as Wellington's City Engineer were not limited to the Upper Karori and Morton Dams, which he designed. Morton was heavily involved in projects such as the crematorium at Karori Cemetery, reportedly the first built in the Southern Hemisphere, and proposals for a water supply scheme at the Orongorongo River, east of the Wainuiomata catchment.[11] He also made valuable contributions to

[6] Karen Astwood and Penelope Baines, 'Korokoro Stream Dams,' IPENZ, updated 14 March 2014, https://ipenz.nz/home/news-and-publications/news-article/korokoro-stream-dams.

[7] 'Our Water Supply,' *Evening Post*, 1 June 1900, 2.

[8] ibid.

[9] 'The City Water Supply,' *Evening Post*, 25 February 1902, 2. 'The City Water Supply,' *Evening Post*, 19 April 1902, 4. 'The Waterworks Extension Scheme,' *Evening Post*, 9 May 1902, 5.

[10] Cooke, *Our Water History on Tap*, 14.

[11] Karen Astwood, 'William Hobbard Morton (1866–1923),' IPENZ, updated 2 March 2015, https://ipenz.nz/home/news-and-publications/news-article/william-hobbard-morton. Geoff Mew and Blyss Wagstaff, 'Karori Crematorium and Chapel,' Heritage New Zealand, accessed 17 February 2016, http://www.heritage.org.nz/the-list/details/1399. 'Orongorongo Water', *Evening Post*, 9 April 1915, 8.

Wellington as the General Manager of Tramways during his tenure as City Engineer. The Tramways Committee called him a "man of great capacity and ability and…of inestimable value to the city."[12] When he died in 1923 it was said Wellington "had lost one of its most valuable citizens."[13] His impact was acknowledged in July 1933 with the installation of a memorial plaque in the Town Hall's vestibule on the tenth anniversary of his death.[14] At the unveiling Mayor Thomas Charles Atkinson Hislop (1888–1965) stated that:

> To carry the heavy responsibilities of his various offices effectively required the highest degree of technical ability, of untiring energy, resolution, integrity, and tact. Under all these tests Mr. Morton emerged triumphant.[15]

Morton was also an early member of the New Zealand Society of Civil Engineers and served the profession in his role as the Society's Honorary Secretary from 1920 up until a few months before his death.[16]

Morton's department was considering the practicalities of the Wainuiomata waterworks extension by mid-1907, although construction was to wait until the Karori works were complete. The plans and specifications for constructing the dam at Solomon's Knob were being prepared by March 1908.[17] The new dam was upstream of the 1880s one and designed to take over its functions. Positioning the new dam at a higher level also increased water pressure to the city. The level of interest in the project is perhaps reflected by the printing of an artists impression and section drawings of the dam in the *Dominion* during October 1908.[18] At the end of October Martin, Hurrell, and Snaddon's tender of £46,424 was accepted and they began construction work the following month on Morton's reinforced concrete buttress dam.[19]

Martin, Hurrell and Snaddon were a Wellington-based building contracting company. James Barry Martin (1861?–1931) and Albert Ernest Hurrell (1865–1939) formed a

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[12] Valuable Services', *Evening Post*, 13 June 1922, 4.

[13] 'Late City Engineer', *Evening Post*, 29 June 1923, 8.

[14] 'Late Mr. W. H. Morton', *Evening Post*, 12 April 1933, 9. The plaque reads: Erected by fellow officers in the memory of William Hobbard Morton City Engineer, Wellington 1904–1923 The elements so mixed in him that Nature might stand up and say to all the world – This is a man!

[15] 'Tablet unveiled,' *Evening Post*, 27 June 1933, 5.

[16] The Society was established in early 1914 and Morton was elected a member in September of that year. *Proceedings of the New Zealand Society of Civil Engineers 1920–1921* (Wellington: New Zealand Society of Civil Engineers, 1921), 3. 'Obituary', *Proceedings of the New Zealand Society of Civil Engineers 1922–1923* (Wellington: New Zealand Society of Civil Engineers, 1923), 235.

[17] 'The City's Works,' *Evening Post*, 8 July 1907, 8. 'The Water Supply,' *Evening Post*, 4 March 1908, 2.

[18] *Dominion*, 23 October 1908, 8.

