LOCH KATRINE WATER SUPPLY TO GLASGOW, SCOTLAND, 1855-1903

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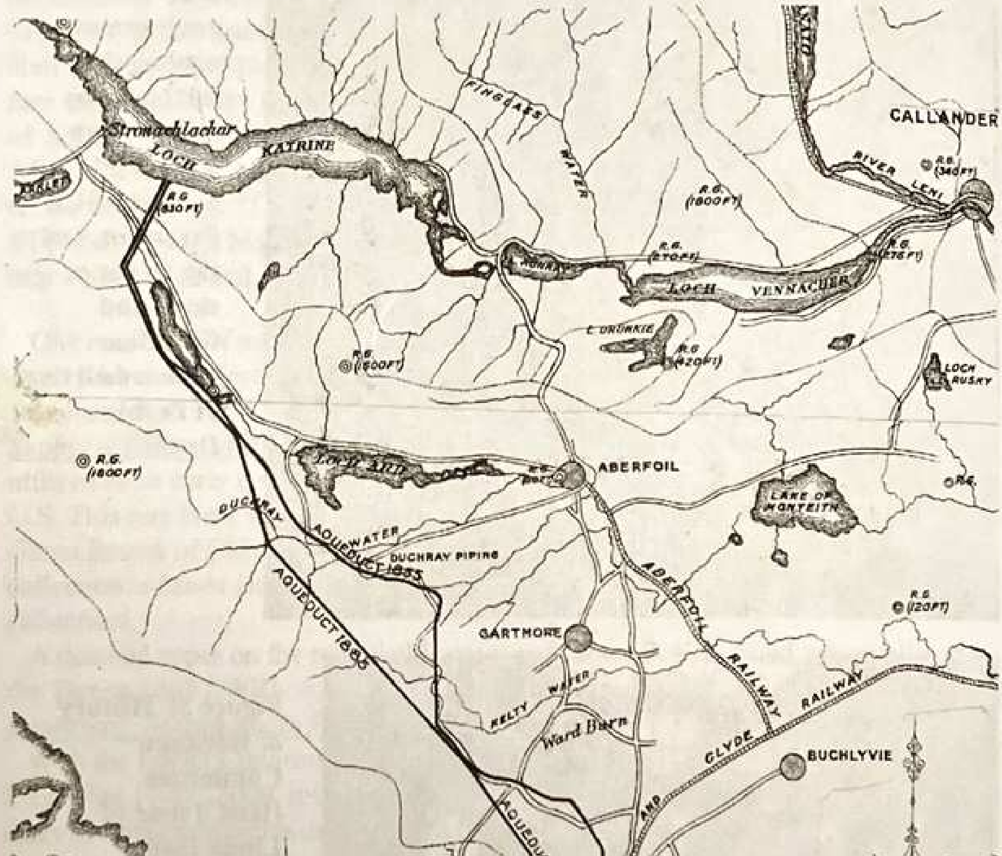

Figure 1. Loch Katrine Waterworks – North end and 1855 and 1885 aqueducts[1]

It was not until Loch Katrine was harnessed that a plentiful supply of water was obtained for Glasgow from one of the largest waterworks ever constructed either in

ancient or modern times. It was designed and constructed under the direction of the leading water engineer of the day, J.F la Trobe Bateman.

The idea of bringing in water to the city by gravity from Loch Katrine, some 35 miles [56 km] away with a catchment area of 22,800 acres [9231 ha] was suggested by Professor Lewis Gordon CE as early as 1846, but revived and developed by Dr J. Macquorn Rankine and J. Thomas CE in 1852.

Late in 1852 Bateman was brought in to review the various possibilities for improving Glasgow's water supply. In 1853 he reported that raising Loch Katrine's natural level only 4 ft [1.2 m] by means of a small dam, and providing a draw-off 3 ft [0.9 m] below the natural outlet, use could be made of the top 7 ft [2.1 m] of water, to supply 50 mgd [million gallons a day - 227,300 m^3d] to the city by gravity. He advised that 'no other source' than Loch Katrine 'will meet all the requirements of the case'. This view was supported by R. Stephenson and I.K. Brunel in 1854.

