Taihoro Nukurangi

A classification of New Zealand's coastal hydrosystems

Prepared for Ministry of the Environment

October 2016

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NIWA CLIENT REPORT No: HAM2016-062

Report date: October 2016
NIWA Project: MFE15204

Quality Assurance Statement		
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	Approved for release by:	Dr David Roper

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Executive Summary

New Zealand has a long (18,000 km including estuarine shores) and highly varied coastline. New Zealand's coastal water bodies, flowing and still, fresh to saline, span a wide range of environments; coastal wetlands; systems fed by small streams to large braided rivers; systems located at the interface of low to high-energy ocean settings; systems on muddy through sandy to gravelly coasts; and also large complex systems that are made up of several types or classes.

The coastal hydrosystems classification described herein aims to reconcile and clarify coastal hydrosystem terminology and produce a hierarchy and classification of coastal wetland, riverine, estuarine and marine types. This report also provides some environmental parameters for the systems and gives examples of how the classification can be used to manage these systems and their catchments. The work began in June 2013 with workshops in June 2013 and January 2014 to explore ideas and the co-authors presenting ideas at conferences. In October 2015 MFE provided funding for NIWA, Hume Consulting Ltd and the University of Canterbury to work with the Department of Conservation to develop the classification further. Input from practitioners at a two-day stakeholders' workshop in February 2016 contributed to the development of the classification and ensured its alignment with management applications.

Many different terms are employed to describe these coastal hydrosystems, often in conflicting or confusing ways, in common language, scientific literature, legislative and planning documents. We have adopted the term "coastal hydrosystem" to describe coastal features that span a gradient from near coast freshwater lakes/wetlands (lacustrine/palustrine environments) to marine. This label avoids many pitfalls: it avoids mistakenly labelling all systems *estuaries*; it encompasses hydrosystems that are not end-of-river environments as well as large systems with multiple freshwater features; and unlike "waterbody", it incorporates geomorphic, ecological and hydrological aspects of each system. In this report we provide a review (along with a glossary) of terms used to describe different kinds of coastal hydrosystems in use in common, statutory and scientific language and explain why precise definitions are important for coastal management.

The coastal hydrosystems classification is based on a hierarchical view of the abiotic components that comprise the environments of coastal hydrosystems. Our classification presents detail at the geomorphic class level (III) of the hierarchy because this level is particularly important for coastal management and conservation needs at national and regional scales. However, to provide the wider context, we show how this can nest within a wider six-level hierarchy. Detail at levels IV to VI is best developed for specific management needs at the local scale using the description of structural and compositional habitat features.

Geomorphic class, Level III of the hierarchy, sees hydrosystems defined as single type units/systems (or classes), each with associated characteristics. The classification recognises 11 geomorphic classes that are different enough from each other in their properties and the way they respond to natural and anthropogenic forcings that they need to be considered separately for management purposes. To keep the total number of classes small but at the same time recognise that some have a wide variety of characteristics that have different management implications, some classes have subclasses. Composite systems occur where a system contains subsystems representing different geomorphic classes. Whether a composite system is classified as a single class or a collection of several classes depends on the management question. The geomorphic classes are representative of types of systems that have been largely unmodified by anthropogenic activities such as reclamation, dredging, road/rail causeways and river-channel diversions. They exclude systems that have been totally created by humans such as small coastal lakes and flooded pits created by gravel and goldmining activities. The key characteristics of each of the geomorphic classes and subclasses are described and illustrated using Google Earth images and schematics.

Geomorphic class	Subclass
1. Damp sand plain lake	
2. Waituna-type lagoon	A. Coastal plain depression; B. valley basin.
3. Hāpua-type lagoon	A. Large hāpua-type lagoons; B. medium hāpua-type lagoons; C. small hāpua-type lagoons; D. intermittent hāpua-type lagoons.
4. Beach stream	A. Hillside stream; B. damp-sand plain stream; C. stream with pond; D. stream with ribbon lagoon; E. intermittent stream with ribbon lagoon.
5. Freshwater river mouth	A. Unrestricted; B. deltaic; C. barrier beach enclosed.
6. Tidal river mouth	A. Unrestricted; B. spit enclosed; C. barrier beach enclosed; D. intermittent with ribbon lagoon; E. deltaic.
7. Tidal lagoon	A. Permanently open; B. intermittently closed.
8. Shallow drowned valley	
9. Deep drowned valley	
10. Fjord	
11. Coastal embayment	

This report identifies and provides a list of environmental variables that describe the characteristics and properties of about 500 discrete coastal hydrosystems. These can be used to provide national and regional statistics on coastal hydrosystems and answer questions such as: *How many are there? Where are they located? How many do we have of certain classes? Which are rare in a region? Which is the biggest? Where are the marine versus freshwater dominated systems?* While many small damp sand plain lakes and beach stream hydrosystems remain unclassified, the report offers guidance on how to classify these remaining systems.

The report finally illustrates the management uses of the classification with examples of the value of using correct terminology, mapping the distribution of types and a multi criteria analysis approach showing how services, values, threats and effects in systems are associated with geomorphic classes/subclasses.

1 Introduction

New Zealand has a long (18,000 km including estuarine shores) and highly varied coastline (Hume et al. 1992; Goff et al. 2003). Occurring along these shores are coastal hydrosystems. Coastal hydrosystems are subject to a range of human-use pressures that can compromise their values. Situated at the interface of freshwater and/or terrestrial, and ocean environments, they comprise an integral part of the *ki uta ki tai* or *mountains to the sea* management concept. To enable sustainable management of this complex coastline it is necessary to understand the types of systems it contains. Classification of ecosystems provides a means to organise knowledge and enable a systematic grouping of sites into categories (or classes) on the basis of their evolutionary or controlling factors. It supports coastal management by recognising the diversity among different hydrosystems and how they function, assisting monitoring and reporting on conditions, and enabling targeted management approaches.

New Zealand's coastal hydrosystems, flowing and still, fresh to saline, span a wide range of environments; coastal wetlands; systems fed by small streams to large braided rivers; systems located at the interface of low- to high-energy ocean settings; systems on muddy through sandy to gravelly coasts; and also large complex systems that are made up of several types or classes. Many different terms are employed to describe these systems, often in conflicting or confusing ways, in common language, scientific literature, legislative and planning documents. Terms used on the 1:50,000 topographic maps include harbour, inlet, sound, fjord, estuary, bay, lagoon, river mouth, coastal wetland, mangrove and saltmarsh. Statutes use a myriad of coastal environment terms: a few are well defined but many remain legally undefined and ambiguous. A consequence of this is that users pick definitions to suit their purpose, creating confusion and, sometimes costly, debate. In Appendix A to this report we provide a review (along with a glossary) of terms used to describe different kinds of coastal hydrosystems in use in common, statutory and scientific language and explain why precise definitions are important for coastal management. We also acknowledge the relationship Māori have with these places and that they too have developed terminology over centuries. We however, do not attempt to explore this in detail.

We have adopted the term "coastal hydrosystem" to describe coastal features that span a gradient from near coast freshwater lakes/wetlands (lacustrine/palustrine environments) to marine. The term avoids the common error of referring to all such features as estuaries, mislabelling the numerous types that are non-estuarine and have different behavioural characteristics and management sensitivities from any truly estuarine environment. It also encompasses the coastal systems that do not represent end-of-river environments (e.g., some pocket beaches and embayments) or are so large and complex as to be fed by several freshwater drainage features (rivers, streams, wetlands) but which are dominated by none (e.g., some harbours, fjords, sounds and coastal-lacustrine systems). And, unlike "waterbody" or "coastal waterbody", it incorporates the multiple aspects of each system, including beaches, spits, barriers, river mouths, wetlands, saltmarshes and other geomorphic, ecological and hydrological features.

Classification systems are used widely around the world (see Finlayson and van der Valk 1995) though many would be probably better defined as typologies (*sensu* Bailey 1994). We refer to our approach as a classification system rather than a typology, as it has the same purpose as other management-based classifications in regular use in NewZealand, for example LENZ (Land Environments of New Zealand), REC (Rivers Environment Classification) and MEC (Marine Environment Classification).

The classification in this report builds on earlier studies on New Zealand freshwater and estuarine wetland systems, including those described by Stephenson et al. (1983) for wetlands, Ward and Lambie (1999) for performance indicators for wetlands, Kirk and Lauder (2000) for coastal lagoons in the South Island, Williams et al. (2007) for historically rare terrestrial ecosystems and *Wetland Types in New Zealand* (Johnson and Gerbeaux 2004). It also builds on the hydro-geomorphic classification Estuarine Environment Classification of Hume et al. (2007) which used some methods and data layers from the River Environment

Classification of Snelder et al. (2004) and previous hydrodynamic and geomorphic classifications by Heath (1976) and Hume and Herdendorf (1988) respectively. It provides additional classes or types that were missing from, or poorly represented in Hume et al. (2007) and Johnson and Gerbeaux (2004), including *hāpua-type lagoons*, *waituna-type lagoons* and features on the South Island's gravelly coasts that are recognised in work by Kirk and Lauder (2000), Hart (2009) and by the West Coast Marine Protection Forum (2009). River and coastal stream mouths are also included so that the classification goes beyond estuaries to consider a wider suite of palustrine, lacustrine, riverine and marine water bodies. It links both the wetland typology of Johnson and Gerbeaux (2004) and the Estuarine Environment Classification of Hume et al. (2007), while expanding the definition of classes in Hume et al. (2007). The work began in June 2013 with workshops in June 2013 and January 2014 to explore ideas and the co-authors presenting ideas at conferences. In October 2015 MFE provided funding for NIWA, Hume Consulting Ltd and the University of Canterbury to work with the Department of Conservation to develop the classification further. Input from practitioners at a two-day stakeholders' workshop in February 2016 contributed to the development of the classification and ensured its alignment with management applications.

2 The classification

In this section of the report, and in order to provide the wider context, we describe how 'Hydrosystem' and Geomorphic class' nest within, and are supported by, a six-level hierarchical classification for coastal hydrosystems. However, the focus of this report is at the 'Hydrosystem' and Geomorphic class' (Levels II and III of the hierarchy), because these levels are particularly important for coastal management and conservation needs at national and regional scales. Detail at the other levels is best developed for specific management needs and particularly for the lower levels, using the description of structural and compositional habitat features obtained at the local level.

At each level within the six-level hierarchical classification (Table 2-1) there is a gradient in properties and differences within the environments and their components. The hierarchy of levels is based on factors that control processes that are the dominant cause of variation in hydrosystem character at the associated spatial scale. These controlling factors capture how coastal hydrosystems function, with abiotic components dominating the top levels and biotic components dominating the lower levels. That is, the classification postulates that climate, geological, oceanic, riverine and catchment factors control a hierarchy of processes and broadly determine the physical and biological characteristics of coastal hydrosystems. Each level relates to a different spatial scale and is suitable for specific applications.

Level		Controlling factors	Spatial scale (km^2)
I	**Global** Temperate Australasian Realm	Climate, landmass, watermass	Macro 10^6 - 10^4
II	**Hydrosystem** Palustrine, lacustrine, riverine, estuarine, marine	Landform, water regime	10^3
III	**Geomorphic Class** 11 classes and 21 subclasses	Geomorphology, hydrodynamics	Meso
IV	**Tidal Regime** Subtidal, intertidal, supratidal	Inundation by the tide	10^1
V	**Structural Class** Vegetation, substrate, water structure	Bio-, geo- and hydro-components	1
VI	**Composition** Dominant biota, substrate and water types	A mixture of the above	Micro 0.1

Table 2-1: How the hydrosystem and geomorphic class levels nest within a wider hierarchical classification.

Level I Global scale

High-level coastal spatial units can be differentiated using global-scale variation in processes such as solar radiation, heating and cooling, evaporation and precipitation. These process variations are controlled at the global scale by three key factors: climate (latitude), oceanic watermass and large landmasses. These factors are used to discriminate the polar, temperate, and tropical domains within which marine and coastal units share broadly similar characteristics, both physical (e.g., temperature, nutrient concentrations and salinities of the incoming water) and ecological (e.g., primary productivity). Classified at a global scale, New Zealand coastal hydrosystems lie within the temperate Australasia realm (i.e., Realm 11 in Spalding et al. 2007)[1].

[1] Spalding et al. (2007) proposed a nested system of 12 realms, 62 provinces and 232 ecoregions covering all coastal and shelf waters of the world. Realm 11 (Temperate Australasia) can thus be further subdivided into provinces (in italics) and ecoregions (in roman type):
TEMPERATE AUSTRALASIA
53 Northern New Zealand
195 Kermadec Island
196 Northeastern New Zealand
197 Three Kings-North Cape

Level II Hydrosystem: *palustrine, lacustrine, riverine, estuarine, marine*
Hydrosystems are differentiated by variations in general landform, broad hydrological setting (water regime) and dominance of seascape, waterscape or landscape characteristics, plus other characteristics like salinity regimes. New Zealand has palustrine, lacustrine, riverine, estuarine and marine coastal hydrosystems. These are equivalent to those proposed by Johnson and Gerbeaux (2004) for New Zealand wetlands and to those typically applied globally (e.g., by the Ramsar Convention Secretariat 2010).

Level III Geomorphic class: *11 classes (with subclasses in some categories)*
Geomorphic classes are discriminated by landscape and waterscape characteristics such as geology and basin morphometry and by hydrodynamic features due to river and oceanic forcing. Many of these classes are equivalent to those discussed by Hume et al. (2007). Some are recognised by other authors in other countries (e.g., Madden et al. 2010, Durr et al. 2011) but they are usually grouped into one category of hydrosystem: estuarine systems.

Level IV Tidal regime: *supratidal, intertidal, subtidal*
Variations between these three tidal regimes are based on the degree of inundation of the substrate: supratidal - areas where the substrate is above the highest tide level but is affected by splash and spray or inundated by storm surges, intertidal - periodically exposed and flooded by tidal action, subtidal - continuously submerged. The tidal regime was recognised by previous New Zealand authors (e.g., Ward and Lambie 1999, Johnson and Gerbeaux 2004) and we include it to allow compatibility with those classification systems. Managers may also need to assess the extent of supratidal, intertidal or subtidal areas, as these often support very specific life forms adapted to the sometimes extreme characteristics associated with them, such as temperature, drying and salt concentration. Some, such as intertidal areas, can also support important feeding areas for birds. Some researchers have described this level as a modifier rather than as a classification level (e.g., Farinha et al. 1996), and all aspects may not apply to all classes. Variations between the three tidal regimes are based on the degree of inundation of the substrate (from continuously submerged or regularly and periodically exposed and flooded by tidal action, to areas where the substrate is above the highest tide level but is affected by splash and spray or inundated by storm surges).

Level V Structural class: *bio-, geo- and hydro- components*
This level differentiates variations in biotic, abiotic and water components, for example the water column (e.g., vertical layering, temperature, salinity), currents (e.g., wave-induced), water masses (e.g., plumes), wave climates and surf characteristics, and in boundary hydroforms (linear features formed at the conjunction of two or more water masses). Abiotic and biotic features are other variable components commonly used to classify wetland types; vegetation and substrate structure in particular are described by Johnson and Gerbeaux (2004). The features and characteristics associated with biotic, abiotic and water components are outside the scope of this report. Refer to the US coastal and marine ecological classification standard (Federal Geographic Data Committee 2012) (http://www.fgdc.gov/standards/projects/cmecs-folder/CMECS_Version_06-2012_FINAL.pdf) or to Robertson et al. (2016b) for a full or partial description of hydro- and geo-components, and to Johnson and Gerbeaux (2004) for bio-components.

54 Southern New Zealand
198 Chatham Island
199 Central New Zealand
200 Southern New Zealand
201 Snares Island

Level VI: Composition

This level, the expression of all the above controlling factors, differentiates variation in compositional types, which are discriminated by one or more of the dominant biota, substrate or water types. Refer to Johnson and Gerbeaux (2004) and Clarkson et al. (2013) for plant species names currently encountered in wetlands, including coastal hydrosystems.

Levels IV, V and VI can be clearly defined using either existing datasets: for level IV, the 1:50,000 NZ Topographic Map/Digital Topographic Database, the RNZN hydrographic charts and LiDAR information that is becoming increasingly available for many regions and/or Johnson and Gerbeaux (2004); for Levels V and VI, Grove et al. (2012) has successfully used Johnson and Gerbeaux (2004) for mapping coastal vegetation in Canterbury. More recently, others (e.g., Stevens and Robertson 2015, p.24) have also adopted broad-scale habitat classification definitions equivalent to those of Johnson and Gerbeaux (2004) for the mapping of coastal habitats in the Tasman region (Stevens and Roberston 2015).

3 Geomorphic class

In this section we describe the distinguishing characteristics of each geomorphic class. This level of the hierarchy is particularly valuable for application where coastal management plans are made for individual systems either as standalone coastal compartment plans or as a part of catchment plans. It provides a means of identifying systems that are similar in their controlling factors and therefore can be managed in a similar way. It promotes a strategic approach to hydrosystem management in recognising that a system as a whole must be managed from terrestrial through to marine environments (*ki uta ki tai/mountains to the sea)*.

There is a description of the methodology used to determine the geomorphic classes, along with a rationale for our choice of names for the classes, in Appendix B. This methodology was supported by the development of a classification key[2] (Appendix C), Google Earth images and schematics for the systems (Appendix D) and a database for some 500 coastal hydrosystems (Appendix E).

3.1 Characteristics of geomorphic classes

Our classification recognises 11 geomorphic classes, along with subclasses in some categories, that are different enough in their properties and responses to natural and anthropogenic forcings, to be considered separate for management purposes (Table 3-1). The classes and their subclasses are discriminated by their landscape and waterscape characteristics, such as geology, geomorphology and hydrodynamic characteristics arising from river and oceanic forcing and basin morphometry.

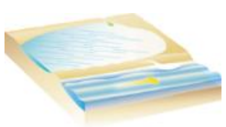
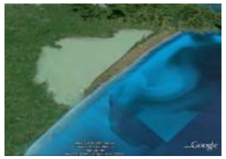
Table 3-1: Geomorphic classes and 21 subclasses in the classification.

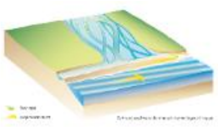
Geomorphic class	Subclass
1. Damp sand plain lake	
2. Waituna-type lagoon	A. Coastal plain depression; B. valley basin.
3. Hāpua-type lagoon	A. Large; B. medium; C. small; D. intermittent.
4. Beach stream	A. Hillside stream; B. damp sand plain stream; C. stream with pond; D. stream with ribbon lagoon; E. intermittent stream with ribbon lagoon.
5. Freshwater river mouth	A. Unrestricted; B. deltaic; C. barrier beach enclosed.
6. Tidal river mouth	A. Unrestricted; B. spit enclosed; C. barrier beach enclosed; D. intermittent with ribbon lagoon; E. deltaic.
7. Tidal lagoon	A. Permanently open; B. intermittently closed.
8. Shallow drowned valley	
9. Deep drowned valley	
10. Fjord	
11. Coastal embayment	

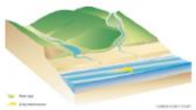
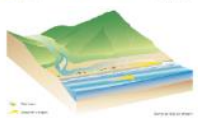
Table 3-2 details the distinguishing characteristics of the classes and subclasses, lists reference examples of each and terminology used to describe the classes by others. Appendix D provides a selection of Google Earth images and schematics which illustrate the key distinguishing characteristics of classes and subclasses at a scale where detail can be seen more clearly.

[2] A classification key is a tool that aids the identification of entities by offering a sequence of identification steps, each with multiple alternatives, the choice of which determines the next step.

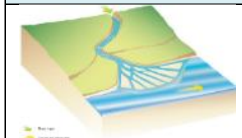
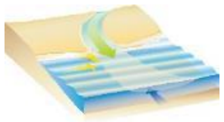
Table 3-2: Distinguishing characteristics of the geomorphic classes and subclasses. Examples of each class are shown as a schematic and a Google Earth image. More detail is shown in the larger versions of the Google Earth images and schematics in D.

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
Palustrine   Manukau	**1. *Damp sand plain lake*** <u>Other terminology</u>: Dune lake; Coastal lake	**1A**: Lakes on Kaipara North Head, Manukau North Head (Auckland); Parengarenga Spit (Northland); Mangawhai Spit (Auckland); Okupe Lagoon (Kapiti Island); Farewell Spit (Golden Bay).	Small, shallow (1-2 m deep), typically fresh water bodies. They never have a connection to the sea (no tidal inflow). Often elongate in shape and located in the depressions between rows of sand dunes on damp sand plains and often associated with vegetated wetland areas. The basins in which they occur form where the wind has removed sand to form shallow depressions down to about the level of the water table. They are fed by freshwater inputs from rainfall and groundwater and are brackish due to salt spray and evaporation. Variable planform, ephemeral in space and time and can dry out in drought conditions. Dominant substrate is muddy sand and peat. Refer to Champion and de Winton (2012) for further description and classification of coastal dune lakes.
Lacustrine   Te Waihora	**2. *Waituna-type lagoon*** Source: Kirk and Lauder (2000) Subclass A: *coastal plain depression* Subclass B: *valley basin* <u>Other terminology</u>: Barrier- or barrier beach-enclosed freshwater lagoon; coarse clastic mixed sand and gravel barrier lagoons (e.g., Carter et al. 1984);	**2A**: Te Waihora Lake Ellesmere (central Canterbury); Washdyke and Wainono Lagoons (south Canterbury); Ohuia Lagoon (Hawkes Bay); Waituna Lagoon (Southland). **2B**: Te Roto o Wairewa Lake Forsyth (central Canterbury); Lake Onoke (Wairarapa); Lake Kohangatera (Pencarrow Head, Wellington); Ohuia Lagoon (Hawkes Bay).	Large (several km^2), shallow (mean depth 2 to 3m) coastal lagoons barred from the sea by a barrier or barrier beach (no tidal inflow). Waterbody is typically fresh, fed by small streams, with brackish pockets in time or space. Drainage to the sea is generally by percolation through the barrier. Their most frequent state is closed to the sea. Short-lived openings occur when water levels build a sufficient hydraulic head in the lagoon to breach the enclosing barrier, due to river inflows and/or severe storm wave overtopping. Sustained openings to the sea are rare (decadal-century time scales) unless created artificially. They may experience tidal inflows for short periods (1-2 tidal cycles) after natural barrier breaches whereas recent observations indicate that artificial breaches can result in openings that experience tidal ingress for up to several weeks (e.g., Te Waihora Lake Ellesmere). Wind waves and wind-induced currents are important agents for mixing. Observations of historical lagoon ridges suggest that these agents were even more important in pre-human times when depth and fetch of the waterbodies were greater than today. Situated on wave-dominated high-energy mixed sand/gravel coasts. Dominant substrate is very fine sand and mud.

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
 Ohuia Lagoon  Te Roto o Wairewa	coastal lake; Incorrectly termed ICOLL (Intermittently Closed and Open Lakes and Lagoons)		Two subclasses are recognised: *coastal plain depressions* (2A) are the most common type occupying depressions on low-lying coastal land that were typically coastal embayments during the early Holocene but have since been isolated from the ocean by barriers (e.g., Wainono Lagoon); *valley basins* (2B) occur in river valleys as more elongate-shaped and slightly deeper water bodies (e.g., Te Roto o Wairewa Lake Forsyth). Sometimes incorrectly labelled ICOLLs (Intermittently Closed and Opened Lakes and Lagoons of Haines et al. 2006). However, waituna barriers typically comprise coarser sediment and are therefore more permeable than those of ICOLLs. This, for most of the time, allows the lake to drain by percolation through the barrier, preventing build-up of water and hydraulic head. Hence the barrier breaches less often than in the case of ICOLLs.
Riverine   Rakaia	**3. *Hāpua-type lagoon*** Source: Kirk and Lauder 2000; Hart 2009 Subclass A: *large* Subclass B: *medium* Subclass C: *small* Subclass D: *intermittent* Other terminology: Barrier beach enclosed wave-dominated river or stream mouth lagoon; river mouth lagoon. Note that *te hāpua* means a pool of	**3A**: Waitaki and Rakaia Rivers (Canterbury). **3B**: Rangitata, Waiau, Hurunui and Ashburton Rivers (Canterbury); Raukokore River (Papatea Bay East Cape). **3C**: Conway, Opihi, Waipara, Pareora and Kōwhai Rivers (Canterbury); Karakatuwhero River (Te Araroa Bay, East Cape). **3D**: Ashley River (north Canterbury), currently i.e., 2016 in tidal (non-hāpua-type) mode.	Narrow (10s to 100s m wide), elongated (<100m to several km long) and shallow (several metres deep) river mouth lagoons that are, except for usually a single narrow outlet enclosed along their ocean boundary by coarse clastic barrier beaches formed by strong longshore sediment transport. They occur on coasts that are generally wave-dominated and exposed to high swell wave energies, typically mixed sand and gravel, have micro- to lower meso-tidal ranges, typically have rising backshores, and are characterised by late Holocene erosion, or recent stability trends. Narrow (restricted) outlet. Usually no tidal inflow (no tidal prism, only river outflow), although can temporarily experience tidal inflows for a few hours to days after a large flood breaches or widens the outlet, before longshore transport re-establishes the constriction. They typically experience a tidal backwater (freshwater) effect in the lagoon where water outflow/and/or percolation from lagoon to sea is reduced at high tidal levels. Salt-water entry occurs via spray and wave overtopping during storm events. The highly mobile outlet (positionally unstable) can migrate for hundreds of metres to kilometres along the shoreline at sub-annual time scales, with lagoon elongation growing in relation to outlet migration alongshore.

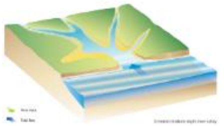
	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
Ashburton  Ashburton  Kowhai  Ashley	water, lagoon or pond whereas scientific borrowing of the term has applied it more narrowly to the specific hydrosystem type described here.		They are not ICOLLs as they do not occur on sandy coasts and do not have a state where tidal ingress is sustained. They experience only very short-lived (minutes to hours) tidal flows under exceptional circumstances such as storm events with elevated water levels and large waves. **3A**: Form at the mouths of large braided rivers with alpine source areas, where flows are large enough to maintain an open outlet, except under short-lived exceptional circumstances during storm events (when they can 'fill and spill' within a tidal cycle) or after significant river flow reduction due to upstream practices (e.g., dams and water extraction). **3B**: Form at the mouths of hill rivers. Closures vary from occasional and short-lived during high-energy wave events to seasonally-sustained during low flow periods under significant freshwater extraction pressures. Both outlet flows and barrier beach percolation are significant in this subclass. **3C**: Form at the mouths of streams and small rivers. Closures are common and sustained at river base flow conditions. Percolation through the barrier sediments dominates under river low-flow conditions (and during closure). Openings may occur at higher river flow levels and during wave events. **3D**: Occur on coasts at places where wave and tide dominance switches over time. Depending on long-term wave climate cycles and how freshwater regimes are altered by upstream practices, they may switch between two different equilibrium states, such as between *hāpua-type lagoon* and *tidal river mouth*, sustaining each state for years to decades.
Riverine  	**4. *Beach stream*** Subclass A: *hillside stream* Subclass B: *damp sand plain stream* Subclass C: *stream with pond* Subclass D: *stream with ribbon lagoon*	**4A**: Heaphy Stream (West Coast SI); Stony River (Taranaki); Te Awanga Stream (Hawkes Bay); Tokakoriri Creek (north of Haast); creek south of the Nile River West Coast SI; streams on Cape Palliser. **4B**: Dean Lamplough and Chatterbox streams	Occur where a very shallow stream flows over the beach face to the sea. This differs from a river where the larger flow cuts a subtidal channel through the beach face to the sea. Drainage to the sea occurs for most of time, except during drought conditions and/or when waves build a beach berm to bar off the outlet, at which time flow percolates through the beach face to the sea. No tidal prism (inflow) except during storm events coupled with high tides. Generally small. Dominant substrate is sand or mixed sand and gravel. **4A:** Flow down from mountains and follow a short steep path to the sea. Occur on mixed sand/gravel coasts. **4B:** Flow direct to sea over the flat plain; no pond at mouth.

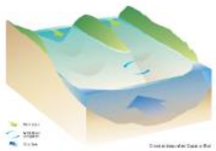
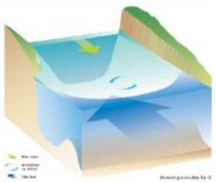
	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
 Heaphy Stream  Mohikinui Stream  Piha River	Subclass E: *intermittent stream with ribbon lagoon* <u>Other terminology</u>: Stream; ribbon lagoon; hillside stream; perched stream; coastal stream	(between Mokihinui and Hector, West Coast SI); Granity Stream (West Coast SI). **4C**: Piha Stream, Te Henga Stream (Bethells Beach (Auckland west coast), Hahei Stream and Waikapohai Stream, (Coromandel east coast); Kaiwhata River (Wairarapa), Kōhaihai River (West Coast SI) **4D**: Saltwater Creek/New River (just north of Kumara Junction) and Mohikinui Stream (both West Coast SI). **4E**: Duffers Creek/Te Rahotaiepa; Armoroa River, West Coast SI; Jones Creek (West Coast SI); Omoeroa River (West Coast SI); Waikoriri River (Shearers Swamp, West Coast SI).	**4C:** Have a shallow pond/small lagoon behind the beach. **4D:** Narrow (several 10s of metres), elongate and shallow lagoon that is coast-parallel. Often runs along the dune slack (back dune depression or swale), behind the beach barrier or along the seaward margin of large coastal wetlands, for 100s of m or several km. May have multiple stream inflows. Mouth can migrate for 100s of m along the shoreline at annual time scales. Primarily hydraulically connected to the river with a little input from wetland drainage. **4E:** Narrow (several 10s of metres) elongate water body, running parallel to the coast. The outlet can close off. Connected to a large coastal wetland system that drains into a river mouth, it is typically fed by a braided sand/gravel river (typical of West Coast South Island). Primarily hydraulically connected to the wetland and fed by groundwater drainage from swamps (e.g., Shearer Swamp). Differs from 6E which has tidal influence and an outlet that never closes.
Riverine	**5. *Freshwater river mouth*** Subclass A: *unrestricted* Subclass B: *deltaic*	**5A**: Clarence River (Canterbury). **5B**: West coast Coromandel Peninsula streams if non-tidal (e.g., Tapu, Waiomu, Te Puru).	Permanent connection to the sea, never closes off. Occurs where river flow is large enough to cut a permanent subtidal channel through the shoreline and beach to the sea. River channel gradient to the sea is steep enough to prevent tidal ingress. There may be some overtopping of the barrier beach by waves in storm events when water levels are elevated. River flow dominates the hydrodynamics. No tidal prism or saline intrusion (inflow), although there can be

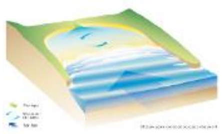
	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
  Clarence  Tapu  Paringa	Subclass C: *barrier beach enclosed* <u>Other terminology</u>: River mouth	**5C**: Ōpouawe River (Wairarapa); Haast River; Paringa River; Cook River; Canoe Creek (a small 5C); Fox River (all West Coast SI).	a tidal backwater effect. Dominant substrate is mixed sand and gravel. **5A:** No delta as wave energy is strong and littoral drift carries the sediment away from the mouth. **5B:** Delta is able to build at mouth as river emerges onto a coastline sheltered from wave energy and sediment supply exceeds the ability of waves to carry it away. **5C:** River mouth restricted by a narrow low beach barrier built by waves. Outlet stays within the boundaries of the main river channel, and doesn't migrate longshore away from the main river channel. No lagoon. River (not wave) dominated and longshore transport less than for *hāpua-type lagoon* coast. Also doesn't experience extreme low flows like some *hāpua-type lagoons*. Substrate is mixed sand and gravel.
Estuarine 	**6. *Tidal river mouth*** Subclass A: *unrestricted* Subclass B: *spit enclosed* (sand/mud) Subclass C: *barrier beach enclosed* (mixed sand/gravel) Subclass D: *intermittent with ribbon lagoon*	**6A**: Waihou River (Waikato); Kauaeranga River (Thames); Te Awakairangi/Hutt River (Wellington). **6B**: Whanganui River (Taranaki); Manawatu River (Manawatu); Whakatane River (Bay of Plenty); Grey River and Karamea River	Elongate, narrow and shallow (mean depth several metres) basins that have a permanent connection to the sea for most of the time. They occur where river and tidal flow are large and persistent enough to maintain a permanent subtidal channel through the shoreline and beach to the sea. River flow delivered during a tidal cycle is a significant proportion of the basin's volume, and is greater than the tidal volume entering. Thus, the hydrosystem-scale hydrodynamic processes are dominated by river flows and these classes are well flushed. Floods can expel all the seawater from the system for days. In deeper systems an estuarine circulation pattern can be set up where outflowing freshwater is balanced by the inflow of seawater entrained beneath

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
 Waihou  Whakatane  New River  Motueka	Subclass E: *deltaic* <u>Other terminology</u>: Tidal river; river mouth; tidal stream; ICOLL; blinder; dead arm; back barrier stream	(West Coast SI). **6C**: Poerua River (Hikimutu Lagoon); Whanganui River; Hokitika River; Arahura River; Waitaha River (6C today, was 6D in the past) (all West Coast SI); Pahaoa River (Wairarapa). **6D**: New River (Greymouth); Totara Lagoon (Ross); Waita River (West Coast SI). **6E**: Motueka River (Tasman Bay); some west coast Coromandel Peninsula streams if tidal (e.g., Tapu, Waiomu, Te Puru); Korokoro Stream (Wellington). *Note*: Tidal rivers can be a component in large systems e.g., the Wairoa River (6A) and the Helensville River (6A) are components of the Kaipara Harbour.	freshwater and a salt wedge develops. Seawater can intrude kilometres up estuary in low-gradient coastal plains. Wind-generated mixing and wave-driven resuspension are minor as wind fetch and waves are small and depths are largely too great for significant bed stress to be produced. Thus sediments inside the waterbody tend to be muddy except in areas of high tidal flows. **6A**: Wide unrestricted mouth. Emerges on low-wave energy shores where there is insufficient littoral drift to build a spit or barrier across the entrance. Salt wedge present and saline intrusion occurs for kilometres upstream in flat land. Dominant substrate is fine sand and mud. **6B**: Narrow inlet restricted by sandy spit with lagoon or wide tidal channel upstream. Emerges on sufficiently high wave energy shores where littoral drift has built a spit or beach barrier across the entrance. Tidal flow through the entrance. Salt wedge present. Dominant substrate is fine sand or mud. **6C**: Similar to 6B but occurs on a mixed sand/gravel coast. Maintains a permanent connection to the sea for most of the time. Hydrodynamics are controlled by the flow in the main river channel; side arms, if present, play little role. Only minor lateral migration of the outlet compared to 6D. **6D**: Narrow, elongate and shallow; runs close to the shoreline up and down coast for kilometres along the dune slack and away from the main river inflow. May have multiple stream inflows. Mouth can breach anywhere along the barrier which can be kilometres long. Hydrodynamics controlled by both the flow in the main river channel, and also flows from adjacent wetlands into the side arms (this water is usually tannin-stained). Frequently connected to the sea (lower reaches are brackish) which sets it apart from 4D *beach stream* (which is never connected to the sea). Small systems are more sensitive to anthropogenic modifications (e.g., mechanical opening to alleviate flooding). Never closes. **6E**: Shallow channelised rivers discharging sandy or gravelly sediment to build a delta into a low-energy coastal environment such as a coastal embayment or fetch-limited sea. The delta can accumulate in the absence of longshore transport.