[19] 'Solomon's Knob Dam', *Evening Post*, 30 October 1908, 8. 'Municipal Works,' *Evening Post*, 12 November 1908, 7.

carpentry and building contracting company around 1905 and were joined by George Snaddon (1860–1952) soon after. Snaddon formerly had a plumbing business.[20] Several early tenders were unsuccessful, such as for some Public Trust Office Building and Central Public Library work in 1906, and at Parliament Buildings the next year.[21] However, in 1907 they won the contract to construct George Winder's warehouse on the corner of Cuba and Manners streets, which later became known as the James Smith and Sons' Building.[22] Martin, Hurrell and Snaddon seems to have been a reasonably short lived venture, only lasting until 1912 or 1913.[23]

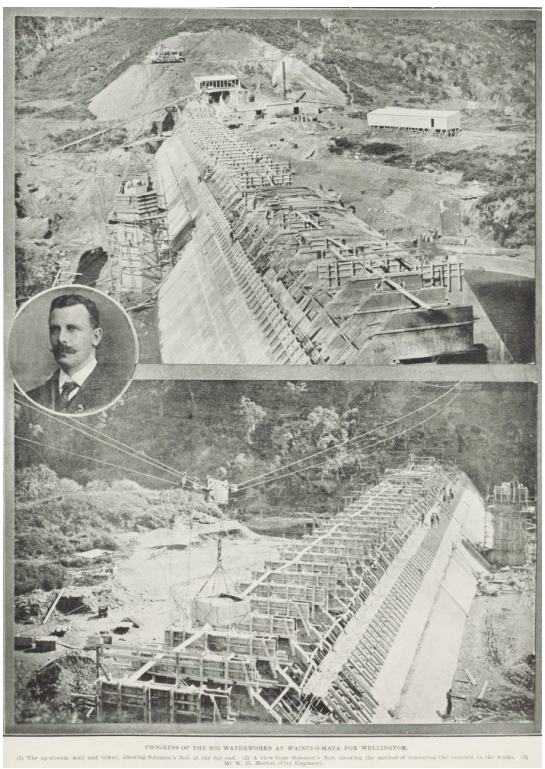

Figure 1: Progress of the big waterworks at Wainui-o-mata for Wellington. *New Zealand Graphic*, 14 September 1910, 17. Sir George Grey Special Collections, Auckland Libraries, NZG-19100914-17-1.

The portrait insert is of Morton.

Martin, Hurrell and Snaddon had approximately 70 labourers working at the Solomon's Knob site. The work camp known as 'Navvy Town' was located about

[20] *Stones' Wellington, Hawke's Bay and Taranaki commercial, municipal, and general directory and New Zealand annual* (Dunedin: Stone, Son and Co., 1905), 751. 'Snaddon, George,' *The Cyclopedia of New Zealand [Wellington Provincial District*] (Wellington: Cyclopedia Company Limited, 1897), accessed 16 February 2016, http://nzetc.victoria.ac.nz/tm/scholarly/name-429015.html. *Stones' Wellington, Hawke's Bay and Taranaki commercial, municipal, and general directory and New Zealand annual* (Dunedin: Stone, Son and Co., 1903), 788.

[21] *Progress*, 1 December 1906, 44. *Nelson Evening Mail*, 27 December 1906, 2. *Taranaki Herald*, 21 May 1907, 7.

[22] *Progress*, 1 December 1906, 44. *Evening Post*, 29 April 1909, 3. Michael Kelly, 'Art Deco Heritage Trail', Wellington City Council, URL: http://wellington.govt.nz/recreation/enjoy-the-outdoors/walks-and-walkways/across-the-city/art-deco-heritage-trail/james-smith-building (accessed October 27 2015).

[23] It appears that the last *Stones'* directory entry for the company is in the 1912–1913 edition: *Stones' Wellington, Hawke's Bay and Taranaki commercial, municipal, and general directory and New Zealand annual* (Dunedin: Stone, Son and Co., 1913), 1017. Some of the company's machinery and other equipment was for sale in March 1912. *Evening Post*, 16 March 1912, 8.

three km from the end of the Wainuiomata River valley, where the materials receiving shed was. The majority of the labourers lived in the camp's collection of huts and tents. Large workshops and sheds were also built.[24] Hurrell lived onsite for three years and was commended for his commitment to overseeing the project.[25]

Initial works included creating a tramline from the receiving shed and removing the spur that was Solomon's Knob. Foundation work was well progressed by August 1909.[26] An aerial rope-way was used during the dam's construction to transport materials across the valley. In September 1910 council members inspected the dam's progress. Despite an estimated completion date of Christmas, at that stage the up-stream wall still required work (see Figure 1) and foundation problems caused delays.[27] However, by September the following year the structure was finished and Morton expected the reservoir would be filled by the end of that month (see Figure 2).[28]