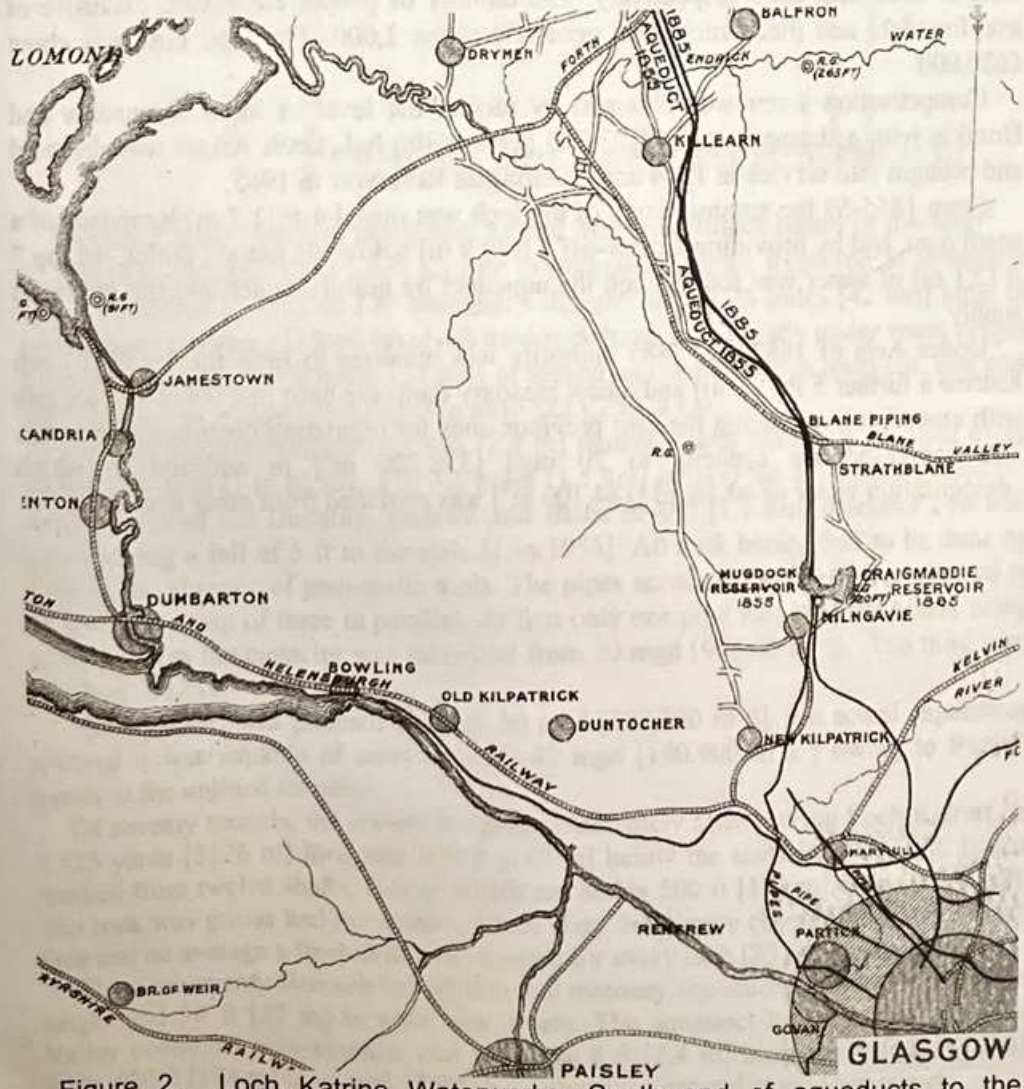

Figure 2. Loch Katrine Waterworks. South end of aqueducts to the Mugdock and Craigmaddie reservoirs servicing the city

The project was approved and Bateman designed and constructed the works as built. J.M. Gale made a key contribution as resident engineer for the rearrangement and redistribution of the pipe-work within the city.

The scheme when opened by Queen Victoria at Loch Katrine on 14th October 1859, had all the hall marks of engineering genius - a plentiful high quality water supply at relatively low cost. The royal party embarked on the 'Rob Roy' at the steamboat pier at the east end of the loch and sailed about five miles to a landing platform opposite the mouth of the tunnel where they stepped ashore. Under a decorative canopy Her Majesty then operated a small handle which opened the sluices admitting water to the inlet basins and tunnel "amid the booming of cannon and the applause of thousands of spectators".[2]

The works, including the first and second aqueducts from Loch Katrine to the new Mugdock and, later, Craigmaddie reservoirs at Milngavie, were constructed under Acts of 1855 and 1885 respectively. The number of people employed, exclusive of iron-founders and mechanics, was generally about 3,000. The total cost was about £630,000.

