BEFORE THE OTAGO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application for resource consents for Project Next Generation
BY	**PORT OTAGO LIMITED**
	Applicant

STATEMENT OF EVIDENCE OF REGINALD MAURICE DAVIS ON BEHALF OF PORT OTAGO LIMITED

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1. **Introduction**

1.1 My name is Reginald Maurice Davis, I reside in Dunedin and I am employed by CPG New Zealand Ltd as a Marine and Coastal Engineer.

1.2 In 2009, I was engaged by Port Otago Ltd to prepare a report on the history of dredging in Otago Harbour. That report, titled 'Short History of Otago Harbour Development and Dredging' is referred to and summarised in the Assessment of Environmental Effects, and is attached to the application for resource consents as Report 15. It forms the basis of my evidence.

2. **Qualifications**

2.1 My qualifications are:

a. Bachelor of Engineering, (Civil) (NZ)
b. Chartered Engineer, (UK)
c. Member of the Royal Institution of Naval Architects, (UK)
d. Fellow of the Institution of Professional Engineers, New Zealand
e. Chartered Professional Engineer, (NZ)
f. International Professional Engineer, (NZ Register)
g. APEC Engineer
h. Maritime New Zealand Recognised Surveyor (18 categories).

3. **Relevant Experience**

3.1 I have worked in the port industry for over 57 years. I have been on the permanent staff of three port authorities over a period of 34 years and have worked as a consultant to nine port authorities over the past 23 years. During this time, I have been actively engaged in the design, construction and maintenance of ports, a major part of which has involved dredging and associated works. I am presently advising four port authorities on dredging methods and equipment.

3.2 Of particular relevance to this evidence is my experience as an employee of Otago Harbour Board, (predecessor to Port Otago Ltd). I was Deputy Engineer to the Board for six years and Chief Engineer for nearly 20 years.

3.3 As Chief Engineer, my duties included responsibility for the design, construction, overall maintenance and operation of all engineering works and equipment associated with those works.

3.4 Principal amongst the works was the design and construction of the Port Chalmers Container Terminal which included the development of the main shipping channel between Port Chalmers and the sea. It is this channel and its associated turning basin which is the subject of the application for consents for further works to deepen and widen the channel.

3.5 My qualification and experience as a Naval Architect have enabled me to understand ship behaviour and in particular, the compounding effects of confined channels.

4. Scope of Evidence

4.1 My evidence discusses Otago Harbour's progressive developments which have enabled the port to meet the demands of local and international traders over a period now approaching 200 years.

4.2 Although this is a Regional Council Hearing, I record that I have read the Environment Court's Code of Conduct for Expert Witnesses (2006) and agree to comply with that code.

5. Sedimentary Processes

5.1 The coastal processes of erosion and sedimentation are discussed in detail in the evidence of Martin Single. However, I stress that the combined effects of the littoral (inshore coastal) processes and the tidal regime within the harbour are dominant factors in the engineering development and navigational operations in the harbour.

5.2 A large supply of sand crosses the harbour entrance and the ingoing tide carries some of this into and redistributes it within the harbour. The outgoing tide transports some sand back out of the harbour, but overall there is a net retention of sand in the harbour.

6. **Harbour History**

6.1 The first recorded commercial use of the harbour was by European sealers and whalers in the 1820's. At this time, the harbour was recognised as a shallow tidal inlet.

6.2 What is probably the first chart of the harbour, drawn in 1824 and titled Port Oxley, shows an anchorage in what is now known as Harington Bend. The chart extends only a short distance beyond the bend and is shown in Figure 1.