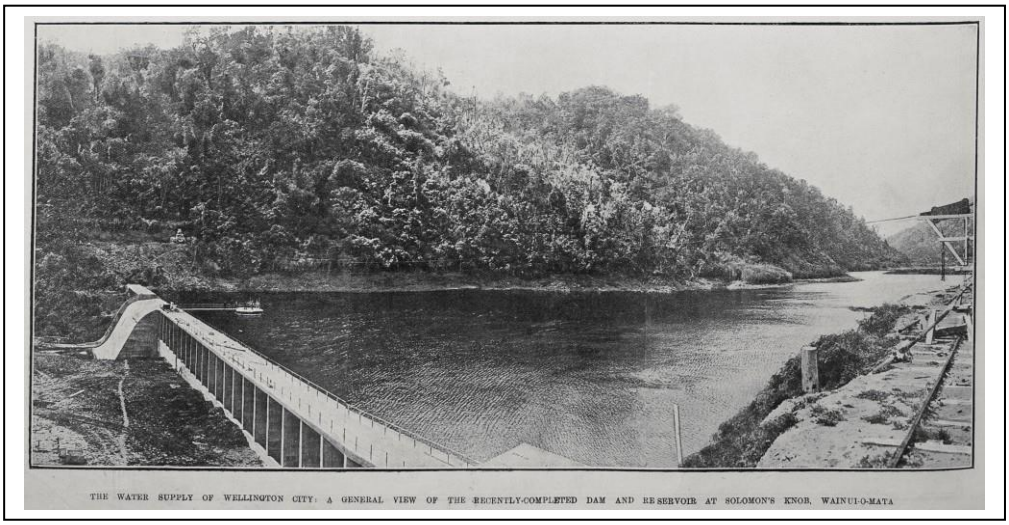

Figure 2: The water supply of Wellington city: a general view of the recently-completed dam and reservoir at Solomon's Knob, Wainui-o-mata. *Auckland Weekly News*, 9 November 1911, 14. Sir George Grey Special Collections, Auckland Libraries, AWNS-19111109-14-4.

Another group from the council, including Mayor Thomas Mason Wilford (1870–1939) and engineering staff, journeyed to the site in November of 1911. They viewed the newly completed dam before enjoying afternoon tea by the reservoir lake. The mayor was appreciative of the dam's ample water supply. He also offered his congratulations to Morton and the contractors, going on to say:

[24] 'A Day's Excursion,' *Evening Post,* 25 August 1909, 3.

[25] 'At Solomon's Knob', *Dominion*, 14 November 1911, 5.

[26] 'A Day's Excursion,' *Evening Post,* 25 August 1909, 3.

[27] 'The New Dam', *Evening Post*, 21 September 1910, 2.

[28] *Evening Post*, 16 September 1911, 4.

> The men who carry out important works in this country are soon forgotten. The public has only a short memory as far as the inauguration of new schemes is concerned. There is nothing to perpetuate the name of those who carry out such schemes. I think we should do what I propose. We should be prepared to call the dam in the future the Morton dam, as a compliment to Mr. Morton, and a token of our appreciation of his work.

He then added it was "the least the council could do."[29] The Mayor's suggestion was applauded.[30] This seems to have been enough for the name to be adopted into common use.[31] In response, Morton praised his staff and noted he was happy with the finished product: "I think it will be a lasting job."[32]

The associated duplicate water main from Gracefield to Wellington was completed in December 1912.[33] However, Wellington soon experienced its three driest years on record up to that time. People were warned to be conscientious with water use and the Morton Dam and reservoir's size was criticised.[34] As a result further expansion of the waterworks was considered. An Orongorongo River scheme proposed in 1915 was revisited in 1919 and 1920. Only a weir and intake was required on the Orongorongo River and an additional pipeline because Morton decided to gravity feed the water directly to the lower Karori reservoir. This scheme was completed in 1926. When further water storage plans were considered in 1928 City Engineer George Adam Hart (1870?–1948) stated that there was little promise in expanding either the Wainuiomata or Orongorongo schemes. Instead, the city would look to the Hutt River for more water.[35]

After almost 70 years in service, the Morton Dam's future came into question. A range of water supply sources, such as the Waiwhetu aquifer at Waterloo and lakes at Te Marua, Upper Hutt, more than compensated for the Morton Dam's storage capacity. Furthermore, the risk to Wainuiomata residents and others if the dam failed in an earthquake, the spillway's limited flood capacity, as well as silt levels in the reservoir and other issues, meant the Morton Dam was not considered a good back-up water supply source.[36] Therefore in 1987 Wellington Regional Council, who had

[29] 'At Solomon's Knob', *Dominion*, 14 November 1911, 5.

[30] ibid.