Compensation water was obtained by raising the level of lochs Vennacher and Drunkie with a drainage area of 23,000 acres [9308 ha]. Loch Arklet was dammed and brought into service in 1914 and Glenfinglas Reservoir in 1965.

From 1855-59 the summer level of the loch was raised 4 ft [1.2 m] by means of a small dam, and by providing a draw-off 3 ft [0.9 m] below the natural outlet, the top 7 ft [2.1 m] of water was fed through the aqueduct by gravity to achieve the promised supply.

Under Acts of 1883 and 1885 authority was obtained to raise the level of Loch Katrine a further 5 ft [1.5 m] and a new masonry dam was built just below the old one with nine sluices replacing the four previous ones for regulating compensation water. This increased the capacity to 70 mgd [318,200 m^3] in addition to which compensation water of 40.5mgd [184,100 m^3] was provided from other sources.

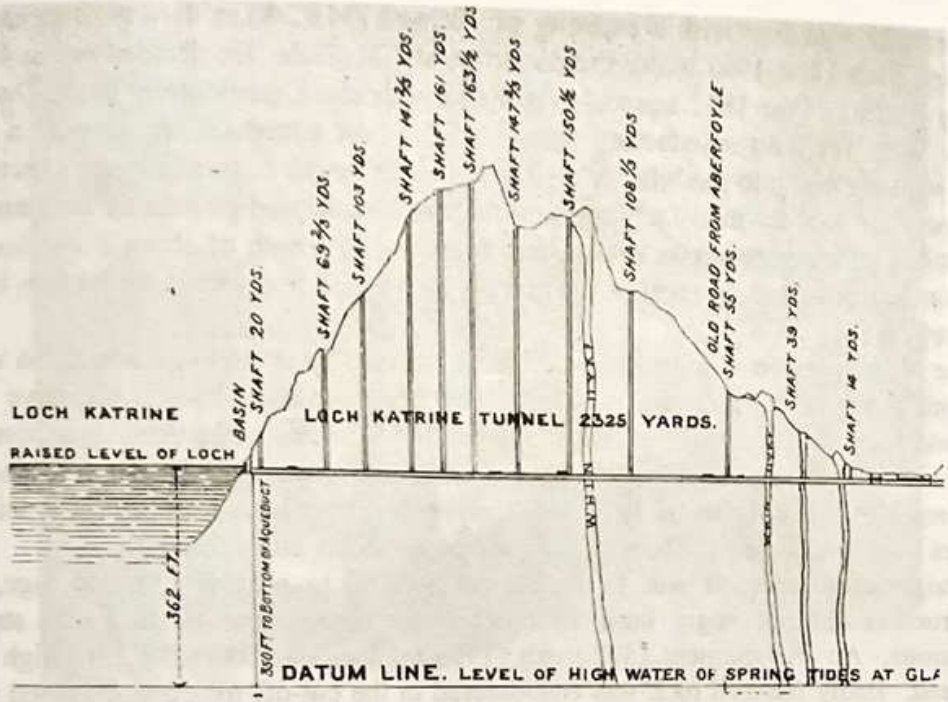

Figure 3. Loch Katrine aqueduct tunnel from the intake basin at the loch[2]

The first aqueduct from Loch Katrine to Mugdock Service Reservoir at Milngavie was constructed in 1855 to J.F. Bateman's design. It was 26 miles [42 km] long, of which thirteen miles [21 km] involved hard rock tunneling, mostly under spurs of Ben Lomond and just over 9 miles [14 km] of arched aqueduct built in open cut, and cost £468,000, or an average of £18,000 a mile [£11,250 a km].