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
Estuarine   Blueskin Bay  Ngunguru  Hoopers	**7. *Tidal lagoon*** Subclass A: *Permanently open* Subclass B: *Intermittently closed* <u>Other terminology</u> Lagoon; Bay; Inlet; Tidal inlet; River; ICOLL; Estuary; Harbour	**7A**: Blueskin Bay (Otago); Motueka Lagoon (Tasman); Whangateau Harbour (Auckland east coast); Ngunguru River (Northland); Tairua Harbour (Coromandel); Estuary of the Heathcote and Avon Rivers/Ihutai (Christchurch); Awaroa Inlet (Abel Tasman); Te Awarua-o-Porirua Harbour (Wellington). **7B:** Hoopers Inlet (Otago); Saltwater Lagoon and Ōkārito Lagoon (Westland); Ōpārara River (Karamea, West Coast SI) Note: *Tidal lagoons* can form a component inside large systems e.g., the Waionui Inlet at Kaipara Harbour South Head.	Shallow (mean depth 1-3 m), circular to elongate basins with simple (not dendritic) shorelines and extensive intertidal area. A narrow entrance to the sea, constricted by a spit or sand barrier. Ebb and flood tidal delta sand bodies form in the sea and bay sides of the entrance. Strong reversing tidal currents flow through the entrance. The tidal prism makes up a large proportion of the total basin volume. River input is small compared to tidal inflow so hydrodynamic processes are dominated by the tides. Despite the narrow entrance they generally have good flushing because much of the water leaves the estuary on the outgoing tide. River inputs dominate the hydrodynamics for short periods (days) during floods when seawater can be completely expelled. On the incoming tide flood waters get backed up by the tide causing low-lying land around the margins to be flooded. Wind-generated, mixing and resuspension of bottom sediments occur at high tide; this is more pronounced in larger and circular open water bodies with larger fetch. The combination of wave resuspension of the substrate and flushing results in generally homogeneous and sandy substrates. These classes are also well mixed because strong flushing, wind mixing and the shallow depths prohibit density stratification. Salinity is close to that of the sea. Water clarity is good because of the flushing and the sandy substrate. The spit or barrier can be overtopped by waves and breached in extreme events leading to multiple entrances. Dominant substrate is sand. **7A:** Permanently open. Circular to elongate planform and always open to the sea. Well flushed. **7B:** Intermittently closed. Lagoons bar off infrequently and can become eutrophic, until the entrance is breached and tidal exchange resumes.
Estuarine/ Marine	**8. *Shallow drowned valley***	Raglan, Kaipara, Hokianga, Whangarei, Parengarenga, Whangaroa, Mahurangi and	Shallow (mean depth generally less than 5m due to extensive intertidal area) with complex dendritic shorelines and numerous narrow arms leading off a main central basin or channel. Extensive intertidal flats cut by drainage channels.

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
  Paremoremo  Maungamaungaroa  Mahurangi  Kaipara	<u>Other terminology</u> Drowned river valley; harbour; tidal creek; creek; inlet; estuary.	Waitemata Harbours (North Island); Lyttelton Harbour (Canterbury); Whanganui Inlet (northern West Coast SI). Tidal creeks commonly form the tidal arms of large systems such as the Waitemata Harbour (e.g., Lucas, Paremoremo and Brighams Creeks); Mangemangeroa Estuary (Auckland), the Manukau Harbour (Pahurehure Inlet and Mangere Inlet) and the Bay of Islands (e.g., Kerikeri Inlet; Opua Inlet).	Range in size from small tidal creeks (e.g., Mangemangeroa) to large harbours (e.g., Kaipara). Tidally dominated. Mouth always open and constricted by hard headlands or substantial barriers. Flood and ebb tidal sandy deltas are present at the tidal inlet on high wave energy littoral drift shores (e.g., Raglan, Kaipara, Hokianga) but absent on zero-drift shores (e.g., Mahurangi and Waitemata). While sand bodies at the entrance change in planform shape, the inlet does not migrate much because most are fixed by a rock headland on one shore. The systems are largely infilled with sediment. Large systems tend to be sandy at the mouth and in the central basin areas, and muddy in the tidal arms and headwaters. Wind-generated circulation and mixing and wave resuspension of the substrate is important in the wide open central water body where wind fetch is great enough for this to happen. Small tidal creeks are generally very shallow elongate waterways with extensive intertidal areas of muddy substrate. They occur on shores sheltered from wave energy and littoral drift. They often form the shallow arms of larger shallow drowned valleys such as the Waitemata and Kaipara Harbours. The water is generally turbid because of the muddy substrate. Sedimentation rates are generally high as the small fetch does not allow waves to develop and resuspend sediment. These systems are destined to infill. *Shallow drowned valleys* differ from *tidal lagoons* in that they have a greater mean depth. This, along with their planform complexity, means they are not as well flushed.

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
Estuarine/ Marine   Akaroa  Queen Charlotte	**9. *Deep drowned valley*** <u>Other terminology</u> Ria; sound; firth; harbour	Firth of Thames; Wellington Harbour; Queen Charlotte Sound (Tōtaranui); Port Underwood; Akaroa Harbour.	Large, deep (mean depth 10 to 30 m), mostly subtidal systems formed by the partial submergence of an unglaciated river valley. They remain open to the sea. Typically, they have a straight planform without significant branches but they can be dendritic: this pattern is inherited from the drainage pattern of the flooded river valley. In the Marlborough Sounds and Wellington Harbour there are islands, summits of partly submerged hills. The size of the valleys seems large for the size of the rivers currently entering the system. Both river and tidal inputs over the tidal cycle are small proportions of the total basin volume. The wind may modify the circulation and become a dominant force on occasions, but it is not responsible for the mean circulation over extended periods of time. In elongate systems a circulation pattern (estuarine) is set up where outflowing freshwater is balanced by the inflow of seawater entrained beneath freshwater. There is also a strong longitudinal gradient (head to mouth) in hydrodynamic processes with riverine forcing and stratification dominating in the headwaters and tidal forcing near the entrance. The systems are characterised by poor flushing, which is pronounced in the headwaters and in more complex shaped systems that have multiple arms. Ocean swell and wind waves are unimportant in substrate resuspension processes because of the large depth of the basin. The substrate is generally fine sand or mud. They differ from *shallow drowned valleys* in that they are deeper, do not have sand deltas at the mouth, have far less intertidal area and hydrodynamics are less dominated by the tides.
Estuarine/ Marine 	**10. *Fjord*** <u>Other terminology</u> Drowned glacial valley; fiord; sound.	Charles Sound; Thompson/Doubtful Sound; Bligh Sound; Milford Sound.	Long, narrow and very deep (mean depth 70 to 140 m) U-shaped basins with steep sides or cliffs, formed in glacial valleys flooded by the sea following the last glacial and sea-level rise. The basin is subtidal, with only small intertidal areas in the headwaters and is characterised by sills at the mouth and along the length of the system that were formed as glacial terminal moraines. Both river and tidal inputs over the tidal cycle are very small proportions of the total basin water volume. Water movement near the surface is controlled primarily by

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
 Charles Sound  Thompson Sound			thermohaline forcing where the circulation is maintained by the large density differences produced by the salinity contrast between freshwater and oceanic water. The resulting circulation pattern is characterised by out-flowing freshwater, which is balanced by the inflowing seawater entrained beneath freshwater. Wind may modify this circulation and wind-driven circulation may become a dominant force on occasions, but it is not responsible for the mean circulation over extended periods. Consequently, these estuaries are characterised by poor flushing, particularly in more complex-shaped (multiple arm) systems. The very deep basin and partitioning by sills means that flushing takes place in a relatively thin layer of freshwater, which moves over the top of a 'quiescent zone' of seawater. Substrate resuspension by ocean swell or wind waves is not an important hydrodynamic process because of the basin depth. As a consequence, the substrate is generally fine sand or mud.
Marine   Matai Bay	**11. *Coastal embayment*** <u>Other terminology</u> Embayment; pocket beach; bay; semi-enclosed coastal embayment; cove.	Taemaro Bay, Matai Bay (Northland); Sleepy Bay (Banks Peninsula); Lyall Bay (Wellington); Kawau Island (Bon Accord Harbour) and Rocky Bay (Waiheke Island).	An indentation in the shoreline with a wide entrance, bounded by rocky headlands and open to the ocean. The waterbody is shallow to medium depth (4 to 8 m) and circular to elongate in planform. They are mostly sub-tidal with small intertidal areas restricted to the headwaters, or the sheltered side arms of the more elongate types. There is little river influence and circulation is weak from tidal and wind-generated currents. The entrances are wide and open to the ocean, allowing swell to enter the bay and resuspend seabed sediments, thus hydrodynamic processes are dominated by the ocean. Pocket beaches occur in the upper reaches. There are no sand bodies (tidal deltas) on the ocean side of the entrance. Wind- and wave-driven mixing occur. The substrate tends to be sandy. Wave refraction disperses wave energy through the bay and, along with the sheltering effect of the headlands, shelters the embayments from storms. Sedimentation and infilling is very slow because inputs from streams are small and waves entering resuspend sediments, which can then be transported out by currents. *Coastal embayments* occur on rocky headland coasts with good examples occurring on the Northland and Auckland east coasts. On Banks Peninsula the eroded flanks of two large shield volcano

	Geomorphic class (Level III) and terminology	Reference examples	Important distinguishing characteristics
 Taemaro Bay  Sleepy Bay			complexes formed narrow steep-sided valleys that were flooded during sea-level rise following the last glacial to form many small *coastal embayments*. They differ from *shallow drowned valleys* in that they are largely subtidal and the wide mouths allow ocean forcing by waves.

3.2 Composite systems

Composite systems are those that contain subsystem(s) or components representing different geomorphic classes. This is a function of scale. For instance, the large Kaipara Harbour as a whole may be classified as a *shallow drowned valley* (class 8), but it contains subsystems that may be classed as *tidal rivers* (class 6, Wairoa and Helensville Rivers) and *tidal lagoons* (class 7 Waionui Inlet). It also contains some small *shallow drowned valleys* (Tauhoa and Oruawharo Rivers). Whether the classification is applied to a composite system as a whole or to a component depends on the management application. For instance, in the case of the Kaipara Harbour, when harbour-wide effects of catchment runoff are being considered it is best to consider the whole system as a *shallow drowned valley* because tidal circulation causes exchanges between waters from the Wairoa River in the north, the central basin and waters from the southern part of the harbour. If, however, the management issue being considered is more local, such as the effects of freshwater extraction from the northern arm of the harbour (the Wairoa River) for irrigation purposes on salinity intrusion (e.g., Hume and Male 1985), then it should be the characteristics of the Wairoa *tidal river* that are considered.

3.3 Stability of geomorphic classes

Coastal hydrosystems can be significantly impacted by natural and anthropogenic disturbances because they are affected by dynamics of both land and sea, and often are associated with human habitation and use.

3.3.1 Natural processes

Natural disturbances cause varying degrees of change in hydrosystem morphology and planform shape (footprint). For instance, the outlet of *hāpua-type lagoons* (class 3) may close off from the sea for long or short periods and/or the outlet might be highly mobile. The footprints of some *damp sand plain lakes* (class 1) and *tidal lagoons* (class 7) change markedly as freshwater inputs and groundwater levels change due to climatic or anthropogenic influences. In many systems, ocean waves continually pound the barrier beaches or spits that shelter inland development from direct wave attack and erosion. High water levels associated with storm surges allow large waves to overtop and breach spits, and waves to enter and erode the inner shores, causing changes that are sometimes permanent. These dynamic characteristics vary with geomorphic class (Table 3-3) and show varying degrees and rates of recovery.

Generally, hydrosystems will not change from one class to another unless there is a substantial and long-term change in the controlling processes: for example, changes in basin shape, river hydrology, tidal inflows or prism, wave climate or, in some cases, engineering interventions to stabilise or alter mouth and/or channel locations. While large floods or wave events may change the forcings in a system temporarily (e.g., river flow dominating over tides for several tidal cycles), systems generally will return to their pre-event state.

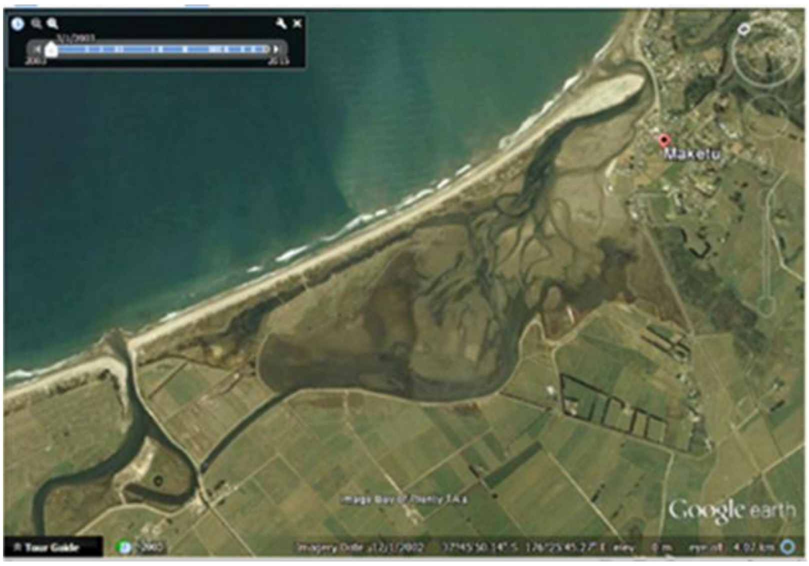
Table 3-3: **Summary of the temporal and spatial dynamics of geomorphic classes and subclasses.**

	Geomorphic class	Hydrosystem temporal state				Hydrosystem spatial state
		Permanently closed	Mostly closed	Mostly open	Permanently open	Planform shape change
1	Damp sand plain lake	X				X
2	Waituna-type lagoon					
	A. coastal plain depression		X			X
	B. valley basin		X			
3	Hāpua-type lagoon					
	A. large hāpua-type lagoon			X		X
	B. medium hāpua-type lagoon			X		X
	C. small hāpua-type lagoon		X			X
	D. intermittent hāpua-type lagoon			X		X
4	Beach stream					
	A. hillside stream				X	
	B. damp sand plain stream			X		
	C. stream with pond			X		X
	D. stream with ribbon lagoon			X		X
	E. intermittent stream with RL			X		X
5	Freshwater river mouth					
	A. unrestricted				X	
	B. deltaic					X
	C. barrier beach enclosed					X
6	Tidal river mouth					
	A. unrestricted				X	
	B. spit enclosed				X	
	C. barrier beach enclosed				X	X
	D. intermittent w ribbon lagoon			X		X
	E. deltaic				X	X
7	Tidal lagoon					
	A. permanently open				X	
	B. intermittently closed			X		X
8	Shallow drowned valley				X	
9	Deep drowned valley				X	
10	Fjord				X	
11	Coastal embayment				X	

3.3.2 Anthropogenic impacts

Geomorphic class changes occur over longer timescales and are often associated with anthropogenic impacts. Examples of change in geomorphic class caused by human intervention include the Waimataitai Lagoon near Timaru, where changes in catchment hydrology caused the system to change from a *waituna-type lagoon* (class 2) to a *coastal embayment* (class 11); and the case of the Maketu Estuary in the Bay of Plenty a change from *tidal river mouth* to *tidal lagoon*: (see inset box).

Human intervention can change geomorphic class: the case of Maketu Estuary



Maketu Estuary is a small (2.3 km^2), shallow tidal lagoon in the Bay of Plenty which receives inflows from the Kaituna River. Since records began in 1877 and until 1957, the Kaituna River generally flowed out to sea via Maketu Estuary's eastern outlet, although at times the river breached an outlet channel through the spit between the estuary and the sea at a westward location (Park 2014). Under this historical scenario, the system would have fitted into the geomorphic class tidal river mouth (class 6). Burton and Healy (1985) described how prior to 1957 Kaituna River discharge into the Maketu averaged 47 m^3/s. The hydrosystem exhibited a typical tidal river mouth entrance configuration at the eastern outlet (upper right of image), with a very small ocean bar and no flood tide delta, and river flows dominated over tides. In February 1957, a new channel was artificially opened to divert the river directly to the sea at Te Tumu in the west (lower left of image) to prevent flooding of farmland around the shore. River discharges of only 2 m^3/s were left flowing into the estuary. The flushing ability of the estuarine ebb tide flows was substantially reduced and the estuary exhibited extensive build-up of sandy intertidal flats. It developed a substantial flood tide delta and larger ebb delta at the original eastern entrance, features characteristic of the geomorphic class tidal lagoon (class 7). The build-up of sediment and increase in salinity have had wide-reaching effects including affecting fish and shellfish stocks (Gregory 1981), significantly reducing saltmarsh habitats (Donovan and Larcombe 1976; Bergin 1994), degrading water quality (Goodhue 2007; Bramley 2010) and impeding access and navigation. Because of this, restricted flows were re-diverted back to the estuary in 1996.

Arguably one of the greatest historical impacts on coastal hydrosystems has been their large-scale conversion by draining, reclamation, entrance controls by jetties and damming or dredging for various developments including farming, marinas, ports and causeways for roading. Human activities have resulted in the loss of approximately 95% of the fringing wetlands in pre-European New Zealand that were associated with present day coastal hydrosystems (Pawson and Holland 2005). Examples of these activities include: (i) river diversions by separation of the tributary inflows from the main stem along with training works to stabilise the position of the mouth of the Clutha River (Figure 3-1); (ii) river diversion out of the lagoon and direct to the sea at the mouth of the Waimakariri River (Figure 3-2) and the Maketu River diversion mentioned previously; (iii) reclamation at Lake Grassmere (Kapara Te Hau) to form evaporation ponds for salt works (Figure 3-3); and (iv) almost complete closure of Orakei Basin by a railway causeway and tidal gate (Figure 3-4). It is, however, arguable (and perhaps variable between regions) whether these activities remain the number-one threat or if catchment and freshwater resource development has in some regions (e.g., irrigation in the Canterbury region), overtaken them.

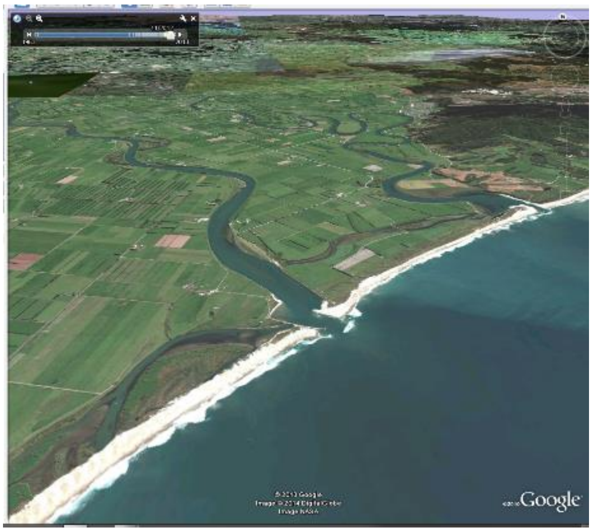


Figure 3-1: Clutha River, Otago.

Figure 3-2: Waimakariri River, Canterbury.

Figure 3-3: Lake Grassmere, Marlborough.

Figure 3-4: Orakei Basin, Auckland.

4 Inventory of environmental variables

4.1 The database

In developing the classification, we identified some 500 discrete coastal hydrosystems and built a database that provides a selection of frequently-asked-for environmental variables (Appendix E). The database comprises information from two sources.

The first source is from a database developed for over 400 estuaries by Hume et al. (2007). These variables were used for various purposes including:

- Examining the relationship between physical characteristics of intertidal areas and the size and diversity of wader bird populations (Whelan et al. 2003).
- Developing predictive models of small fish presence and abundance in northern harbours (Francis et al. 2005).
- Predicting macrofaunal species distributions along estuarine gradients (Ellis et al. 2006).
- Developing an extension of the CLUES (Catchment Land Use for Environmental Sustainability) tool (Elliott et al. 2016) to predict estuarine nutrient concentrations and other parameters (CLUES-Estuaries: Plew et al. 2015).

The database of Hume et al. (2007) excluded variables for most palustrine, lacustrine and riverine systems, which in this study we term *damp sand plain lakes, waituna-type lagoons, hāpua-type lagoons, beach streams* and *freshwater river mouths*.

The second source is data that we have compiled for *waituna-type lagoons*, *hāpua-type lagoons*, *freshwater river mouths* and *beach streams*. While the list is largely complete for the first three, we provide just a few examples for *damp sand plain lakes* and *beach streams* as these are very numerous and need to be classified and mapped at a local level as specific management needs arise.

Appendix E documents the procedures used in calculating the environmental variables in order that users are aware of limitations in accuracy and use the data accordingly. As better methodologies emerge, a decision can be made as to whether revision is necessary. There is a further description of this in Hume (2014).

As well as providing the database for environmental variables in Appendix E of this report, we have provided the data in several different forms to facilitate its use (these will be made available via the MFE website) namely:

- Excel (.xls) spreadsheet of environmental variables.
- GIS shape files (polygons) and point files.
- Google Earth point files (.kmz) – when both these files are opened together, they show the system polygons and points at the mouths of the systems which if "clicked on" (selected) display the environment variables for the selected hydrosystem.

4.2 Distribution of coastal hydrosystems in New Zealand

The environmental variables can be used to provide national and regional statistics that offer answers to questions such as: *How many are there? Where are they? How many do we have of this class? Which are rare in a region? Which is the biggest? Where are the marine- versus freshwater-dominated systems?*

Table 4-1 and Figure 4-1 show the distribution of the various geomorphic classes of coastal hydrosystem throughout New Zealand and illustrate that:

- *Waituna-type lagoons* and *fjords* are the rarest geomorphic classes.
- *Tidal river mouths, tidal lagoons* and *coastal embayments* are the most abundant geomorphic classes (although *damp sand plain lakes* and *beach streams* in particular are very abundant).
- Geographical occurrence in New Zealand varies with geomorphic class. For instance, *waituna-type lagoons, hāpua-type lagoons* and *freshwater river mouths* occur primarily in the South Island; *fjords* are restricted to the southwest corner of the South Island; *shallow drowned valleys* occur mostly in Northland, Auckland and Waikato; *coastal embayments* are abundant in Northland, Auckland, Canterbury and Southland; *tidal river mouths* and *tidal lagoons* are distributed throughout New Zealand. This reflects the fact that geographical occurrence is related to catchment runoff, geology, tectonics (e.g., faulting), antecedent conditions (e.g., glaciation), geomorphology and hydrodynamics (sections 3 and 4 of this report). For instance, *hāpua-type lagoons* are restricted to high wave energy mixed sand/gravel coasts with small tidal range, *fjords* occur in very deep glacier-cut valleys and coastal embayments occur on rocky headland low littoral drift shores.
- The distributions also make it very clear that councils in New Zealand have different suites of coastal hydrosystems. For instance, Northland Regional Council and Auckland Council have mostly *tidal lagoons*, *shallow drowned valleys* and *coastal embayments* to manage, while the West Coast councils (South Island) have primarily *freshwater river mouths* and *tidal river mouths* to manage. Environment Southland has the widest variety of hydrosystems to manage. A consequence of this is that the councils have different information requirements and issues to deal with and require different approaches in respect of monitoring and management of their coastal hydrosystems.

Table 4-1: Distribution of coastal hydrosystems geomorphic classes by council region in New Zealand. Note that classes 1 *damp sand plain lakes* and 4 *beach streams* and are excluded from the statistics as only a small selection were mapped. Note that some hydrosystems (e.g., Kaipara Harbour and Firth of Thames) appear in two council regions.

Council region	2 Waituna-type lagoon	3 Hāpua-type lagoon	5 Freshwater river mouth	6 Tidal river mouth	7 Tidal lagoon	8 Shallow drowned valley	9 Deep drowned valley	10 Fjord	11 Coastal embayment	Total
Northland Regional Council				3	16	9	5		20	53
Auckland Council			1	1	8	14	2		23	49
Waikato Regional Council			2	8	11	20	2		8	51
Bay of Plenty Regional Council		4		7	5	1	1			18
Gisborne district Council		1		9	1					11
Hawkes Bay Regional Council	4	2		5	3					14
Taranaki Regional Council				11						
Horizons Regional Council				7						
Greater Wellington Regional Council	3	1	1	8		1	1		6	21
Tasman District Council		3	4	2	22	3				34
Nelson City Council					6					
Marlborough District Council	1	2	1	2			5		6	17
West Coast Regional Council		3	11	27	7					48
Environment Canterbury	4	11		1	1		2		22	41
Otago Regional Council				4	13		1			18
Environment Southland	2	2	1	2	6	2	2	12	21	50
Chatham Islands District Council	2				1				5	8
Total	16	29	21	97	100	49	22	12	111	

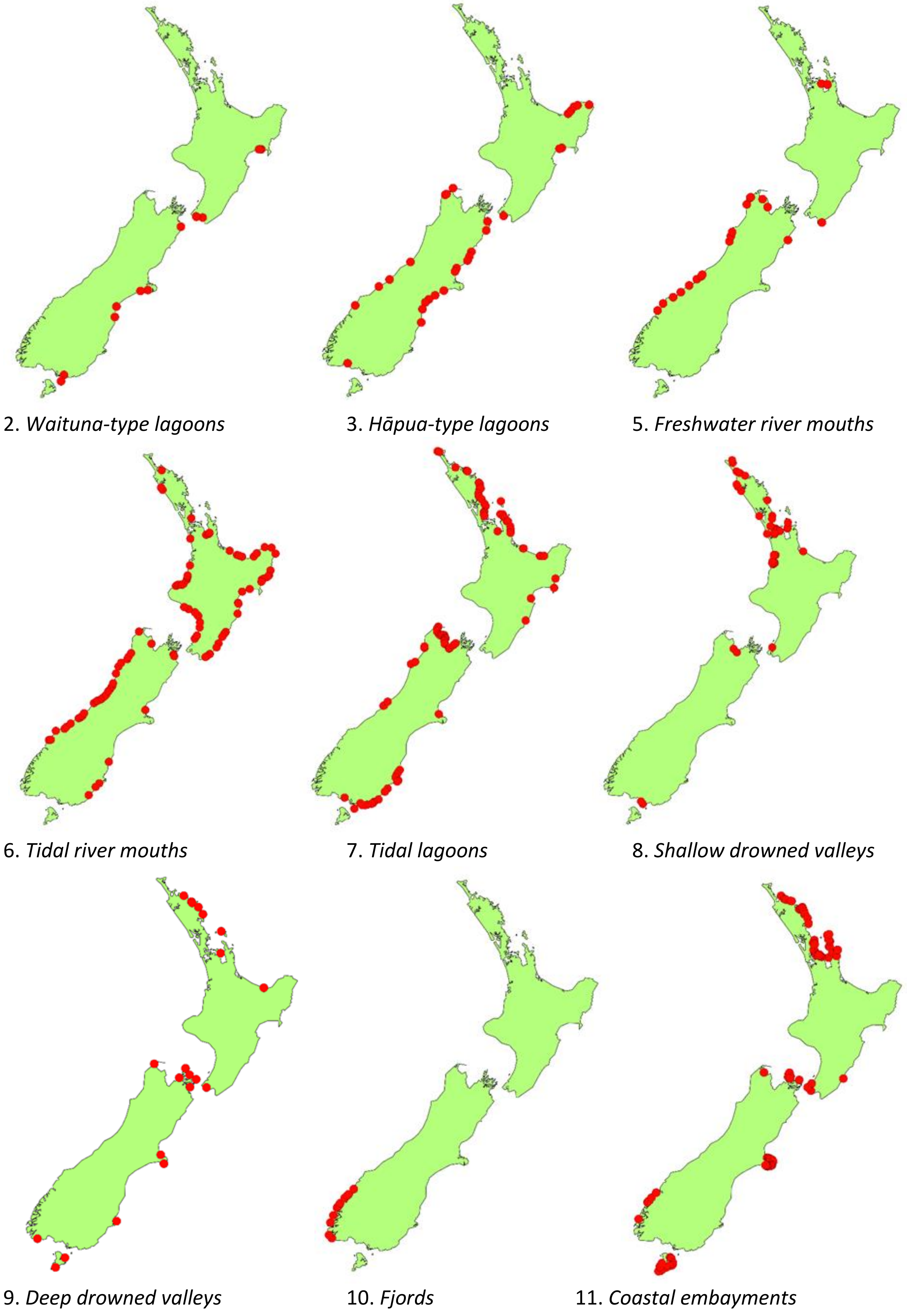


Figure 4-1: Distribution of the various geomorphic classes of coastal hydrosystem throughout New Zealand. Note that *damp sand plain lakes* and *beach streams* have not been mapped and that Chatham Island is excluded from these maps.

Table 4-2 illustrates some of the key distinguishing characteristics of the geomorphic classes (described in more detail in Table 3-2) as being:

- *Waituna-type lagoon* – Very narrow mouth (if open), very shallow, zero tidal prism, large surface area, relatively small catchment area, low freshwater input.
- *Hāpua-type-lagoon* – Narrow outlet, very shallow, small surface area, zero tidal prism, large catchment area and river inflow volume over tidal cycle.
- *Freshwater river mouth* – Narrow entrance, very shallow, zero tidal prism, large river inflow volume over tidal cycle.
- *Tidal river mouth* – Small surface area, shallow, small intertidal area, large river inflow volume over tidal cycle compared to tidal prism.
- *Tidal lagoon* – Narrow mouth, sand deltas at mouth, very shallow, extensive intertidal area, large tidal prism compared to river inflow volume over tidal cycle.
- *Shallow drowned valley* – Very shallow, dendritic planform, extensive intertidal area, large tidal prism compared to river inflow volume over tidal cycle.
- *Deep drowned valley* – Medium depth, no sand deltas at the mouth, large surface area, small intertidal area, large tidal prism compared to river inflow volume over tidal cycle.
- *Fjord* – Very deep, mostly subtidal, small tidal prism and small river inflow volume over tidal cycle, prism and river volume small compared to total volume of water body.
- *Coastal embayment* – Wide mouth, medium depth, small catchment and river discharge.

Table 4-2: Some key distinguishing characteristics of coastal hydrosystems in New Zealand. The values in the table are the mean for the geomorphic class. Note that geomorphic classes 1 *damp sand plain lakes* and 4 *beach streams* and are excluded from the statistics as they have not been mapped.

Hydrosystem class	Mean width of mouth (m)	Mean depth (m)	Mean surface area at HW (m^2)	Mean intertidal area (%)	Mean spring tidal prism (m^3)	Mean total volume (m^3)	Mean catchment area (km^2)	Mean river inflow volume over tidal cycle (m^3)
Waituna-type lagoon	6	1	15641091	0	0	14780454	427	739258
Hāpua-type-lagoon	88	1.5	288365	0	0	358251	1557	3872314
Freshwater river mouth	74	2	273202	0	0		510	1316752
Tidal river mouth	233	3	1162242	14	2471868	4898102	1296	3218290
Tidal lagoon	311	2	4515747	64	3012496	5276518	197	490236
Shallow drowned valley	1143	2	46756263	67	86998457	193593650	438	936536
Deep drowned valley	4913	11	128644214	17	288310169	1642769915	485	1168443
Fjord	2728	92	64945489	1	121136411	6963116023	398	4204420
Coastal embayment	1287	8	3046341	8	5837590	42307206	20	61903

5 Applications to management

Generally, classifying ecosystems is found useful because it can:

- Map, evaluate and rank systems in a consistent way, at national, regional or local scale.
- Help with conservation and restoration planning, e.g., producing broad-scale/fine-scale sets of representative areas upon which to focus efforts.
- Provide a framework that can easily describe the natural values, functions and ecosystem services attached to the different classes of hydrosystem, recognise associated values threats and effects, enabling management needs and practices to be tailored appropriately.
- Build inventories of environmental variables and enhance and simplify information in geospatial databases.
- Assist in developing assessments and monitoring of environmental trends with appropriate indicators or water-quality limits set for each class.
- Fulfil national and international state-of-the-environment reporting requirements in a consistent way.
- Enable scientists and managers to better understand functions, processes and services attached to specific types of systems and provide uniformity in concepts and terminology.
- Raise public awareness of the diversity, values and uses of and anthropogenic effects on different coastal hydrosystem types.

Both a nationally accepted classification and consistent application of terminology are important to the identification and management of priorities under statutes and policies such as the Resource Management Act 1991 (RMA), the Coastal Policy Statement (NZCPS) or the National Policy Statement for Freshwater (NPS-FW). The RMA and NZCPS[3] in particular contain objectives and policies and reference to coastal hydrosystem terminology and types and the coastal environment in general (Appendix Table A-1).

The next section provides examples of different ways the classification can support decision-making.

5.1 Mapping systems and conservation and restoration planning

The database for the hydrosystems (Appendix E) can be used to build geospatial maps to show where the different types of system occur once the data are input to Geographical Information System (GIS) and linked to hydrosystem shape files[4].

One such application is for mapping rare systems, which is a pre-requisite for implementing policy 11 (a) (iv) of the NZCPS to "avoid adverse effects of activities on habitats of indigenous species that are naturally rare". Estuaries, lagoons, damp sand plains and dune slacks have been identified by Williams et al. (2007) as 'historically rare'. It is possible to map the location of unmodified systems, once rules are developed to define "unmodified" for the various classes. In the simple example that follows (Figure 5-1) "unmodified" was defined by the level of modification of catchment land cover, where modified is "pasture + urban" from a landcover database, and unmodified is "indigenous vegetation, tussock, scrub & regenerating bush, bare ground, wetland". This, of course, assumes that changes in catchment land cover cause changes in runoff and soil erosion and a corresponding deterioration of water quality. The unmodified systems mapped in green were those where less than 20% of the landcover is modified from its pre-European state.

[3] Further information on these policy statements can be found at http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/coastal-management/managing-coastal-policy.pdf and http://www.mfe.govt.nz/fresh-water/national-policy-statement/about-nps, respectively.
[4] Shape files for the hydrosystems will be available from the MFE website for this purpose.