[31] 'City's First Need,' *Evening Post*, 9 January 1912, 2. For example, there was no formal Council motion reported in the local newspapers. From 14 November 1911 the dam was most frequently termed 'Morton Dam' in the *Evening Post* and *Dominion* newspaper articles, significantly more so than the alternatives: Solomon's Knob Dam, Wainui Dam, and Wainui-o-mata Dam.

[32] 'The Morton Dam', *Evening Post*, 14 November 1911, 4.

[33] 'City Water Supply,' *Evening Post*, 2 April 1912, 2. 'A Year of Civic Progress,' *Dominion*, 17 December 1912, 8.

[34] 'Our Water Supply', *Dominion*, 20 January 1917, 12.

[35] Cooke, *Our Water History on Tap*, 16–17, 19.

[36] John Morrison, attachment in email message to Karen Astwood, 18 April 2016, 5, 11. IPENZ.

managed the asset since 1980, looked at its options for decommissioning the dam. A report was produced that put forward a range of ideas from the removal of the entire dam to just modifying the spillway.[37]

The report's main recommendation was the removal of a section of the dam. The option of demolishing the entire structure was rejected for cost and practical reasons but also with some consideration for its engineering heritage values. By removing a section, the majority of the dam remained intact and an indication of the spillway's original form would remain, but the river could resume its pre-dam flow and the identified potential structural risks would be negated.[38] The removal works were carried out and the dam was officially decommissioned in 1988. A few years later, Geoffrey Thornton noted that "[i]n spite of its redundancy it joins the ranks of abandoned technological monuments which contribute to the country's heritage of industrial archaeology."[39]

Figure 3: The Morton Dam's remaining spillway section and artificial rapids, September 2015. IPENZ.

[37] Ibid., 34. Kate Zwartz, email message to Karen Astwood, 25 April 2016. IPENZ. The Wellington Regional Water Board took over the Wellington City Council's bulk water supply assets in 1973. The Wellington Regional Council then took over the Board's functions and assets in 1980. John Morrison, attachment in email message to Karen Astwood, 11.

[38] J Duggan, 'Environmental Impact Assessment: Morton Dam Low Level Spillway and River Intakes Wainuiomata Catchment', Wellington Regional Council (1986), 2, 4, 8. John Morrison, attachment in email message to Karen Astwood, 5.

[39] Geoffrey Thornton, *Cast in Concrete: Concrete construction in New Zealand, 1850–1939* (Auckland: Reed, 1996) 128.

Social narrative

Clean water supply is a fundamental facility for any population, especially when it comes to maintaining appropriate levels of public health in urban centres. Therefore, water supply systems were developed from relatively early in New Zealand's history, starting in Dunedin with the Ross Creek water supply in 1867 and Wellington followed with its municipal Karori supply in 1878.[40] Correspondingly, as populations and industrial demand grew so did the need to expand water supply systems, often polarising ratepayers because of the significant cost to local councils.[41] However, with the addition of the Wainuiomata catchment to the capital's system in late 1911 Wellingtonians had confidence the city would retain its reputation as "the cleanest [and heathiest] city in the Southern Hemisphere."[42]

The Morton Dam was the main component in the capital city's third expansion of its original municipal system. The dam was an important feature of the water supply system, in particular for those living in Wellington's developing hill-top suburbs.[43] It was anticipated with the addition of the Morton Dam's reservoir to the existing water supply system there would be adequate supply for a population of approximately 75,000. This was generous at the time of the dam's completion to compensate for future growth.[44] By 1946 other sources had been added into Wellington's system to cater for the population of 123,750 served by the municipal supply. This was New Zealand's second largest system at the time, with Auckland being the largest.[45]

Visits to the Wainuiomata Morton Dam site proved to be a popular outing for Wellington City councillors. Under "the flimsy guise of an inspection,"[46] the mayor and councillors, along with their families, would make annual Wainuiomata trips. Since the pretext of the visits was to examine the waterworks, the Morton Dam was always looked at closely and the visits usually also consisted of speeches, lunch, bush walks and blackberry picking in what was considered "one of the loveliest valleys

[40] Robert E. Offer, *Walls for Water: Pioneer dam building in New Zealand* (Palmerston North: Dunmore, 1997), 21. Christine Dann, 'Sewage, water and waste - Dirt and disease,' *Te Ara - the Encyclopedia of New Zealand*, updated 13 July 2012, http://www.TeAra.govt.nz/en/sewage-water-and-waste/page-2.

[41] Offer, *Walls for Water*, 22.

[42] 'The Morton Dam,' *Evening Post*, 14 November 1911, 4.

[43] Cooke, *Our Water History on Tap*, 14.

[44] 'The Cry for Water,' *Evening Post*, 19 April 1902, 2.