6.3 Much of the harbour was occupied by sand banks, exposed at low tide.

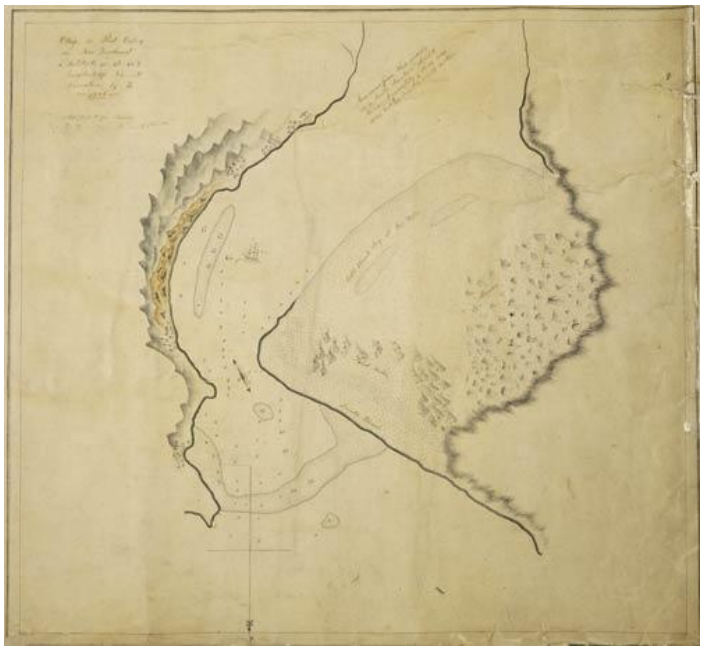


Figure 1 "Port Oxley" drawing by James Herd dated 1826
(Source: www.teara.govt.nz/NewZealanders/NewZealandPeoples/EuropeanDiscoveryOfNewZealand/9)

6.4 A survey made by Captain Stokes on *HMS Acheron* in 1850 was the first comprehensive survey of the harbour, see Figure 2.

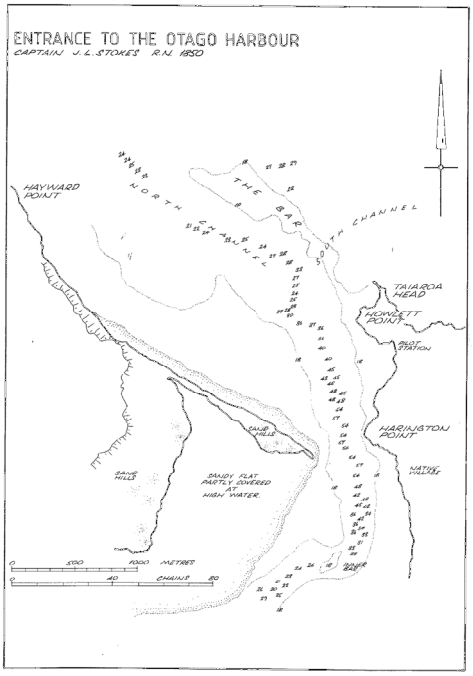


Figure 2 Tracing of Harbour Entrance chart from Stokes 1850

6.5 Both charts showed the existence of a sand bar both inside and seaward of the entrance. These shoal areas are referred to in the evidence of others.

6.6 Captain Stokes' survey showed that ships with draft over 21 feet (6.4m) could not get further into the harbour than Harington Point. Vessels drawing 21 feet or less could, with care, get to Port Chalmers.

7. Development of the Harbour

The First Harbour Works

7.1 The first administration of the harbour as a commercial port was under the jurisdiction of the Provincial Council which recognised the need to deepen the entrance, to create an adequate channel from Port Chalmers to Dunedin and to 'dredge out a dock or port in the foreshore at Dunedin'. The Provincial Council, in 1859 embarked on a development programme which was estimated to take 30 years to complete.

7.2 The Provincial Council had the first dredger for the port built in 1868. This was the original *New Era*. A second bucket dredger, the *Vulcan* (Figure 3), was built in 1877 by which time the administration of the port had passed to the newly constituted Otago Harbour Board.