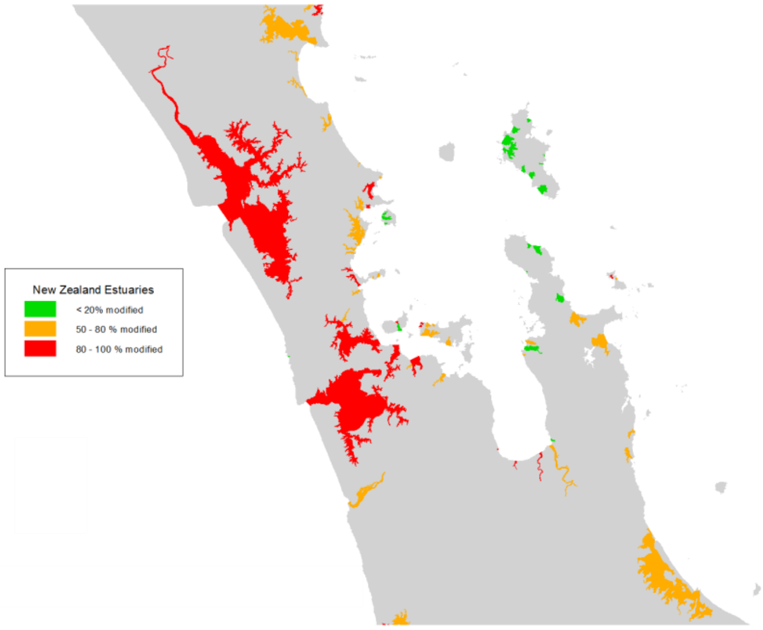


Figure 5-1: This example adapted from Hume et al. (2007) shows mapping of unmodified (green) and highly modified (red) estuaries.

5.2 Catchment land and water use planning and consenting

The following two case studies illustrate how correct classification of coastal hydrosystems has important consequences for the way their catchments are managed. Incorrect classification can lead to incorrect assessment of environmental effects and hence erroneous management actions.

Hurunui River: are low flows impacting on an estuary or a hāpua-type lagoon?

The Hurunui River discharges to sea on the Canterbury coast. At its mouth is a *hāpua-type lagoon*. The image shows its gravel barrier, elongate lagoon and narrow outlet to the sea that migrates considerable distances up and down the coast at annual time scales. During the initial feasibility investigations of constructing water storage dams on the south branch of the river and the outlet of Lake Sumner, a report assessed the environmental effects downstream. It described the system as an estuary. A desktop assessment of the effects of the proposed dam was written using textbook knowledge of estuarine responses to impoundment. Both the substance and conclusions of this assessment were incorrect because the system is not an estuary but a *hāpua-type lagoon* (subclass B). The Department of Conservation and others informed the decision makers correcting this error. Without this correction this assessment would have led to significant underestimation of the geomorphic and ecological effects of altering low flows, clearly illustrating the importance of correct classification.

Wainono Lagoon: is the nutrient-management regime for a shallow freshwater lake or a waituna-type lagoon?

Wainono Lagoon and its history (e.g., Schallenberg and Saulnier-Talbot 2014) was the focus of attention in submissions made at a hearing held in September 2015 on the Partially Operative Canterbury Land and Water Regional Plan, Plan Change 3. The recognition of the lagoon as a coastal rather than freshwater hydrosystem ("a shallow lake") became central to the discussion on how to manage nutrient levels.

It was argued (Gerbeaux 2015, Schallenberg 2015) that Wainono should be described as a *waituna-type lagoon*. It was acknowledged that the system behaved like a coastal lake which, though it was more usually closed from the sea than opened to it, received inputs of sea water. This caused its salinity to vary: its brackishness, (along with the shallowness of the system, a strong influence from flood inflow events and a particular regime of water level and salinity fluctuations characteristics) made Wainono more like similar coastal brackish lagoons than inland shallow freshwater lakes (Gerbeaux 2015). Schallenberg (2015) argued that the proposed use of a freshwater lake ecological model for managing nutrients in the lagoon, as proposed by Plan Change 3, may not capture important biogeochemical differences between freshwater lakes and brackish lakes/lagoons. One key example related to the different availability of phosphorus, a key plant nutrient in Wainono Lagoon, between freshwater lakes and coastal marine systems. Salts can cause dissolved inorganic and organic phosphorus to flocculate in the water column. In addition, phosphorus immobilisation (availability) in bed sediments differs markedly between freshwater lakes and coastal marine systems. These are just two ways in which brackish and freshwater lakes can have different phosphorus dynamics. Schallenberg concluded that a freshwater model which did not incorporate these processes influencing phosphorous dynamics was therefore an inappropriate management tool.

5.3 Recognising values, threats and effects to coastal hydrosystems

In this section we show how values, threats and effects are related to geomorphic type and provide a matrix table methodology to assist in management applications.

The management issues and ecosystem services associated with coastal hydrosystems have been reported by a number of authors (e.g., Dugan 1990, Agardy and Alder 2005, Ramsar Convention Secretariat 2010). They argue that factors influencing management are strongly linked to the set of values and threats associated with different types of hydrosystem. It follows that a classification that recognises different classes of hydrosystems, their distinguishing characteristics and associated values, threats and effects will be valuable in coastal management.

The many uses and values of New Zealand's estuarine systems have been reviewed by Thrush et al. (2013) under a new ecosystem services framework proposed by the Millenium Ecosystem Assessment (MEA 2005). In it, functions and values are labelled "ecosystem services" and are grouped as follows:

(i) *provisioning*: production of food, materials and medicines/pharmaceuticals

(ii) *regulating and maintenance*: storing and cycling nutrients, maintaining hydrological cycles, maintaining hydraulic connection and shoreline stability

(iii) *supporting*: provision of habitat and ecological community resilience, and

(iv) *cultural*: contribution to social and individual well-being.

For a long time one of the main sources of information for assessing the conservation values associated with coastal wetlands has been the WERI (Wetland of Ecological and Representative Importance) inventory, along with other scientific or non-scientific reports and papers, including those developed under DoC's Coastal Resource Inventory Programme. Values important to Māori are receiving increased recognition (e.g., see objective 3 of NZCPS, and objective D1 of NPS-FW) and have been reviewed in Environs Holdings Te Uri of Hau Settlement Trust (2011) and Harmsworth et al. (2013, 2014).

Prior to the work of Thrush et al. (2013), Allen et al. (2010), Batstone et al. (2009), Beaumont et al. (2008, 2010), Gerbeaux (2003, 2004) also referred to those functions and values as:

- life-supporting values – habitats for species, corridors, ecotones, resulting from hydrological, water-quality, biological and ecological interactions and processes
- socio-cultural values – such as aesthetic, recreational, educational, cultural (including Maori) and spiritual attributes, and
- production values – such as the presence of renewable and non-renewable resources, and by the role of water in tourism or industrial (aquaculture, ports) and urban development.

Knowledge of these functions, values and services provides us with direction on what kind of management and/or monitoring is needed to maintain these features at each site and also gives guidance on what is likely to be at stake when a site is proposed for use and/or development.

Both the NZCPS and the NPS-FW make reference to a number of values that require management attention. For instance, NZCPS policies that focus on the management of values (plus associated services and uses) are: policies 8 (aquaculture), 9 (ports), 11 (biodiversity), 13 (natural character), 15 (natural features and landscapes), 17 (historic and archaeological sites), 18, 19, and 20 (recreation). The NPS-FW also contains a number of clear references to values in the objectives and policies. In particular a focus on values is found in: Objective A1 and B1 *("to safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems*"); Objective A2 ("*The overall quality of fresh water within a region is maintained or improved while: a) protecting the significant values of outstanding freshwater bodies; b) protecting the significant values of wetlands*"); Objective B4 ("*To protect significant values of wetlands and of outstanding freshwater bodies*"); Policy CA2 (b) ("*identifying the values for each freshwater management unit*"); Objective D1("*ensure that tāngata whenua values and interests are identified and reflected in the management of fresh water including associated ecosystems*"); Policy D1 b) ("*work with iwi and hapū to identify tāngata whenua values and interests in fresh water and freshwater ecosystems in the region*"); Appendix 1 of the NPS-FW contains a list of relevant values as well.

Values, threats and effects can often be specific to particular types of coastal hydrosystem. For example, types strongly influenced by riverine input may require more integrated planning and management of their catchments than *coastal embayments*, which are more marine influenced*; tidal river mouths* and *waituna-type lagoons* may hold strong Māori values; *fjords* may require less management of coastal hazard risks than *tidal lagoons*.

Below we describe an application of our classification to management that involves a multi criteria analysis approach illustrating how services, values, uses and drivers of change (threats and effects) in systems are associated with geomorphic classes (Table 5-1, Table 5-2, Table 5-3). This approach was trialled at our workshop with stakeholders held in February 2016. We consider that it will be particularly useful to managers in regions where a wide variety of classes/subclasses are present and who need to prioritise the factors likely to influence a management response. We have developed tables for just four classes by way of example. Our recommendation would be for the tables to be further developed locally with management purpose in mind, because the values, services, threats and effects are likely to vary from region to region and require knowledge at that level to be most useful.

In the examples provided, the matrix tables list in the left columns the possible services, values, uses and threats and effects. Here we have attempted as much as possible to use the management terminology used by MacDiarmid et al. (2012), Stevens and Robertson (2009), Stevens and Robertson (2015), Gerbeaux et al. (2016) and Robertson et al. (2016a, b). Depending on the management purpose, other categories could of course be added. The services, values and uses are grouped in ecosystem services categories currently in use (and briefly described above in this section): provisioning, regulation, habitat, cultural services. We have also included in the table an economic value category that some managers may need to recognise as part of their management response (see Table 5-1). Threats and effects (Table 5-2 and Table 5-3) are grouped in categories reflecting the geographic origin of the driver (s) causing change to coastal hydrosystems; change that often leads to a management response: land-origin, in-situ-origin, marine-origin.

The top rows of the tables list the coastal hydrosystem geomorphic class. The degree of importance of the services, values, uses and drivers of change is shown by the different colour and size of the dots: red = high, orange = medium and black = low. Cells with no dot indicate that the services, values, uses and threats and effects listed on that row are not relevant.

Besides the opportunity to record what value/threat/effect may be present in one class or another, a multi criteria approach also enables to assign a degree of importance to those values and drivers of change associated to geomorphic subclasses (which was identified at the February 2016 workshop as the most suitable level for general management purpose). We have represented this in the matrix tables using dots of different colour and size.

Table 5-1: Services, values and uses for coastal hydrosystems. The coloured subheadings are adapted from Thrush et al. (2013).

Services, values and uses	● (low)	● (medium)	● (high)									
	low	medium	high									
Geomorphic class	**Damp sand plain lake**	**Waituna-type lagoon**		**Hāpua-type lagoon**				**Beach stream**				
Geomorphic subclass	**1A**	**2A**	**2B**	**3A**	**3B**	**3C**	**3D**	**4A**	**4B**	**4C**	**4D**	**4E**
Provisioning services												
Fish production (snapper, cod, tuna/eels)	low	medium		medium	medium	medium	medium	low	low	low	high	medium
Shellfish production (scallops, pipi, cockles)												
Other food production (birds)				medium	medium							
Raw materials production (plants, kelp/poha, gravel mining)												
Production for medicinal use (chemical extracts from species)												
Regulation and maintenance services												
Waste regulation (removal of some pollutants)												
Storage and cycling of nutrients		medium	medium									
Climate regulation (carbon sequestration, high rates of gas exchange)												
Sediment formation and bed stability												
Maintenance of hydrology and shoreline protection		high	high	medium	medium	medium	medium	low	low	low	medium	medium
Habitat and ecologic community services												
Provision of habitat for species and communities (biodiversity)	low	high	high	low	low	low	low	low	low	medium	medium	medium
Provision of ecological values (connectivity, resilience, natural character)												
Provision of genetic resources												
Feeding grounds (for birds)				medium	medium							
Roosting areas (for birds)				medium	medium							
Cultural services												
Cultural and spiritual heritage values (Maori and non-Maori)	low	high	high	high	high	high	high	low	low	medium	medium	low
Recreation values (water sports, bird watching, walking, surfing)	low	medium	medium	medium	medium	medium	medium	low	low	medium	medium	low
Amenity, aesthetics and landscape values	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium	medium
Education and scientific values												
Economic resource (existing or potential - note that those are potentially threats but can be												
Habitat for aquaculture (mussel/slamon farms)												
Tourism (Visitor centres, diving operations, boating tours)												
Transport routes, navigation, mooring												
Locations for industrial, agricultural & urban infrastructure development (ports, moorings)												

Table 5-2: Threats to coastal hydrosystems. The threats are adapted from MacDiarmid et al. (2012).

Threats		•	🟡	🔴									
		low	medium	high									
	Geomorphic class	**Damp sand plain lake**	**Waituna-type lagoon**		**Hāpua-type lagoon**				**Beach stream**				
	Geomorphic subclass	**1A**	**2A**	**2B**	**3A**	**3B**	**3C**	3D	**4A**	**4B**	**4C**	**4D**	**4E**
Land origin													
Catchment development	Water extraction	•	🔴	🔴	🔴	🔴	🔴	🔴				•	🟡
	Rural land use change	•	🔴	🔴	🔴	🔴	🔴	🟡	•	•	🟡	🟡	•
	River diversion	•	🔴	🔴	🔴	🔴	🔴	🔴					
	Dams on rivers	•	•	•	🔴	🔴	🔴	🔴	•	•	•	•	•
	Diversion races												
Urban development/population increase	Sewage discharge	•	•	•	•	•	•	•	•	•	🟡	•	•
	Overharvesting	•	•	•	•	•	•	•	•	•	•	•	•
	Residential development	•	•	•	•	•	•	•	•	•	•	•	•
	Industrial development	•	•	•	•	•	•	•	•	•	•	•	•
	Infrastructure development	•	•	•	•	•	•	•	•	•	•	•	•
In-situ													
Engineering works & interventions	Artificial opening	•	🔴	🔴	🔴	🔴	🔴	🟡	•	🟡	🟡	•	•
	Reclamation	•	•	•	•	•	•	•	•	•	🟡	•	•
	River training works	•	•	•	•	•	•	•	•	•	•	•?	•
	River straightening/realignment	•	•	•	•	•	•	•	•	•	•	•	•
	Dredging for navigation	•	•	•	•	•	•	•	•	•	•	•	•
	Entrance/outlet training works	•	🟡	🟡	🟡	🟡	🟡	🟡	•	•	🟡	•	•
	Sand and gravel mining	•	•	•	•	•	•	•	•	•	•	•	🟡
	Marinas and moorings												
	Marine energy generation												
Aquaculture	Caged fish												
	Mussel farms												
	Clam harvesting												
Earthquakes	Land elevation changes												
	Liquefaction												
Increased human usage	Overharvesting		🟡	🟡	•	•	•	•	•	•	•	🟡	•
	Increased foot and vehical use impact	•	🟡	•	•	•	•	•	•	•	🟡	🟡	•
	Agriculture expansion (stock grazing)												
	Biosecurity												
Marine origin													
No specific threats but climate change will impact on the marine environment and have many ramifications for coastal hydrosystems													
Global	Climate change	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡

Table 5-3: Effects of stressors on coastal hydrosystems.

Effects		•	🟡	🔴									
		low	medium	high									
	Geomorphic class	**Damp sand plain lake**	**Waituna-type lagoon**		**Hāpua-type lagoon**				**Beach stream**		**Beach stream - pond**	**Beach stream - ribbon**	
	Geomorphic subclass	**1A**	**2A**	**2B**	**3A**	**3B**	**3C**	**3D**	**4A**	**4B**	**4C**	**4D**	**4E**
Land origin	Alteration of hydrology		🟡	🟡	🔴	🔴	🔴	🔴	•	•	•	🟡	•
	River flooding (+ from climate change)		•	•	•	•	•	•	•	•	•	•	•
	Sediment run-off		🔴	🔴	•	•	•	•	•	•	•	•	•
	Nutrient run-off	🟡	🔴	🔴	🟡	🟡	🟡	🟡	•	•	•	•	•
	Contaminant run-off	•	🟡	🟡	•	•	•	•	•	•	•	•	•
	Impeded fish passage		🟡	🟡	•	•	•	•	•	•	🟡	🟡	•
	Ground water level fluctuation												
In-situ													
Habitat/species loss or conversion	Loss of mahinga kai	•	🔴	🔴	🔴	🟡	🟡	🟡	•	•	🟡	🟡	•
	Loss of threatened species	•	🟡	🟡	🟡	🟡	🟡	🟡	•	•	🟡	🟡	🟡
	Loss of mangroves												
	Loss of saltmarsh area	•											
	Loss of seagrass beds												
	Acidification (climate change)												
Habitat/species degradation	Increased turbidity	•	🔴	🔴	•	•	•	•	•	•	•	•	•
	Increased muddiness	•	🔴	🔴	•	•	•	•	•	•	•	🟡	•
	Sedimentation	•	🟡	🟡	•	•	•	•	•	•	•	•	•
	Degraded water quality	•	🔴	🔴	🟡	🟡	🟡	🟡	•	•	🟡	🟡	•
	Eutrophication	•	🔴	🔴	🟡	🟡	🟡	🟡	•	•	🟡	•	•
	Alteration of hydrology	•	🔴	🔴	🔴	🔴	🔴	🔴	•	•	•	•	•
	Competition by invasive species	•	•	•	•	•	•	•	•	•	•	•	•
	Expansion of mangroves												
	Retreat of seagrass beds to shallow water												
	Diseases carried by invasive species												
	Degraded shellfish health/condition												
Marine origin	Shoreline erosion		🟡	🟡	🟡	🟡	🟡	🟡	•	•	🟡	🟡	•
	Sea flooding		🟡	🟡	🟡	🟡	🟡	🟡	•	•	🟡	🟡	•
	Barrier/spit breaching		🟡	🟡	🟡	🟡	🟡	🟡	•	•	•	•	•
	Sea level rise		🟡	🟡	•	🟡	🟡	🟡	•	🟡	🟡	🟡	🟡
	Salinity intrusion		•	•	•	•	•	•	•	•	•	•	•

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7 Acknowledgements

The work began in June 2013 with the co-authors presenting ideas at conferences workshops and scoping workshops held on 17 June 2013 and 22 January 2014 where, along with the authors, the following persons participated: Derek Brown (DOC); Rob Bell, Malcolm Green, Mark Pritchard, Scott Stephens, Murray Hicks, David Plew, Julian Sykes and John Zeldis (NIWA); Anna Maradasz-Smith (Hawkes Bay Regional Council).

In October 2015 MFE provided funding to develop the typology further. We are very grateful for the contributions from practitioners at the Stakeholders Workshop, held over 16-17 February 2016 at the University of Canterbury, where an early draft of this classification was reviewed and ideas for improvement to the classification: Richard Measures (NIWA/University of Canterbury); Shane Orchard (University of Canterbury/University of Lincoln); Ken Murray and John Benn (DOC); Malcolm Green, David Plew, Clive Howard-Williams and Iain MacDonald (NIWA); Ton Snelder and Helli Ward (Ministry for the Environment) , Lorraine Dixon (Waahi Whaanui Trust); Anna Madarasz-Smith (Hawkes Bay Regional Council); Megan Carbines (Auckland Council); Pete Wilson (Waikato Regional Council), Fleur Matthews (Southland Regional Council); Justin Cope, Bruce Gabites and Matthew Surman (ECAN). We also thank the university for providing its facilities for our use.

We thank Mark Tucker (NIWA) who drafted the schematics of the geomorphic classes, Sonia Miller for testing the identification key on a selection of coastal hydrosystems of the lower North Island and Allan Schori and Paul Bealing for generating hydrosystem mapped information and distribution statistics.

We thank Malcolm Green for his thorough review of an early draft of this report. Ton Snelder and Helli Ward reviewed a subsequent version. We thank Murray Hicks and John Zeldis for their reviews of the final report.

Funding for this work was provided by the Ministry for the Environment and the Department of Conservation.

8 Glossary

This glossary comprises definitions and descriptions for a set of terms that have been tailored specifically for use alongside the coastal hydrosystems classification and key. For a more general explanation of coastal terms, we recommend use of textbook and coastal or estuaries encyclopaedia definitions. A good online source for some terms and definitions is the Flanders Marine Institute (FMI 2016) Coastal Wiki glossary: http://www.coastalwiki.org/wiki/Category:Definitions. A good source for Te Reo wetland and hydrosystem definitions is in Harmsworth (2002, Appendix 1).

A

ABIOTIC Of the physical and/or chemical components that are devoid of biology.

ACCRETION The accumulation of sediment. Antonym: erosional. See also: *progradation*.

AEOLIAN Pertains to the activity of the winds and more specifically, to the winds' ability to shape the surface of the Earth, by eroding, transporting and depositing sediment.

B

BACKSHORE This area is considered “the beach” by many recreational users, but forms only a part of the beach in coastal science. A beach backshore is the area between the upper swash limit (sometimes the berm crest) and the seaward edge of a dune, cliff or other feature such as a lagoon shore (Figure G1). The backshore is typically subaerial under normal conditions, subject to swash under storm conditions and to aeolian sand transport at other times. This zone is the main source of dune sand and its width influences the extent of dune development (Hesp, 1999). For coastal hydrosystems, another kind of backshore can exist landward of the hydrosystem waterbody: a lagoon or estuary backshore is the area between the landward waterline of the hydrosystem waterbody and the terrestrial hinterland. It is generally subaerial, but subject to inundation by storms or river floods.

BACKWATER EFFECT, TIDAL This occurs in freshwater bodies that are hydraulically connected to the ocean through a barrier beach or along a river channel above the upstream limit of saltwater intrusion. They can be observed as a fluctuation in the freshwater surface elevation, without saltwater intrusion, in response to the changing tidal phase.

BAR A submerged, sand or gravel deposit or embankment occurring in the breaker zone, produced through the action of breaking waves and/or nearshore currents. Typically bars are shore-parallel, but shore-normal bars can occur under certain circulation conditions. Single or multiple rows of bars can occur. Bars tend to be highly mobile, shifting in response to changing wave and tide conditions: they generally migrate seawards under storm conditions. Rip current channels can produce gaps in longshore bar formations (FMI, 2016). The term bar is sometimes used erroneously to refer to a barrier beach, which unlike a bar has a subaerial component. The presence of bars is often evident from patterns of wave breaking seen as line of white water in the surf zone (see Figure 8-1).

Figure 8-1. Waves breaking over multiple sets of bars on a dissipative sand beach at Piha, Kohunui Bay in the Auckland Region. Note the expansive backshore landward of the swash zone, and the small system draining out across the beach in the centre right of the image (*beach stream* class 4B).

BARRIER A large, typically shore-parallel, sand and/or gravel deposit that lies between the sea and a coastal hydrosystem, which has subaerial and submarine components (Figure 8-2). Barriers are initially built up by the action of waves and nearshore currents, and can be reworked by fluvial flows and further developed via aeolian processes. They may have one or more gaps allowing exchanges between the hydrosystem and sea, or they may be continuous and close off the hydrosystem from the sea. Barriers can be attached to the mainland at one, both or no ends. Coastal barriers have a beach on their seaward face, sometimes including one or more berms, and may have well developed progradation ridges and/or dune ridges, and hydrosystem linked facies, in the back-barrier environment. Mixed sand and gravel barriers, such as the barriers enclosing Waituna Lagoon in Southland and Te Waihora Lake Ellesmere in Canterbury, are unusual internationally.

BARRIER BEACH Narrow, low-lying features that typically lack the well-developed progradation or dune ridges of other barrier types (Figure 8-2). They are typically shore-parallel and more youthful than other barriers – many occur on high-energy wave-dominated eroding coasts. Barrier beaches separate coastal hydrosystems from the sea during normal conditions but are subject to wave wash-over and/and breaching during storms or river floods.

BASIN A geological structural depression formed by tectonic down-warping of previously flat-lying strata and covered by seawater. Otherwise referred to as an "ocean basin".

BAY A hydrosystem that is connected to the open ocean or to the main body of a lake, formed by an indentation in the shoreline. Bays are typically semi-sheltered from wave energy by their enclosing hinterland features, such as headlands or peninsulas, compared to adjacent open-water environments.

BEACH An accumulation of sediment deposited by waves that is situated between the wave base (i.e., maximum depth where waves can transport beach sediments shoreward) and the upper limit of swash. A beach may be divided into different process zones, including: the nearshore (where waves shoal between the wave base and breakers), the surf zone (between the break point and shoreline), and the swash zone (between the shoreline and upper limit of wave swash), and the backshore and dunes which are landward of these zones (Short, 1999).

Different types of beach include sand (with dissipative (Figure 8-1), intermediate and reflective subtypes: see below); gravel; composite (sand nearshore and swash zones with a gravel backshore); and mixed sand and gravel (Figure 8-2). Dissipative sand beaches function to dissipate wave energy via a wide surf zone, with several lines of bars and breakers. Reflective sand beaches reflect much of their incident wave energy back to sea without much dissipation, and have narrow surf zones and often only a single line of bars or a nearshore step feature. Intermediate sand beaches function across a spectrum between reflective and dissipative.

Top: Ashburton river mouth (*hāpua-type lagoon*, class 3C), enclosed by a mixed sand and gravel barrier beach. This barrier beach features a single line of breaking waves; no dunes; and an outlet (not an inlet).

Bottom: Kaitorete barrier, enclosing Te Waihora Lake Ellesmere and the smaller Te Roto o Wairewa Lake Forsyth (*waituna-type lagoon* classes 2A and 2B respectively). Note the large barrier width in the image right, where dunes are well developed, and the lagoon shoreline features on the landward barrier shore. Only the narrow barrier section at Taumutu (image left) is currently subject to wave washover and sea storm breaching.

Figure 8-2. Example types of mixed sand and gravel barriers.

BEACH STREAM A riverine system that occurs where a very shallow stream flows over the beach face to the sea. This differs from a river where the larger flow cuts a subtidal channel through the beach face to the sea. Drainage to the sea occurs for most of time, except during drought conditions and/or when waves build a beach berm that bars off the outlet so flow percolates through the beachface to the sea. No tidal prism (inflow) occurs except during storm events coupled with high tides. These are generally associated with small water bodies where the dominant substrate is sand or mixed sand and gravel.

BERM An accretionary, typically shore-parallel beach feature constructed by wave swash, occurring at the upper limit of the wave swash uprush. Berms mark the transition between the predominance of wave versus aeolian processes on a beach. Berm crests may resemble a step or ridge between the foreshore and backshore zones or, on fine-grained beaches, the berm may be indistinct. Berm crests tend to be most apparent on coarse sediment beaches that have a steeper beach face and near-horizontal backshore (Hughes and Turner, 1999). Mixed sand and gravel beaches typically exhibit a berm constructed at the limit of swash during every day swell conditions as well as a storm berm, at a higher elevation on the beach, constructed by storm wave swash. Berms result during lower-energy conditions and can be completely eroded during storms.

BOULDER A rock fragment with a diameter of between 200 and 630 mm on the ISO (International Organisation for Standardisation) scale, which makes it larger than a cobble**.**

BRACKISH WATER with a salinity level (0.05 to 3% salinity) between seawater (3 to 5% salinity) and freshwater (<0.05% salinity). Brackish water is a characteristic of all estuarine and some marine, riverine and lacustrine coastal hydrosystems as well as open coast environments subject to large river discharges). Brackish water is not necessarily an indication that a system is tidal: it may occur due to the tidal mixing of seawater and freshwater from land drainage, and/or due to wave overtopping in systems with low freshwater inputs or long water residence times.

BRAIDED RIVER A river with high sediment load of primarily gravelly and sandy sediment having numerous channels which repeatedly branch and rejoin, forming a pattern of low bars and shallow channels. Braided rivers typically have steep channel gradients, a high degree of flow variability and a larger proportion of their sediment load travels as bedload compared to straight or meandering river types.

BREAK POINT A nearshore area that marks the onset of depth-limited breaking (i.e., excluding white capping). This area can delineate the outer limit of the surf zone, or there may be several break points within a surf zone of mixed wave heights. On reflective coarse sediment beaches, the break point often occurs above a submerged step or bar.

C

CENTRAL BASIN A wide, open and roughly circular expanse of water just landward of a narrow inlet which receives drainage from tidal arms draining the headwaters of large composite systems.

CHANNEL A relatively narrow open conduit in which water flows through a hydrosystem out to sea (in palustrine through riverine systems), bi-directionally between the sea and coastal hydrosystem (daily in estuarine through marine systems), or between bars in a beach nearshore. *Subtidal channels* are submerged throughout the tidal cycle and may co-exist with shallower intertidal areas such as mudflats within estuarine and lagoonal systems. *Intertidal channels* occur at elevations between low and high tide and include the features that cut across beach surfaces to drain small *hāpua-type lagoons* (class 3C) and some beach streams (class 4). Intertidal channels may exhibit water flows across all tidal stages due to freshwater discharge, or only at higher tidal stages where freshwater flows are small or when there is no hydraulic head between the hydrosystem and sea. See also: *outlet*, *inlet*.

CHENIER PLAIN An accretionary feature consisting of a plain with long, sandy or shelly wave-built ridges or cheniers separated by intervening mud-flat deposits and vegetated substrates. The ridges are typically 1 to 6 m high, tens of kilometres long, hundreds of metres wide, and are often wooded while *chenier plains* can be tens of kilometres wide and are associated with shorelines characterised by generally low wave energy, low gradient, muddy shorelines, and abundant sediment supply.

CLASTIC SEDIMENT A deposit comprising non-cohesive particles (clasts), including gravel and sands.

CLAY A fine-grained, sometimes plastic sediment composed of particles that are <0.002 mm in size. Cohesive due to its electromagnetic properties, clay often occurs as a mixture with silts in the form of mud.

COASTAL Of the interface zone between marine, terrestrial and atmospheric environments. The coastal zone includes the part of the ocean that is influenced by terrestrial processes and the part of the land which is influenced by marine processes.

COASTAL EMBAYMENT An indentation in the shoreline with a wide entrance bounded by rocky headlands and open to the ocean. The water body is shallow to medium depth (4 to 8 m) and circular to elongate in planform. They are mostly sub-tidal with small intertidal areas restricted to the headwaters, or sheltered side arms of the more elongate classes. There is little river influence and circulation is weak from tidal and wind-generated currents. Hydrodynamic processes are dominated by the ocean. Pocket beaches occur in the upper reaches. There are no sand bodies (tidal deltas) on the ocean side of the entrance. Wind- and wave-driven mixing occur. The substrate tends to be sandy. Wave refraction disperses wave energy through the bay and, along with the sheltering effect of the headlands, shelters the embayments from storms. Sedimentation and infilling of the bay is very slow because inputs from streams entering the bay are small and waves entering the bay resuspend sediments which can then be transported out of the bay by currents.

COASTAL HYDROSYSTEM A coastal system comprising hydrological, geomorphic and ecological components, including significant surface water and/or groundwater components, that spans within a gradient through freshwater to brackish to saline.

COASTAL SQUEEZE The loss of coastal habitats and ecosystems that can occur as natural deposits are eroded in front of a structure that maintains a fixed shoreline position on a retreating coast.

COBBLE A rock fragment with grain size of between 63 and 200 mm, which makes it larger than gravel but smaller than boulders**.**

COMPOSITE BEACH This has a sandy foreshore and nearshore where waves operate under lower energy conditions, and a gravel berm on the backshore where waves operate under storm conditions.

COMPOSITE HYDROSYSTEM Large systems (e.g., the Kaipara Harbour) that contain subsystems or components representing different geomorphic classes. This is a function of scale. Whether the classification is applied to the whole system or a component depends on the management question.

CUSP A feature that occurs on a beach as a small indentation (the cusp bay) between two small protrusions (cusp horns), approximately parabolic in shape, and formed via wave processes from unconsolidated sands and/or gravels. Cusps often occur in a regular series along the upper swash limit of a reflective sand or mixed sand and gravel beach, giving the shoreline a “crinkle cut” appearance. Larger, single cusps can occur singly in the lee of a structure.

D

DAMP SAND PLAIN Flat areas where wind has removed sand down to a level where the water is permanently just below the surface or occasionally above it, stabilising the sand and preventing further surface lowering, often formed between a series of sand dunes. Damp sand plains are initially colonised by small plants such as sand carex (*Carex pumila*), *Selliera radicans* and *Gunnera dentata*, and then by progressively taller plants over time such as knobby club rush (*Ficinia nodosa*).

DAMP SAND PLAIN LAKE A palustrine system comprising a small, shallow (1-2 m deep), typically freshwater body (never having a connection to the sea – no tidal inflow). Often elongate in shape and located in the depressions between rows of sand dunes on damp sand plains and often associated with vegetated wetland areas. The basins in which they occur form where the wind has removed sand to form shallow depressions down to about the level of the water table. They are fed by freshwater inputs from rainfall and groundwater and are brackish due to salt spray and evaporation. They are variable in planform, ephemeral in space and time, and can dry out in drought conditions. Their dominant substrate is muddy sand and peat.

DEEP DROWNED VALLEY Large, deep (mean depth 10 to 30 m), mostly subtidal systems formed by the partial submergence of an unglaciated river valley. They remain open to the sea. Typically, they have a straight planform without significant branches but they can be dendritic. The size of the valleys seems large for the size of the rivers currently entering the system. Both river and tidal inputs over the tidal cycle are small proportions of the total volume of the basin. The wind may modify the circulation and become a dominant force on occasions, but it is not responsible for the mean circulation over extended periods of time. In elongate systems a circulation pattern (estuarine) is set up where outflowing freshwater is balanced by the inflow of seawater entrained beneath freshwater. There is also a strong longitudinal gradient (head to mouth) in hydrodynamic processes with riverine forcing and stratification dominating in the headwaters and tidal forcing near the entrance. The systems are characterized by poor flushing, which is pronounced in the headwaters and in more complex shaped systems that have multiple arms. The substrate is generally fine sand or mud.

DELTA *River deltas* are accumulations of river-derived sediment that form where the sediment supply to a large waterbody exceeds the amount of sediment removed by erosion and/or redistribution processes such as waves, currents and tides. Active deltas can appear as subaerial and/or submarine fan or lobe shaped deposits dissected by drainage channels, while relict deltas can appear as shoreline bulges of low-lying land (Figure 8-3). There are few active river deltas on the open coast, with the best examples occurring in the fetch-limited Golden Bay area; they are relatively common at the mouths of rivers that discharge into the sheltered waters of coastal systems.

Tidal deltas (Figure G4) are the sand shoals and tidal channels on the landward and seaward side of tidal inlets. Flood (incoming) tidal currents deposit sand inside the narrow entrance of the inlets where current velocities decrease to form a flood tidal delta. Ebb tidal (outgoing) currents deposit sand outside the entrance to form an ebb tidal delta, whose shape depends on whether there is a headland at the entrance, and on the relative strength of the tidal currents versus the waves. Where currents are strong the deltas protrude offshore. Where the waves overpower the ebb tidal currents, the delta sand body is flattened against the coast.

Figure 8-3. Top: Flood and ebb tidal deltas at Blueskin Bay, Otago (*tidal lagoon* class 7a).

Middle: Open coast river delta just WNW of Patons Rock and near Onekaka, Golden Bay (*freshwater river mouth* class 5b).