[45] 'Municipal water supply and sewerage data,' *New Zealand Engineering*, Vol. 2:12 (December 1947), 1250.

[46] 'Over The Hill', *Evening Post*, 18 February 1915, 2.

imaginable."[47] These 'inspections' halted around 1924, resuming again in February 1930.[48]

Officials were keen not to create too much public interest in the picturesque site because access was prohibited.[49] This measure was meant to limit water pollution, but the strict rules surrounding access were a point of contention for those wishing to fish or camp in the area.[50] Despite its decommissioning, the Morton Dam is still within the restricted access water catchment area managed by Greater Wellington Regional Council. The council organises a small number of walking tours every year, visiting the Morton Dam and area beyond.[51]

[47] Quote from 'Over The Hill', *Evening Post*, 18 February 1915, 2. 'City Water,' *Evening Post*, 10 March 1921, 6.

[48] 'At Wainui', *Evening Post*, 13 February 1930, 10.

[49] See: 'Over The Hill', *Evening Post*, 18 February 1915, 2. *Evening Post*, 22 December 1939, 5.

[50] 'Forest Reserves', *Evening Post*, 18 July 1927, 10.

[51] 'Park-Specific Management and Policies Wainuiomata Recreation Area,' Greater Wellington Regional Council, 93. http://www.gw.govt.nz/assets/Parks-and-Recreation/Parks-Network-Strategy/10-Wainuiomata-Recreation.pdf (accessed 27 September 2015).

Physical narrative

The Morton Dam formerly contained the Wainuiomata River and is located next to Reservoir Road in the restricted area of Wainuiomata Water Collection Area in Lower Hutt. To the structure's immediate west is a bush-clad hillside and regenerated trees and scrub come up to the dam wall in the former reservoir basin.[52] There may be features associated with the dam's construction and operations in the surrounding area, such as remnants of the aerial ropeway used in its construction.[53] The main buttress wall and remaining spillway section provides an impressive feature behind lawn at the entrance to the Greater Wellington Regional Council's water treatment plant and carpark.

Figure 4: View of the Morton Dam from entrance to the water treatments station's carpark, September 2015. IPENZ.

Context

Early medium to large scale dam building in New Zealand, like Wellington's Lower Karori Dam (1878), featured puddled clay core techniques. In line with contemporary developments in Britain and the United States of America (USA), in the early 1900s concrete dams were introduced and came into popular use around New Zealand for

[52] The regeneration of the bush on the former lake floor is greater than was anticipated when the dam was decommissioned. John Morrison, attachment in email message to Karen Astwood, 15.

[53] Kate Zwartz, email message to Karen Astwood.

large-scale water supply, irrigation and hydro-electricity dams, with structures such as Nelson's Brook Dam (1904).[54] Some examples of gravity and arch types similar in scale to the Morton Dam's length of 128 m and height of 17 m include the following dams: Upper Karori (1908), Waitakere (1910), Manorburn (1917) and Arapuni (1930).[55] Later hydro-electric dams, such as Karapiro (1947), Roxburgh (1950) and Clyde (1990) were substantially larger with lengths ranging between 335 and 490 m and heights between 67 and 102 m.[56] From the mid-20th century rolled earth dams superseded concrete gravity and arch structures as the most common type for new dams, with some notable examples including the series of Hunua Ranges water supply dams in Auckland (constructed 1950–1977) and North Otago's Benmore power station's dam (1965).[57]

Contemporary with the development of concrete gravity and arch dams were reinforced concrete buttress dams in the USA. Buttress dams date back to Roman times. The potential of modern concrete buttress dams only began being explored in earnest at the turn of the 20th century. The two main types of buttress dams are multiple arch and flat slab. The idea for the first reinforced concrete flat slab buttress dam is attributed to Norwegian-American engineer Nils Fredrick Ambursen (1876–1958) who patented his design in 1903.[58] By the 1920s this was the predominant buttress dam type.[59]

The Morton Dam is an Ambursen-type dam. Ambursen's company, Ambursen Hydraulic Construction Company of Boston, quickly became buttress dam specialists. They were involved in the construction of 22 between 1904 and 1908, across a

[54] Offer, *Walls for Water*, 40–43. The earliest known mass concrete gravity dams are the Korokoro Stream dams, Wellington, constructed in 1903 and 1904. Astwood and Baines, 'Korokoro Stream Dams,' IPENZ. The Brook Dam was a larger scale concrete gravity dam, measuring 94 m in length and 12 m high.