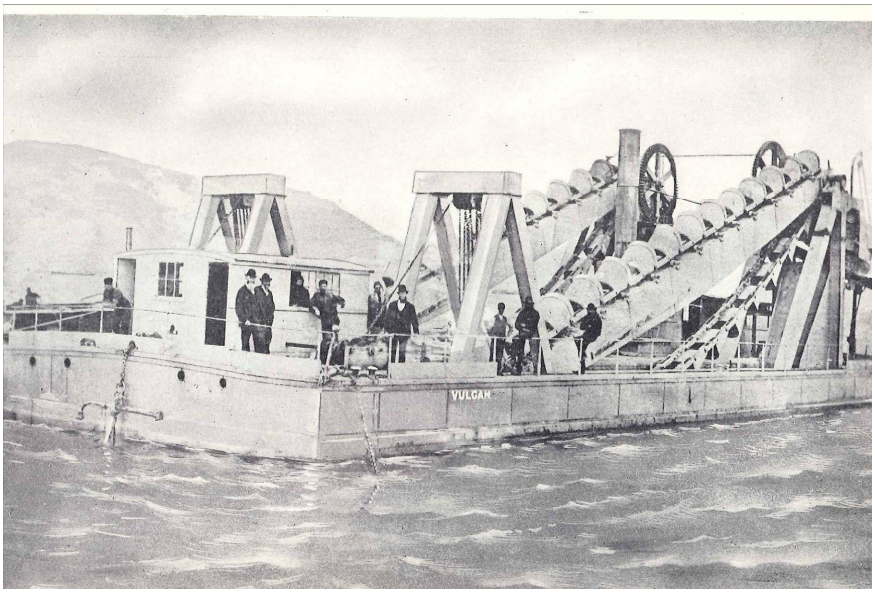


Figure 3 The bucket dredge *Vulcan* circa. 1877

7.3 The early efforts of the first two dredgers were concentrated in improving the berths and access to the Dunedin basin.

7.4 A third bucket dredger, the *222* was built in Scotland and delivered to the Harbour Board in 1882, see Figure 4. This was a hopper dredger and was acquired for its capability, albeit somewhat limited, to dredge the bar at the harbour entrance. This dredger did major development work at the entrance, Harington Bend and Deborah Bay.

Figure 4 The bucket-dredge *222*

7.5 Significant works were undertaken to deepen the outer bar; the inner bar was completely removed by a combination of dredging and natural scour and the alignment of the channel at Harington Bend and Deborah Bay was improved. The Port Chalmers basin was also dredged.

7.6 Based on detailed surveys in 1875, it was estimated that to provide a channel 18 feet (5.5m) deep at low tide, with a bottom width of 300 feet (91m), a volume of 4.1 million cubic yards (3.15M m^3) would have to be excavated.

7.7 To this was added a further 3.2 million cubic yards (2.45M m^3) to dredge the Dunedin basin and berths making a total of 7.3 million cubic yards (5.6M m^3).

7.8 Concurrent with dredging, the Harbour Board undertook major works to construct training walls within the Upper Harbour and at the entrance for the purpose of directing the flow of water into defined channels to maintain or improve their depth through the process of tidal scour. The largest of these works was the mole at Aramoana, construction of which commenced in 1884. It had the effect of altering the natural mechanisms that formed the sand bar across the harbour entrance, so that adequate shipping depths at the entrance could be maintained by the combination of scour and dredging.

Further Development

7.9 With Otago being well established as a major export port, the Harbour Board continued to develop the port to meet the needs of the larger ships that were being brought into the trade.

7.10 The major part of this development was in dredging. The need for increased dredging capacity for both development and maintenance was evident, so in 1929 the Harbour Board took delivery of a new bucket hopper dredger *Otakou*, designed and built in Scotland to meet the specific requirements of Otago Harbour, see Figure 5. At the time, this was the largest bucket dredger in the Southern Hemisphere and equal to the largest in Europe.

7.11 In order to accelerate the effects of scour induced by the mole, in 1936 the bucket dredger was fitted with trailing suction dredging equipment so that it could work in the swell conditions which prevail at this location.

7.12 The large bucket dredger and a stationary suction dredger were in constant use until the major demands of the developments which commenced in the early 1970's exceeded their capabilities.

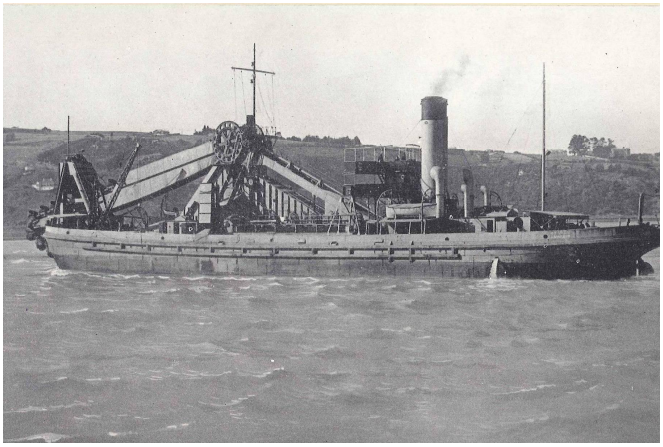


Figure 5 The bucket-dredge *Otakou* in Otago Harbour 1929

Dredging of Rock

7.13 During the harbour development there has been a number of major projects to remove rock from the bed of the harbour. Several of these involved the improvement of access to the Upper Harbour through the islands during the 1930's and again in the 1950's. Excavated rock was used to top up the groynes which were constructed to stabilise the channel at the Kaik and Harington Bend.