Bottom: River deltas at the mouths of the Totara and Whangaroa Rivers inside Whangaroa Harbour (*shallow drowned valley* class 8), Northland.

DENDRITIC Having a branched form resembling a tree.

DEPRESSION A landform at a level below the surrounding area.

DISSIPATIVE BEACH These feature fine to very fine sand, and wide gently-sloping surf zones throughout which spilling breakers dissipate their energy, typically over a series of bars. Few sand beaches experience the persistent high-energy wave environments (> 2 m waves) that make a beach modally dissipative. More commonly, they transition towards a dissipative state temporarily while subject to high-energy waves, moving back to intermediate states between high-energy events (Short 1999). Muriwai in west Auckland is a good example of a modally dissipative beach.

DUNE A mound or ridge of sand-size sediment that has been formed by aeolian processes. In beaches, dunes occur landward of the beach berm, inland of the limit of everyday wave action but subject to storm wave attack. Dunes can be partially, fully or not vegetated.

DUNE HYDROSYSTEM Several sorts of hydrosystem are associated with coastal dunes and different related terms are used. These hydrosystems are often grouped under the term *dune lakes* (see Champion and de Winton 2012). Of relevance because of their proximity to the coastline are: (i) *damp sand plain lakes*, which are close to the sea but never connected to it (see Table 4-2); (ii) *dune slacks*, which lie close to the sea, are ephemeral, can be vegetated (but are not always), are fed hydrologically by either rain, high water table and sometimes high tides, and often small or mobile and difficult to map; (iii) *dune hollows* or *dune wet hollows*, depressions in the upslope part of the dune system. All are considered to be shallow palustrine systems (see also Champion and de Winton (2012) for an extensive list of other, inland types).

DUNE SLACK See *dune hydrosystem*.

DUNE SWALE The small valley-like depression between dune ridges, aligned roughly parallel to the coast. These areas may be moister than, and characterised by a vegetation community that differs from, the surrounding sand environment.

E

ECOTONE The transition zone between plant communities.

EMBAYED BEACH A beach sheltered by a headland or similar landform, which impedes longshore transfers of sediment and/energy between the embayed beach and adjacent coastal environments.

EMERGENT PLANTS Aquatic plants which are rooted in water but have stems or foliage above the water surface; or terrestrial plants with a crown held above the level of the surrounding vegetation canopy**.**

EPHEMERAL Transitory, short-lived, existing only briefly. An ephemeral stream might exist under certain seasonal or high rainfall conditions but is not perennial, i.e., not characterised by continuous flows all year round during normal rainfall conditions. In a different sense, estuaries are considered ephemeral since they are typically sediment sinks that infill and transition to wetlands and then land, over geological time.

ESTUARINE International definitions vary greatly. In this classification “estuarine” is used to describe systems that are transition zones between fresh and seawater environments, which typically experience daily tidal ingress. This excludes features that only experience tidal influences such as a backwater effect without tidal ingress.

ESTUARY A coastal hydrosystem that is partly enclosed by land, open to the sea for extended periods, within which seawater is measurably diluted by land drainage, and which typically experiences daily tidal ingress (i.e., has a tidal prism).

EUTROPHIC Having waters rich in phosphates, nitrates, and organic nutrients that promote a proliferation of plant life, especially algae, whose decomposition can deprive the water column of oxygen leading to the death of fauna associated with those habitats.

F

FIRTH The word has similar origins to that of *fjord* and is generally used to refer to a coastal basin of glacial origin into which flows a large river, although international use of this term is varied.

FJORD Also: *Fiord*. An estuarine/marine system that is long, narrow and very deep (mean depth 70 to 140m) with U-shaped basins with steep sides or cliffs, formed in glacial valleys flooded by the sea following the last glacial. The basin is subtidal, with only small intertidal areas in the headwaters. It is characterised by sills at the mouth and along the length of the system that were formed as terminal moraines of glaciers. River and tidal inputs are very small proportions of the total water volume. Water movement near the surface is controlled primarily by thermohaline forcing where the circulation is maintained by the large density differences produced by the salinity contrast between freshwater and oceanic water. The resulting circulation pattern is characterised by out-flowing freshwater, which is balanced by the inflow of seawater entrained beneath freshwater. Wind may modify this circulation and wind-driven circulation may become a dominant force on occasions, but it is not responsible for the mean circulation over extended periods of time. Flushing is poor, particularly in multiple-arm systems. The very deep basin and partitioning by sills means that flushing takes place in a relatively thin layer of fresh water, which moves over the top of a 'dead zone' of saline water. The substrate is generally fine sand or mud.

FLOODING Inundation of land that is normally dry, for example by storm runoff, overflow from a stream or river; or the rise in water in a coastal system associated with tidal inflow.

FLOOD TIDE The incoming or rising part of a tidal cycle, occurring between low tide and the subsequent high tide (as opposed to the ebb tide or return flow part of the tidal cycle).

FORESHORE The intermittently wet part of the beach that lies between the low and high water levels. The foreshore is legally defined under S2 of the RMA as "any land covered and uncovered by the flow and ebb of the tide at mean spring tides and, in relation to any such land that forms part of the bed of a river, does not include any area that is not part of the coastal marine area".

FRESHWATER Water that has low concentrations of dissolved salts (<0.05% salinity) and other dissolved solids.

FRESHWATER RIVER MOUTH A riverine system that has a permanent connection to the sea and never closes off. Occurs where river flow is large enough to cut a permanently subtidal channel through the shoreline and beach to the sea, with a gradient steep enough to prevent tidal ingress. There may be some overtopping of the barrier beach by waves in storm events when water levels are elevated. River flow dominates the hydrodynamics. No tidal prism or saline intrusion (inflow), although there can be a tidal backwater effect. Dominant substrate is mixed sand and gravel.

G

GEO-COMPONENT Structure and features associated with the abiotic parts of a hydrosystem (e.g., tidal flat, chenier plain, bar, harbour basin, beach berm, boulder field, delta, depression, dune slack, headland).

GRAVEL Coarse-grained sediment deposit with particle sizes ranging from 2 to 63 mm. It can indicate high-energy conditions, a coarse-grained sediment source that has been little reworked, and/or biogenic production (e.g., shell gravels).

GROUNDWATER Water occurring beneath the Earth's surface in soil pore spaces and rock formation fractures.

H

HABITAT The environment occupied by an organism or a community of organisms.

HĀPUA-TYPE LAGOON A narrow (10s to 100s of metres wide), elongated (<100 m to several km long) and shallow (several metres deep) river-mouth lagoon enclosed along its ocean boundary by a coarse clastic barrier beach formed by strong longshore sediment transport. They occur on coasts that are generally wave-dominated and exposed to high swell wave energies, typically mixed sand and gravel, have micro- to lower meso-tidal ranges, and are characterised by late Holocene erosion or recent stability trends. They have a narrow (restricted) outlet and usually no tidal inflow (no tidal prism, only river outflow), although can temporarily experience tidal inflows for a few hours to days after a large flood breaches or widens the outlet, before longshore transport re-establishes the constriction. They typically experience a tidal backwater effect in the lagoon where water percolation from lagoon to sea is reduced at high tidal levels. Saltwater entry to the lagoon occurs via spray and wave overtopping during storm events. The highly mobile outlet can migrate for 100s of metres to kilometres along the shoreline at sub-annual time scales, with lagoon elongation growing in relation to outlet migration alongshore.

HEADWATERS Close to or forming part of the source of a stream or river; the furthest place inland in a river, stream or tributary from its coastal drainage area or from its confluence with another river.

HINTERLAND The area landward of a feature that is controlled by a different set or balance of processes. A beach hinterland is the area landward of the reach of wave swash and aeolian processes. This can include cliffs which, under normal conditions, are primarily eroded by subaerial processes but which may be affected by wave attack during storms. A hydrosystem hinterland could include terrestrial environments landward of the shore and fringing wetlands that are very rarely subject to inundation.

HYDRAULIC HEAD This exists where there is an elevation difference, and therefore a pressure differential, between the waterbody and ocean surface. The force of a hydraulic head can drive flows through a porous medium such as a barrier beach or sand spit from a higher- towards a lower-elevation water body. For example, *hāpua-type lagoons* typically have a hydraulic head between their lagoonal waterbody (higher-elevation) and the adjacent sea across all tidal stages, enabling their unidirectional seaward flows, whereas *fjords* are unlikely to have a hydraulic head between the waterbody and the ocean, allowing two-way water exchanges.

HYDRAULICALLY CONNECTED For coastal hydrosystems, this is where two or more surface water and/or groundwater bodies are physically linked such that exchanges can occur between them in one or more directions.

HYDRO-COMPONENT Structure and features associated with the watery part of a hydrosystem such as depth and water column layers; salinity; temperature; and hydroform types (e.g., surface current, longshore current, rip current, eddy, tidal flow, wind-driven current, seiche, plume, wave, storm surge, surf zone, swell, tsunami). Hydro-components may also have distinct biogeochemical features (e.g., euphotic zone, chlorophyll levels, oxygen levels).

HYPERSALINE Having salinity in excess of 40 parts per thousand i.e., higher than that of seawater (c.35 parts per thousand): this can occur where wet soils or ponded water are subject to high evaporation rates.

I

ICOLL Intermittently Open and Closed Lakes and Lagoon, a term given to some temperate Australian, sandy coastal hydrosystems with intermittent ocean connections. ICOLLs occur where extended periods of summertime dry weather and variable winter rainfall produce highly variable river flows, such that rivers may have zero discharge to the coast for months to years. ICOLL is an umbrella term that includes a spectrum of lagoonal through to estuarine hydrosystems, all of which are subject to fire regimes in their catchments producing large but infrequent pulses of sediment and nutrient inputs into river and coastal systems. These nutrient pulses occur in regimes that were historically habituated to very low nutrient levels (Roy et al. 2001). ICOLL is a term that should be used cautiously outside Australia and only in relation to hydrosystems that experience similar catchment and river flow regimes – this report argues that the term does not apply to New Zealand coastal hydrosystems and, in particular, is misused when referring to gravelly systems.

INLET A channel between the waterbody and the ocean through which there are typically bidirectional flows, due to tides, often with land/river drainage (Figure 8-4). Inlets occur on tide-dominated coasts, including those with sandy spits, and tend not to occur on micro-tidal wave-dominated coasts, including those characterised by mixed sand and gravel beaches.

Features that aid in identifying an inlet include the presence of spits and recurves enclosing the inlet channel, flood tide deltas on the hydrosystem side of the inlet, and tidal flats around the periphery of a lagoon or along the edges of the coastal reaches of river channels. Inlets are associated with tidal prisms and the mixing of seawater and freshwater from land drainage on a diurnal basis. A review of imagery through time can be useful in determining the temporal frequency of tidal ingress (typically diurnal versus rare event) and, thus, whether a feature is an inlet or an outlet.

Figure 8-4. Inlet at the mouth of the Estuary of the Heathcote and Avon Rivers/Ihutai, Canterbury (*tidal lagoon*, Class 7). For indications of bidirectional tidal flows, note the presence of flood and ebb deltas on the inside and outside of the inlet channel, and intertidal flats inside the main hydrosystem body; also note the inwards curvature of the spit.

INTERTIDAL Occurring between the elevation of the low and high tides.

INTERTIDAL FLATS Areas of nearly flat, fine sediment deposits adjacent to the shoreline that are alternatively covered and exposed by the tides (Figure 8-4).

INTERVENTION Where humans modify a system to suit some purpose such as hazard reduction. Interventions can be problematic when they do not take account of all values and consequences, such as when artificial openings are created to lower water levels and lessen flooding, with unintended effects on fringing wetland ecology or barrier dynamics.

L

LACUSTRINE A associated with a lakes or other body of open freshwater which is large enough to be influenced by lake processes such as permanent, non-flowing water, fluctuating water levels, and wave action (Johnson and Gerbeaux 2004).

LAGOON An umbrella term for many different types of non-estuarine and estuarine system. Most definitions have in common features such as a shallow coastal waterbody separated from the ocean by some sort of barrier, barrier beach or spit complex, and which is connected at least intermittently to the ocean via one or more outlets or inlets. Many, but not all, lagoons are oriented shore-parallel. For barrier enclosed lagoons, Kjerfve (1994 p3) distinguished between *choked*, *restricted* and *leaky* lagoons according to their ocean connectedness.

LAKE A large body of water that is surrounded by land (also sometimes used to describe smaller bodies of water that are deep and/or persistent). The RMA definition of lake in S2 is "a body of fresh water which is entirely or nearly surrounded by land… the space of land which the waters of the lake cover at its highest level without exceeding its margin".

LITTORAL DRIFT See *longshore current*.

LONGSHORE CURRENT The movement of water along the coast, approximately parallel to the shore and often transporting beach sediments. Longshore currents are typically driven by waves approaching a coast at an oblique angle and/or by tides. Synonyms: *littoral drift*, *longshore drift*.

LONGSHORE DRIFT See *longshore current*.

LONGSHORE TRANSPORT The movement of sediments along a coast by longshore currents, or by swash motions at an oblique angle to the shoreline. This can occur on the foreshore and/or in nearshore environments, and may result in the formation of drift-aligned features such as spits and barriers.

LOW ENERGY COAST A shoreline that is sheltered from large and long period waves. This occurs in large bays (e.g., Golden Bay) and, locally on the open coast, behind islands and reefs.

M

MARINE In most contexts, "marine" refers to seawater environments (i.e., those with saltwater, ~35 parts per thousand salinity). It can also be used to refer to environments beyond the influence of land (as opposed to coastal), or to any navigable body of water (in engineering).

MIGRATION In the geomorphological context it refers to the alongshore shifting in position of an inlet or outlet channel discharge point to the sea. This typically occurs when strong longshore currents and littoral drift progressively extend the length of a barrier beach or spit across an entrance, or when river floods or wave overtopping cause a breach in a barrier.

MIXED SAND AND GRAVEL BEACH A distinctive type of coarse clastic beach where sand and gravel are mixed throughout the steep backshore and swash zones, with a gravel-faced break point step, and a fine sand gently sloping nearshore sand bed. These beaches are highly reflective, having a single, plunging breaker line under most conditions. They typically lack a surf zone (and thus certain surf-zone processes such as rip currents), and are often subject to strong longshore sediment transport. Many are associated with chronically eroding coasts and most lack dunes, having cliff or lagoon hinterlands. These beaches often have an upper storm berm as well as an "everyday conditions" berm. They occur in micro- to meso-tidal, wave-dominated settings (Kirk 1980). Distinguishing features are the coarse clastic sediment size range from sand through to gravel (note: it is advisable to dig 10-20 cm down as these beaches sometimes have a shallow gravel lag deposit on the surface, obscuring the mixture of sediments below), the presence of beach cusps, and the single breaker line and lack of a well-developed surf zone (see Figure 8-2).

MUD A fine grained, soft cohesive mixture of silt and clay sized particles. Mud is indicative of a low-energy coastal hydrosystem environment.

O

OUTLET A channel linking the waterbody and the ocean, through which there are typically unidirectional, seaward-only flows, and which lacks tidal ingress under everyday conditions (Kirk and Lauder 2000) (Figure 8-5). Systems that drain to sea via an outlet have no tidal prism (a function of tidal ingress) but rather can experience a backwater effect where hydrosystem drainage varies with water-level variations on the seaward side of the barrier beach. That is, drainage through the outlet and barrier beach percolation are less efficient at higher tidal levels, resulting in an increase in water levels at tidal cycle intervals (e.g., by up to 1 m in the Rakaia *hāpua-type lagoon* class 3A). Outlets tend to occur on wave-dominated coasts, including on mixed sand and gravel coasts, and not on tide-dominated coasts, which are more commonly sandy or finer grained. Outlets may comprise shallow stream-like channels across the surface of a beach (e.g., in beach stream class 4; or *hāpua-type lagoon* class 3C), or deeper channels carved through a barrier down to subtidal levels (e.g., in *hāpua-type lagoons* 3A and 3B). Outlets do not experience daily tidal ingress, meaning that their hydrosystems are without tidal prisms and are non-estuarine. They may experience rare and short-lived instances of tidal ingress, such as over one or two tidal cycles after a major flood which has breached the barrier or significantly widened the outlet. A review of outlet imagery through time can be useful in determining the temporal frequency of tidal ingress (rare event versus typically daily) and thus whether a feature is an outlet or an inlet.

Figure 8-5. Outlet at Rakaia River (*hāpua-type lagoon*, class 3A). Indications of unidirectional outflow include the sharp edges of the barrier deposits adjacent to the outlet channel, and the absence of floodtide deltas or intertidal flats within the hydrosystem. The mixed sand and gravel barrier beach (identified by the presence of a single breaker line and lack of a dissipative surf zone, as well as the presence of cusps) also indicates the channel is more likely to be an outlet than inlet, since mixed sand and gravel beaches tend towards wave rather than tide dominance.

P

PALUSTRINE Freshwater wetlands fed by rain, groundwater or surface water, but not directly associated with an estuarine, lacustrine, or riverine hydrosystem.

PERCOLATION The movement, and filtering, of fluids through a porous material (FMI, 2016). Large volumes of water can percolate out to sea through long porous gravel barriers, and to a lesser degree sandy spits, resulting in less water available to maintain surface outlet openings.

PLANFORM The outline shape of a shoreline or feature as projected upon a horizontal plane or as seen from above (i.e., in aerial or plan view). Antonym: *profile*.

POCKET BEACH A type of beach that is partially sheltered by shoreline constraints in both alongshore directions, such as a beach constrained between two headlands. See also: *bay*, *coastal embayment*.

PROFILE The outline shape of a formation such as a beach or river channel as viewed from the side. Antonym: *planform*.

PROGRADATION The deposition of sediment such that the shoreline or another beach contour is shifted seaward.

PROTECTION In the coastal context it refers to measures aimed at armouring or buffering a coast against hazards such as erosion, retreat or flooding, thereby protecting human infrastructure such as roads and houses, often at the expense of other values such as beach dynamics and ecosystems. Coastal protection structures are frequently responsible for *coastal squeeze*. This term is often labelled a misnomer since such structures typically protect the hinterland at the expense of natural coastal features and attributes.

R

RECURVE See *spit*.

REFLECTIVE SAND BEACH These lie at the steep end of the sand beach spectrum, reflecting a relatively large portion of their incident wave energy back out to sea. They are commonly associated with lower wave heights and/or longer wave periods, and occur in almost all coarse sand settings, but can also occur in fine to medium sand settings under low wave conditions (<1 m). They are relatively narrow overall, often with cusps, with a narrow swash zone and a narrow breakpoint step beyond which stretches a low and relatively featureless nearshore. They lack a surf zone such that waves move shoreward unbroken, eventually collapsing or surging on the beach face with relatively little energy dissipation (Short, 1999). Tata Beach in Tasman Bay is a good example.

REVERSING TIDAL CURRENTS Bi-directional tidal water flows.

RIBBON LAGOON Narrow (~2 to 50 metres), elongate (~0.5 to 10 km), shallow (~0.5 - 4m) and sometimes tidal, these typically run parallel to the shoreline along the dune slack or swale, landward of a barrier beach, or along the seaward margin of large coastal wetlands. They often comprise the slow-flowing lower reaches of a small stream with a lowland catchment, and may have multiple stream inflows. The outlet might discharge into a larger river mouth or coastal hydrosystem, or can migrate at different timescales up to several kilometres along the shoreline. Natural (and sometimes human-induced) processes can cause the outlet to close off intermittently, with no surface-flowing connection to the sea. Tidal influence diminishes with distance from the outlet and depending on other physical aspects of the lagoon. Ribbon lagoons are common in Westland.

RIVERINE A system comprising rivers, streams or other open channels, both natural and artificial, where the dominant process is continually or intermittently flowing freshwater. Although many river ecosystems occupy landforms such as valley floors, floodplains and deltas which owe their genesis to river processes, the riverine hydrosystem is restricted to that part containing river flow and to the extent covered by the mean annual flood. (the term often preferred beyond that direct influence when wet is *palustrine*).

ROCK REEF A rocky structure that rises above a sandy, gravelly or muddy seafloor, providing variation in habitat substrate and water depths compared to its surroundings.

S

SALINE/SALTWATER INTRUSION The movement of seawater into a freshwater aquifer.

SALINITY The quantity of dissolved salts in water, especially of seawater or its diluted products. Salinity is often recorded, by convention, as parts per thousand (‰), which refers to the grams of salts in a litre of water. However, it is measured as a conductivity ratio and therefore has no physical units (https://www.myroms.org/forum/viewtopic.php?t=294).

SALTMARSH A wetland class defined by Johnson and Gerbeaux (2004) as embracing coastal habitats of mineral and vegetated substrates in the intertidal zone, but including also those biotic components in the supratidal zone which, though non-tidal, have similar saline substrates and constancy of soil moisture.

SALT-WEDGE A distinct wedge of dense, saline water that occurs at the bottom of the water column, having a greater vertical extent towards the ocean, tapering upstream into hydraulically-connected rivers. Salt-wedges are common where the mixing of fresh and salt waters is limited.

SAND Sediment with particle sizes between 0.063 and 2.0 mm. Sands are finer than gravel but coarser than silts.

SEA LEVEL is represented by a statistic such as Mean Sea Level (MSL), which is the average level of one or more of the ocean's water surfaces from which a datum can be set and heights such as elevations can be measured. In reality the level of the sea surface is constantly changing, both at short time scales, with changes in meteorology, weather and climate cycles, and over geological timescales with changes in climate.

SEDIMENT Naturally occurring material (e.g., muds, silts, sands, gravels, cobbles, boulders, chemical precipitates and/or fossil fragments) that is broken down by weathering, erosion and/or biogenic processes and subsequently transported via the action of wind, water or ice, and/or by the force of gravity.

SEDIMENTATION The deposition of material or varying size, both mineral and organic, away from its origin or source by the action of water, wind, gravity or ice; the process of transportation and deposition of particles onto the bottom of a waterbody or onto a coastal landform (FMI, 2016).

SHALLOW DROWNED VALLEY **S**hallow (mean depth generally less than 5m due to extensive intertidal area) with complex dendritic shorelines and numerous narrow arms leading off a main central basin or channel. Extensive intertidal flats are cut by drainage channels. They range in size from small tidal creeks (e.g., Maungemaungeroa) to large harbours (e.g., Kaipara). Tidally dominated. The mouth is always open and constricted by hard headlands or substantial barriers. Flood and ebb tidal sandy deltas are present at the tidal inlet on high wave energy littoral drift shores (e.g., Raglan, Kaipara, Hokianga) but absent on zero drift shores (e.g., Mahurangi and Waitemata). While sand bodies at the entrance change in planform shape, the inlet does not migrate much because in most systems it is fixed by a rock headland on one shore. These systems are largely infilled with sediment.

SHALLOW WATER A wetland class defined by Johnson and Gerbeaux (2004) as aquatic habitats with water generally less than a few metres deep, having standing water for most of the time, and including the margins of lacustrine, riverine, and estuarine waters plus small bodies of water which may occur within palustrine systems.

SILT Fine-grained sediment with particles between 0.002 and 0.064. Silts are finer than sand but coarser than clay.

SOUND Large ocean inlets, typically wider than fjords. The term is also used to describe narrow ocean channels between two bodies of land. Sounds can be of river or glacial valley origin.

SPIT A depositional landform built across an indentation in the shoreline by the action of longshore currents, and limited by the scour of tides into and out of the system. Spits grow from their proximal end, which is attached to land and generally represents the widest part of the spit formation, towards a distal end that is unattached to land and forms one side of the inlet channel. The distal end may have a hooked or recurved shape, i.e., a planform which bends around into the system due to the action of sediment transport induced by incoming tidal flows and/or onshore winds. When the formation processes continue across an inlet to fully close it off, the landform name changes from spit to barrier. The presence of a spit indicates the occurrence of tidal ingress and estuarine environments.

STREAM A small, narrow river that is mostly shallow (wadeable) but which, when blocked at the mouth, may exhibit deeper (non-wadeable) parts. In this classification we use the term *stream* to describe features that flow over the beach face to the sea. This differs from *rivers*, where the larger flow cuts a subtidal channel through the beach face to the sea.

SUBSTRATE The rock, sediment, peat or soil ground or seabed surfaces upon which plants, algae and pelagic fauna grow, or the material underlying a non-vegetated wetland (Johnson and Gerbeaux 2004).

SUBAERIAL Used in geomorphology to describe events or features that are formed, located or taking place immediately on or near the Earth's land surface.

SUBTIDAL Occurring below the lowest tide level and permanently inundated.

SUPRATIDAL Occurring above the highest tide level. Can be influenced by splash and spray, and includes areas inundated by storm surges

SURF ZONE The zone located between the wave shoaling and swash zones that is the "part of the nearshore where incident waves break and breaking-induced processes dominate the fluid motion, and sediment transport processes" (Aagaard and Masselink, 1999 p72).

SWAMP A wetland class defined by Johnson and Gerbeaux (2004) as soligenous (where water supply is augmented by groundwater seepage or surface run-off that has been in contact with mineral materials in adjacent land). This class usually combines mineral and peat substrates, and has moderate water flows and fluctuations, often with some standing water or surface channels. Swamps are relatively nutrient-rich and carry inputs of dissolved nutrients and often also suspended inorganic sediments.

T

TANNIN An astringent, polyphenolic biomolecule that binds to, and precipitates, proteins and various other organic compounds including amino acids and alkaloids, and which is found in wood and other plant materials. When waterways flow slowly through forests or bogs, they can develop acidic, transparent, dark-stained water that resembles black tea due to the leaching of tannins from decaying vegetation (also known as a "blackwater river"). These contrast with those coloured blue-green by dissolved minerals, such as those fed by glacial and periglacial source areas.

TEMPORARY **F**eatures or characteristics that endure periods of time of days to weeks. See also: *ephemeral*.

TIDAL 'Tidal system' characterises systems that experience tidal ingress, but not those that experience tidal backwater effects without tidal ingress.

TIDAL INGRESS This occurs where there are daily inflows from the ocean according to the cycle of the tides. Brackish water is not necessarily an indicator of tidal ingress since it can result from wave overtopping. Where flow data are unavailable, visual features that indicate tidal ingress include spit recurves, flood deltas, extensive intertidal flats and saltmarsh vegetation.

TIDAL LAGOON A shallow (mean depth 1-3 m), circular to elongate basin with simple (not dendritic) shorelines and extensive intertidal area. They have a narrow entrance to the sea constricted by a spit or sand barrier. Ebb and flood tidal delta sand bodies form in the sea and bay sides of the entrance respectively. Strong reversing tidal currents flow through the entrance. The tidal prism makes up a large proportion of the total basin volume. River input is small compared to tidal inflow and hydrodynamic processes are dominated by the tides. Despite the narrow entrance they generally have good flushing because much of the water leaves the estuary on the outgoing tide. River inputs dominate the hydrodynamics for short periods (days) during floods when seawater can be completely expelled from the system, and on the incoming tide flood waters get backed up by the tide, causing low lying land around the margins to be flooded. Wind-generated mixing and resuspension of bottom sediments occur at high tide, a process that is more pronounced in the larger and circular shaped more open water bodies with larger fetch. The combination of wave resuspension of the substrate and flushing results in these classes having generally homogeneous and sandy substrates; they are also well mixed because strong flushing, wind mixing and the shallow depths prohibit density stratification. Salinity is close to that of the sea. The spit or barrier can be overtopped by waves and breached (rare occurrence) in extreme events leading to multiple entrances. Dominant substrate is sand.

TIDAL PRISM The volume of seawater water that enters an estuarine coastal hydrosystem on the incoming (flood) tide.

TIDAL RIVER MOUTH An elongate, narrow and shallow (mean depth several metres) basin with a permanent connection to the sea for most of the time. They occur where river and tidal flow are large and persistent enough to maintain a permanent subtidal channel through the shoreline and beach to the sea. River flow delivered during a tidal cycle is a significant proportion of the volume of the basin, and is greater than the tidal volume entering the basin. Hydrosystem-scale hydrodynamic processes are dominated by river flows and these classes are well flushed. Floods can expel all the seawater from the system for periods of days. In deeper systems an estuarine circulation pattern can be set up where outflowing freshwater is balanced by the inflow of seawater entrained beneath freshwater and a salt wedge develops. Seawater can intrude kilometres up estuary in low-gradient coastal plain situations. Wind-generated mixing and wave-driven resuspension are minor as wind fetch and waves are small and depths are largely too great for significant bed stress to be produced by the small waves. Sediments tend to be muddy except in areas of high tidal flows.

TOPOGENOUS A term occasionally used for a wetland formed behind a topographic barrier that impedes drainage, especially in situations having a relatively small catchment and therefore receiving a water supply mainly from rainfall.

V

VALLEY, GLACIAL A valley formed by glacial erosion, typically characterised by a U-shaped profile. *Fjords* (geomorphic class 10) occupy drowned glacial valleys.

VALLEY, RIVER A valley formed by flowing water, typically characterised by a V-shaped profile that may be more or less steep depending on the nature of flows that formed it. Steep river valleys are produced by mountain and other high-gradient rivers, while shallower river valleys are formed by lower-gradient lowland waterways. *Shallow drowned valleys* and *deep drowned valleys* (geomorphic classes 8 and 9) occupy valleys that were carved out by rivers but whose profile may have changed due to subsequent erosion and/or infilling.

W

WAITUNA-TYPE LAGOON A lacustrine system comprising large (several km^2), shallow (mean depth typically 2 to 3m) coastal lagoons barred from the sea by a barrier or barrier beach. They do not normally experience daily tidal ingress and are typically fresh, fed by streams or small rivers, with brackish pockets in time or space. Drainage to the sea is typically via percolation through the barrier. Their most frequent state is closed to the sea: short-lived openings occur when, due to river inflows and/or severe storm wave overtopping events, water levels build a sufficient hydraulic head to breach the enclosing barrier,. Openings to the sea are rare (decadal-century time scales) unless created artificially. They may experience tidal inflows for short periods (1-2 tidal cycles) after natural barrier breaches whereas recent observations indicate that artificial breaches can result in openings that experience daily tidal inflows for up to several weeks (e.g., Te Waihora Lake Ellesmere). Wind waves and wind currents are important agents for mixing.

WATER REGIME The combination of four main hydrological factors: water source, movement, fluctuation, and the periodicity of wetness.

WAVE DOMINATED Coasts are wave dominated where the relative influence of waves dominates over that of tides or rivers. Micro-tidal (tidal range <2 m) coasts tend to be wave dominated under moderate wave energy conditions while coasts with greater tidal ranges can also be wave dominated if subject to very high wave energy ocean conditions. Wave dominated coasts typically exhibit smooth barrier planforms, few inlets, and poorly developed ebb deltas (Davis and Hayes, 1984).

WAVE OVERTOPPING This occurs where waves overtop a subaerial and/or submarine coastal structure such as a barrier beach, low-lying spit, intertidal reef or seawall, transmitting wave energy and seawater over the structure into a leeward waterbody or onto the hinterland. Fan- and lobe- shaped deposits on the landward side of barrier beaches and spits can indicate an environment subject to wave overtopping.

WETLAND According to the RMA S2 definition, wetland "includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions".

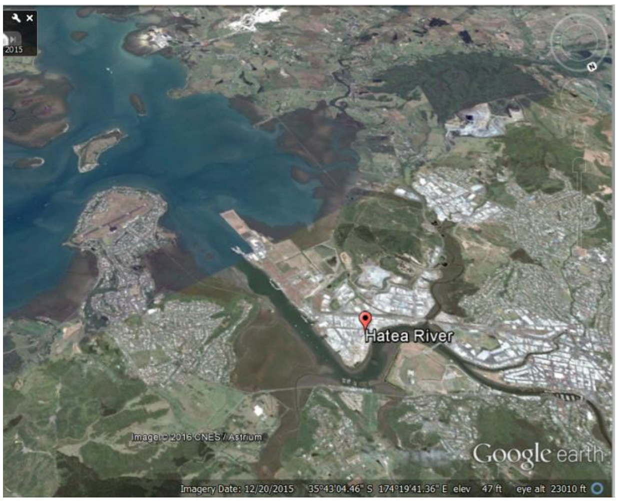
Appendix A Review of terminology associated with coastal hydrosystems

In this section we provide a review of terms used to describe different kinds of coastal hydrosystems in use in common, statutory and scientific language and explain why precise definitions are important for coastal management. We focus on terms that are relevant to our discussion of geomorphic classes in section 4 of this report. We also explain why we chose to use the term *coastal hydrosystem* to avoid the various issues associated with more specific terms such as *estuary, estuarine, coastal lake and lagoon*.

With New Zealand's long, rich and varied coastline, and with many people living in coastal cities and never more than 130 km inland from the sea, many New Zealanders live, work and play in the coastal zone (Hume et al. 1992; Goff et al. 2003). As such, people are familiar with coastal terms such as *harbour, inlet, sound, fjord, estuary, bay, lagoon, river mouth, coastal wetland, mangrove* and *saltmarsh*, to name a few. Some 17 different terms are used on the 1:50,000 topographic maps alone. But most people, if asked, would probably struggle to explain the differences between these everyday terms. Many New Zealand coastal hydrosystems are readily dubbed *estuaries, wetlands* or *lagoons*. However, an estuary, wetland or lagoon may mean something different to the general public compared to what it means to a scientist or environmental lawyer. We also acknowledge the relationship Māori have with these places and that they too have developed terminology over centuries. We however, do not attempt to explore this in detail.

The wide range of terminology that we use to describe our coastal environment and hydrosystems in New Zealand (Table A-1 and Glossary) sees some terms that are well defined and the features they refer to easily identified in the field or on maps, others that are described but difficult to delineate in reality and others having several definitions to choose from. Unfortunately, however, many of these terms remain legally undefined. This leads to users picking from the range of definitions to suit their purpose, a situation that creates confusion and debate in council and Environment Court hearings, where there is an as-yet-unmet expectation of clear and nationally consistent terminology. The case of Northland Regional Council v Philbrick (2015) provides a good illustration of this situation (see inset box).

Northland Regional Council v Philbrick (2015): Estuary or harbour? No, it's a drowned valley estuary



In 2015, an Environment Court decision ordered a vessel owner to cease mooring his boat in part of Whangarei Harbour. This boat had, allegedly, been moored in the lower reaches of the Hātea River section of the upper harbour between 2009 and 2015 with the owner living on board in breach of the Regional Coastal Plan.

The Northland Regional Coastal Plan (NRCP) Rule 31.4.9(a) stipulates that anchorage of recreational or commercial vessels to the foreshore or seabed is permitted provided that certain conditions are met, including that:

"(ii) The craft does not remain at anchor for a period of more than 14 consecutive days within the same embayment, inlet, or estuary except where anchorage for a longer period is made necessary by reason of bad weather, accident, or emergency."