[55] Karen Astwood, 'New Zealand large concrete dams,' unpublished research list, IPENZ, 8 March 2016. "Similar scale" is defined here as dams 100–175 metres in length and 15–65 metres high. The completion date of each structure is in brackets.

[56] ibid.

[57] Norman Firth, 'Hunua Ranges Water Supply Rolled Earth Dams,' IPENZ, updated 10 February 2015, https://ipenz.nz/home/news-and-publications/news-article/hunua-ranges-water-supply-rolled-earth-dams. 'Benmore Power Station,' IPENZ, updated 19 August 2015, https://ipenz.nz/home/news-and-publications/news-article/benmore-power-station.

[58] D Jackson, *Building the Ultimate Dam: John S. Eastwood and the Control of Water in the West* (Oklahoma: University of Oklahoma 2005), 31. 'Dam US 734796 A,' Google Patents, accessed 15 March 2016, http://www.google.com/patents/US734796.

[59] James Sutherland et. al. (ed.), *Historic Concrete: Background to Appraisal* (London: Thomas Telford, 2001), 351.

number of the USA's western states as well as in Ontario, Canada.[60] Many of these structures were relatively small scale compared with their concrete gravity dam counterparts, with heights ranging from 3 to 12 m. However, taller structures followed, such as the La Prele Dam, Wyoming (completed 1909), which was 109 m long and 41 m high.[61] The longest of these early structures appear to be the Warrior Ridge Dam in Pennsylvania (1906) at 114 m in length and the Ellsworth Dam in Maine (1907–1908) at 152 m long.[62] Therefore, in 1907 and 1908 when the Morton Dam was being planned, its scale placed it among the largest for this type of dam in the world.

Like most New Zealand engineers during this period Morton would have primarily relied on technical journals, professional body proceedings and imported books to keep up-to-date with international engineering developments.[63] For example, the fifth edition of Edward Wegmann's book on dams, produced in 1908, was updated to include information on Ambursen's buttress dams, including general descriptions, diagrams and some specifications.[64] It is unknown whether Morton saw this particular publication. However, newspaper comments made by Morton suggest he made an effort to be well-versed in the latest international engineering and municipal developments and issues.[65] It is thought that it was through this flow of international engineering literature that Morton became aware of developments in concrete flat slab buttress dams and designed one for the Wainuiomata catchment.

There were many benefits propounded in relation to Ambursen-type dams. These included greater stability in flood situations compared with "ordinary masonry dams," adaptability to a variety of standard kinds of foundation, no upward water pressure on the dam's base, and the type's internal access that was useful for inspections. Perhaps the most attractive features were the relatively rapid construction phase and

[60] Edward Wegmann, *The Design and Construction of Dams…* (New York: John Wiley and Sons, 1908), 210. These include structures in Illinois, Kentucky, Maryland, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island and Vermont. 'At Solomon's Knob', *Dominion*, 14 November 1911, 5.

[61] Wegmann, *The Design and Construction of Dams*, 210. 'La Prele Dam,' Structurae, accessed 16 March 2016, https://structurae.net/structures/la-prele-dam.

[62] Wegmann, *The Design and Construction of Dams*, 219. *The Ellsworth Dam on the Union River at Ellsworth Maine* (Boston: Ambursen Hydraulic Construction Company, 1908), 2. Available from Internet Archive, accessed 16 March 2016, https://archive.org/details/ellsworthdamonun00amburich.

[63] William Newnham, *Learning Service Achievement: Fifty years of engineering in New Zealand* (Wellington: New Zealand Institution of Engineers, 1971), 20. Morton was an Associate Member of Britain's Institution of Civil Engineers from 1905 so should have had access to their proceedings and other publications. 'Obituary', *Proceedings of the New Zealand Society of Civil Engineers, 1922–23*, 235.

[64] Wegmann, *The Design and Construction of Dams*.

[65] For example: 'The fire risk,' *Dominion*, 30 June 1909, 4; and 'Fishy water,' *Dominion*, 22 February 1915, 6.

materials costs savings.[66] The reduction in the quantity of concrete materials was highlighted in relation to the Morton Dam. It was estimated that the Upper Karori gravity dam used about 1,200 cubic metres (m^3) of concrete. In contrast the Morton Dam, which is similar scale, required around 900 m^3 of concrete due to its reinforced concrete buttress design.[67]

Soon after completion the Morton Dam was described as "unique in Australasia."[68] By the 1920s there were approximately 200 examples of this type around the world and they were still being constructed in the mid-20th century. However, in contrast to concrete gravity dams, Ambursen-type and other reinforced concrete buttress dams did not catch on in New Zealand and are said to have only enjoyed "temporary popularity" worldwide. A draw-back of the type was that increasing labour costs soon began to out-weigh any materials cost savings.[69] Also, especially pertinent in the New Zealand context, another "disadvantage, at least where earthquakes occur, is the lack of lateral stability of the buttresses."[70]