7.14 In 1966-67, rock was removed from the east side of the Port Chalmers basin to provide the bed for the caissons for Beach Street Wharf and to deepen part of what was to become the berths at Beach Street. Blasting was required to fracture the rock which was then excavated and disposed of at sea off Heyward Point. Rock from the caisson trench was used to backfill behind the caissons.

7.15 The Beach Street berth was further deepened in the mid-1990's. This was once again carried out by blasting the rock, excavated by the grab dredge *Vulcan* and disposed of in the Heyward Point and Spit disposal grounds.

7.16 The channel at both Rocky Point and Acheron Head has been successfully deepened on an incremental basis, without blasting over the period 1990 to 2000. The incremental increase in depth is due to the nature of the material and the equipment available. Once exposed to the elements, the rock weathers to a state where the grab dredge *Vulcan* can excavate the surface layer. Once the harder underlying material is exposed, this is left until it then follows the same weathering process.

8. **The Container Era**

8.1 As the result of progressive development of the Lower Harbour channel and the turning basin, by 1969 Port Chalmers could handle ships up to 230m length, 10m draft and more than 35,000 tonne displacement.

8.2 In 1971 the depth in the entrance channel was increased to a minimum of 13.7m at low tide. This work was beyond the capacity of the Otago Harbour Board's own plant, so the Australia-based trailing suction dredger *Geopotes V* was chartered for this purpose. At the same time, the Harbour Board adopted the policy to develop the Lower Harbour Channel to enable its use by ships with drafts of 11.6m at high tide and 10.1m at low tide.

8.3 In June 1975 authority was given for the Harbour Board to develop Port Chalmers as a container port.

8.4 Due to the large scale of the development of the channel and turning basin, chartered dredgers were used. In 1975 a contract was awarded to Sydney-based WestHam Dredging Pty Ltd to dredge to the following parameters:

- The Lower Harbour Channel (Port Chalmers to the entrance) – minimum depth 12.2m at low tide over a bottom width of 183m.
- Port Chalmers Turning Basin, 503m diameter with minimum depth 12.2m at low tide.
- George Street Wharf Berth 13.7m at low tide.

8.5 These parameters were set to allow ships with drafts up to 11m to transit the channel at any state of the tide.

8.6 The contract was completed early in 1977, the total volume dredged being 3.9M m^3. This enabled Port Chalmers to offer 24 hour operation to the largest container ships trading to New Zealand at that time.

8.7 The channels and turning basin side slopes were formed by "box cutting". In this process, the bottom of the channel or basin is dredged to its intended final depth to a line which is midway up the expected final batter, as determined from the natural bottom slope, pre-dredging. The dredged face is then allowed to slump to its natural batter.

8.8 It is noted that all material dredged in this contract was dumped at sea.

8.9 By the time the development dredging was completed, the 48 year old bucket dredger *Otakou* had been withdrawn from service and laid up for disposal.

8.10 The Timaru Harbour Board's trailing suction dredger *WH Orbell* was chartered as required for maintenance of the Lower Harbour Channel until the board acquired the new trailing suction dredger *New Era* in 1985. The New Era remains in service today

9. Recent Dredging Works – Post 1985

Maintenance Dredging

9.1 With the commissioning of the trailer suction dredge *New Era* in 1985, see Figure 7, the Otago Harbour Board gained the ability to undertake all dredging maintenance works without any reliance on external contractors. Detailed figures of dredging and disposal during this period are shown in Figure 6. At a high level this analysis shows a reducing annual volume of dredging over this period. In particular, less dredging occurred between 2006-2008 when the *New Era* was contracted out to other ports, or laid up.

