THE SPECTRUM OF COASTAL STRUCTURES USED TO COMBAT EROSION AT WAINUI BEACH, GISBORNE, NEW ZEALAND

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Abstract: Property erosion at Wainui Beach was identified as a problem in the 1900s, leading to the first coastal structures being built in the 1920s for the sole purpose of protecting beachfront property. Individual homeowners privately constructed isolated seawalls from concrete, timber, or stone-filled oil drums. In the 1960s responsibility for coastal protection was accepted by the wider community, with the construction of a groin system along 2.1 km of the beach, and a short log-rail seawall between the southernmost groins. However, isolated private constructions continued to appear. A second public protection scheme – a series of gabion baskets – was assembled in the mid 1970s and coexisted with the groin system into the 1980s. During the 1970s engineers evaluated the existing groins and reported that they were ineffective, leading to the eventual removal of most of the groins in the early 1980s. Subsequently, the 1980s and 1990s only saw the addition of rip-rap at several places along the shoreline. A review of the available data indicates that these structures were all erected in response to foredune or property erosion suffered from large episodic storms, or a sequence of closely-spaced smaller storm events. The magnitude of episodic storm erosion at Wainui is significantly greater than long-term shoreline trends, which could lead to the misinterpretation of future coastal responses. This paper discusses the lessons we have learnt from the history of coastal structures at Wainui Beach and identifies significant knowledge gaps, which have important implications for future long-term solutions.

Keywords: Wainui Beach, erosion, coastal engineering, groins, seawall, rip-rap, gabions, storms, property erosion, Gisborne.

INTRODUCTION

Erosion from sea level rise forced by global warming has been identified as a major impact of climate change on New Zealand (MfE, 2001). This may exacerbate existing erosion, or involve new erosion, causing increasing coastal risk, particularly where beachfront developments lie extremely close to, or in the path, of regular and episodic natural sediment movements. This has been the case at Wainui Beach, Gisborne. This predominantly sandy shoreline has a well-documented history of shoreline movements and property erosion, and accompanied with that, a long history of coastal protection structures.

The purpose of this paper is to review the spectrum of structures that have been implemented in the past at Wainui Beach to prevent property erosion. A chronology of past erosion events and coastal engineering structures will demonstrate how incomplete knowledge leads to incorrect decisions and inappropriate solutions, and can reveal important information that may help our future search for long-term solutions.

Wainui Beach, Gisborne

Wainui Beach is located 4-5 km SE of Gisborne City on the East Coast of the North Island of New Zealand. This beach has an approximate NE-SW alignment to the South Pacific Ocean, and extends for ~6 km between Tuaheni and Makorori Points (Figure 1). The Wainui settlement was established around 1912 (Gibb & Jones 1976), and residential development steadily increased between 1915 and 1940. This development still continues, and up until 2002 the number of beachfront properties exceeded 110.

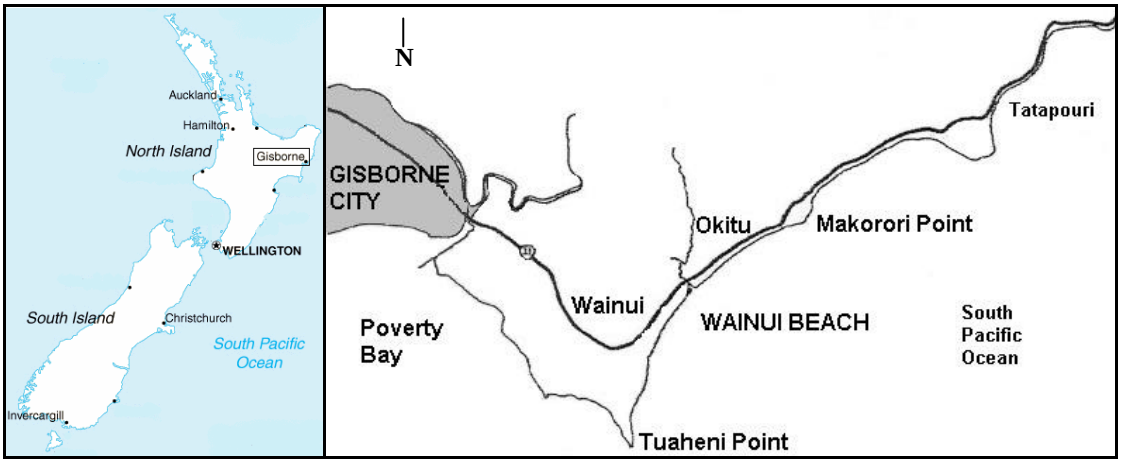

Figure 1. Location of Wainui Beach (adapted from Gibb, 2001).