The Whangarei coastal hydrosystem is labelled harbour on maps and charts, but has been scientifically classified as a drowned valley estuary (Hume et al. 2007). According to the latter definition, the vessel owner was in breach of the NRCP. However, the owner disputed this, arguing that the harbour was nowhere classified as a type of estuary in the NRCP, that this classification was not represented in any charts or maps and that the harbour perhaps represented several estuaries. While the regional council's interpretation of the NRCP prevailed at the end of the day, this outcome resulted after years of fraught correspondence between them and a frustrated boat owner regarding alleged NRCP breaches and the eventual Environment Court decision. This case exemplifies some of the challenges faced by agencies and the public in trying to enforce or conform to statutes in the absence of a single, accepted and nationally consistent system of coastal hydrosystem terminology and classification.

Estuary, estuarine

Confusion arises when we ask: Is the word *estuary* synonymous with *estuarine system* or is it an appropriate name for describing a limited number of several different classes of *estuarine systems* and *estuarine environments*? And are *lagoons* a type of *estuary*? Do both *lagoons* and *estuaries* include areas of *wetland*? According to the RAMSAR definition (UNESCO 1994), many of our large, shallow coastal hydrosystems, including Tauranga Harbour for example, could be classified as *wetlands*, a definition that does not sit comfortably with coastal oceanographers who would recognise them as *estuaries*.

Many different definitions of *estuaries* and *estuarine environment* have been produced, based around ideas conveying a transition zone between fresh and seawater environments, between riverine and marine habitats, and/or between river channels and the open coast. Key features common to many such definitions include tidal circulation and/or salinity gradients, and distinct geomorphic features and shapes, sometimes with sharp and sometimes with transitional boundaries.

Pritchard (1967, p3), for example, defined an *estuary* as: "*a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which sea water is measurably diluted by fresh water from land drainage*". In this widely-adopted northern hemisphere definition, Pritchard (1967) characterises estuaries as hybrid river-ocean features, without explicitly mentioning tides. He excluded a number of coastal hydrosystem types, including *coastal lagoons* lacking either fresh or sea water inputs and/or a free connection to the open sea, and brackish seas such as the Baltic.

Several subsequent authors have emphasised the important role of tidal processes and degrees of fresh and sea waters mixing. Woodroffe (2003, p. 321), for example, articulated estuaries as the *"tide-influenced lower parts of rivers and their valleys"*, which exist on a continuum with, and are sometimes difficult to distinguish from, deltas or river-derived accumulations of sediment. McLusky and Elliot (2004) emphasised differences in the hydrodynamics within different estuaries, drawing attention to freshwater volumes and regimes, tidal ranges, and evaporation levels. Under this approach, they distinguish different types of estuarine hydrosystem as well as the different types of areas existing within each estuarine hydrosystem.

Woodroffe's (2003) delineation of the upstream boundary of an estuary is similar to the RMA (Resource Management Act, 1991) definition of the upstream limit of *coastal water* (Appendix A). The lack of an explicit definition of estuaries in either the RMA 1991 or the New Zealand Coastal Policy Statement (NZCPS) 2010, along with use of the additional term *tidal estuaries* in the NZCPS 2010 (Appendix A), however, means that it is unclear as to which hydrosystems can be legally classified as estuaries in New Zealand.

In addition to the above international definitions, several New Zealand projects have offered their own definitions of estuaries. For the purposes of their Naturally Uncommon Ecosystems project (http://www.landcareresearch.co.nz/publications/factsheets/rare-ecosystems), for example, Landcare Research describe estuaries as "…where fresh water from rivers mixes with salt water. They are formed where the underlying or adjacent topography constrains the mixed water throughout the tidal cycle. *They are formed behind barriers such as sand spits and coastal embayments, at river mouths, in drowned river valleys with gently sloping substrates, and even in fjords. Their inland limit is where salinity reaches a dilution of 5% of the marine concentration (Clarkson et al. 2003)"* (DiBona and Williams 2016). This bespoke definition has some commonalities with, but also differences from, commonly recognised international definitions. Similarly, Hume et al. (2007) and Potter (2001) describe an estuary as "*…a partially enclosed body of water formed where freshwater from the land meets and mixes with saltwater from the ocean. Estuaries vary in size and can also be termed bays, lagoons, harbours, inlets, sounds, wetlands and swamps*".

Most of the coastal hydrosystems in New Zealand that could be described as estuaries according to international definitions are not labelled estuary on topographic maps or in official place names (McLay 1976). Instead, they are variously labelled *river, stream, creek, lagoon, lake, inlet, haven, harbour, bay, arm, cove, sound* or *burn*. The few exceptions to this include: Matapouri Estuary (Northland), Waikawau Estuary (Coromandel),), Estuary of the Heathcote and Avon Rivers/Ihutai (Canterbury), New River Estuary and Jacobs River Estuary (both in Southland).

Lagoons and coastal lakes

Lagoon and coastal lake are terms that, like estuary, are commonly used in New Zealand and internationally but which, depending on the geographic location, discipline and author, are variously applied to different kinds of features. In New Zealand, systems described as lagoons have also been described as estuaries (e.g., Brooklands Lagoon, Canterbury), ICOLLs (Intermittently Closed and Open Lakes and Lagoons, e.g., Lake Waihola in Otago and Wainono and Te Waihora in Canterbury), coastal lakes or *waituna-type lagoons* (Wainono, Te Waihora and Wairewa in Canterbury, and Waihora in Southland) and river mouth systems or *hāpua-type lagoons* (e.g., the Waitaki, Rangitata, Ashburton, Rakaia, Hurunui and Pareora coastal hydrosystems in Canterbury).

The temperate Australian term ICOLLs (Roy et al. 2001), as well as the South African term TOCE (Temporarily Open and Closed Estuaries, Whitfield 1992, Whitfield and Bate 2007)) should be used cautiously outside Australia and South Africa respectively. The terms arose out the mismatch between European conceptualisations of estuary and the very different hydrological regimes existing within the coastal hydrosystems of these settings. These two terms highlight the intermittent nature of hydrosystem-ocean connections. In their regions of application, extended periods of summertime dry weather and variable winter rainfall produce highly variable river flows, whereby rivers may be dry with zero discharge entering the coastal hydrosystems for months to years.

ICOLL is somewhat of a hybrid or umbrella term that includes the spectrum of lagoonal through to estuarine coastal hydrosystems occurring on temperate Australian sandy coasts. This concept also encompasses the distinctive fire regimes of ICOLL catchments, which produce large but infrequent pulses of sediment and nutrient inputs into river and coastal systems. Roy et al. (2001, p. 351) comment that "*irregular flood and fire regimes strongly influence estuary hydrology and nutrient inputs*" in their description of ICOLLs. These nutrient pulses occur in regimes which, historically, had long been habituated to very low nutrient levels. These levels have changed only recently, with the introduction of European agriculture and development in Australia, contrasting the long history of catchment development in Europe.

Given their specific provenance and catchment associations, the terms ICOLL and TOCE should be used cautiously outside temperate Australia and South Africa respectively, and only in regions characterised by similar catchment, nutrient and hydrology regimes. New Zealand catchment regimes differ markedly from those where ICOLLs and TOCEs occur due to our more abundant rainfall and river flow regimes, and the absence of fire ecology. New Zealand application of the ICOLL term also seems to have been associated with gravelly coasts. It would appear that the intermittent ocean connections of the New Zealand systems described elsewhere as ICOLLs could be explained by the wave domination and high percolation rates of river water through the gravel barriers on such coasts. This contrasts the temperate Australian, sandy coast context from which the term arose, where the intermittent ocean connection is largely a function of the highly variable river flow regime. Accordingly, in this report we do not apply the labels ICOLL or TOCE to any of our intermittently open or closed New Zealand hydrosystems, since this country's climate, catchment hydrology, and nutrient release regimes, and lagoon hydrodynamics differ markedly from those of temperate Australia and South Africa.

Kjerfve (1994, p.3) defined a coastal lagoon as "*a shallow coastal water body separated from the ocean by a barrier, connected at least intermittently to the ocean by one or more restricted inlets, and usually oriented shore-parallel*". For barrier-enclosed lagoons, he distinguished between choked, restricted and leaky lagoons according to the degree of connection between the lagoon waterbody and the ocean, and to the dominant hydrodynamic and morphological conditions in the lagoon (Duck and da Silva 2012).

Kirk and Lauder (2000) introduced the terms hapua (hereafter hāpua*)* and waituna into the scientific literature to describe the two types of predominantly freshwater and non-tidal hydrosystems occurring along New Zealand's high-energy mixed sand and gravel coasts. Hāpua was adopted from Te Reo Māori, where it means a pool, lagoon or shallow lake, whereas waituna came from Lake Waituna in Southland, which is the archetype of the waituna-type lagoon class of coastal hydrosystem. According to Kirk and Lauder (2000), hāpua occur where barrier beaches are built by longshore drift in front of river mouths: here, long, shore-parallel waterbodies are carved out between dynamic barrier beaches and the hinterland (e.g., on the Rangitata, Ashburton, Rakaia, and Hurunui Rivers). In comparison, waituna are the more 'spread out' coastal lake-like features that form in topographic depressions such as between the Quaternary fans of large braided rivers (e.g., Te Waihora Lake Ellesmere occupies the inter-fan depression between the Rakaia and Waimakariri Rivers).

Terminology related to important features within coastal hydrosystems

Terms such as spit, barrier, barrier beach, boulder bank and sand bank have been relatively clearly and precisely defined in the scientific literature at one time or another. The glossary provided in this report brings together a set of careful definitions for some of these features, so that they may be usefully incorporated into the descriptions and distinctions made in the present classification.

Coastal hydrosystem terminology used in this classification

Tagliapietra et al. (2009, p499) identified a tidal concept (the presence of tides) as central to the most restrictive definitions of estuary, which sits within a gradient from largely freshwater to largely marine environments. They argue that, although the term estuary is applied to a broad range of coastal hydrosystems in common parlance, it is scientifically more correct to apply it to "*a precise subclass, the proper estuaries*" (i.e., those with a tidal concept). Similarly, Elliott and McLusky (2002) discouraged use of the term *estuary* in reference to non-tidal environments, since this term originated from the Latin terms *aestuarium* and *aestus*, meaning tide or billowing movement. For the purposes of our classification and classification, we use the essence of this tidal concept (i.e., does a hydrosystem typically experience daily tidal ingress and, thus, can be said to have a tidal prism), to delineate the boundary between our *riverine* and *estuarine* geomorphic classes.

Tagliapietra et al. (2009, p499) also identify *transitional environment* as an umbrella concept which encompasses waterbodies, features and environments that are not wholly marine or terrestrial and riverine, but which are subject to a mix of these influences. This term is somewhat similar to the coastal hydrosystem term used in this report, since it describes hydrosystems that are, by definition, coastal. Tagliapietra et al. (2009) further describe *transitional environments* as various types of lagoon, estuary, delta, embayment, coastal waterway and related environments, which may or may not include tides, and which can be brackish, freshwater or saline, as well as other coastal environments such as beaches and prodeltas.

We have adopted the term coastal hydrosystem to refer to the collective of types of estuarine, coastal riverine and coastal lacustrine environments encompassed by the classification. Coastal hydrosystems is a collective label that avoids the common error of referring to all such features as estuaries, mislabelling the numerous types of system that are non-estuarine and which have behavioural characteristics and management sensitivities that differ from those of any estuarine environment (e.g., hāpua and waituna). Our collective term also usefully encompasses the coastal hydrosystems that do not represent *end of river environments* (e.g., some pocket beaches and embayments), or that are so large and complex as to be fed by several freshwater drainage features (rivers, streams, wetlands) but which are dominated by none (e.g., some harbours, fjords, sounds and coastal-lacustrine systems). And, unlike the terms waterbody or coastal waterbody (Table A-1), our term usefully incorporates the multiple aspects of each system, including beaches, spits, barriers, river mouths, wetlands, saltmarshes and other geomorphic, ecological and hydrological features, as well as the semi- or fully-enclosed coast-proximal waterbody.

Table A-1. Coastal hydrosystem terms used in New Zealand statutes.

Term	Statutory sources and definitions
coastal marine area	**RMA 1991, S2(1):** "*the foreshore, seabed, and coastal water, and the air space above the water—* *(a) of which the seaward boundary is the outer limits of the territorial sea:* *(b) of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of—* *(i) 1 kilometre upstream from the mouth of the river; or* *(ii) the point upstream that is calculated by multiplying the width of the river mouth by 5*"
marine and coastal area	**Marine and Coastal Area Takutai Moana Act 2011, S9(1):** "*the area that is bounded,—* *(i) on the landward side, by the line of mean high-water springs; and* *(ii) on the seaward side, by the outer limits of the territorial sea; and* *(b) includes the beds of rivers that are part of the coastal marine area (within the meaning of the Resource Management Act 1991; and* *(c) includes the airspace above, and the water space (but not the water) above, the areas described in paragraphs (a) and (b); and* *(d) includes the subsoil, bedrock, and other matter under the areas described in paragraphs (a) and (b)*"
coastal environment	**NZCPS 2010, Policy 1(2):** "*includes:* *(a) the coastal marine area;* *(b) islands within the coastal marine area;* *(c) areas where coastal processes, influences or qualities are significant, including coastal lakes, lagoons, tidal estuaries, saltmarshes, coastal wetlands, and the margins of these;* *(d) areas at risk from coastal hazards;* *(e) coastal vegetation and the habitat of indigenous coastal species including migratory birds;* *(f) elements and features that contribute to the natural character, landscape, visual qualities or amenity values;* *(g) items of cultural and historic heritage in the coastal marine area or on the coast;* *(h) inter-related coastal marine and terrestrial systems, including the intertidal zone; and* *(i) physical resources and built facilities, including infrastructure, that have modified the coastal environment.*"
intertidal zone or area	**NZCPS 2010, Glossary:** "*The landward boundary of the intertidal zone or area is the extreme or area high water of spring tides, which is the average of the two highest tides at the period of the year when the range of the tides is greatest. The seaward boundary*

	of the intertidal zone or area is the extreme low water of spring tides, which is the average of the two lowest tides at the period of the year when the range of the tides is greatest.”
mouth	**RMA 1991, S2(1):** “*for the purpose of defining the landward boundary of the coastal marine area, means the mouth of the river either—* *(a) as agreed and set between the Minister of Conservation, the regional council, and the appropriate territorial authority in the period between consultation on, and notification of, the proposed regional coastal plan; or* *(b) as declared by the Environment Court under section 310 upon application made by the Minister of Conservation, the regional council, or the territorial authority prior to the plan becoming operative,—* *and once so agreed and set or declared shall not be changed in accordance with Schedule 1 or otherwise varied, altered, questioned, or reviewed in any way until the next review of the regional coastal plan, unless the Minister of Conservation, the regional council, and the appropriate territorial authority agree*”
coastal water	**RMA 1991, S2(1):** “*seawater within the outer limits of the territorial sea and includes—* *(a) seawater with a substantial fresh water component; and* *(b) seawater in estuaries, fiords, inlets, harbours, or embayments*”
sea water	Referred to in S2(1), but not defined in, RMA 1991.
water body	**RMA 1991, S2(1):** “*fresh water or geothermal water in a river, lake, stream, pond, wetland, or aquifer, or any part thereof, that is not located within the coastal marine area.*”
lake	**RMA 1991, S2(1):** “*a body of fresh water which is entirely or nearly surrounded by land*” “*the space of land which the waters of the lake cover at its highest level without exceeding its margin.*”
land	**RMA 1991, S2(1):** “land *(a) includes land covered by water and the airspace above land; and* *(b) in a national environmental standard dealing with a regional council function under section 30 or a regional rule, does not include the bed of a lake or river, and* *(c) in a national environmental standard dealing with a territorial authority function under section 31 or a district rule, includes the surface of water in a lake or river.*” **Te Ture Whenua Māori Act 1993/ Māori Land Act 1993:** “*land (a)means—* *(i) Māori land, General land, and Crown land that is on the landward side of mean high water springs, and* *(ii) Māori freehold land that is on the seaward side of mean high water springs, but* *(b) does not include the common marine and coastal area.*”
coastal lakes	Referred to but undefined in NZCPS 2010, Policy 1(2).
lagoons	Referred to but undefined in NZCPS 2010, Policies 1(2) and 11.
[tidal] estuaries	Referred to but undefined in RMA 1991, S2(1) and in NZCPS 2010, Preamble, Objective 1, Policies 11, 19(3), 26(2).
[intertidal] saltmarshes	Referred to in NZCPS 2010, Policies 1(2), 11, 14 but undefined in RMA or NZCPS.
wetlands	**RMA 1991, S2(1):** “*includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions*” **UNESCO (1994) RAMSAR:** “*wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*”

Appendix B Determination and naming of the geomorphic classes

How we determined the geomorphic classes

The starting point for defining the classes and subclasses was the eight classes defined by Hume et al. (2007). To this we added classes to accommodate palustrine, lacustrine and riverine systems.

We then worked our way around the New Zealand coast using Google Earth imagery and topographic maps, while trying to fit some 500 systems into the eight classes. During an iterative process, we added and subtracted classes, developed subclasses and identified distinguishing characteristics for each class and subclass. Systems on parts of the coast where there was little information and a large variety of classes, including the southeast coast of the North Island and the west coast of the South Island, presented the greatest challenge. What guided the need to modify existing, or add additional, classes or subclasses was whether there was a benefit for management purposes.

Google Earth imagery, unavailable at the time of Johnson and Gerbeaux (2004) and Hume et al. (2007) was particularly valuable (Figure B-1 and Appendix D). With its ever increasing number of historical images, combined with hydrographic and topographic maps and local knowledge, it provided essential information: the spatial or temporal nature of connection to the sea (wide or narrow? permanent or temporary? outlet or inlet?); tidal inflow indicated by spits recurved inwards at the mouth of a system, mangroves or whitebait fishing stands along river banks; tidal dominance indicated by extensive intertidal areas and flood and ebb tidal deltas; tannin-stained waters indicating a significant contribution of freshwater input from coastal wetlands; sandy substrate indicated by lighter colour and nearshore bars; coarser mixed sand/gravel substrate indicated by a grey colour and beach cusps and a lack of bars offshore. Google Earth historical views also provided valuable information on entrance migration along the coast and whether the mouth gets breached by the sea or river, or closes off from time to time.

Figure B-1. Google Earth images are used to illustrate the geomorphic classes. At Blueskin Bay Otago the extensive intertidal area, narrow inlet, flood and ebb shoals and enclosure by a recurved sand barrier signify that this system is very shallow and tidally dominated – key distinguishing characteristics of a class 7 *tidal lagoon*.

While this method is partially subjective and relies on expert opinion, we are confident that the adopted methodology will correctly classify most systems. However, there are borderline or transitional systems that are difficult to assign to a class/subclass without further information.

We allocated some types to subclasses to keep the total number of classes small, while recognising that certain classes span a wider variety of characteristics, qualities and associated management implications. For example, the beach stream subclasses 4D (*stream with ribbon lagoon*) and 4E (*intermittent stream with ribbon lagoon*) look very similar from a geomorphic point of view. Both are connected to large coastal wetlands, but 4D is connected to the river with minor wetland drainage inputs whereas 4E is hydraulically dominated by wetland groundwater drainage and, unlike 4D, its outlet closes from time to time – so their catchments should be considered and managed differently. For instance, human pressures on and changes in systems like 4D that close off might lead to further interventions such as mechanical opening to allow fish passage, mitigate flooding or prevent the lagoon becoming eutrophic.

It was useful to develop schematics to describe the key characteristics of each class (see Figure B-2). These conceptual models have been used by other workers to describe and identify key processes (e.g., Ryan et al. 2003). The conceptual models were developed into comprehensive illustrations that provide concise and clear descriptions of important features such as basin morphometry, river and oceanic forcing. These schematics allow detailed technical concepts to be summarised as a basis for dialogue with environmental managers and other stakeholders.

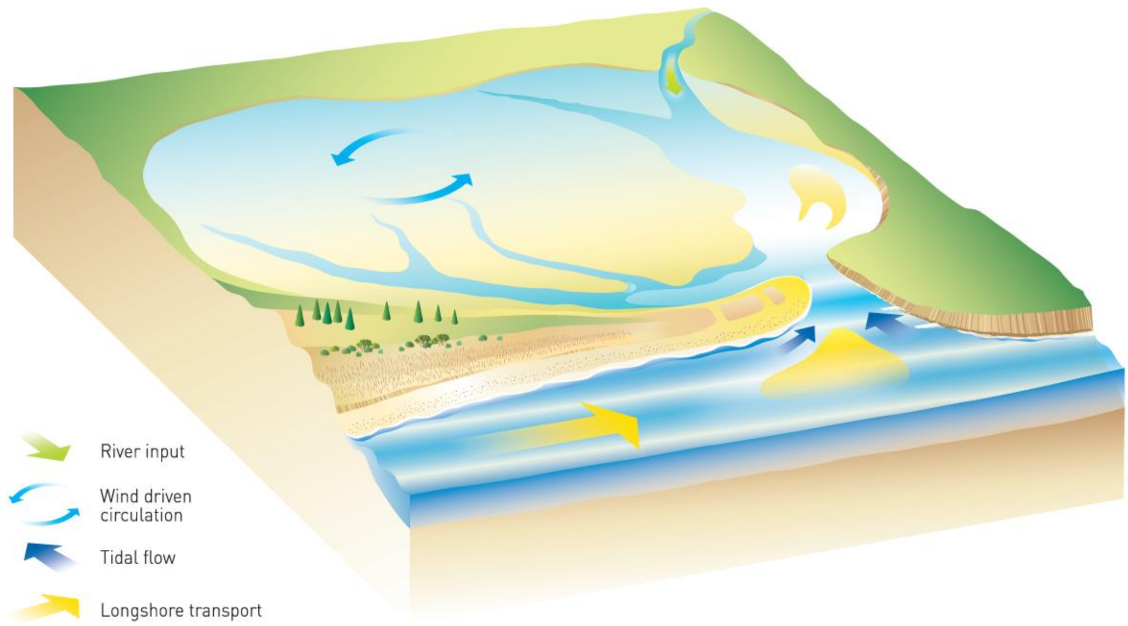


Figure B-2. A schematic illustrating the key characteristics of geomorphic class 7 *tidal lagoon*.

The geomorphic classes, for the most part, represent types of systems that have been largely unmodified by anthropogenic activities such as reclamation, dredging, road and rail causeways and river-channel diversions. However, they include some systems that have been modified to an extent that has totally changed their class e.g., the Maketu Estuary (Bay of Plenty) and the Waimakariri River/Brooklands Lagoon (Canterbury) where river diversion has changed the systems from *tidal river mouth* or *freshwater river mouth* to *tidal lagoon* (see section 3.3 of this report). They exclude systems that have been totally created by humans such as small coastal lakes and flooded pits created by gravel and goldmining activities.

Naming the classes

In choosing names for our classes and subclasses, we responded to direction from participants at the February 2016 stakeholders' workshop. These practitioners recommended keeping the names simple, limited to two or three words, and linked to names in common use. Names where selected that captured the morphology and driving processes (e.g., tides or river forcing): for example, *tidal lagoon* and *tidal river mouth*. For some systems, namely those with limited occurrence, we have co-opted and expanded upon local names: for example, *waituna* and *hāpua* as introduced by Kirk and Lauder (2000). For other systems, such as the *fjord*, we chose a name that is widely used in day-to-day language and the scientific literature.

The subclasses adopted distinctive identifiers, without repeating the class name, to keep subclass names brief. For example, Class 6 *tidal river mouth* subclass A is simply named *unrestricted* as opposed to *unrestricted tidal river mouth*; and subclass B is simply named *lagoonal* as opposed to *lagoonal tidal river mouth*. This does not preclude, when discussing individual systems out of the context of the full classification, use of a longer name which might be more appropriate. In some cases, such as the *damp sand plain stream*, we used names that reflect the type of environments (i.e., *damp sand plains*, after Kenny and Hayward, 2013) in which the systems are located.

Appendix C Identification key

To guide the determination of the classes we also developed a key. An identification key is a tool that aids the identification of entities, whether at the hydrosystem or geomorphic class level. It works by offering a sequence of identification steps, each with multiple alternatives, the choice of which determines the next step. At each step, the user must answer a question about one or several features of the hydrosystem to be determined.

A tree diagram summarising how the key works for the classification is presented Figure C-1. It illustrates that our classification at the geomorphic class level is essentially hierarchical. It shows that it sits along gradients from enclosed-freshwater to open marine and also from shallow to deep. The diagram also shows (the blue dotted boxes) how the geomorphic classes (red font) nest within the hydrosystems level (II) of the overarching classification (i.e., palustrine, lacustrine, riverine, estuarine to marine - the blue dotted boxes).

The identification keys (Table C-1 and Table C-2) for hydrosystem types and geomorphic classes offer a fixed sequence of identification steps (the numbers on the left), each with multiple alternatives. The choice (the number on the right) of the diagram determines the next step to proceed to. All steps, but one in Table C-2 (Step 4), have only two alternatives. At each step, the user must answer a question about one or more features (distinguishing characteristics) of the entity to be identified (these features relate to the controlling factors in Table 3-2). For example, a step in the geomorphic class key may ask about how permanent or not the connection with the sea is; or the presence/absence of certain geomorphic features; or the prevailing hydrodynamic features.

Whenever possible, the feature used at each identification step is a diagnostic character; that is, each alternative is common to all members of a group of entities, and unique to that group (for instance we defined all coastal hydrosystems as having hydrological and geomorphic as having components influenced by the interaction between freshwater and seawater and the first steps are designed around this feature). It is also differential, meaning that the alternatives separate the corresponding subgroups from each other (e.g., where present is tidal ingress limited or strong?).

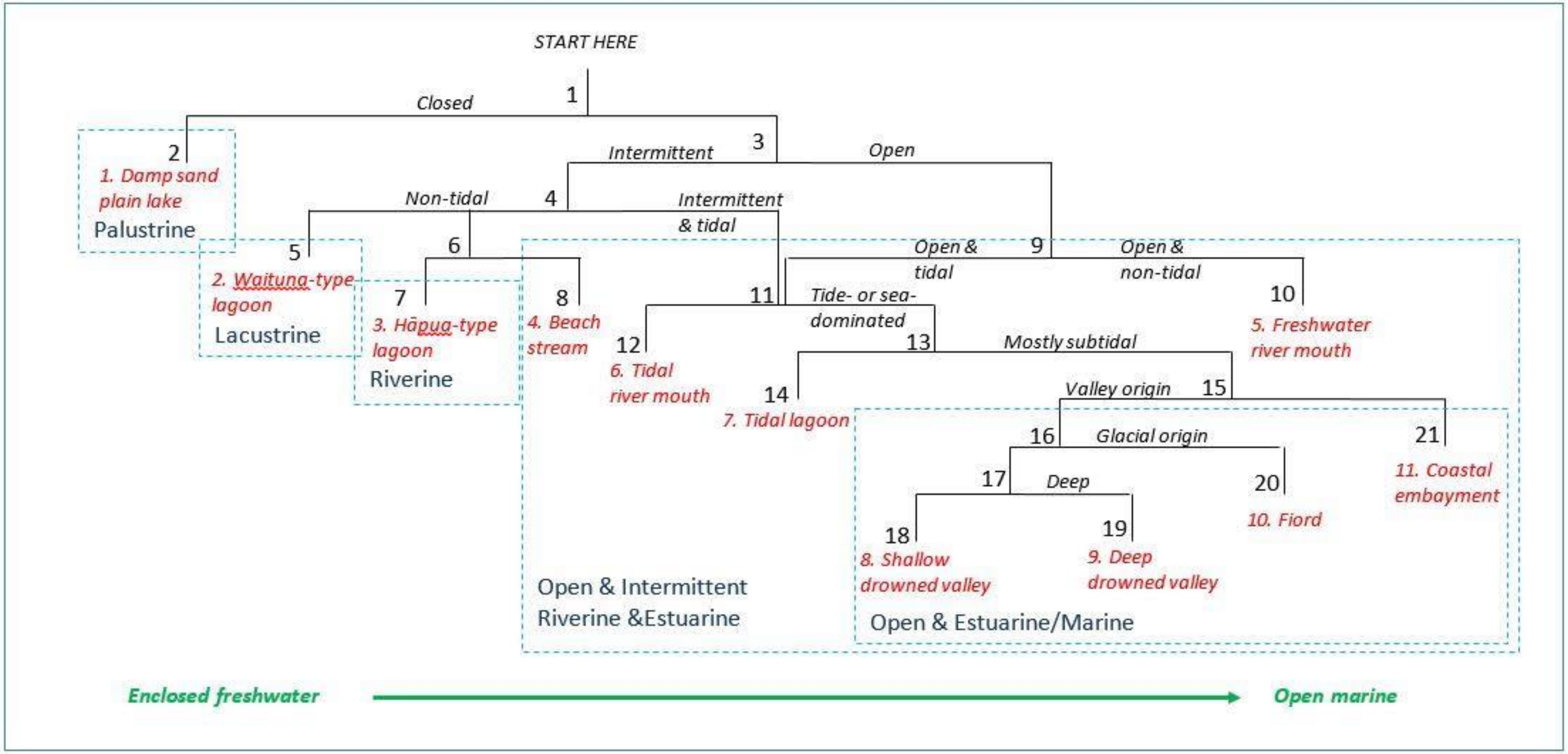


Figure C-1. Tree diagram of hydrosystem types and geomorphic classes. The blue dotted boxes describe the hydrosystem environment (Level II in the overarching classification (Table 2-1).

Table C-1. Key to hydrosystems types. Numbers at the right indicate which following entry to refer to.

Key to Hydrosystems Types		
1	Not located within the coastal[5] zone …………………………………………………………………	2
1.	Located within the coastal zone…………………………………………………………………………	3
2.	***Inland hydrosystem*** (refer to Johnson and Gerbeaux 2004)	
3.	Water regime not or not typically influenced by tidal water…………………………………………	4
3.	Water regime dominated by diurnal tidal ingress ……………………………………………… ……..	10
4.	Never opened to the sea; shallow with substrate mostly inundated or saturated…………………	5
4.	Intermittently closed and opened, or permanently connected to the sea under natural[6] regime………………………………………………………………………………………………………	6
5.	***Palustrine*** (refer to Johnson and Gerbeaux 2004)	
6.	Not in a large valley basin or coastal depression; linear; strong permanent freshwater flow influence; flowing out to sea over or through a beach, or via a shallow[7] subtidal channel………………………………………………………………………………………………………	8
6.	In a large shallow valley basin or coastal depression; on wave-dominated high energy mixed sand-gravel coasts; often brackish; some influence of lake processes such as wave action……………………………………………………………………………………………………	7
7.	***Lacustrine***	
8.	***Riverine***	
10.	Not semi-enclosed with little or no freshwater inflows (wide open connection to the sea)...	12
10.	Semi-enclosed, extensive intertidal areas, a permanent but narrow entrance to the sea …..	11
11.	***Estuarine***	
12.	***Marine***	

[5] "The *coastal zone* may be defined as the interface between land and sea, where marine processes influence terrestrial environments, and where terrestrial processes influence marine environments."

[6] Natural is defined as "without any management interventions". Under such natural conditions the system can be alternatively closed and opened.

[7] When flow is large enough, a permanent deeper subtidal channel may be created through the shoreline and beach to the sea.

Table C-2. Key to geomorphic classes. Numbers at the right indicate which following entry to refer to. The user is required to use the key to hydrosystem types before this one.**Key to Geomorphic Classes**

Note that you are required to use the key to hydrosystems before using this one.

1. Never opened to the sea 2
1. Intermittently* or permanently opened to the sea...3

2. **class 1 *Damp sand plain lake***

3. Not permanently opened to the sea...4
3. Permanently opened to the sea..9

4. Intermittently[8] opened to the sea; *lacustrine*..5
4. Intermittently opened to the sea; no diurnal tidal ingress; *riverine*...6
4. Intermittently opened to the sea; diurnal tidal ingress present; *estuarine*...............................11

5. **class 2 *Waituna-type lagoon***

5a. 2A: *in coastal plain depression* (e.g., Te Waihora)
5b. 2B: *in valley depression* (e.g., Lake Forsyth)

6. Stream or river mouth without elongated and narrow lagoon parallel to the sea...................8
6. River mouth with an elongated and narrow lagoon parallel to the sea; along wave-dominated high energy Eastern coasts; typically outflow only or very short-lived (1- 2 tidal cycles) tidal inflows for a few hours to days after a large flood breaches or widens the outlet 7

7. **class 3 *Hāpua-type lagoon***

7a 3A: large (at the mouth of large braided rivers that are alpine-fed)
7b 3B medium (at the mouth of foothill-fed rivers)
7c 3C small (at the mouth of streams and lowland-fed streams and rivers)
7d 3D intermittent[9] (depends on long-term wave climate cycles and river-flow regimes)

8. **class 4 *Beach stream***

8a. 4A: on gravelly/rocky coast; flowing down directly from hillside into the sea
8b. 4B: on sandy coast without a small pond/lagoon; flowing over damp sand plain and beach to sea
8c. 4C: on sandy coast, with a small pond/lagoon
8d. 4D: on mixed sand-gravel coast, often elevated/perched behind a beach, regularly closing /opening with a mobile inlet/outlet (e.g., Granity; Paroa; Wellington east coast)
8e. 4E: narrow elongate water body running parallel to the coast (typically found along West Coast SI), connected to large coastal wetland system that drains into a river mouth

9. Permanently opened to the sea; no or very limited tidal ingress...10
9. Permanently opened to the sea; strong tidal ingress present...11

10. **class 5 *Freshwater river mouth***

10a. 5A: unrestricted non-tidal river mouth

"[8]Intermittently" is defined as "lack of connection with the sea at least at low tide; connection may happen only at high and/or spring tide or during storm events. Closure can happen under natural conditions (in absence of human intervention)".