Morton Dam's features

The Morton Dam was an innovative type in the early 20th century, a fact recognised in media reports about its construction.[71] This reinforced concrete structure was described as being "like an athlete in high training, not an ounce of superfluous fat on him, but one complete whole of strongly linked muscles, sinews and nerves".[72]

Construction began in late 1908 and a year later the foundations were complete. The dam originally consisted of 46 buttresses, with horizontal and vertical steel reinforcing throughout the superstructure, as well as some in the foundations. The buttresses, approximately 60 cm thick, are spaced 3 m apart, creating cells open at the front but enclosed by the 45 degree angle upstream wall, which tapers in thickness slightly toward the top. The buttresses have openings for the dam's internal walkway.[73] These are typical features associated with flat slab buttresses dams, as published in Wegmann's book.[74] There was some settlement of the structure during construction

[66] Wegmann, *The Design and Construction of Dams*, 212.

[67] The New Dam', *Evening Post*, 21 September 1910, 2.

[68] 'Wainui visited,' *Evening Post*, 11 February 1914, 3.

[69] Sutherland et. al., *Historic Concrete*, 351.

[70] Offer, *Walls for Water,* 68.

[71] For example, the design was described as: "in the forefront of modern engineering…" in 'The New Dam,' *Evening Post*, 21 September 1910, 2.

[72] 'The New Dam,' *Evening Post*, 21 September 1910, 2.

[73] 'Solomon's Knob Dam,' *Dominion*, 23 October 1908, 8. 'The New Dam,' *Evening Post*, 21 September 1910, 2.

[74] Wegmann, *The Design and Construction of Dams*, 210–12.

because of inconsistent ground conditions. This caused some cracking that was sealed with additional concrete slabs.[75]

The dam's deck, which is about 4 m wide, was originally flat with metal hand-rails attached on each side of its length (see Figure 2).[76] However, in 1940 a 30 centimetre high concrete parapet was formed around the reservoir-side handrail posts (see Figure 5). This slight addition to the Morton Dam's height was a response to a near over-topping of the structure the previous year. The force of the flood waters damaged the concrete apron at the base of the spillway and this was repaired. Works were also completed at the Lower Karori Dam as a result of the same "exceptional" late 1939 heavy rain events.[77]

Figure 5: View along the Morton Dam's deck, towards the valve tower (middle right of image), September 2015. IPENZ.

The Morton Dam was decommissioned in 1988. To release the water and the related pressure on the structure, approximately half of the Morton Dam's 33 m wide spillway and several buttress sections from the west side were removed.[78] The wall ends were then finished with pre-cast concrete panels. The cut in the dam wall sections and spillway stopped several metres above normal stream level. Therefore, the decommissioning project included creating artificial rapids (see Figure 3). Some of the demolition concrete, topped with large boulders, was used to create this gradual

[75] Offer, *Walls for Water,* 68.

[76] 'Solomon's Knob Dam,' *Dominion*, 23 October 1908, 8.

[77] 'More Water', *Evening Post*, 21 November 1940, 13. Quote from *Evening Post*, 22 December 1939, 5.

[78] Offer, *Walls for Water,* 68. Duggan, '*Environmental Impact Assessment,* 8.

decline for the water.[79] The decommissioning also involved removing the strainer house and spillway cushion.[80] The valve tower's concrete shaft, located near the spillway, was revealed when the reservoir was drained. The tower's access bridge was probably removed at this time. However, piping and external evidence of its mechanisms have been left in place.

Comparative analysis

The Upper Karori Dam, constructed between 1906 and 1908 and also designed by Morton, is recognised as one of New Zealand's first large scale concrete gravity dams.[81] The other notable contemporary of the Morton Dam is Auckland's Waitakere Dam, another concrete gravity dam that was constructed between 1906 and 1910.[82] Both these structures are several metres taller than the Morton Dam and the Waitakere Dam is longer at 175 m. However, at the time the Morton Dam was constructed these types of structures were said to be the "old style of dam".[83] Compared with these types of structures the Morton Dam was "utterly different from all our preconceived notions of what a dam should be."[84]

Described as "the great dam at Wainui,"[85] opinion around the time of the Morton Dam's construction and completion rated it as the City Engineer's greatest engineering achievement, often comparing it with the Upper Karori Dam to emphasise the point. For example, while the Upper Karori Dam was recognised as representing a more traditional dam type "in its modern perfection,"[86] the Morton Dam was held up as "a greater piece of engineering, for instance, than the Karori dam…".[87]

In 1921 the only other reinforced concrete buttress dam in New Zealand, the Upper Nihotupu Auxiliary Dam, was completed in Auckland's Waitakere Ranges.[88] Demand

[79] John Morrison, email message to Karen Astwood, 27 April 2016. IPENZ.