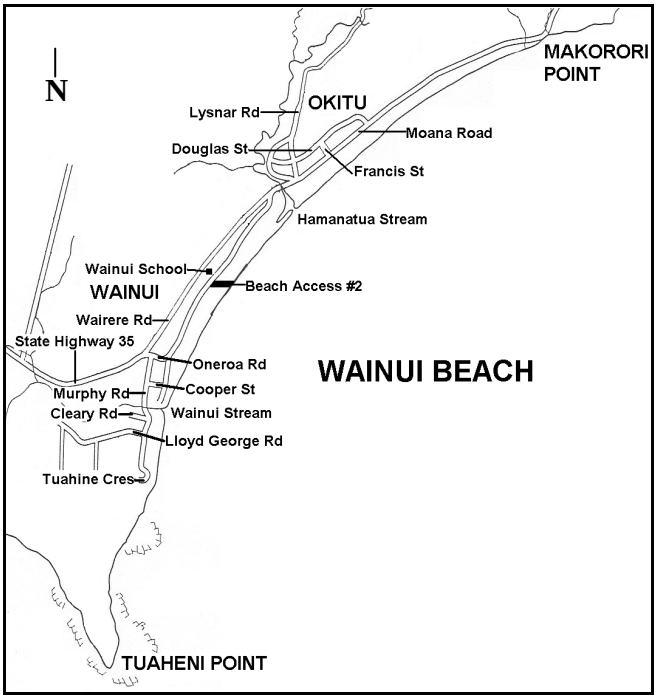

Figure 2. Street Map of Wainui Beach showing all locations mentioned in the text.

The beach consists of a predominantly sandy shoreline, backed by a substantial dune system between the two rocky headlands of Tuaheni and Makorori. Two streams occur along this stretch of shoreline; Wainui Stream to the south, and the larger Hamanatua Stream in the middle (Figure 2). South of Hamanatua Stream, on the primary dune, is ~2 km of intense residential development interspersed with numerous public beach access reserves, while to the north is an undeveloped 50-60 m-wide public recreational reserve.

Wainui Beach lies within the active Hikurangi Deformation Front (Beanland & Haines 1998), which is associated with uplift and intense deformation. The principal rock formations are silty sandstones and muddy siltstones (flysch) that rest upon a lower plastic bed of marls and bentonitic rocks (Stoneley 1962; Kingma 1965; Ridd 1970). The bounding headlands are composed of these "soft" sedimentary rocks, and a seaward dip of the strata triggers frequent landsliding events.

SHORT-TERM COASTAL EROSION AT WAINUI BEACH (1900-2002)

Wainui Beach experiences a very high level of short-term variability in shoreline position. These fluctuations are unpredictable in both space and time, and occur at magnitudes far greater than the long-term shoreline trend (Dunn, 2001). The earliest recorded localized erosion occurred in 1909 on the southern side of Oneroa Road (Adye 1964). Adye (1964) also summarizes a series of small episodic movements along the Wainui shoreline between 1909 and 1953 (Figure 4).

The first major storm to generate real public concern occurred in July 1955 when there was exceptional retreat of the foredune that undermined several houses near the present day Wainui Beach School (Figure 3). A massive erosion scarp remained after the storm, and it was estimated the foredune retreated by 15m (Gibb 1981). This major event triggered two very important matters in regard to the erosion of Wainui:

1. The first 'scientific' report on the erosion; and
2. The first public request for coastal protection structures.

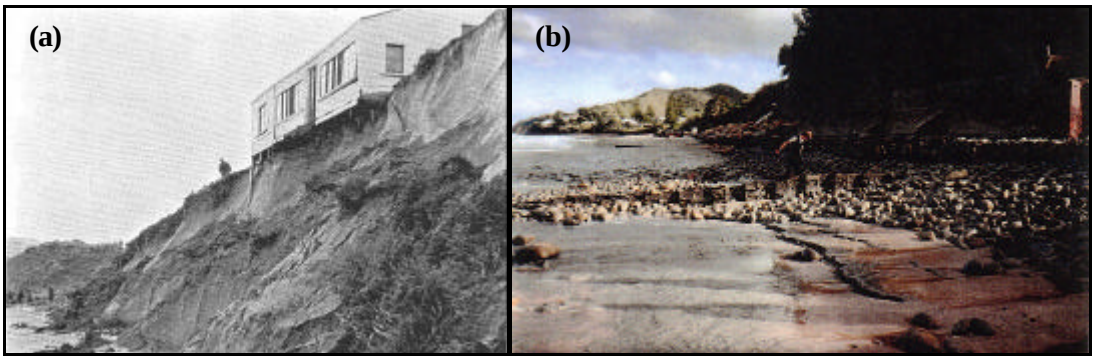

Figure 3. Foredune retreat from the "July 1955" storm (a) (*Gisborne Photo News*, August 1955) and the beach minus its sand cover, right (b) (photo courtesy of Dave Peacock).

Storms were very frequent during the autumn and winter months of 1973-74, resulting in considerable erosion from the northern side of Hamanatua Stream to Tuaheni Crescent (Figure 2). The stretch of beach between Hamanatua Stream and Francis Street was stripped of its sand cover so that the underlying rock platform was revealed from the primary foredune to the waterline. Gibb & Jones (1976) estimated 5-10 m of foredune retreat occurred south of Hamanatua Stream; however, this was directly associated with the presence of spur groins. A further 15 m of retreat was recorded in the winter of 1978 near Oneroa Rd, the Hamanatua Stream outlet, and southern flank of Makorori Point (Gibb 1998).

The 1980s were also an active decade, with the most notable changes in autumn and winter of 1985-87. However, it wasn't until the 1990s that erosion comparable to that recorded in 1955 reoccurred. In the autumn and winter months of 1992 many beachfront residents between Oneroa Road and Tuahine Crescent witnessed intense storm activity, beginning in early May and persisting until October. This activity removed enormous amounts of sand from the beach and foredune. This 7-month period has been classed as the worst in recent times (Peacock 1992) and produced ~8 m of retreat (Gibb 1998). The following autumn and winter seasons in 1993-1995 delivered more high waves and wreaked more havoc along the already vulnerable beach, destroying gabion baskets and a solid concrete seawall near Oneroa Road. The beginning of the 21st Century has seen moderate changes, but no major threats to beachfront developments.

Considering all erosion events for 1900-2002 (Figure 4), it is apparent that there are several parts of the beach that can be categorized as erosion-prone (Dunn 2001). They include south of Wainui Stream, Cooper Street to Oneroa Road, and around the mouth of Hamanatua Stream. However, anywhere along the 4 km of sandy beach can undergo significant erosion, and no part of this beach can be thought as free from erosion (Gibb 1998; Dunn 2001).

Causes of Erosion – Changes with Time

The earliest known report on Wainui Beach erosion by Haskell (1955), in response to the July 1955 storm, stated that the erosion was caused by a "south-east storm combined with high tides". It was further suggested that the stability of the beach relies upon the protection from Tuaheni Point; if the headland retreats, so too will the sandy beach. Haskell (1955) also noted that numerous episodic erosion events during the previous 20-30 years had generally occurred "during storms and high tides". Gibb & Jones (1976) stated rip current channels and spur groins were the two leading causes of foredune erosion. Wave refraction around the rock platform at the south end of the beach was also recognized as a contributing factor. A later study by Gibb (1981) to define a coastal hazard zone (CHZ) for Wainui Beach, also related the erosion to retreat of Tuaheni and Makorori Points and sea level rise.