[9] Hydrosystems of this subtype may switch between two different equilibrium states, hāpua-type lagoon and tidal river mouth, sustained each for years to decades

10b. 5B: deltaic non-tidal river mouth with delta
10c. 5C: barrier beach enclosed (restricted) river mouth with little tidal influence (tidal backwater only)

11. No strong marine influence (tidal prism not larger than river input, estuarine with still strong riverine influence) ……12
11. Strong marine influence ……13

12. **class 6 *Tidal river mouth***
12a. 6A: wide unrestricted mouth and no lagoon (mostly subtidal channel); on low-energy coast; within large composite system
12b. 6B: narrow inlet restricted by sandy spit with lagoon or large tidal channel upstream of mouth; on sufficiently high energy coast
12c. 6C: similar to 6B but on a mixed sand-gravel coast; with short elongated tidal lagoon and noticeable but minor lateral migration of inlet/outlet over time
12d. 6D: similar to 6C but with very narrow, elongate and shallow lagoon, major lateral (up to several km) migration of inlet/outlet; freshwater often contributed by flow in main river channel and by adjacent wetlands (highlighted by the presence of tannin stained water)
12e 6E: unrestricted mouth with shallow channelized arms discharging sandy or gravelly sediment to build a delta into a low energy coast

13. Not mostly sub-tidal (mostly intertidal); very shallow (mean depth 1-3m)…… 14
13. Mostly sub-tidal; shallow to very deep……15

14. **class 7 *Tidal lagoon***
14a . 7A: permanently open tidal lagoon
14b . 7B: intermittently closed tidal lagoon (e.g., Hoopers Inlet)

15. Not a drowned valley; shallow (mean depth 4-8 m); marine……21
15. Drowned valley origin……16

16. Not of glacial origin……17
16. Of glacial origin ……20

17. Not deep (mean depth <5 m) ……18
17. Deep (mean 10-30 m), mostly subtidal, with few estuarine components ……19

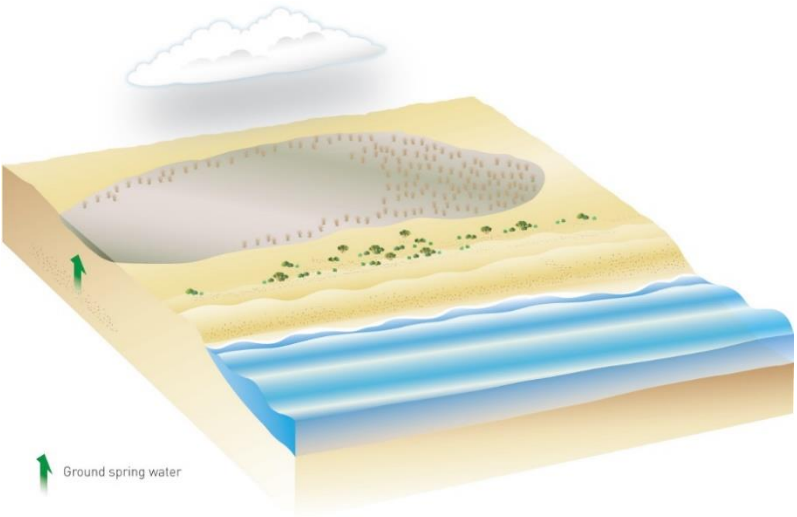
18. **class 8 *Shallow drowned valley***
18a. 8A: small and shallow (mean depth several metres) elongate basins including tidal creek (s) and extensive mudflats
18b. 8B: extensive and shallow (<5m mean depth) with complex dendritic shorelines and numerous narrow arms leading off a main central basin subject to wind-generated circulation, mixing and waves

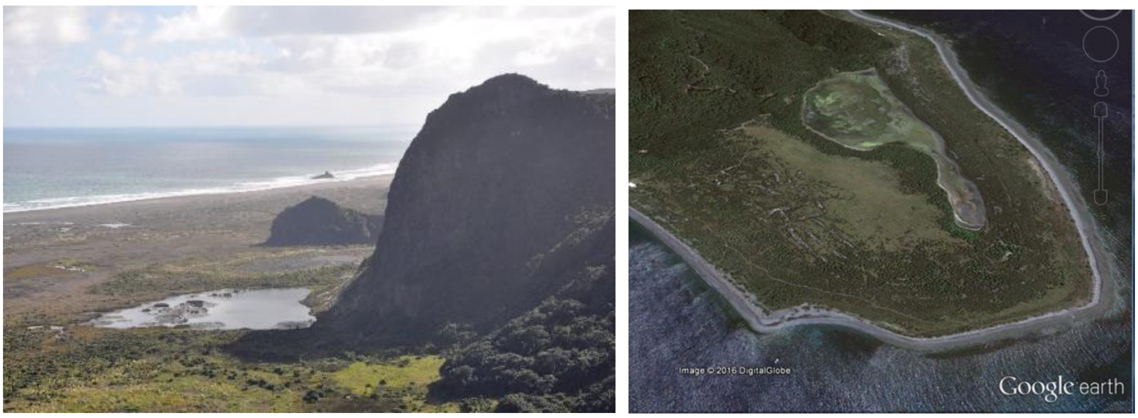
19. **class *9 Deep drowned valley***
20. **class 10 *Fjord***
21. **class 11 *Coastal embayment***

Appendix D Google Earth images and schematics of geomorphic classes

This appendix provides a selection of Google Earth images and schematics which illustrate the key characteristics of the geomorphic classes and subclasses at a scale where detail can be seen more clearly.

Class 1. *Damp sand plain lake*

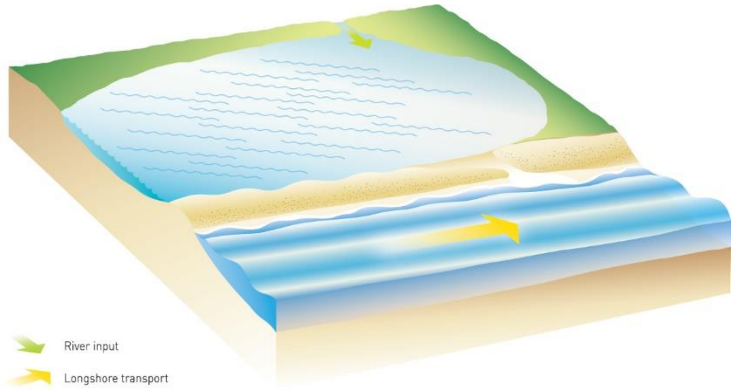




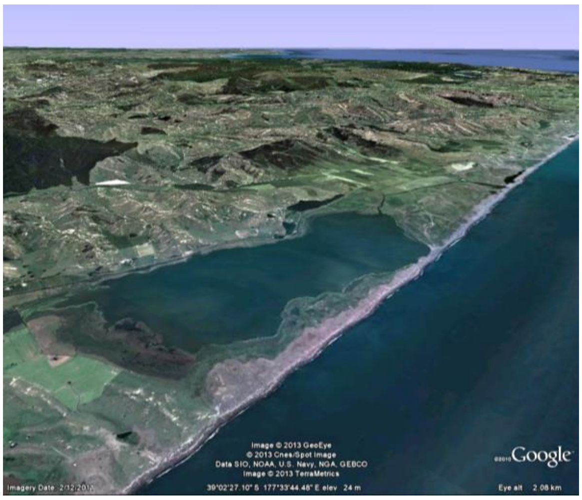
1A *Damp sand plain lake*: Manukau North Head, Auckland and Okupe Lagoon, Kapiti Island.

1A *Damp sand plain lake*: Parengarenga Spit, Northland and Mangawhai Spit, Auckland.

Class 2. *Waituna-type lagoon*

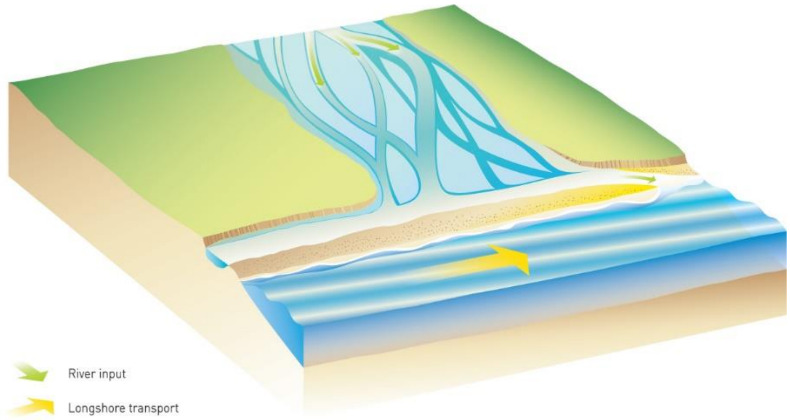


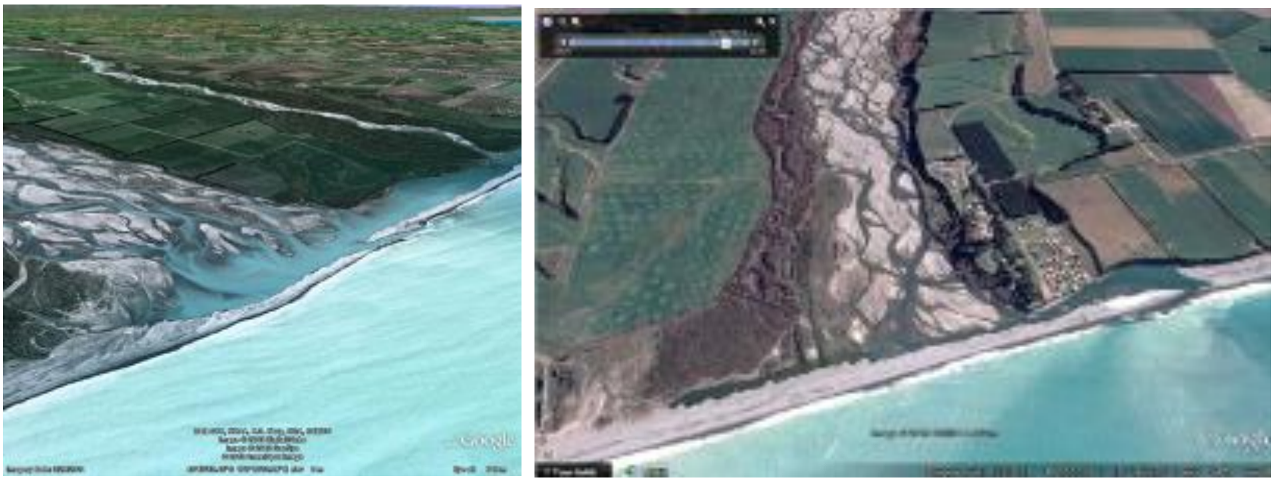

2A *Coastal plain depression*: Lake Ellesmere/Te Waihora and Wainono Lagoon, Canterbury.



2A *Coastal plain depression*: Ohuia Lagoon, Hawkes Bay. 2B *Valley depression*: Te Roto o Wairewa (Lake Forsyth), Canterbury.

Class 3. *Hāpua-type lagoon*

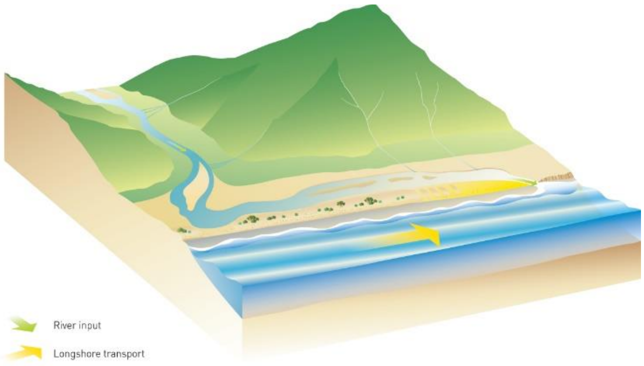




3A *Large hāpua*: Rakaia River. 3B *Medium hāpua*: Ashburton River, Canterbury.

3C *Small hāpua*: Kowhai River, Canterbury. 3D *Intermittent hāpua*: Ashley River, Canterbury.

Class 4. *Beach stream*

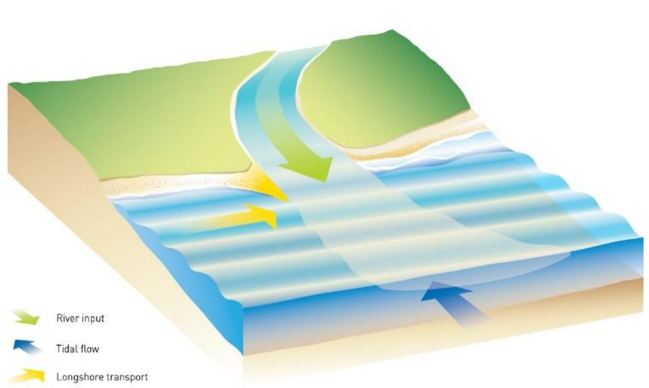


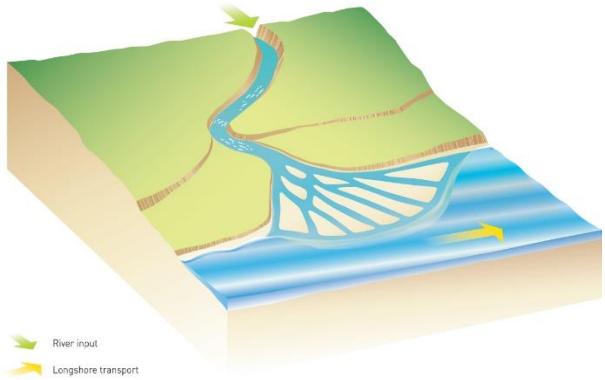
4C *Stream with pond*. 4D *Stream with ribbon lagoon*.

4A *Hillside stream*: Heaphy Stream, West Coast South Island. 4B: Granity Stream, West Coast South Island.

4C *Stream with pond*: Piha Stream, Auckland. 4D Stream south of Mohikinui, West Coast South Island.

Class 5. *Freshwater river mouth*



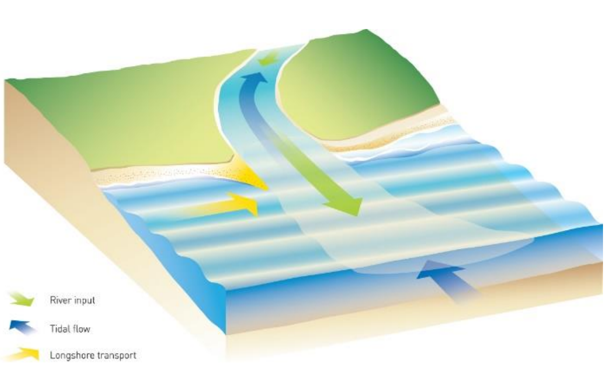


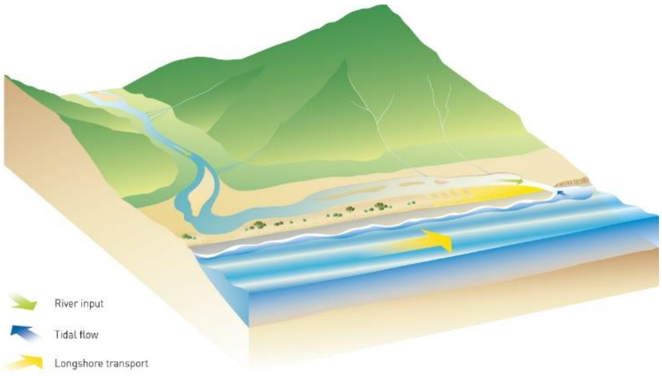
5A **Unrestricted**. 5B *Deltaic*.

5A *Unrestricted*: Clarence River, Canterbury. 5B *Deltaic*: Tapu River, Coromandel.

5C *Barrier beach enclosed*: Paringa River and Haast River, West Coast South Island.

Class 6. *Tidal river mouth*





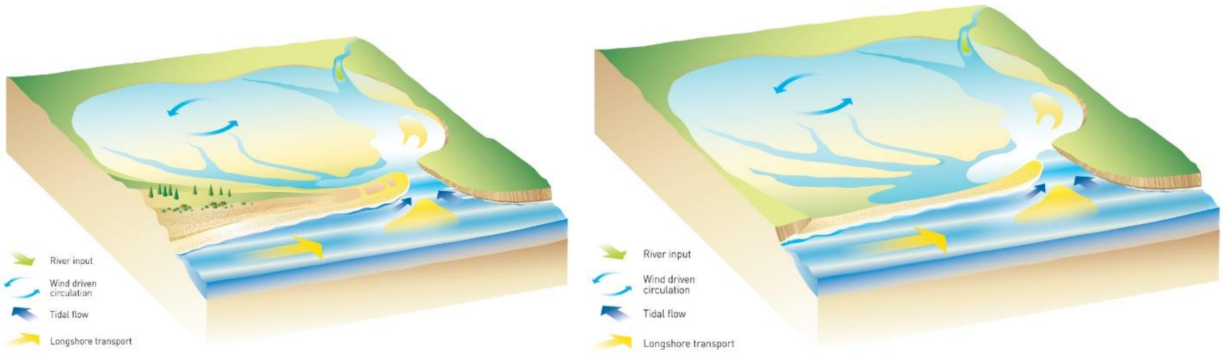
6A *Unrestricted*. 6D *Intermittent with ribbon lagoon*.

6A *Unrestricted*: Waihou River, Waikato. 6B *Spit enclosed*: Whakatane, Bay of Plenty.

6C *Barrier beach enclosed*: Arahura River, West Coast South Island. 6D *Intermittent with ribbon lagoon*: New River, Greymouth.

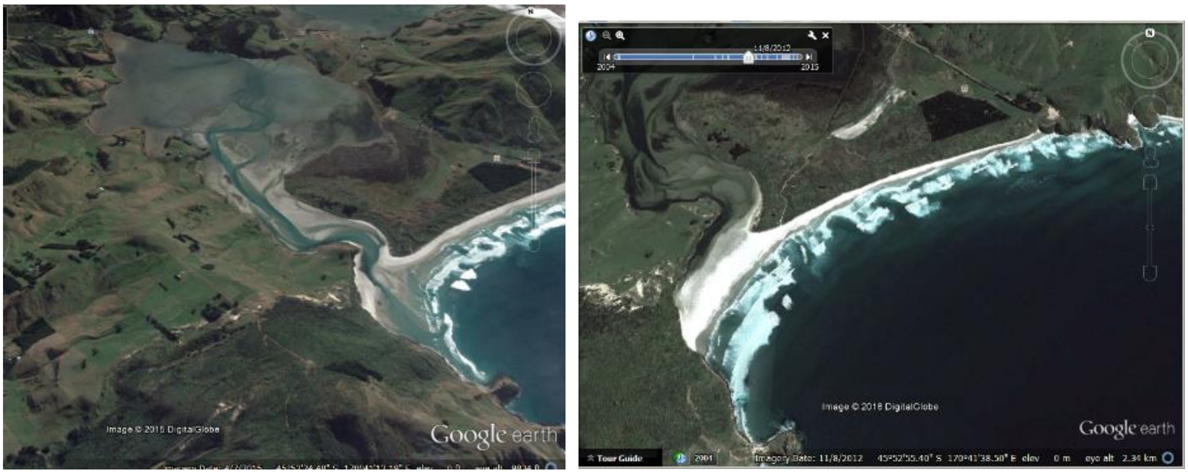
6E *Deltaic*: Motueka River, Tasman Bay.

Class 7. *Tidal lagoon*



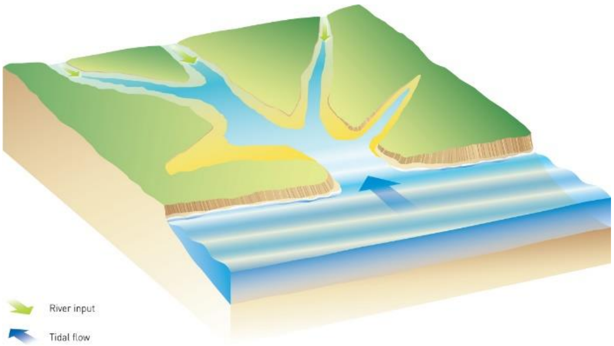
7A *Permanently open* enclosed with barrier (left) and barrier beach/spit (right).

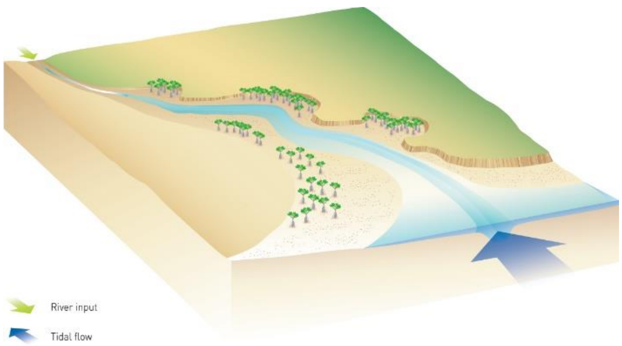
7A *Permanently open*: Blueskin Bay, Otago and Ngunguru River, Northland.



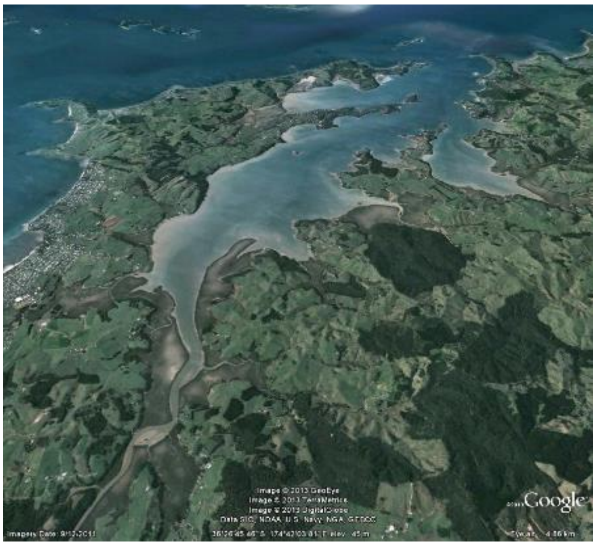
7B *Intermittently closed*: Hoopers Inlet, Otago in its open (left) and closed (right) states.

Class 8. *Shallow drowned valley*





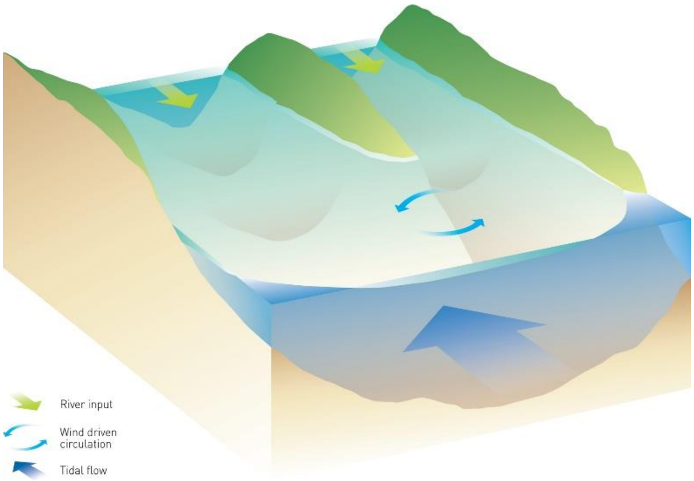
8 *Shallow drowned valley* (left) and detail of a tidal arm/tidal creek (right).



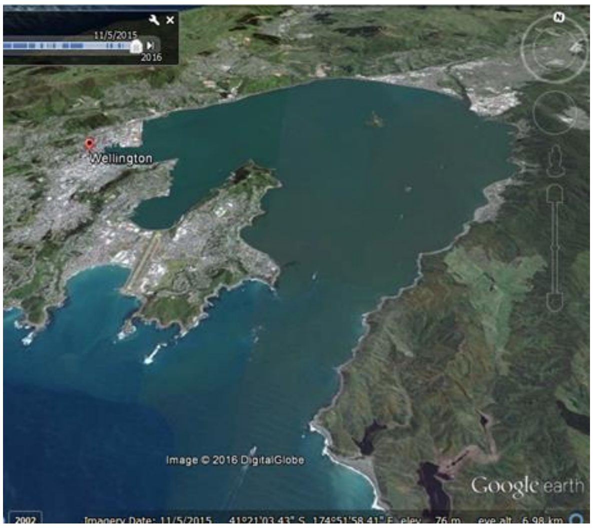
8 *Shallow drowned valley*: Mahurangi and Waitemata Harbours, Auckland.

8 *Shallow drowned valley*: Paremoremo Creek in the Upper Waitemata Harbour and Hokianga Harbour, Northland.

Class 9. *Deep drowned valley*

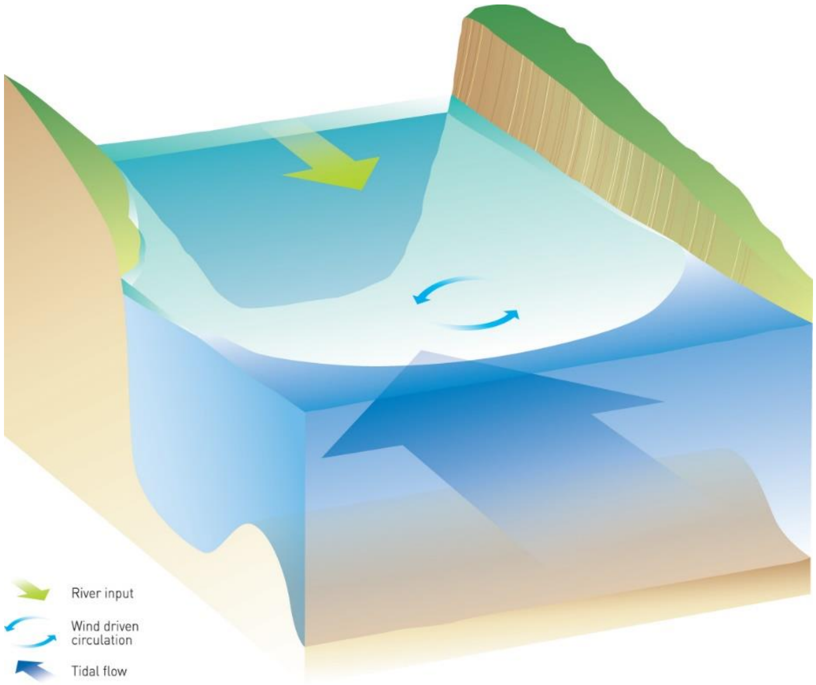


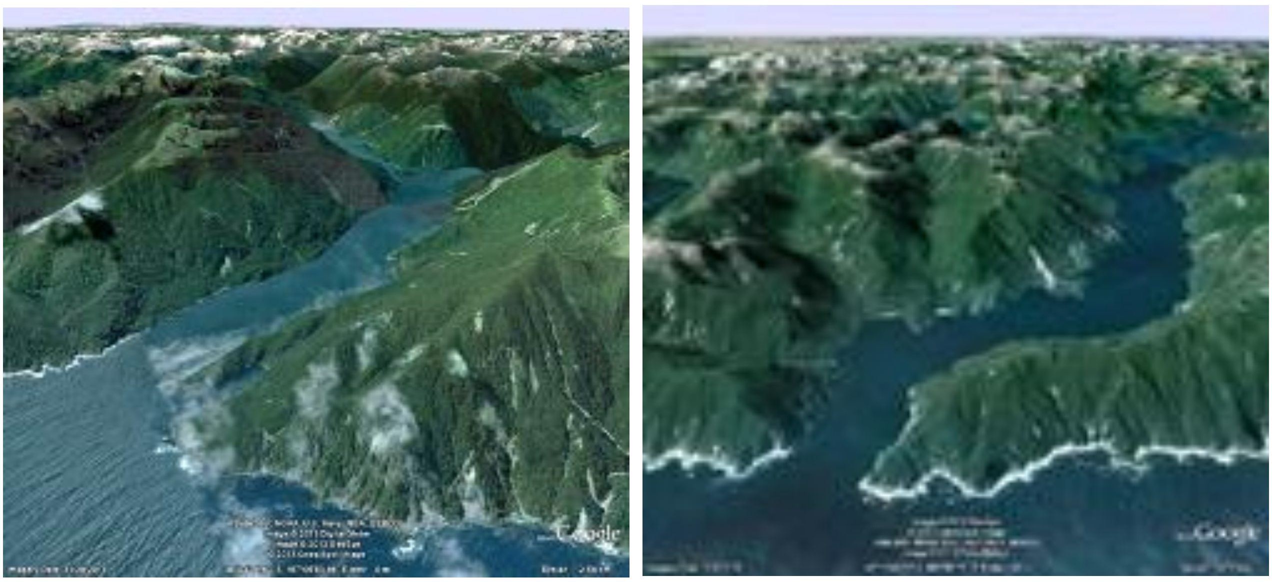
9 *Deep drowned valley*: Akaroa Harbour and Queen Charlotte Sound (Tōtaranui).



9 *Deep drowned valley*: Firth of Thames and Wellington Harbour.

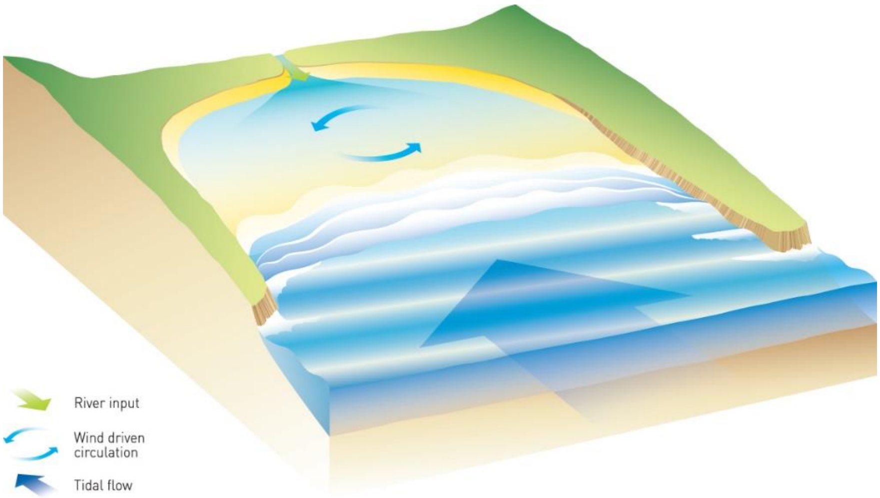
Class 10. *Fjord*





10 *Fjord*: Charles Sound and Thompson Sound, Fiordland.

Class 11. *Coastal embayment*



11 *Coastal embayment*: Matai Bay and Taemaro Bay, Northland.

11 *Coastal embayment*: Sleepy Bay, Banks Peninsula.

Appendix E Inventory of environmental variables

This appendix provides a selection of statistics for about 500 of New Zealand's coastal hydrosystems along with descriptions of their methods of calculation.

The data will also be made available via the MFE website as:

- Excel (.xls) spreadsheet of environmental variables.
- GIS shape files (polygons) and point files.
- Google Earth point files (.kmz) – when both these files are opened together, they show the system polygons and points at the mouths of the systems which if "clicked on" (selected) display the environment variables for the selected hydrosystem.

The database

This database comprises information from two sources.

The first source is the Estuarine Environment Classification (EEC) database developed for over 400 estuaries by Hume et al. (2007). It provides the environmental variables listed below. The inset shows how these attributes are displayed in the Google Earth.

- Hydrosystem name
- Council region
- Geomorphic class (NZ coastal hydrosystem classification)
- Coordinates of mouth (latitude and longitude NZTM2000)
- Width of mouth (m)
- Shoreline perimeter length (m)
- Surface area at spring high tide (m^2)
- Intertidal area (% of high tide area)
- Mean depth at spring high tide (m)
- Total volume at spring high tide (m^3)
- Spring tidal range (m)
- Spring tidal prism (m)
- Catchment area (km^2)
- River inflow volume during a tidal cycle, 12.4 hr (m^3)
- Coordinates of mouth (NZMG).

Wellington Harbour

Wellington Harbour	
Hydrosystem_name	Wellington Harbour
Council region	GWRC
Geomorphic_class	9
Geomorphic_subclass	
NZTM2000_latitude	5420523.743
NZTM2000_longitude	1753461.647
Width_of_mouth__m_	2801
Shoreline_perimeter_length__m_	73285
Surface_area_at_spring_high_tide_A__m2_	85421181
Intertidal area % of high tide area	0
Mean_depth_at_spring_high_tide_D__m_	16
Total_volume_at_spring_high_tide__m3_	1369490185
Spring_tidal_range__m_	1
Spring_tidal_prism_P__m3_	88321085
Catchment_area__km2_	639
River_inflow_over_tidal_cycle_R12__m3_	1862827
Coordinates_of_mouth_easting__NZMG_	2663485
Coordinates_of_mouth_northing__NZMG_	5982236

Directions: To here - From here

It is important to note that this database was compiled over 2003-2006 and that there is now more up-to-date information available for some of the variables via the NZ River Environment Classification (REC2) and in particular, updates to the LCDB and Google Earth imagery. This has not been incorporated into our database.

The second source is data compiled as part of this study to incorporate environmental variables *for damp sand plain lakes, waituna-type lagoons, hāpua-type lagoons, beach streams* and *freshwater river mouths* systems. For these systems the dataset of variables is more limited because for instance *waituna-type lagoons, hāpua-type lagoons, beach streams* and *freshwater river mouths* have no tidal incursion and therefore no tidal prism or intertidal area.

While the list is largely complete for *waituna-type lagoons, hāpua-type lagoons* and *freshwater river mouths* systems, we provide just a few examples for *damp sand plain lakes* and *beach streams* as these systems are very numerous around the coastline and best mapped at a local level.

We have classified all the coastal hydrosystems into the 11 geomorphic classes, and most at the subclass level. Comparing this classification with the geomorphic class characteristics in Table 3-2 gives users a description of the characteristics and properties for about 500 coastal hydrosystems.

Calculation procedures

In the EEC database systems were named using names from the NZMS 1:50,000 topographic maps. Where the system is not named on the maps, it was named after the major river/stream input(s).

The computation procedures involved identifying/defining the systems on the NZMS 1:50,000 maps, defining low-tide and high-tide areas at 1:50,000 scale, and extracting the areas as GIS shape files.

The original EEC database of Hume et al. (2007), now held on the NIWA project drive, had over 50,000 cells relating to some 50 different environmental variables for over 400 estuaries for the mainland and some of the offshore Islands. It was populated with physical variables descriptive of basin morphometry (e.g., mean depth, area at low and high tide, % intertidal area), oceanic forcing (e.g., tide range, tidal prism), river forcing (e.g., river inflow), characteristics of the contributing catchment (including area, topography, geology and land cover) and other factors such as climate variables.

Data mining and computation using numerical and analytical models and GIS were used to generate the database. Variables were derived from NIWA's digital elevation model (DEM) (30 m cell size) of New Zealand, the 1:50,000 Digital Topographic Database, the NZ Land Resource Inventory (NZLRI) and Land Cover Database (LCDB), the NZ Exclusive Economic Zone (EEZ) Tidal Model (Walters et al. 2001), digital files of the RNZN hydrographic charts, and various publications and reports. Computation using numerical and analytical models and GIS was also used to derive the variables.

The process of defining the planform and upper (landward) and lower (seaward) limits of coastal water bodies, which involves some subjectivity, was as follows:

- Digital 1:50,000 maps were used to identify estuary basins that were at least 0.5 km long.
- The high water line defined the shoreline of the estuary.
- The seaward boundary, or mouth, of each estuary was drawn at an inlet constriction, or where the shoreline diverges up or down coast. This boundary was easily defined in most situations. However, seaward boundaries were difficult to define for estuaries with funnel-shaped mouths. In these few cases the boundary was drawn to follow the general trend of the hard shore coast either side of the mouth.

- The upstream limit of the estuary was easy to define in most cases because of the generally steep topography of the coast. However, in river-dominated elongate estuaries we defined the upstream boundary as the upstream limit of salinity intrusion under average tidal and river flow conditions at high water. Where there were no salinity data, a decision was made based on anecdotal evidence, the location of freshwater intakes and geomorphic information such as the location of river bars or where significant tributaries enter a system. In practice, the final class assigned to estuaries was insensitive to the precise location of the upstream limit and seaward boundary.