[80] John Morrison, attachment in email message to Karen Astwood, 5, 22. The strainer house was not an original feature. Its purpose was to remove floating organic material from the water.

[81] Karen Astwood and Georgina Fell, 'Karori Water Supply Dams and Reservoirs,' IPENZ, updated 20 September 2012, https://ipenz.nz/home/news-and-publications/news-article/karori-water-supply-dams-and-reservoirs.

[82] John La Roche and Karen Astwood, 'Waitakere Ranges Water Supply System,' IPENZ Engineering Heritage Register Report (17 August 2011), 8, 24.

[83] 'Solomon's Knob Dam,' *Dominion*, 23 October 1908, 8.

[84] 'The New Dam,' *Evening Post*, 21 September 1910, 2.

[85] 'To-day and to-morrow,' *Evening Post*, 21 January 1913, 13.

[86] 'Solomon's Knob Dam,' *Dominion*, 23 October 1908, 8.

[87] 'The New Dam,' *Evening Post*, 21 September 1910, 2.

[88] Offer notes that, while the Morton and Upper Nihotupu were the only reinforced concrete buttress dams, there were smaller scale gated water control structures that also used this construction type, such as the Kawarau Falls

and slow progress at the Upper Nihotupu Dam put pressure on the council to come up with a cost-effective and reasonably quick solution, which seems to have been the reason behind choosing an Ambursen-type dam for the auxiliary structure.[89] To expedite additional water storage, James Tyler (1878?–1953), the Assistant City Engineer, designed an auxiliary dam similar in form to the Morton Dam, but smaller in scale at 84 long and 11 m high.[90]

Waitakere Dam remains in service, unlike the other structures. The water level behind the Upper Karori Dam was lowered as part of its decommissioning but the structure did not undergo any significant changes.[91] The Nihotupu Auxiliary Dam has also been decommissioned. This occurred in 1986 when two channels, several metres high and wide, were created through the dam's wall.[92] Therefore, the Morton Dam has undergone the most structural alteration of this group of dams because of the removal of sections of its wall and spillway. However, the dam's original form substantively remains, providing sufficient evidence for the Morton Dam's importance in New Zealand's engineering history.

Key physical dates

November 1908	Morton Dam's construction begins.
Late 1909	Foundations complete.
September 1911	Construction complete.
1912	Duplicate water main complete.
1940	Spillway apron flood damage repaired and parapet added.
1988	Dam decommissioned. Part of the spillway and several cell sections are removed.

Dam (1926). Offer, *Walls for Water*. 68. 'Kawarau Falls Dam,' IPENZ Engineering Heritage, accessed 9 March 2016, http://www.ipenz.org.nz/heritage/itemdetail.cfm?itemid=397.

[89] Offer, *Walls for Water*, 70. 'Water supply problems,' *New Zealand Herald*, 20 December 1919, 10.

[90] Matthews & Matthews Architects, 'Upper Nihotupu Auxiliary Dam heritage assessment,' Auckland City Council (2004), 15.

[91] Astwood and Fell, 'Karori Water Supply Dams and Reservoirs,' 21. John Morrison, attachment in email message to Karen Astwood, 20.

[92] Matthews & Matthews Architects, 'Upper Nihotupu Auxiliary Dam heritage assessment,' 25.

C. Assessment of significance

Constructed between late 1908 and 1911, the Morton Dam in Wainuiomata has historic and social significance because for most of the 20th century it was an important component in the water system supplying essential services to Wellington, New Zealand's capital city.

This structure has engineering importance because it is a reasonably early large scale New Zealand concrete dam. The Morton Dam has special engineering significance as a rare example of a New Zealand reinforced concrete flat slab buttress dam, which was among the largest of this type in the world at the time it was designed.

The Morton Dam was named upon its completion in honour of its designer, Wellington City Engineer William Hobbard Morton, who was one of New Zealand's concrete dam pioneers. He was an important early 20th century New Zealand engineer, especially celebrated for his wide-ranging contribution to the capital city's infrastructure. The Morton Dam is the outstanding example of the application of Morton's cutting-edge engineering knowledge.

Therefore, the Morton Dam is of sufficient engineering heritage significance to merit inclusion of the IPENZ Engineering Heritage Register.

D. Supporting information

List of supporting information

N/A

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