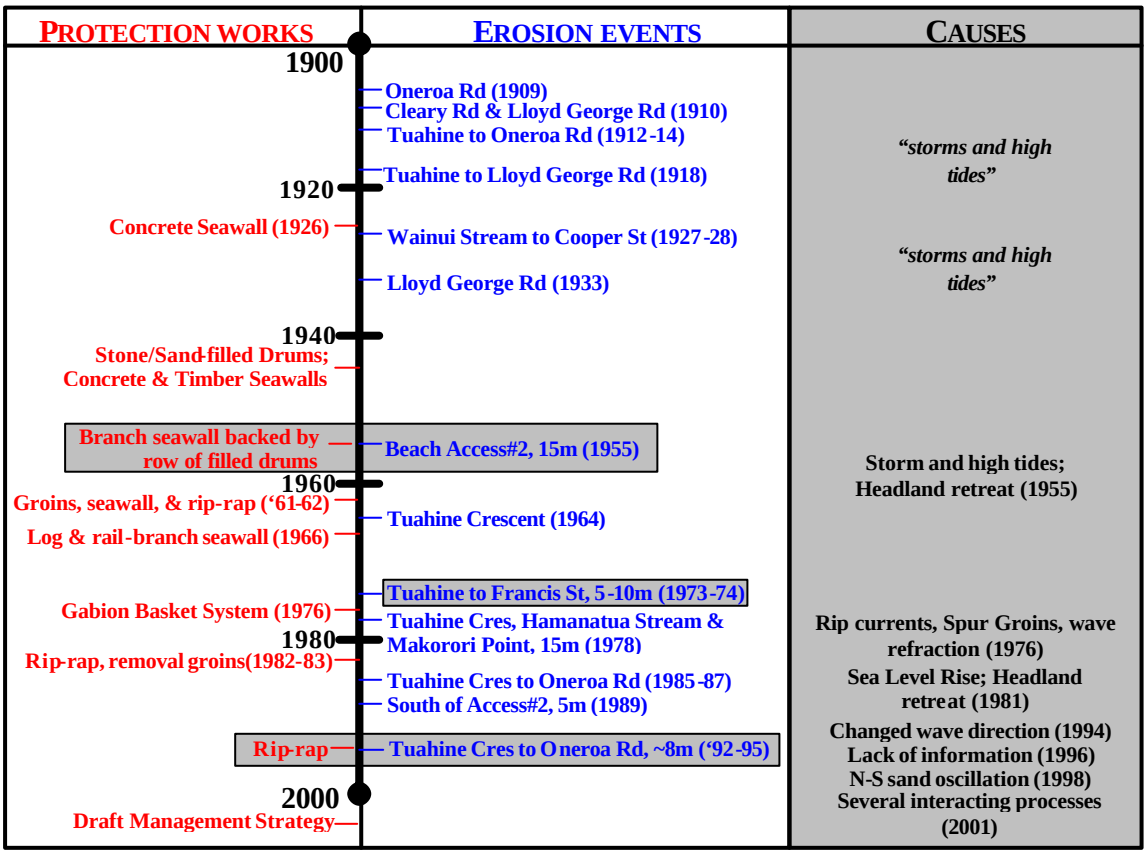

Figure 4. Summary of coastal erosion, protection works, and causes of erosion for 1900-2002. Shaded areas indicate the most extreme erosion events (note immediate engineering response).

Hence, by the 1990s, it was considered that storm waves, high tides, rip currents, sea level rise, and retreat of the headlands were all "causes" of the past erosion at Wainui Beach. However, it was subsequently recognized by Single (1993) and Komar (1996) that comprehensive information regarding coastal processes and beach changes had not been available, leading to an inadequate understanding of the erosion hazard. This was complicated by growing recognition of other factors that could contribute to erosion at

Wainui Beach. They included a long-term change in wave direction (Dean 1994) and a north-south oscillation in sediments (Peacock 1992; 1998).

A thorough study of the processes contributing to coastal erosion at Wainui Beach was not attempted until Komar (1996) and Dunn (2001). Dunn (2001) concluded that a high level of short-term variability in shoreline position ("cut and fill" cycle) drives the most destructive and extensive changes at Wainui Beach. Shoreline fluctuations consistently affect the toe of the main foredune, upon which intense development occurs. Erosion was attributable to the interaction of several coastal processes, and not solely due to storm waves (Dunn 2001). These processes were: persistently high storm waves driving energetic rip currents and bi-directional longshore currents, coincidence with extreme water levels, a high level of infragravity energy in rip channels and the swash zone, and wave focusing at the shoreline (via refraction). The extent to which each of these processes operates varies for different parts of the beach. For example, wave refraction and wave focusing at the shoreline is most active at south end of beach. Further, Wainui Beach was considered to be a "closed" beach system with minimal long-term sand losses (Dunn 2001).