Once defined, each water body basin (*Estuary area at high tide*) was delineated as a polygon (shape file) in a GIS database and associated with the polygon of its contributing catchment. Catchment boundaries are the land boundaries that encompass the drainage basin of the water body (*Catchment area*) above the mouth, and were derived from the DEM.

Estuary area at spring low tide (m^2): derived from the 1:50000 LINZ DTDB by subtracting the intertidal area from the high water area. The accuracy of this number depends how well LINZ defined the high water line and the intertidal line from the aerial photographs when undertaking the mapping.

Estuary area at spring high tide (A) (m^2): derived from the coastline of the 1:50000 LINZ DTDB which is high water. The accuracy of this number depends how well LINZ defined the high water line from the aerial photographs.

% intertidal at spring tide (%): calculated from the GIS shape files derived from the 1:50000 DTDB.

Width of mouth (m): the seaward boundary or mouth of an estuary was drawn at an inlet constriction, or where the shoreline diverges up or down coast. The seaward boundary was easily defined in most situations. Seaward boundaries were difficult to define for estuaries with funnel-shaped mouths. In these few cases the boundary was drawn to follow the general trend of the hard shore coast either side of the mouth.

Estuary volume at high tide (m^3): calculated depending on the type of data available for each estuary:

- From detailed bathymetry datasets from NIWA archives created for numerical model grids (38 estuaries).
- Following on-screen digitising soundings from the electronic versions of Navy hydrographic charts. The unrectified TIFF files were georeferenced to the 1:50,000 shoreline (estuary polygons) in GIS, a Triangulated Irregular Network (TIN) was created for each estuary from the bathymetry dataset, and then a surface analysis was undertaken to calculate estuary volume from the TINs (131 estuaries).
- The sum of the volume of water at low tide plus the tidal prism P, where the low tide volume was calculated as the product of mean depth and surface area at low tide (274 estuaries). This latter method mostly applied to very small and shallow (mean depth generally <1 m) estuaries where there was no bathymetric data available and where the tidal prism was generally a significant proportion of the total volume. Mean depth at low water was estimated from anecdotal evidence. Surface area at low water was computed from 1:50,000 digital charts using GIS.

Mean depth at high tide (D) (m): total estuary volume at high water divided by the estuary area at spring high tide.

Shoreline length (m): length of the shoreline of the estuary, excluding the distance across the mouth of the estuary, but may include the length across the upper boundary cut-off (e.g., the line across the upper limit of river mouth estuaries). The upper limit of the estuary is the limit of estuarine intrusion.

Spring tide range (m): used the NIWA EEZ tidal model to extract tide range (M2 and S2 tidal constituents) information at the mouth of each estuary or at the closest model node to the mouth.

Spring tidal prism (P) (m^3): the product of spring tidal range (Ts) and the area of the estuary at mid tide (Am):

P = Ts x Am

The spring tidal range was computed using the NIWA EEZ tidal model to extract tide range (M2 and S2 tidal constituents) information at the mouth of each estuary or at the closest model node to the mouth. The area of the estuary at mid tide (Am) was calculated as:

Am = (AHW + ALW)/2

where AHW (the area at high tide) and ALW (the area at low tide) were computed from 1:50,000 digital topographic maps using the GIS. The estimates of P compared well with tidal prism determined by field measurements (tidal gaugings) and calculations from hydrographic charts (e.g., Heath 1976; Hume and Herdendorf 1988, 1992 and 1993).

River inflow volume during a tidal cycle (R12) (m^3): from an estimate of mean annual flow into the estuary (cumecs) and a tidal period of 12.4 hours. An annual runoff surface ($mm/km^2/yr$) has been estimated for the whole of New Zealand at a spatial resolution of 1 km^2 using a water-balance model, based on rainfall and potential evapotranspiration (Woods 2003). We used the GIS to sum this surface within the catchment of each estuary to estimate annual runoff because most estuaries lacked flow-measuring stations on their inflowing streams and rivers.

Geomorphic class: 11 classes in Level 3 of the classification.

Disclaimer

This dataset was created for the purpose of developing and testing a classification for New Zealand coastal hydrosystems. Its accuracy and integrity reflects that purpose. We recommend that users exercise their own skill and care with respect to their use of the data and that users carefully evaluate its accuracy, currency, completeness and relevance of it for their particular purposes. The authors do not guarantee, and accept no legal liability whatsoever arising from, or connected to, the use of this dataset.

Table E-1. Environment variables and classification for coastal hydrosystems in New Zealand. While we have confidence in the allocation to geomorphic class for most of these systems there are some where more information and local knowledge is needed to resolve any uncertainty (this is particularly the case for *beach streams* and *freshwater river mouths*). (* = value undefined)

Hydrosystem name	Regional council	Geomorphic class	NZTM2000 latitude of mouth	NZTM2000 longitude of mouth	Width of mouth (m)	Shoreline perimeter length (m)	Surface area at spring high tide A (m^2)	Intertidal area (% of high tide area)	Mean depth at spring high tide D (m)	Total volume at spring high tide (m^3)	Spring tidal range (m)	Spring tidal prism P (m^3)	Catchment area (km^2)	River inflow over tidal cycle R12 (m^3)
NORTH ISLAND														
CAPE REINGA														
Tapotupotu Bay	NRC	7B	6189817	1573828	25	5734	242135	1	3	797044	2.3	557185	14	22252
Waitahora Stream	NRC	7B	6187463	1581170	20	5421	206589	0	1	206506	2.2	0	6	9832
Waitangi Stream	NRC	4C	6190579	1596512	25	4222	59021	0	1	58779	2	0	12	17734
Parengarenga Harbour System	NRC	8	6179628	1599101	1000	190179	64769535	82	2	1.1E+08	2	74683095	224	385353
Houhora Harbour	NRC	8	6146219	1614350	388	30034	13201725	87	1	19560356	2	14648771	132	230160
Rangaunu Harbour	NRC	8	6139917	1625675	1643	127630	1.02E+08	78	2	2.48E+08	2	1.22E+08	552	1133197
Matai Bay	NRC	11	6146736	1638650	1324	9778	2244895	7	9	20270627	1.9	4217028	3	5323
Awapoko River	NRC	6B	6128549	1639372	204	21499	621457	47	3	1581009	2	928354	89	195349
Taipa River	NRC	7A	6127652	1642996	104	23568	1546948	52	2	3706197	2	2234740	126	292069
Mangonui Harbour	NRC	8	6129124	1648111	346	42884	8685508	68	1	11929984	2	11218376	76	171150
Takerau Bay	NRC	11	6135171	1650484	554	2285	236442	1	6	1490234	1.9	456821	1	2265
Taemaro Bay	NRC	11	6133743	1653081	727	4313	703611	3	5	3726052	1.9	1345496	4	9487
Waimahana Bay	NRC	11	6132463	1657092	227	2058	215371	8	6	1193351	1.9	401044	7	15957
Whangaroa Harbour	NRC	9	6125866	1669194	297	103346	25401380	32	4	1.09E+08	1.9	41307851	256	697867
Whangaihe Bay	NRC	11	6127530	1674456	305	2146	204080	3	5	983997	1.9	389449	2	4665
Mahinepua Bay	NRC	11	6126797	1677852	617	3253	496006	3	3	1596911	1.9	947726	7	14449
Takou River	NRC	7A	6115453	1685868	616	9495	589550	57	2	1064981	1.9	811887	73	175315
Tahoranui River	NRC	7A	6113394	1688046	591	6626	254657	25	2	621026	1.9	429703	27	65726
Tapuaetahi Creek	NRC	7A	6112931	1689531	524	7069	381743	84	1	485568	1.9	425482	12	27894

Hydrosystem name	Regional council	Geomorphic class	NZTM2000 latitude of mouth	NZTM2000 longitude of mouth	Width of mouth (m)	Shoreline perimeter length (m)	Surface area at spring high tide A (m^2)	Intertidal area (% of high tide area)	Mean depth at spring high tide D (m)	Total volume at spring high tide (m^3)	Spring tidal range (m)	Spring tidal prism P (m^3)	Catchment area (km^2)	River inflow over tidal cycle R12 (m^3)
Te Puna /Kerikeri Inlet System	NRC	9	6103988	1697363	1910	136250	35776929	11	5	1.76E+08	1.9	64786580	258	711342
Opua Inlet System	NRC	9	6099498	1699963	3756	235777	52132097	20	4	2.02E+08	1.9	90004189	953	2450404
Paroa Bay	NRC	11	6096593	1706274	678	10699	1660007	27	3	4652984	1.9	2755026	4	9827
Manawaora Bay	NRC	11	6097919	1707596	1767	19957	6575097	7	6	38744602	1.9	12159634	11	24466
Parekura Bay	NRC	11	6099111	1712325	687	15050	3581209	37	4	14893034	1.9	5605251	23	52455
Omakiwi Cove	NRC	11	6099558	1712756	585	2613	375366	8	4	1664974	1.9	691874	0	765
Oke Bay	NRC	11	6101539	1715815	850	3961	670155	1	10	6541153	1.9	1279573	1	1704
Deep Water Cove	NRC	11	6104405	1717626	1117	6347	1283662	0	22	28637035	1.9	2453313	3	6398
Outu Bay	NRC	11	6101495	1719187	824	3690	487028	1	10	5087988	1.9	926322	1	1469
Whangamumu Harbour	NRC	11	6099443	1720083	1558	11807	2478380	1	17	41029541	1.9	4711274	2	3752
Bland Bay	NRC	11	6088375	1724845	1386	11881	3406568	3	5	16993476	1.9	6415453	4	8552
Whangaruru Harbour	NRC	9	6083915	1723108	1342	45065	11684453	26	4	44236086	2	19897380	73	179887
Helena Bay	NRC	11	6078682	1725329	1510	12667	2788789	3	4	12202396	1.9	5262636	28	75462
Mimiwhangata Bay	NRC	11	6078631	1727593	2216	11034	3909526	3	6	22294769	1.9	7386532	3	6808
Ngunguru River	NRC	7A	6056069	1737153	196	48404	5124654	55	2	11875487	1.9	7228451	87	208290
Matapouri Bay System (MBS)	NRC	7A	6063593	1737322	567	10929	915553	61	2	1580950	1.9	1223426	16	35437
Matapouri Bay MBS	NRC	11	6063593	1737322	567	3108	417057	19	5	2077939	1.9	725674	1	1165
Matapouri Estuary MBS	NRC	7A	6063050	1736938	49	7919	498471	96	1	517153	1.9	497713	15	34295
Tutukaka Harbour	NRC	9	6057652	1739789	607	7589	1004857	4	5	4884170	1.9	1902412	4	9302
Whananaki Inlet	NRC	7A	6069158	1733246	144	16913	2096804	75	2	3550490	1.9	2514250	54	132079
Horahora River	NRC	7A	6051905	1736424	79	22757	1473736	70	2	2309703	1.9	1862424	88	206153
Pataua River	NRC	7A	6046726	1738012	97	23496	2813735	85	1	3584537	1.9	3152066	46	104021

Hydrosystem name	Regional council	Geomorphic class	NZTM2000 latitude of mouth	NZTM2000 longitude of mouth	Width of mouth (m)	Shoreline perimeter length (m)	Surface area at spring high tide A (m^2)	Intertidal area (% of high tide area)	Mean depth at spring high tide D (m)	Total volume at spring high tide (m^3)	Spring tidal range (m)	Spring tidal prism P (m^3)	Catchment area (km^2)	River inflow over tidal cycle R12 (m^3)
Taiharuru River	NRC	7A	6046287	1740404	685	30476	3592105	87	1	4425331	1.9	3949736	16	35443
Taiharuru Bay	NRC	11	6044993	1740855	467	1965	217174	3	2	453651	1.9	416096	0	588
Awahoa Bay	NRC	11	6042823	1740979	927	3308	467857	10	3	1359689	2	869832	1	3055
WHANGAREI														
Whangarei Harbour System	NRC	8	6032037	1736621	2389	196102	1.04E+08	58	4	4.58E+08	2	1.48E+08	297	684499
Ruakaka River	NRC	7A	6026003	1731986	1003	19498	827301	50	3	2070573	2	1250387	92	207483
Waipu River	NRC	7A	6015966	1733540	393	45941	1548895	41	3	4339888	2	2499800	228	509072
Mangawhai Harbour	NRC	7A	6005087	1744178	1438	39324	4830618	67	2	9718917	2	6562592	12	21967
Pakiri River	AC	7A	5987809	1755096	104	3679	89150	35	2	213063	2.1	155329	32	71823
Omaha Cove	AC	11	5982167	1762818	745	3667	285067	0	8	2256953	2.2	624012	4	8354
Whangateau Harbour	AC	7A	5979043	1759913	444	32405	7460453	85	2	11663589	2.2	9491105	42	95773
Millon Bay	AC	11	5971119	1758172	1228	6560	1017808	62	2	1953712	2.4	1714237	6	12301
Matakana River	AC	8	5970354	1756088	635	35865	4177585	76	1	4786883	2.4	6318279	50	114685
Mahurangi Harbour System	AC	8	5958080	1755154	1354	87160	24565021	51	3	67261470	2.5	44892812	122	280320
Te Muri-O-Tarariki	AC	7A	5957207	1754133	80	4004	264554	100	1	325814	2.5	325629	17	37689
Puhoi River	AC	7A	5956275	1753462	83	18747	1693119	71	2	3693641	2.5	2697410	43	97326
Waiwera River	AC	7A	5954474	1753157	161	11883	992771	64	2	2364498	2.5	1659432	38	84502
Orewa River	AC	7A	5948377	1752267	296	15495	1280293	89	1	1899475	2.5	1758642	28	61644
Okoromai Bay	AC	11	5945806	1762033	874	4481	1059101	27	3	2832822	2.5	2310461	7	10477
Hobbs Bay (Gulf Harbour)	AC	11	5945139	1759931	377	2591	237186	0	5	1075639	2.5	601267	3	6001
Weiti River	AC	6B	5942514	1754873	936	28920	2833304	63	1	7032306	2.5	4937928	33	70414
Okura River	AC	7A	5941042	1754983	519	13268	1359335	79	1	861712	2.5	2089152	27	54233

Hydrosystem name	Regional council	Geomorphic class	NZTM2000 latitude of mouth	NZTM2000 longitude of mouth	Width of mouth (m)	Shoreline perimeter length (m)	Surface area at spring high tide A (m^2)	Intertidal area (% of high tide area)	Mean depth at spring high tide D (m)	Total volume at spring high tide (m^3)	Spring tidal range (m)	Spring tidal prism P (m^3)	Catchment area (km^2)	River inflow over tidal cycle R12 (m^3)
AUCKLAND														
Waitemata Harbour System	AC	8	5921691	1762135	2659	262760	79848102	36	4	3.42E+08	2.7	1.77E+08	427	887458
Lucas Creek WHS	AC	8	5929172	1748216	407	18372	1515016	87	2	2321528	2.7	2321528	35	68503
Tamaki River	AC	8	5920496	1768325	2269	96827	16963199	40	3	49163825	2.8	37427602	109	186013
Whitford Embayment System (WES)	AC	8	5915687	1775314	3269	44610	11064418	82	2	25549889	2.8	18516635	61	104987
Mangemangeroa Estuary WES	AC	8	5913226	1774291	694	8102	602242	87	2	920056	2.8	963637	10	17111
Turanga Creek WES	AC	8	5912811	1774737	291	15331	1493124	74	1	2202889	2.8	2670640	28	49136
Waikopua Creek WES	AC	8	5914005	1776489	1394	12686	1739241	100	1	2032921	2.8	2463504	16	26486
Wairoa River	AC	8	5909922	1786199	833	28905	2503260	42	3	8679788	2.9	5774004	311	637732
Orere River	AC	5B	5907444	1799999	28								44	35545
Miranda Stream	WRC	7A	5882036	1806098	159	1252	73681	95	2	130134	3.3	126642	1	1005
Firth of Thames System	WRC/AC	9	5914745	1805191	20869	249325	7.29E+08	15	9	6.87E+09	2.9	1.92E+09	4194	8367134
Firth of Thames	WRC/AC	9	5914745	1805191	20869	135897	7.17E+08	15	3	1.89E+09	2.9	1.89E+09	544	1139658
Waitakaruru River	WRC	6A	5877829	1812667	838	9579	484292	64	3	1442025	3.3	1092075	167	271961
Piako River	WRC	6A	5880883	1821680	862	28386	1697671	26	4	7426156	3.3	4900022	1461	2439637
Waihou River	WRC	6A	5883571	1825332	1000	76562	9914351	7	2	59347457	3.3	31594215	1980	4394084
Kauranga River	WRC	6A	5885727	1825717	960	5323	256609	55	3	842741	3.3	612254	132	360249
THAMES														
Tapu River	WRC	5B	5903825	1822416	45								26	53090
Te Mata River	WRC	5B	5905642	1822130	22								27	64490
Kirita Bay	WRC	11	5916907	1815318	470	2602	338963	9	3	1065676	2.9	928268	4	9240
Manaia Harbour	WRC	8	5920119	1816165	1471	26646	6348868	76	3	20538114	2.8	11080679	59	168704

Hydrosystem name	Regional council	Geomorphic class	NZTM2000 latitude of mouth	NZTM2000 longitude of mouth	Width of mouth (m)	Shoreline perimeter length (m)	Surface area at spring high tide A (m^2)	Intertidal area (% of high tide area)	Mean depth at spring high tide D (m)	Total volume at spring high tide (m^3)	Spring tidal range (m)	Spring tidal prism P (m^3)	Catchment area (km^2)	River inflow over tidal cycle R12 (m^3)
Te Kouma Harbour	WRC	8	5921610	1816404	568	11894	2742733	46	4	10226151	2.8	5915819	6	13600
Coromandel Harbour	WRC	8	5924973	1816930	2225	36506	25401553	21	5	1.4E+08	2.8	62796785	60	154014
Colville Bay	WRC	8	5944717	1817981	1680	13037	4598848	5	3	13665726	2.6	11660466	43	101566
Waiaro Estuary	WRC	7A	5947958	1816272	96	2248	91819	0	4	328276	2.6	236567	14	32660
NORTH TIP COROMANDEL														
Stony Bay	WRC	11	5957840	1817794	1249	6065	1215158	1	8	9982717	2.1	2498637	17	37752
Port Charles	WRC	11	5957317	1820249	2807	15332	4968842	2	9	46090872	2	10050641	31	70934
Waikawau Estuary	WRC	7A	5947454	1825512	674	4088	239801	95	1	254465	1.9	242475	28	63880
Kennedy Bay System (KBS)	WRC	11	5938071	1830448	973	16931	4879667	15	6	29286184	1.9	8586637	56	129154
Kennedy Bay Estuary KBS	WRC	7A	5938320	1828148	351	8881	523973	91	1	593615	1.9	545200	51	118499
Whangapoua Harbour	WRC	7A	5932366	1834833	681	41309	13014569	80	1	17164235	1.9	14902971	107	274664
Mercury Bay System (MBS)	WRC	11	5923114	1845849	3633	147201	35711113	36	5	1.64E+08	1.7	50508655	510	1603076
Mercury Bay MBS	WRC	11	5923114	1845849	8630	24475	18928818	3	9	1.61E+08	1.7	32298500	41	100883
Whitianga Harbour MBS	WRC	7A	5920368	1841659	218	110355	15495586	72	1	13026023	1.7	17110627	450	1449472
Purangi River	WRC	7A	5919741	1846065	78	12961	1286710	95	0	622318	1.7	1167979	18	46722
Tairua Harbour	WRC	7A	5900748	1854820	280	35070	6046969	51	1	7749027	1.7	7702351	282	952910
Wharekawa Harbour	WRC	7A	5888948	1856591	496	11158	1935498	86	1	2164594	1.7	1888011	83	269459
Whangamata Harbour	WRC	7A	5878865	1855574	202	21501	4365495	78	1	6488899	1.7	4552366	50	160719
Otahu River	WRC	7A	5875667	1855535	170	15778	955800	60	2	1516965	1.7	1138659	70	233431
WAIHI BEACH														
Tauranga Harbour	BOPRC	8	5829840	1878823	1128	327072	2E+08	77	2	4.25E+08	1.7	2.12E+08	1300	3415721

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System														
Maketu River	BOPRC	6A	5815833	1904321	190					3548243	1.7		1226	3452243
Maketu Estuary	BOPRC	7A	5815834	1904320	192	12907	2182561	58	2	3548524	1.7	2639051	2	45792
Waihi Estuary	BOPRC	7A	5815731	1906462	78	17482	2640150	57	2	4353159	1.7	3213142	414	1113586
Waitahanui Stream	BOPRC	4	5807295	1916699	40	3063	29458	0	3		0	0	114	302844
Tarawera River	BOPRC	6	5799584	1933183	30								838	1064593
Rangitaiki River	BOPRC	6	5797125	1941298	35								2939	3050874
Whakatane River	BOPRC	6B	5792996	1952463	129	28526	1507392	31	4	6359039	1.7	2169092	1772	4805620
Ohiwa Harbour	BOPRC	9	5787567	1964612	1820	88444	26840959	84	2	44190150	1.7	26561008	186	425573
Waiotahi River	BOPRC	7A	5786806	1969479	376	24649	994756	68	2	1744343	1.7	1114065	148	360749
Waioeka River	BOPRC	7A	5786502	1974530	306	26228	936378	14	3	3093189	1.7	1481683	1173	3793540
Waiaua River	BOPRC	7A	5786947	1985542	492	4832	180124	59	2	289650	1.7	215979	109	303384
Torere River	BOPRC	3D	5790078	1994077	11			0		0	0	0	65	158113
Hawai River	BOPRC	6B	5793504	1998404	14								73	167090
Motu River	BOPRC	3A	5800409	2003773	144			0		0	0	0	1386	3644170
Haparara/Waikakariki River	BOPRC	6C	5806376	2009966	8								168	412152
Kereru River	BOPRC	3B	5815883	2015872	5			0		0	0	0	141	247396
Raukokore River	BOPRC	3B	5821279	2028834	9			0		0	0	0	354	1158941
Whangaparaoa River	BOPRC	6B	5830191	2041063	145	7777	157673	0	3	418937	1.7	261264	181	520639
Wharekahika River	GDC	6D	5828169	2067549	224	2942	49569	34	2	99537	1.6	66886	154	411703
Karakatuwhero River	GDC	3C	5822931	2071567	140	1380	25152	0	2	50304	0	0	106	297587
EAST CAPE														
Waiapu River	GDC	6B	5804805	2083244	68								1729	3905334

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Uawa River (Tolaga Bay)	GDC	6B	5739245	2063556	137	26245	1129627	23	3	3216449	1.5	1475920	557	1276990
Pakarae River	GDC	6B	5719814	2057593	70	14900	264347	0	2	645017	1.4	381278	246	565690
Waiomoko River	GDC	6B	5717340	2054972	26	7823	118230	0	2	288697	1.4	170479	75	172784
GISBORNE														
Pouawa River	GDC	6B	5713940	2051824	45	1645	58883	8	2	135668	1.4	81407	45	91533
Turanganui River	GDC	6B	5707429	2036956	388	26648	602762	0	1	2074707	1.4	869183	314	640236
Waipaoa River	GDC	6B	5703399	2029765	285	19098	1073747	2	4	4675430	1.4	1529244	585	1125912
Wherowhero Lagoon	GDC	7A	5699403	2029419	109	8718	515405	23	2	1052427	1.4	655772	50	89292
Maraetaha River	GDC	6A	5695195	2028449	68	4356	57769	1	2	139987	1.4	82547	84	215034
Maungawhio Lagoon	HBRC	7A	5663838	2024178	117	14195	959805	79	1	1034215	1.4	829969	74	185883
Nuhaka River	HBRC	4C	5665895	2011256	42	4219	114044	0	2		0	0	207	585591
Tahaenui River	HBRC	4D	5667130	2003656	0	4607	77874	0	1		0	0	58	147862
Whakaki Lagoon	HBRC	2A	5667269	1995395	0	14297	4749001	0	1	4749001	0	0	44	97015
Te Paeroa Lagoon	HBRC	2A	5667393	1990970	0	5850	607238	0	1	604566	0	0	4	8563
Wairau Lagoon	HBRC	2A	5667415	1989423	0	3865	186172	0	1	185129	0	0	4	7516
Ohuia Lagoon	HBRC	2A	5667360	1987190	0	7481	551842	0	1	551787	0	0	32	68242
Wairoa River	HBRC	6B	5666819	1982703	174	21383	2498812	16	4	9734902	1.5	3409409	311	637732
Waihua River	HBRC	3D	5664224	1971243	1	5403	92920	0	2	230207	0	0	142	309449
Mohaka River	HBRC	3B	5660951	1962573	22			0		0	0	0	2435	3422073
Waikari River	HBRC	6C	5656578	1953428	39	6992	137195	0	2	339576	1.5	202449	329	650275
Aropaoanui River	HBRC	4C	5644327	1944769	0	2749	63234	0	1		0	0	149	325588
NAPIER														
Ahuriri Estuary	HBRC	7A	5622801	1935008	125	33917	2745765	9	0	561571	1.5	3853629	144	200405

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Ngaruroro River	HBRC	6B	5613134	1937438	171	18514	718823	0	3	2485690	1.5	1048044	3382	6931812
Tukituki River	HBRC	6B	5609417	1938738	24								2500	1967314
Mangakuri River	HBRC	6B	5570773	1935604	24	1554	27169	0	2	64771	1.4	37602	112	183872
Pourerere Stream	HBRC	4C	5554262	1930036	58	1705	20518	0	2		0	0	39	64581
Porangahau River	HBRC	7A	5537426	1914520	0	24336	2264782	26	1	1667332	1.4	0	846	1430724
Akitio River	HRC	6B	5499347	1889248	57	5896	260469	0	2	614967	1.4	354498	585	1083358
Owahanga River	HRC	6B	5491406	1883246	78	10053	589793	0	2	1391322	1.4	801529	411	798914
Mataikona River	GWRC	6B	5480398	1875994	53	3246	102670	0	2	242096	1.4	139426	189	408308
Castlepoint	GWRC	11	5466404	1871513	319	2788	285326	47	2	443334	1.3	293509	11	18313
Whareama River	GWRC	6A	5454860	1861258	47	3376	118091	0	2	276805	1.3	158714	530	917784
Kaiwhata River	GWRC	4C	5435026	1850845	7			0			0	0	102	137511
Motuwaireka Stream	GWRC	4C	5447339	1858630	230	2637	53854	0	2		0	0	33	55208
Patanui Stream	GWRC	6D	5439530	1853769	143	1620	27359	7	2	60854	1.3	35312	46	77029
Pahaoa River	GWRC	6C	5413624	1827484	23	4940	160577	0	2	370772	1.3	210195	650	1163886
Oterei River	GWRC	6C	5404265	1815043	0	4388	71782	0	1	71782	1.3	0	66	111425
Awhea River	GWRC	6C	5402080	1810483	0	3301	56818	0	1	56818	1.3	0	149	276212
Opouawe River	GWRC	5C	5395542	1802057	20								105	207830
CAPE PALLISER														
Lake Onoke/Turanganui River	GWRC	2A	5414876	1779022	0	18814	6653550	0	2	13307100	0	0	3433	7774924
Orongorongo River	GWRC	4A	5413021	1758887	13			0			0	0	94	191053
Wainuiomata River	GWRC	3C	5413795	1756911	30	2432	40514	0	1	40514	0	0	134	363330
Lake Kohangatera	GWRC	2B	5417925	1755825	0	3812	213263	0	1	212559	0	0	33	64306
Lake Kohangapiripiri	GWRC	2B	5419017	1755102	0	2405	109815	0	1	107970	0	0	6	9455

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PENCARROW HEAD														
Wellington Harbour	GWRC	9	5420524	1753462	2801	73285	85421181	0	16	1.37E+09	1	88321085	639	1862827
Lyall Bay	GWRC	11	5421219	1750624	1464	7195	2435581	0	8	19926805	1	2472115	14	24121
Ohau Bay	GWRC	11	5433522	1738363	761	2570	357325	0	6	2038928	0.6	212251	4	6090
Te Ikaamaru Bay	GWRC	11	5433435	1739528	1357	3976	703019	0	7	4743860	0.6	415484	6	10897
Ohariu Bay	GWRC	11	5436055	1743386	1036	2990	441212	0	3	1424578	0.7	290759	75	128081
Titahi Bay	GWRC	11	5448177	1753491	891	2891	390948	0	3	1264686	1	385084	1	1631
Te Awarua-o-Porirua Harbour	GWRC	8	5449358	1756494	688	27134	7469203	11	1	9678790	1	7413661	211	394510
Waikanae River	GWRC	6B	5473437	1768818	723	6654	331270	50	2	618297	1.8	451237	21	37380
Otaki River	GWRC	6C	5485676	1777293	75	6101	162113	0	3	487150	2	325037	368	1800703
Waikawa Stream	HRC	4D	5493158	1780893	521	3980	111227	0	2		0	0	76	152417
Ohau River	HRC	4D	5496494	1782225	241	6386	282578	0	3		0	0	183	489408
Manawatu River	HRC	6B	5516768	1787557	769	20542	2131037	2	4	9050692	2.3	4869597	5887	11503469
Rangitikei River	HRC	6B	5536541	1789027	429	8515	393895	4	4	1690595	2.4	931087	3928	7749821
Turakina River	HRC	6B	5560928	1782650	1308	7131	430385	34	3	1189344	2.5	903827	973	1472473
Whangaehu River	HRC	6B	5565755	1779040	23	7369	434608	0	5	1978770	2.6	1109554	1981	4187249
WANGANUI RIVER														
Wanganui River	HRC	6B	5576009	1769203	197	21531	3222410	0	2	18106722	2.6	8439492	7072	17502151
Waitotara River	TRC	6A	5588296	1744973	287	4923	103513	0	4	387553	2.7	284040	1173	2299323
Whenuakura River	TRC	6B	5595530	1729294	244	4413	139768	47	3	383403	2.9	309675	474	865640
Patea River	TRC	6B	5596306	1727513	132	4551	234400	32	4	1047793	2.9	573063	1054	2428731
Manawapou River	TRC	4B	5609532	1715780	5			0			0	0	121	80160
Tangahoe River	TRC	4B	5609972	1715323	10			0			0	0	285	171972

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Waingongoro River	TRC	4B	5617469	1702397	12			0			0	0	233	337309
Okahu River	TRC	4B	5644545	1666400	5			0			0	0	34	75303
Warea River	TRC	4A	5656750	1666935	10			0			0	0	31	65311
NEW PLYMOUTH														
Stony River	TRC	4A	5663721	1670813	9			0			0	0	53	261964
Waiwakaiho River	TRC	6B	5678545	1695768	133	4123	87739	17	4	319589	3.1	246678	140	615334
Waiongana Stream	TRC	6B	5683236	1702908	138	3344	78050	5	4	309331	3.1	234809	160	462257
Waitara River	TRC	6B	5683857	1706381	153	9854	419729	0	5	2131199	3.1	1293504	1154	3943561
Waiaua River	TRC	4A	5667893	1676574	7			0			0	0	23	53402
Onaero River	TRC	6B	5683190	1718069	114	1860	24752	24	3	86479	3.1	67645	131	344928
Urenui River	TRC	6B	5683493	1720290	24	5009	110508	0	4	453746	3.1	343238	138	425021
Mimi River	TRC	6B	5686563	1724663	366	4467	147931	39	3	459278	3.1	369321	135	379738
Tongaporutu River	TRC	6B	5702533	1737633	228	11366	442663	25	4	1870689	3.1	1203331	273	846493
Mohakatino River	TRC	6B	5711499	1739846	127	2291	70583	2	5		3.1	216433	130	381849
Mokau River	WRC	6B	5714693	1740356	337	18312	1083911	0	5	5511303	3.1	3343698	1452	3915523
Awakino River	WRC	6B	5719180	1740902	190	14283	324272	0	5	1646005	3.1	997461	382	1281390
Waikawau River	WRC	4C	5739791	1742718	62	3408	32866	0	4		0	0	16	40744
Marakopa River	WRC	6B	5758657	1749891	230	17834	659518	14	5	2973975	3	1837757	367	1137806
Waiharakeke Stream	WRC	8	5778223	1758942	891	33318	6185377	93	2	9782841	3	9782841	89	237854
Kaitawa Inlet KHS	WRC	8	5781245	1762236	379	7685	569338	100	1	841197	3	841197	4	6830
Rakaunui Inlet KHS	WRC	8	5781526	1763295	570	23814	1888496	87	2	3142104	3	3142104	43	102156
Awaroa River KHS	WRC	8	5783375	1766163	794	24493	2285808	81	2	4016263	3	4016263	162	490191
Oparau River KHS	WRC	8	5785091	1765494	681	17755	1652197	85	2	2793279	3	2793279	131	387248
Mangaora Inlet KHS	WRC	8	5786196	1762809	874	6653	561788	100	1	830374	3	830374	256	593323

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Te Wharu Bay KHS	WRC	8	5785877	1760976	1160	8820	1872729	100	1	2767234	3	2767234	4	7377
Kawhia Inlet KHS	WRC	8	5783134	1755910	698	65084	52622164	69	2	1.02E+08	3	1.02E+08	54	117289
Kawhia Harbour System (KHS)	WRC	8	5783134	1755909	698	176927	67638196	74	2	1.62E+08	3	1.26E+08	499	1371365
Aotea Harbour System (AHS)	WRC	8	5791295	1757639	1571	61094	31891708	74	3	1.01E+08	2.9	59186968	185	419919
Opotoru River RHS	WRC	8	5814681	1764314	108	21613	1815305	84	2	3078635	2.9	3078635	59	128475
Waitetuna Creek RHS	WRC	8	5815379	1769376	165	27931	5131529	79	2	9057971	2.9	9057971	176	433940
Kerikeri/Waingaro Arm RHS	WRC	8	5815828	1768066	1316	57018	14567792	76	2	26377784	2.9	26377784	224	508199
Ponganui/Paihere Creeks RHS	WRC	8	5815980	1764987	439	10005	978765	100	1	1434284	2.9	1434284	11	25734
Raglan Inlet RHS	WRC	8	5814621	1762192	437	30191	9360373	46	2	20986083	2.9	20986083	53	112143
Raglan Harbour System (RHS)	WRC	8	5814621	1762192	437	142704	31853664	69	1	27652903	2.9	60944182	523	1208674
Kaawa Stream	WRC	4C	5847635	1754095	0			0			0	0	70	70217
Waikato River	WRC	6B	5862651	1751288	728	119622	18174787	8	6	1.17E+08	2.9	49891290	14481	31316401
Manukau Harbour System (MHS)	AC	8	5899010	1735846	2294	461833	3.66E+08	62	6	2.22E+09	2.8	7.1E+08	1023	1913464
Pahurehure Inlet MHS	AC	8	5897599	1765172	510	98940	15213690	64	2	29153366	2.8	29153366	379	694954
Puhinui Creek MHS	AC	8	5900106	1764754	550	8401	643080	100	1	904391	2.8	904391	27	47093
Waitakere River (Bethells Beach)	AC	4C	5916181	1728530	16	1607	33423	0	2		0	0	40	89689
Piha Stream	AC	4C	5909278	1730770	4			0			0	0	12	11033
KAIPARA														
Kaipara Harbour System	AC/NRC	8	5969221	1704377	7037	1170537	7.43E+08	42	5	3.99E+09	2.8	1.62E+09	6266	13592949
Waipoua River	NRC	6B	6052356	1643231	52	6196	134637	22	3	428204	2.7	322823	114	346831