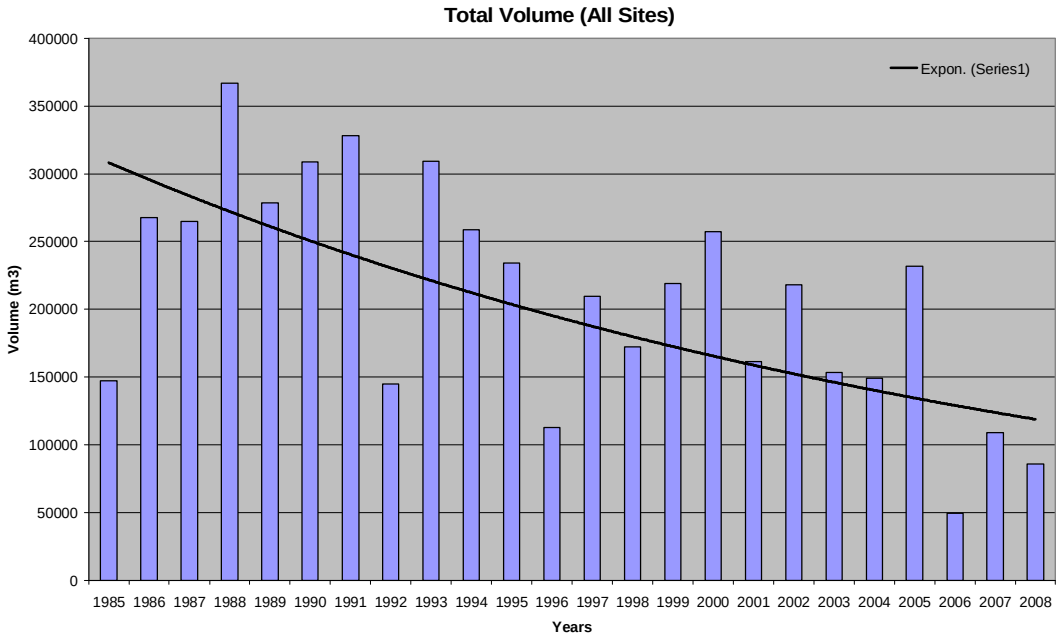


Figure 6 Total Dredging Volume Disposed from Otago Harbour since arrival of New Era in 1985

Figure 7 Dredge *New Era* passing Spit Wharf fully loaded

Lower Harbour Incremental Improvement to 13.0m.

9.2 Over the period from July 2003 to June 2005 the suction dredger *New Era* made incremental improvement to increase the depth of the lower harbour channel to a minimum depth of 12.8m (previously 12.2m). From July 2005 until June 2008, the minimum depth was increased by a further 0.2m to 13.0m.

9.3 This additional 0.8m of depth allowed the largest container vessels visiting the port, the 4100 TEU Albatross class of vessels, additional tidal window to safely sail when at, or near, their maximum draft of 12.6m. Since much of the harbour channel was already deeper than 13.0m, dredging was only required in distinct areas to achieve this increase in depth.

9.4 It is estimated that 100 - 120,000m^3 of the total volume dredged over these latter years came from incremental channel improvements which were undertaken concurrently with maintenance dredging. The incremental dredging was in harbour bed, not previously dredged, consisting predominantly of sand but with some silt and clay materials encountered.

Widening of the Port Chalmers swinging basin

9.5 With vessels getting larger, the desire to incrementally improve the safe navigability of the channel also required a 60 metre widening of the basin turning area during the period from June 2000 to October 2003, with a total of 220,000 m3 being dredged during this time.

10. **Summary**

10.1 In all of the above works, Port Otago has utilised its existing equipment to incrementally improve the channel. Undertaking the work in this manner has achieved the improvements in a low key manner over a period of time and I am not aware of any feedback having been received in relation to adverse effects from this work.

Dredged Volume

Summary of Volume of Material Dredged from Otago Harbour

10.2 The following table summarises dredged volumes.

For Period	Source of Data	Volume m^3
1875 – 1885	Historical Reports	1,150,000
1885 – 1899	No reliable records. Estimate based on previous output of dredges.	1,606,500
1899 – 1909	From dredging records confirmed by D Lusseau, University of Otago, 1999.	3,464,488

1910 – 1913	Estimate based on performance of dredgers.	1,210,000
1914 – 1933	From D Lusseau 1999.	4,904,375
1934 – 1975	From D Lusseau 1999	10,240,244
1976 – 1977	Capital dredge, From D Lusseau 1999	3,902,620
1978 – 1998	From D Lusseau 1999	5,789,471
1999 – 2007	From POL records	1,834,600
	TOTAL	**34,102,298**

Disposal of Dredged Material

10.3 Early records were not specific in regard to disposal. However the records from 1914 onwards are sufficiently reliable for me to deduce that in the period 1875 to 1914, approximately 7.4M m^3 of material was put into reclamations.