COASTAL PROTECTION WORKS (1900-2002)

The first protection work was installed privately in 1926 adjacent to Oneroa Road (Gisborne Herald, 1994). It was a chunky, 20-30 m long, 20 cm thick, solid concrete seawall. Isolated private constructions were built during 1940s, consisting of sand or stone-filled tar drums lining the bottom of the dunes, and concrete and/or timber seawalls scattered along the shoreline. The independent approach to erosion control continued into the 1950s in the form of concrete and timber seawalls. Following the July 1955 storm, the public rallied together and built a private willow branch seawall at the toe of the eroded dune, and placed a row of stone or concrete-filled tar drums behind it (Haskell 1955). The first public appeal for protection works came immediately after the July 1955 storm.

The 1960s saw a switch towards a public, communal attitude to erosion control. The first public scheme, devised in 1958, was constructed between 1961-62, and consisted of a set of 28 spur groins, 18 m in length, 100 m apart along 2 km of Wainui Beach south of Hamanatua Stream (van Melsem 1972). Part of this groin system was reinforced with a vertical railway iron-log seawall (backfilled with rock) between the 2 southernmost groins (Adye 1964; van Melsem 1972). A similar seawall was extended almost to Lloyd George Rd in 1966 (van Melsem 1972), while another seawall was constructed using large blue-gum logs where the July 1955 erosion occurred to replace the ineffective manuka/willow branch wall. The rationale behind the groin system was "there is a tendency for some littoral drift which carries away the eroded sand from the beach" (Haskell 1955), and groins might stop this movement.

Private attempts to protect property and developments continued in the 1970s. Deterioration of the groin system, and the complete destruction of some groins occurred in 1974-75. The groins were not functioning as intended; sand was not being trapped between them. Instead, localized erosion at the foredune adjacent to the groins was detaching them from the foredune. A second public protection scheme was constructed in 1976. It was a gabion basket system, consisting of 1 m^3 baskets filled with rocks, held in place by timber logs, set 5 m seaward of the toe of the foredune (Brown, 1976; Gisborne Herald 1994). These baskets were placed between the two streams, and the prime purpose was to "endeavour to protect the houses…" (Brown, 1976). Therefore, there was a time in the 1970s and early 80s when groins and gabion baskets existed together (Figure 5).

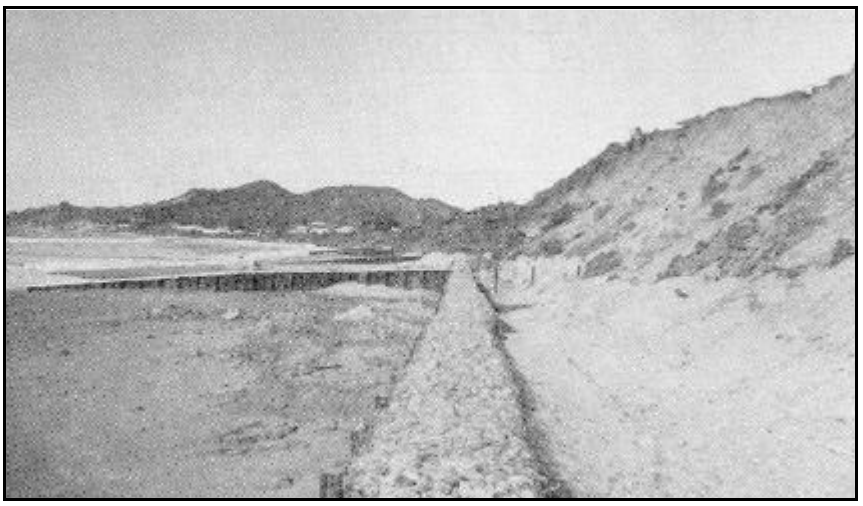

Figure 5. The coexistence of groins and gabion baskets in the mid-70s (from Brown, 1976).

Coastal engineering works were not a major feature of the 1980s. Instead, the groin system was deemed a failure, and all except the most southern and northern groins were removed between 1982-83 due to the public hazard caused by its disintegration (Smaill 1981). Maintenance of remaining structures continued from 1984-92, until a prolonged series of storms from 1992 until 1995 caused extensive erosion along the entire stretch of coast south of Oneroa Road. There were severe erosional "hot-spots" around Lloyd George Road, between Cooper St and Oneroa Road, and at Oneroa Rd. This lead to the private placement of rip-rap in these zones, as well as near Tuahine Crescent where the railway-log seawall was damaged.