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Waimaukau River	NRC	6B	6061246	1637216	238	6634	230951	32	3	678376	2.7	521306	132	387890
Hokianga Harbour System	NRC	8	6068289	1632831	1466	340748	1.06E+08	49	5	4.83E+08	2.7	2.16E+08	1605	4274573
Whangapae Harbour System	NRC	8	6084768	1619705	515	56607	10133520	67	2	24626719	2.7	17954810	301	681195
Herekino Harbour	NRC	8	6094542	1614517	411	24975	4965966	84	2	8424765	2.7	7646102	95	203851
AHIPARA														
Waiatua Stream	NRC	4C	6095748	1613845	136	1651	40189	0	4		0	0	5	11669
Tanutanu Stream	NRC	4C	6102346	1608518	77	4405	171064	0	4		0	0	11	23502
NORTHERN ISLANDS														
KAWAU ISLAND														
North Cove	AC	11	5969046	1763455	542	6256	565385	37	3	1561974	2.4	1089925	3	6439
Bon Accord Harbour	AC	11	5967674	1763147	883	13208	2489135	19	5	12417347	2.4	5424129	12	23093
South Cove Harbour	AC	11	5965497	1764068	603	3058	250330	31	2	614853	2.4	511869	2	4431
RANGITOTO														
Gardiner Gap	AC	11	5929230	1768605	820	3569	354374	60	2	539215	2.6	637554	1	1824
Islington Bay	AC	11	5925912	1769844	1472	8065	1787308	7	4	7859547	2.8	4754895	6	10158
WAIHEKE														
Matiatia Bay	AC	11	5927526	1777007	431	2687	379270	3	5	1743905	2.6	988824	2	2715
Owhanake Bay	AC	11	5928798	1777700	475	2601	293058	2	5	1417337	2.6	746236	1	1689
Oneroa Bay	AC	11	5928413	1780405	1444	6436	1574017	1	8	12801343	2.6	4000498	2	3523
Mawhitipana Bay	AC	11	5928146	1782189	905	2745	375598	9	6	2301964	2.5	914388	2	3064
Te Matuku Bay	AC	11	5919863	1790125	961	12878	2423205	76	1	2792307	2.9	4350612	14	16015
Awaawaroa Bay	AC	11	5920502	1787602	1246	10431	2836091	29	4	10223362	2.9	7014047	14	17641
Rocky Bay	AC	11	5922454	1783575	807	5141	1241262	30	3	4104300	2.9	3000404	5	7675

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Putiki Bay	AC	11	5923660	1780806	1132	18196	3354500	35	3	9953530	2.8	7777440	13	18993
GREAT MERCURY ISLAND														
Huruhi Bay	AC	11	5924064	1778753	2505	11519	4604301	12	6	26462932	2.8	12139148	3	4819
Huruhi Harbour	WRC	11	5945495	1848290	450	4653	517243	10	2	996016	1.9	930518	2	3163
Coralie Bay	WRC	11	5945574	1850109	399	2377	292780	18	3	786567	1.8	478382	1	2715
GREAT BARRIER ISLAND														
Tryphena Harbour	AC	11	5977461	1821201	2669	14801	6425122	4	14	88523586	2.1	13082657	18	40282
Blind Bay	AC	11	5982862	1817755	1667	9308	2781170	5	12	33526268	2.2	5838203	11	24756
Whangaparapara Harbour	AC	11	5984774	1814904	1158	9354	1737549	14	13	22180522	2.2	3508889	13	29415
Port Fitzroy/Port Albercrombie	AC	9	5995342	1807288	2655	60337	18399744	3	19	3.48E+08	2.1	37816307	58	125026
Katherine Bay	AC	11	6000476	1811258	1753	11579	3396260	3	8	27574481	2	6762917	18	38020
Rangiwhakaea Bay	AC	11	6003991	1817375	1178	5007	909460	2	8	7420318	1.9	1700532	7	14528
Whangapoua Creek	AC	7A	5997627	1818415	747	10567	2789750	94	1	2935405	1.9	2767183	31	65265
Awana Bay	AC	4C	5990225	1822907	64	2625	62979	0	3		0	0	33	70389
Kaitoke Creek	AC	4C	5987479	1822540	140	3939	124208	0	2		0	0	18	38743
KAPITI ISLAND														
Okupe Lagoon	GWRC	1	5478590	1764705	0	1761	78967	0	1		0	0	2	2250
SOUTH ISLAND														
PICTON														
Port Underwood	MDC	9	5422065	1692790	1926	52507	24497808	1	12	2.94E+08	1.3	30943063	39	82891
Wairau Diversion	MDC	6B	5411835	1686116	35								3582	5067194

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River														
Wairau River	MDC	6B	5405234	1688674	246	107355	16056402	20	3	44539663	1.3	18842997	4165	8749566
Awatere River	MDC	3B	5393551	1697244	45	3444	86740	0	2	187275	0	0	1573	2382576
Lake Grassmere	MDC	2A	5381309	1698590	46	42772	13675802	0	1	13675802	0	0	62	55869
CAPE CAMPBELL														
Flaxbourne River	MDC	4C	5366402	1698200	4			0			0	0	154	218216
Waima (Ure) River	MDC	3C	5360304	1692832	5			0		0	0	0	157	221548
Clarence River	MDC	5A	5330573	1676621	12								3301	4671701
Conway River	ECAN	3C	5281731	1638339	7			0		0	0	0	503	712342
Waiau River	ECAN	3B	5264679	1631115	34	11935	480899	0	1	480899	0	0	3325	7118881
Hurunui River	ECAN	3B	5249750	1623841	120	6399	178552	0	2	267828	0	0	2678	5031291
Waipara River	ECAN	3C	5222093	1583549	0	5386	114676	0	2	172014	0	0	729	839902
Ashley River	ECAN	3D	5209260	1577874	435	18117	1522496	0	1	761248	0	0	1309	1798778
Waimakariri River	ECAN	6B	5195786	1576659	518	26427	2725134	45	1	6746439	1.8	3733531	3546	7991022
CHRISTCHURCH														
Heathcote and Avon Rivers/Ihutahi	ECAN	7A	5176657	1579735	187	46843	7467154	66	2	13948201	1.8	8942222	211	202910
Lyttelton Harbour	ECAN	9	5173001	1585208	2233	76221	42485268	16	6	2.43E+08	1.8	70438845	106	183359
Port Levy	ECAN	11	5172067	1587122	2036	20108	8187964	2	7	60344379	1.8	14590656	58	124152
Blind/Big Bay	ECAN	11	5171243	1590840	1143	5625	1082396	1	10	10379143	1.8	1926326	7	9193
Little Pigeon Bay	ECAN	11	5170279	1592537	874	4274	476574	0	8	3979252	1.8	851828	4	6660
Pigeon Bay	ECAN	11	5170006	1593688	1592	20038	8968720	0	9	84010556	1.8	15989724	56	121529
Scrubby Bay	ECAN	11	5168943	1596066	565	2463	304646	4	7	1996237	1.8	532413	2	3299
Menzies Bay	ECAN	11	5168859	1597574	1251	5568	1023157	1	9	8854248	1.8	1812483	9	14026

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Decanter Bay	ECAN	11	5167256	1600212	790	4530	829923	0	7	5642346	1.8	1475602	8	13079
Little Akaloa Bay	ECAN	11	5166404	1601017	854	6825	1856330	4	6	11800533	1.8	3233941	18	37349
Okains Bay	ECAN	11	5163866	1606513	1464	12110	3654654	2	5	18315425	1.8	6419886	33	71953
Lavericks Bay	ECAN	11	5159659	1608876	570	3076	445894	11	6	2719883	1.8	746580	10	21566
Le Bons Bay	ECAN	11	5157863	1609872	1072	7990	2292511	6	6	14287266	1.8	3938326	27	60912
Otanerito Bay	ECAN	11	5144888	1605361	616	4134	646768	0	7	4377324	1.8	1149306	11	25213
Sleepy Bay	ECAN	11	5144500	1604822	395	2067	178050	3	7	1171835	1.8	311499	3	6448
Stony Bay	ECAN	11	5143824	1603928	523	2409	278286	2	7	1856834	1.8	490309	7	15897
Flea Bay	ECAN	11	5141649	1601598	584	4471	685292	1	10	6617243	1.8	1205445	10	22800
Damons Bay	ECAN	11	5140631	1599387	617	4513	693518	0	15	10108813	1.8	1227804	6	12635
Akaroa Harbour	ECAN	9	5140121	1596738	1785	60904	43015469	3	11	4.56E+08	1.8	75076211	128	288469
Island Bay	ECAN	11	5139939	1589252	355	2495	201849	0	9	1842196	1.8	357393	4	9322
Long Bay	ECAN	11	5140189	1588388	1275	5202	837416	0	7	5739598	1.8	1480823	8	16939
Horseshoe Bay	ECAN	11	5140941	1585465	1418	6256	1024273	0	11	11022650	1.9	1961739	9	18870
Peraki Bay	ECAN	11	5141762	1584667	825	5904	1183457	1	7	8392199	1.8	2088307	18	40755
Te Oka Bay	ECAN	11	5143358	1581757	996	5056	762041	2	6	4347854	1.8	1346473	9	20434
Tumbledown Bay	ECAN	11	5143838	1581224	385	1990	172289	6	5	804808	1.8	298381	5	10947
Lake Forsyth (Te Roto o Wairewa)	ECAN	2B	5147246	1576729	1	18629	5594633	0	1	5512392	0	0	109	244993
Lake Ellesmere (Te Waihora)	ECAN	2A	5143801	1549789	4	151904	1.98E+08	0	1	1.79E+08	0	0	2635	2973178
Rakaia River	ECAN	3A	5138904	1536620	142	11039	610016	0	2	915023	0	0	2861	8388015
Ashburton River	ECAN	3B	5121584	1504508	1	2015	42258	0	2	63387	0	0	1655	3103659
Rangitata River	ECAN	3B	5106864	1481787	73	3086	79040	0	2	118560	0	0	1715	5567508
Opihi River	ECAN	3C	5095836	1468750	58	5868	160448	0	2	240672	0	0	2373	3003662

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Washdyke Lagoon	ECAN	2A	5086296	1460996	5	3157	230546	0	1	115273	0	0	97	78617
TIMARU														
Saltwater Creek	ECAN	4D	5079368	1461236	2	5430	109627	0	1		0	0	46	35924
Pig Hunting Creek	ECAN	4B	5075285	1460459	0			0			0	0	41	57800
Pareora River	ECAN	3C	5070725	1457880	3			0		0	0	0	539	763272
Wainono Lagoon	ECAN	2A	5047448	1454832	1	13450	3984960	0	1	3792088	0	0	168	146213
Waihao River	ECAN	4D	5040754	1455348	22	14228	358476	0	1		0	0	659	671639
Waitaki River	ECAN	3A	5021966	1453713	127	9584	585709	0	2	1171417	0	0	11947	24903965
Kakanui River	ORC	6B	4993907	1434968	54	5743	190707	0	3	499117	1.6	308411	887	1008766
Orore Creek	ORC	4C	4991468	1433916	2	3519	84795	0	1		0	0	18	15147
Shag River	ORC	7A	4961496	1429511	35	14886	726204	63	2	1332877	1.6	796648	541	592345
Stony Creek	ORC	4C	4958021	1426872	77	3074	155169	0	1		0	0	9	7762
Pleasant River	ORC	7A	4951249	1422624	38	14584	973105	76	1	1443302	1.6	971541	126	110721
Waikouaiti Lagoon	ORC	4B	4946540	1419340	115	4941	494178	0	0		0	0	18	15153
Waikouaiti River	ORC	7A	4943194	1417818	35	19776	1272547	68	2	2180631	1.6	1359584	421	457551
Blueskin Bay	ORC	7A	4932876	1413098	162	20397	6230597	86	1	7559191	1.6	5787209	91	130457
Purakunui Inlet	ORC	7A	4931741	1415396	53	7050	1130231	88	1	1294680	1.6	1027041	9	10956
Otago Harbour	ORC	9	4928797	1423046	696	80619	47912396	45	4	1.85E+08	1.6	60304035	116	164671
DUNEDIN														
Papanui Inlet	ORC	7A	4920627	1423909	444	10757	3629214	90	1	3968608	1.6	3237684	11	12225
Hoopers Inlet	ORC	7A	4916574	1419919	198	12214	3750748	95	1	3636671	1.6	3246593	8	9389
Tomahawk Lagoon	ORC	4B	4913369	1409171	94	2754	197138	0	1		0	0	5	5445
Kaikorai Stream	ORC	6C	4910124	1397656	693	10564	640560	14	3	2100301	1.7	1001228	49	58088
Taieri River	ORC	6B	4896177	1383637	502	16620	1559802	10	3	3915461	1.7	2511015	5703	6056860

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Akatore Creek	ORC	7A	4889482	1382890	332	7573	328983	34	3	895893	1.7	462359	68	77752
Tokomairiro River	ORC	7A	4877339	1372326	165	11684	600104	51	2	1058980	1.7	765229	395	447529
Clutha River	ORC	6B	4864350	1356654	616	115002	6201797	5	3	16401711	1.7	10535431	21062	39999326
Catlins River	ORC	7A	4847185	1347850	797	29461	7868741	65	2	14762375	1.8	9328222	402	641358
Tahakopa River	ORC	7A	4837522	1330014	165	16338	860340	31	2	1939721	1.9	1345484	310	621423
Tautuku River	ORC	7A	4833160	1326549	230	7306	650185	62	2	1338632	1.9	838250	61	104767
Waipati Estuary	ORC	7A	4830479	1320883	72	8763	459476	34	3	1330563	1.9	722401	59	102832
Waikawa Harbour	ES	7A	4827202	1304471	291	24866	6422282	82	2	9835149	2	7574506	241	425765
Haldane Estuary	ES	7A	4824679	1296103	166	9692	1886750	93	1	2337221	2	2064020	70	118500
Lake Brunton	ES	7B	4824833	1285869	1	3347	258532	0	1	258506	2.1	0	13	22164
Toetoes Harbour	ES	7A	4832678	1278016	61	56275	4745903	31	3	11871604	2.1	8589338	5639	9235000
Waituna Lagoon	ES	2A	4833144	1267181	12	42639	13590093	0	1	12588503	0	0	187	299242
Bluff Harbour	ES	8	4828418	1244664	789	92763	54580551	52	2	1.22E+08	2.2	89628434	99	152628
INVERCARGILL														
New River (Oreti) Estuary	ES	8	4838937	1237256	1141	137604	39823925	42	2	60268977	2.2	69607863	3948	6536643
Jacobs River (Riverton) Estuary	ES	7A	4854025	1217100	202	31928	6697056	66	2	14697352	2.3	10151391	1570	2436035
Waiau River	ES	3B	4871024	1182710	233	17538	758127	0	1	758127	0	0	8258	36764655
Big River (Lake Hakapoua)	ES	9	4863703	1131489	442	26014	5491384	0	7	38038249	2	10688413	147	910390
FIORDLAND														
Preservation Inlet	ES	10	4870465	1106441	1940	207827	93730441	1	78	7.3E+09	1.9	1.81E+08	462	3473676
Chalky Inlet	ES	10	4882177	1096131	4508	190222	1.09E+08	0	116	1.27E+10	1.9	2.09E+08	400	3007004
Breaksea/Dusky Sound	ES	10	4928153	1100972	6450	628232	2.84E+08	1	107	3.04E+10	1.8	5.16E+08	1120	12289926

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Coal River	ES	11	4943034	1108032	1890	10057	3211096	2	14	44113235	1.8	5814735	65	609193
Dagg Sound	ES	10	4954886	1111884	2578	52752	15508681	1	50	7.78E+08	1.8	28394024	85	786569
Thompson/Doubtful sound	ES	10	4983166	1125255	1284	325789	1.37E+08	1	138	1.9E+10	1.9	2.55E+08	963	10777107
Nancy Sound	ES	10	4988501	1129469	1445	40695	14511729	0	99	1.44E+09	1.9	27117750	78	823819
Charles Sound	ES	10	4995069	1134214	1853	61821	16444158	4	60	9.9E+08	1.9	30317543	254	3173835
Caswell Sound	ES	10	5000391	1137372	1559	43865	17653253	0	141	2.49E+09	1.9	33290705	266	3237609
Two Thumb Bay	ES	11	5005651	1141161	1321	18361	1219055	2	7	8435863	1.9	2280973	34	310146
Looking Glass Bay	ES	11	5009529	1143823	568	5663	1426614	3	12	17270010	1.9	2666036	13	121587
George Sound	ES	10	5019050	1153338	1500	65377	30964825	0	107	3.3E+09	1.9	58967636	261	2815090
Catseye Bay	ES	11	5022957	1156129	872	8721	856963	5	6	5013355	1.9	1594832	34	312981
Bligh Sound	ES	10	5028469	1163356	2868	48161	21079337	2	69	1.46E+09	1.9	39994109	185	2071551
Sutherland Sound	ES	10	5033274	1168093	2818	37403	10839660	2	11	1.14E+08	1.9	20562346	162	1915193
Poison Bay	ES	11	5041722	1173620	2561	17482	8398822	0	38	3.22E+08	1.9	16135457	66	621368
Milford Sound	ES	10	5052542	1187220	3935	60363	28402480	1	126	3.58E+09	1.9	54781767	539	6081658
Kaipo River	ES	5C	5070672	1195638	14								106	150436
Hollyford River	ES	6B	5078642	1201486	173	19905	1592029	2	3	4667024	2	3103811	1109	12025913
McKenzie Creek	ES	6B	5080141	1209001	3								27	38387
Awarua River	ES	3C	5084330	1210437	228	3532	115480	0	2	230961	0	0	61	496795
Gorge River	WCRC	5A	5096532	1215930	30								144	204484
Cascade/ Martyr River	WCRC	6B	5114616	1228588	756	15450	954809	1	3	2873150	2	1931803	437	4809630
Arawata River	WCRC	5C	5119579	1253197	88								930	1316732
Waiatoto River	WCRC	6B	5122477	1262443	145	24314	1379781	12	3	3946666	2.1	2732735	536	6326373
Okuru River	WCRC	6B	5130072	1269778	146	30458	1679548	25	3	4386557	2.1	3128239	514	5265611

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Haast River	WCRC	5C	5138469	1281378	48								1355	1917863
Waita River	WCRC	6D	5143029	1286125	55	9549	230973	21	3	627421	2.2	445784	138	940544
Whakapohai (Little) River	WCRC	3C	5153894	1297487	4			0		0	0	0	131	184209
Moeraki (Blue) River	WCRC	4C	5154637	1298325	66	3296	62970	0	3		0	0	107	1007898
Paringa River	WCRC	5C	5163270	1312026	136	12256	448265	6	3		2.2	972465	364	3679060
Ohinemaka River	WCRC	6D	5163529	1317338	118	4607	97569	0	3	316944	2.2	219375	80	548359
Mahitahi River	WCRC	6B	5166840	1324606	205	9074	373943	5	3	1184195	2.3	828911	209	2330783
Makawhio River (Jacobs River)	WCRC	6B	5170736	1328365	26	10793	620927	18	3	1791819	2.3	1285453	166	1645218
Manakaiaua River	WCRC	6D	5172926	1332214	114	12087	233231	3	3	751847	2.3	525427	57	375504
Karangarua River	WCRC	3D	5179878	1336746	27			0		0	0	0	408	577747
Ohinetamatatea River (Saltwater Creek)	WCRC	6E	5183220	1338337	111	5460	125707	3	3	404773	2.3	283366	107	668689
Cook River	WCRC	5C	5186252	1340245	27								324	458128
Waikowhai Stream	WCRC	4D	5190317	1344207	4			0			0	0	39	55637
Waikukupa River	WCRC	5C	5197407	1357371	2								66	92987
Omoeroa River	WCRC	4E	5200083	1359139	2			0			0	0	0	62249
Waiho River	WCRC	5C	5202975	1360884	27								290	410659
Three Mile Lagoon	WCRC	7B	5208589	1366592	4	8101	843372	58	0	351518	2.4	0	25	123861
Ōkārito Lagoon	WCRC	7B	5210843	1369400	166	62181	21655253	14	1	18664663	2.4	0	278	1666953
Whataroa River	WCRC	6C	5222525	1376733	37									839585
Saltwater Lagoon	WCRC	7B	5224695	1382797	46	20513	7892959	4	1	7538565	2.4	0	11	47596
Poerua River (Hikimutu Lagoon)	WCRC	6C	5230694	1388784	69	11291	347812	0	3	1195083	2.4	847270	257	1525394

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Wanganui River	WCRC	6C	5232007	1390481	150								521	738157
Duffers Creek/Te Rahotaiepa River	WCRC	6D	5236781	1403540	259	12176	192634	0	1	192306	2.5	0	74	336968
Waitaha River	WCRC	6C	5241476	1409163	325	7663	257346	22	3	778394	2.5	576737	318	3170404
Waikoriri Stm (Shearers Swamp)	WCRC	4E	5244374	1413892	1			0		0	0	0	27	37635
Mikonui River	WCRC	6C	5247997	1417546	42	3345	63335	18	3	196813	2.5	145017	157	1506617
ROSS														
Totara River	WCRC	6D	5255282	1424601	118	39101	939267	1	5	4445826	2.8	2577812	141	742795
Hokitika River	WCRC	6C	5267955	1432372	297								1066	1509614
Arahura River	WCRC	6C	5274688	1438132	18								287	405852
Taramakau River	WCRC	6C	5285983	1446097	457	15167	939567	22	3	2873440	2.5	2136444	997	6860502
Saltwater Creek/New River	WCRC	6D	5290629	1448801	35	9902	211551	0	5	963955	2.6	540852	142	626339
GREYMOUTH														
Grey River	WCRC	6C	5299866	1451193	187	21995	1076103	0	2	3844272	2.6	2768168	3952	16837116
Seven Mile Creek/Waimatuku	WCRC	4C	5306972	1455028	5			0			0	0	37	52732
Deverys Creek	WCRC	4B	5327375	1460876	25	3306	142835	0	1		0	0	11	40147
Canoe Creek	WCRC	5C	5326192	1460896	3								23	
Punakaiki River	WCRC	4C	5335192	1461822	68	2606	53773	0	5		0	0	60	357736
Pororari River	WCRC	6B	5337760	1462533	35	3825	113372	5	4	403921	2.7	295821	104	638086
Fox River	WCRC	5C	5345433	1466132	51								105	148526
Tiropahi River (Four Mile River)	WCRC	4A	5353966	1468311	2			0			0	0	44	62511
Waitakere River (Nile River)	WCRC	5C	5360527	1470940	61	3258	63971	0	4		2.7	175064	127	837513

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Totara River	WCRC	6D	5364660	1472098	295	4755	103342	8	4	367356	2.8	272601	108	613823
Okari Lagoon	WCRC	7A	5370134	1472167	281	12907	1441278	71	2	3398574	2.8	2568110	79	306628
WESTPORT														
Buller River	WCRC	6B	5379530	1482586	163	26603	2385952	11	2	8596491	2.9	6472755	6396	24058167
Orowaiti Lagoon	WCRC	7A	5378122	1488601	191	19090	1851711	71	2	4519994	2.9	3453038	43	153010
Jones Creek	WCRC	4E	5385073	1497744	1	4554	63771	0	1		0	0	21	99226
Ngakawau River	WCRC	6B	5393326	1506343	64	3175	107744	14	4	387127	2.9	293982	195	1354471
Mokihinui River	WCRC	6B	5402862	1511271	223	6840	424052	14	4	1526954	2.9	1160869	751	4743326
Little Wanganui River	WCRC	6B	5417275	1521288	122	8747	385492	29	3	1248904	3	976400	213	937225
KARAMEA														
Karamea River	WCRC	7A	5431842	1524388	726	33374	3968691	68	3	10378445	3	7809114	1307	8257838
Ōpārara River	WCRC	7A	5437516	1524649	161	10764	760272	50	3	2468446	3	1701331	150	806399
Break Creek	WCRC	4C	5442585	1524872	10			0			0	0	20	28660
Kōhaihai River	WCRC	4C	5448865	1524533	10			0			0	0	71	100017
Heaphy River	WCRC	5A	5462383	1524741	101	3418	101243	3	4		3	298221	298	1994463
KAHURANGI POINT														
Big River	TDC	5C	5486907	1537337	111	4058	248897	51	3		3	565975	111	889121
Anaweka River	TDC	5C	5488745	1539828	247	7042	508098	72	3		3.1	995741	30	208344
Turimawiwi River	TDC	3B	5491061	1541996	87	1978	49139	0	1	49139	0	0	58	381669
Anatori River	TDC	3B	5494348	1546369	108	2885	94212	0	1	94212	0	0	74	402827
Paturau River	TDC	6B	5500946	1552076	71	2748	42229	2	4	170602	3.1	129184	77	344068
Whanganui Inlet	TDC	8	5507563	1561227	938	95199	25077712	79	1	29669037	3.1	47196180	87	276094
Green Hills Stream	TDC	3C	5516079	1570410	475	3091	154184	0	4	616735	0	0	7	15103
Wharariki Stream	TDC	4B	5516800	1572969	14			0			0	0	9	11678

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CAPE FAREWELL														
Port Pūponga	TDC	7A	5513867	1577714	77	3548	285328	58	3	993507	3.7	751378	5	10086
Pākawau Inlet	TDC	7A	5507373	1573470	78	5330	741806	100	2	1365591	3.7	1365591	8	17699
Waikato Estuary	TDC	7A	5502454	1572832	208	4245	206243	100	2	378435	3.7	378435	3	9162
Ruataniwha Inlet	TDC	7A	5498051	1573081	1603	37390	6614557	88	2	15028893	3.7	13502253	712	4862693
COLLINGWOOD														
Parapara Inlet	TDC	7A	5492938	1573753	263	12322	1825760	92	2	3899560	3.7	3603422	43	293355
Onekaka Inlet	TDC	7A	5489312	1575613	82	1680	170000	94	2	343964	3.6	327964	19	132350
Onahau River	TDC	7A	5483874	1580880	55	4135	351028	96	2	685996	3.6	660161	22	59132
Takaka River	TDC	5B	5481579	1583045	171	10099	242502	5	4		3.6	858318	878	3502381
Takaka Estuary	TDC	7A	5481240	1584140	168	11053	723810	60	3	2421804	3.6	1838124	7	15604
Motupipi River	TDC	7A	5479812	1587312	386	12845	1208973	82	2	2988676	3.6	2565294	44	100163
Ligar Bay	TDC	7A	5481333	1592098	633	4240	357141	53	4	1280300	3.6	943945	4	9012
Wainui Inlet	TDC	7A	5482173	1595114	288	8278	1826364	83	2	4444235	3.6	3819984	41	93179
Tōtaranui Stream	TDC	7A	5481590	1600578	36	1971	132511	100	2	232910	3.5	232247	8	18843
Awaroa Inlet	TDC	7A	5476978	1602365	306	20555	2348484	98	2	4258318	3.5	4175182	68	153788
Bark Bay	TDC	7A	5470352	1604996	640	4335	512394	26	4	1988990	3.5	1567546	7	16698
Sandfly Bay	TDC	7A	5469454	1604680	78	1985	72489	85	2	169163	3.5	147098	21	48689
Frenchman Bay	TDC	7A	5468456	1604926	141	1863	51286	91	2	108745	3.5	99022	2	3524
Torrent Bay	TDC	7A	5467355	1605192	1076	9953	1650881	28	4	7062550	3.5	4999772	16	36429
Marahau River	TDC	7A	5462000	1601019	274	3773	193844	100	2	347155	3.6	347155	27	61850
Otuwhero Inlet	TDC	7A	5459870	1600804	354	7149	894188	74	3	2479236	3.6	2016584	54	128918
Kaiteretere Estuary	TDC	7A	5456918	1601433	54	2769	173586	88	2	388111	3.6	347700	3	7195
Ferrer Creek	TDC	6C	5453620	1600609	340	3878	204941	94	2	413107	3.6	390236	15	29814

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Motueka River	TDC	5B	5452296	1601923	308	5800	299439	1	5		3.6	1075640	2056	5491681
Motueka Estuary North	TDC	7A	5449936	1602733	205	7923	452906	83	2	1108643	3.6	955470	7	13515
Motueka Estuary South	TDC	7A	5447113	1602479	1064	7247	1555522	80	3	3971053	3.6	3363777	1	1622
Moutere Inlet	TDC	8	5443954	1603343	857	45806	6850955	59	0	1336733	3.6	17558583	187	306875
Waimea Inlet	TDC	8	5429515	1616498	1873	95709	29327435	59	3	99818432	3.7	75693684	933	2092663
Tahunanui Estuary	NCC	7A	5429401	1619237	52	2889	200997	47	4	777752	3.7	563047	10	15869
NELSON														
Nelson Haven	NCC	7A	5431728	1621630	604	29836	12629813	66	3	37895215	3.6	30800259	129	267588
Delaware Estuary	NCC	7A	5443285	1636929	159	18502	3098532	93	2	6270285	3.5	5835251	93	193447
Whangamoa River	NCC	7A	5449688	1644479	128	7805	418739	76	3	1102327	3.5	902338	95	210495
MARLBOROUGH SOUNDS														
Croisilles Harbour	MDC	9	5456357	1653199	5908	67822	44436405	4	12	5.42E+08	3.4	1.49E+08	78	175418
Manuhakapakapa Bay	MDC	11	5471782	1665655	2082	10971	3388206	1	11	38963827	3.3	11199557	11	22559
Greville Harbour	MDC	11	5480573	1666588	1967	35231	11902895	1	11	1.29E+08	3.2	37948037	45	81600
Otu Bay	MDC	11	5488277	1670594	611	6527	1121052	1	8	9254589	3	3383235	12	20683
Port Hardy	MDC	9	5491058	1676299	5474	65552	27185275	0	18	4.94E+08	2.9	78258581	40	68390
Catherine Cove	MDC	11	5474593	1674778	1404	10397	3979810	0	25	97906969	2.4	9603071	8	14113
Admiralty Bay	MDC	11	5467152	1673148	3797	21819	16430276	0	37	6.04E+08	2.4	39831357	13	27502
Pelorous/Kenepuru Sound	MDC	9	5466949	1691456	12496	631715	4.35E+08	3	26	1.13E+10	2.2	9.32E+08	1734	4523650
Port Gore	MDC	11	5461518	1706983	6774	46455	55306921	0	26	1.43E+09	1.8	98899835	34	72315
Queen Charlotte Sound (Tōtaranui)	MDC	9	5450505	1715930	12258	436970	3.06E+08	1	31	9.61E+09	1.5	4.56E+08	342	773973

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SOUTHERN ISLANDS														
STEWART ISLAND														
Waitokariro Lagoon (Ruapuke Is)	ES	2A	4809663	1256798	10	2020	228529	0	1	228301	0	0	0	0
Lagoon Bay (Ruapuke Is)	ES	7B	4811508	1254709	1307	8108	1908772	3	9	17698120	2.1	3928942	0	0
Port William	ES	11	4800362	1226072	1401	7416	2025798	5	7	14611959	1.9	3674593	21	32709
Horseshoe Bay	ES	11	4797409	1230172	900	5558	1246305	5	7	8777944	1.9	2335092	3	3385
Halfmoon Bay	ES	11	4795931	1230816	1581	9722	2240198	2	8	18062281	1.9	4309714	9	10056
Paterson Inlet/Big Glory Bay	ES	9	4793719	1232893	3558	192325	99858348	10	13	1.31E+09	2	1.87E+08	568	1762678
Pikaroro Bay	ES	11	4780460	1236657	1096	4912	993857	1	8	8300369	2.1	2075764	4	4694
Adventure Bay	ES	11	4775629	1236281	1451	23731	6926993	1	15	1.01E+08	2.1	14666882	57	73332
Tikotatahi Bay	ES	11	4771621	1234067	3892	26731	9466135	1	18	1.74E+08	2.2	20497228	15	17081
Lords River	ES	11	4770324	1231301	561	25229	2435773	5	6	15496144	2.2	5238282	90	187833
Big Kuri Bay	ES	11	4769060	1224797	973	5933	880419	1	12	10822522	2.3	1986904	6	14017
Toitoi Bay	ES	11	4768956	1220792	634	12679	556631	0	8	4665011	2.3	1265889	124	303690
Seal Bay	ES	11	4762528	1211409	651	3049	430211	0	8	3449447	2.3	968061	23	76637
Port Pegasus	ES	9	4758057	1198329	3436	121854	27007323	3	21	5.59E+08	2.3	60026595	125	526739
Small Craft Retreat	ES	11	4754226	1195670	720	5324	484902	0	4	1827066	2.2	1089091	4	13072
Broad Bay	ES	11	4750086	1190977	2888	23015	6853312	1	24	1.63E+08	2.2	15203033	14	50388
Flour Cask	ES	11	4748520	1182473	1725	7501	1533755	0	19	29612372	2.2	3330088	8	27920
Easy Harbour	ES	11	4762879	1187532	544	9479	1038573	2	7	7185971	1.9	1989769	3	8762
Three Legged Woodhen	ES	11	4767646	1188385	816	4169	664300	3	11	7486847	1.9	1253406	7	23174
Doughboy Bay	ES	11	4778182	1194898	3696	24037	9018539	2	17	1.56E+08	1.9	16854371	103	432792

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CHATHAM ISLAND														
Lake Wakauia	CIDC	2A	5106590	2435324	1	3598	399757	0	1	399717	0	0	10	0
Lake Pateriki	CIDC	2A	5100326	2460909	13	4445	1319907	0	1	1318323	0	0	5	0
Te Whanga Lagoon	CIDC	7B	5081164	2449657	56	160230	2.03E+08	47	1	1.07E+08	1.1	0	234	0
Whangatete Inlet	CIDC	11	5097202	2431565	997	3968	677801	2	6	3780782	0.7	452100	3	0
Whangamoa Inlet	CIDC	11	5097090	2430254	1234	5181	1042747	2	6	5794752	0.7	694155	5	0
Port Hutt (Whangaroa Harbour)	CIDC	11	5096268	2428787	1083	5205	1170918	2	9	10824179	0.7	779478	5	0
Ocean Bay	CIDC	11	5095266	2422486	2617	9581	3160275	0	17	55164363	0.7	2126865	12	0
Te Koparupau Bay	CIDC	11	5096666	2413246	1208	5177	871346	0	6	4959527	0.7	602797	3	0