10.4 The following table shows the locations used for disposal of dredged material.

			Cu.m
Disposal to Reclamations			16.15M
Dumped within the Harbour			0.45M
Dumped outside of Harbour			
§	Off the Heads	0.29M	
§	At sea (not specific)	5.90M	
§	Off Heyward Point	7.31M	
§	Off Spit	4.00M	17.50M
		TOTAL	**34.10M m^3**

Dredging Equipment

10.5 Apart from the small amount of maintenance dredging done with grabbing equipment and the chartering of the Timaru trailing suction dredger for short periods to do maintenance between 1978 and 1984, all dredging prior to the major contracts in 1975-77 was undertaken by bucket dredgers.

10.6 By their very nature, bucket dredgers create significant disturbance of the sea-bed and they cause high levels of turbidity or suspended sediment as the result of material being disturbed on the sea-bed, by

being washed from the buckets during their passage to the surface and from spillage (overflow) from the buckets as they move from water level and discharge their contents over the top tumbler and into the hopper. They also require heavy anchors and mooring cables, all of which are at some stage either embedded or in contact with the harbour bottom. The bucket dredgers used in Otago Harbour were coal-fired and would have produced significant emissions from this source although it is noted that *Otakou* was able to burn coal or heavy furnace oil and both fuels were used at different times.

10.7 The dredgers used by the contractors, the Timaru Harbour Board's dredger and the Otago Harbour Board's *New Era*, which replaced *Otakou,* are all diesel powered trailing suction dredgers. These dredgers cause less disturbance to the seabed, and because the dredged material is contained within the suction pipe, there is no loss between the drag head and the discharge to the hopper. There is therefore significantly less turbidity than is created by a bucket dredger. The diesel powered dredgers also produce less in the way of emissions and there are no anchors or moorings involved in their operation.

10.8 A pictorial history of dredges owned by the Otago Harbour Board is included in Appendix A.

11. Reclamation

11.1 When dredging first commenced, material disposal was solely in reclamation. There were three good reasons for this:

1. The dredging equipment was not suitable for disposal at sea.
2. It was convenient to transport the material a short distance and place it in reclamations.
3. Reclamation of the foreshore in front of the town removed the unsightly mud flats and provided land area for the growing town of Dunedin.

11.2 Commencing in the very early stages and continuing throughout the various reclamation projects, concerns have been raised over the effect that reclamation would have in reducing the tidal compartment

of the harbour and the consequent inability of the tidal scour to maintain the entrance channel. The earliest engineers' reports recognised the possibility of this happening and applied very basic techniques to manage the risk.

11.3 In the late 1950's the Otago Harbour Board constructed a hydraulic model of the harbour. From this it was possible to make a quantitative assessment of the effects of reclamations and other works. This technology has subsequently been replaced with numerical (computer) modelling, the results of which in relation to Next Generation are to be presented by others.

12. Conclusions

12.1 Significant conclusions to be drawn from these historical facts are:

a. Dredging of the harbour commenced in 1868 and has carried out continuously for more than140 years.

b. During this time, the volume of material removed is of the order of 34.1M m^3.

c. Approximately 51% of this volume (17.5M cu.m) has been disposed of at sea.

d. Most of the dredging has been done by equipment owned by the Harbour Board (and its successor Port Otago Ltd) and the volume dredged averages about 200,000M m^3 per year.

e. There have been two development projects undertaken by chartered dredgers which respectively totalled 50,000M m^3 and 3.9M m^3. These were completed over periods of a few weeks and a little over 1 year respectively.

12.2 Benefits have accrued from dredging operations which, from the beginning of the harbour's history, have been engineered to optimise those benefits in the face of very severe financial constraints in the first half century, hard economic times and competing demands through the next 50 years and the increasing need for environmental protection over the last 48 years.

12.3 The natural processes which caused the deposition of sedimentary materials in the harbour, still exist today and have been modified to

only a relatively minor extent by works such as the mole and the lesser training walls.

12.4 Periodically, dredging will be required to maintain the depth and alignment of the channels required for safe navigation. Dredging has been and will always remain an important part of Port Otago's operations.