In 2002, the Wainui Beach Draft Management Strategy was released. This document represents a joint initiative between the regional council, beachfront property owners and the wider community. The purpose of this strategy is the "protection and enhancement of Wainui Beach and adjoining reserves for the use and enjoyment of future generations". Over the 20th Century, coastal protection at Wainui Beach has been entirely structural, with all structures aimed at trapping sand and preventing its movement in order to protect private property. The Draft Management Strategy continues this approach.

DISCUSSION AND CONCLUSIONS

Combining the history of erosion and coastal protection works reveals interesting and important aspects about the past approach to the erosion hazard and attempts to control it. An immediate reaction to severe erosion in July 1955 was private hard engineering structures. After a 5-year lag, a publicly funded groin system was constructed along Wainui. The delay allowed preparation of a response strategy and organization of financial assistance. It did not involve any research on the causes of the erosion, or why this particular part of the beach was struck. The selection of groins as the response option was founded on the simple observation by Haskell (1955) – "there is a tendency for some littoral drift which carries away the eroded sand … this might be arrested by short, low case groins …". Groins are most effective on coastlines that experience considerable longshore sediment transport (Komar 1998). Whether this applied to Wainui Beach was unknown in 1955.

A gabion basket system was the response to the second public request for protection against property erosion. Why gabion baskets were selected as the erosion protection solution is not known, but again, this response option was not chosen on the basis of new scientific research or an improved understanding of the erosion hazard. Gabion basket effectiveness in high-

energy swash zones, and against coastal processes such as rip currents and wave focusing by refraction was not known. The immediate reaction to severe property erosion in 1992 was rock rip-rap, and again there was no consideration to the causes of the erosion.

Numerous scattered wooden and concrete seawalls remain today. Some are visible, while others have totally disappeared due to considerable sand accretion. The formation of an incipient dune against the July 1955 erosion scarp provides an excellent example of this. The uncovering and covering of old seawalls (as well as the remains of the groins) indicates that the beach is essentially a thin veneer of sand on a predominantly rocky basement (Dunn 2001). Erosion events have been short-lived and localized, mostly associated with erosion "hot-spots" along the beach south of Oneroa Road and around the Hamanatua Stream outlet. Storm waves are not solely causing property erosion, but instead there is an interaction of several coastal processes associated with or generated by the high-energy surf zone and elevated water levels during storms. While Wainui Beach may loose the entire sand cover down to the rocky platform over the period of a few days or weeks, the sand does eventually return. Hence, there is a very high level of short-term variability in shoreline position, width and topography.

Previous protection works at Wainui Beach have prevented the beach and dunes from performing their intended functions of sand sharing with the offshore region. Sediment movement naturally occurs between beaches, dunes, and the offshore region as a mechanism to reduce the amount of wave energy arriving at the shoreline during extreme events. That is, the sediment deposits, in the form of beaches and sand dunes that line them, naturally protect shorelines. In the long-term, Wainui Beach appears relatively stable and the coastal erosion problems are largely a consequence of the short-term cut and fill associated with storms.

The lessons we can learn from the spectrum of coastal structures and chronology of short-term erosion events over the past century are:

1. We need to use scientific information to make better decisions – it is clear that understanding the coastal system and its natural dynamics is the key to good coastal management; or as stated by Dean (1976) "If planned without a fairly good understanding of the cause(s) of the erosion problem and knowledge of sand transport processes, they almost certainty will fail to relieve the problem or will cause an equally severe problem elsewhere";
2. Many physical coastal processes are involved in an erosion event; the coastal processes and dynamics generating erosion at Wainui Beach probably have not been *fully* identified. Without a better understanding of these processes and their affects at Wainui Beach, it seems premature to prepare and apply new management strategies and specify construction standards for protection works;
3. Erosion happens in "bursts" or "pulses" and is difficult to predict in both space and time; in general, rapid sand loss (erosion) during storms is followed by slow sand return (accretion) at Wainui Beach (ie. there is time asymmetry). To allow for this behaviour, coastal management should allow for the natural exchange of sediment between the dunes, beach and offshore. This requires recognition that protection of private property by hard structures interferes with the natural processes that mitigate extreme events;
4. We can no longer follow the path or philosophy used in the past – this limited view arrives at simple solutions such as seawalls (e.g. Komar 1999).

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