The tunnels were unlined, of 8 ft [2.4 m] diameter, and laid on a gradient of 10 inches to a mile [1 in 6336]. For 3¼ miles [1.5 km] in total the aqueduct crossed the deep valleys of the Duchray, Endrick and Blane in 4 ft [1.7 km] diameter cast iron pipes having a fall of 5 ft to the mile [1 in 1056]. All rock boring had to be done by hand in the absence of pneumatic tools. The pipes across the valleys were planned to be laid in a group of three in parallel. At first only one pipe was laid, the others being added later as the capacity was increased from 20 mgd [90,900 m^3d]. The third pipe was laid in 1881.

The aqueduct was planned to carry 50 mgd [227,300 m^3d], but actual experience showed it was capable of carrying only 42 mgd [190,900 m^3d] owing to friction losses in the unlined tunnels.

Of seventy tunnels, the second longest, immediately after leaving Loch Katrine, is 2,325 yards [2126 m] long and 600 ft [183 m] below the summit of the hill. It was worked from twelve shafts, five of which are nearly 500 ft [152 m] deep [F igure 3]. The rock was gneiss and mica slate. About sixty drills were constantly in use at each face and on average a fresh drill was required for every inch [25 mm] in depth.

There are twenty-five substantial iron and masonry aqueducts up to 80 ft [24 m] in height and 90 ft [27 m] in span over rivers. The aqueduct bridge in the Duchray Valley comprises a rectangular cast iron tube 8 ft [2.4 m] high and 6 ft 6 in [2 m] wide, 636 ft [194 m] long, and 52 ft [16 m] above the ground at the lowest part.

The 1885 aqueduct with a capacity of 70 mgd [318,200 m^3d] was designed and executed from 1886-1903 under the direction of J.M. Gale. He decided not to follow closely the line of the 1855 aqueduct, as the large bridges, particularly in the Duchray Valley, were the least satisfactory feature of the first aqueduct. He adopted a more direct route further into the hills. Although a greater length of tunneling was involved, this operation was by then facilitated by the newly invented pneumatic drill and the availability of more powerful explosives. A saving in length of about 2¼ miles [3.6 km] was achieved and, as most of the tunnels were lined with concrete, friction losses were reduced.

The Mugdock and Craigmaddie adjoining service reservoirs are about ten miles [16 km] from the city centre to which they are connected by an extensive pipe network. Mugdock reservoir, constructed from 1855-59, has embankments across two valleys which are respectively 69 ft [21 m] and 53 ft [16 m] high, a water surface of 62 acres [25 ha], a depth of 50 ft [15.2 m] and a storage capacity of 540 million gallons [2.45 million cu^3]. The water is retained by a clay embankment.

Craigmaddie reservoir was first planned in 1880 to provide extra storage, but construction did not begin until 1886 after the completion of road and stream diversions. An embankment 1592 yards [1456 m] long and 93 ft [28.3 m] high was required. Badly fissured rock was encountered in the cut-off trench to be filled with clay puddle to form an impervious barrier. In one place it had to be excavated to a depth of 193 ft [58.8 m] below ground level.

The construction of this trench took more than six years and caused the resignation of the first contractor. The work was thereafter withdrawn from contract and executed by direct labour. The reservoir was finally completed in 1896 and cost about £337,000, more than 2½ times the original estimate. The reservoir has a water surface of 88 acres [21.7 ha], a depth of 42 ft [12.8 m] and a storage capacity of 700 million gallons [3.18 million m^3] These reservoirs were designed and superintended by J.M. Gale, Engineer, Glasgow Water Department.

The Institution of Civil Engineers in Scotland and Panel for Historical Engineering Works are planning a 150th birthday celebration around the October 14, 2009 anniversary of the opening of the Loch Katrine water supply . If it can be managed, this will include a steam-boat trip on the route similar to that taken by Queen Victoria and her party to inspect the inlet basins and aqueduct entrance, but the cannon salute cannot be guaranteed!

Figure 4. A Victorian steamer at the steamboat pier ©Author

References

1. Marwick Sir J. *Glasgow. The water supply of the city. R. Anderson*, Glasgow, 1901. 129-201 and folding map from which figures 1 and 2 have been compiled.
2. Burnet J. *History of the water supply to Glasgow*. Bell & Bain, Glasgow, 1869. 50-154 and folding longitudinal section.
3. Paxton R. and Shipway J. *Civil Engineering Heritage Scotland – Lowlands and Borders*. Thomas Telford Ltd, London, 2007. 246-50, 327-332. Further information.

Acknowledgements

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