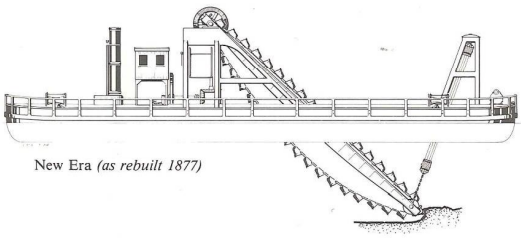
Reginald Maurice Davis

APPENDIX A

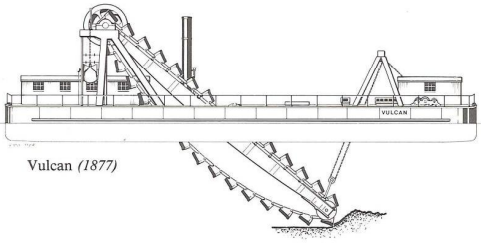
Otago Harbour Board

Dredge Fleet 1877 to 1985

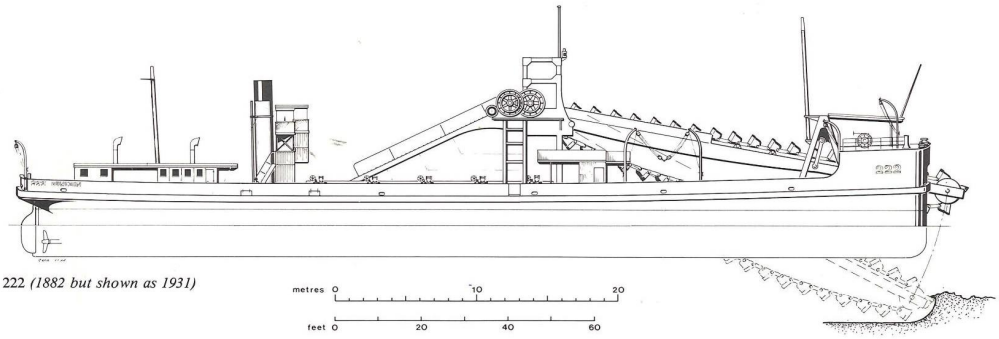
DREDGE FLEET 1877-1985



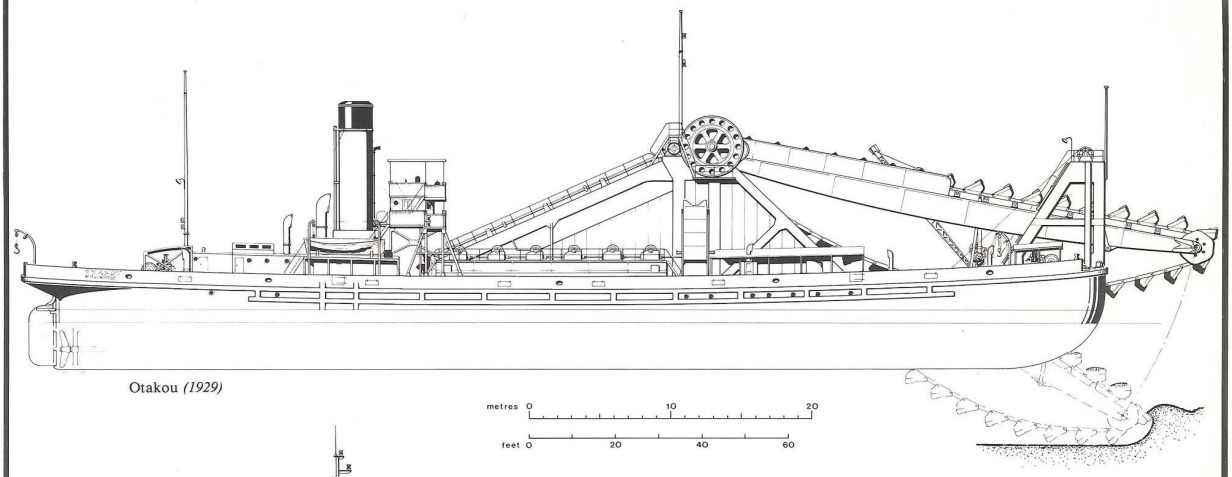
New Era *(as rebuilt 1877)*



Vulcan *(1877)*



222 *(1882 but shown as 1931)*



Otakou *(1929)*

New Era *(1985)*