The “Tripper Wall”
Managing the breakout of small lagoons and creeks across beaches

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Introduction

The breakouts of ephemeral creeks and small intermittently closed and open lagoons (ICOLs) across beaches have sufficient momentum to locally dominate surfzone process and produce a rip-like jet directed offshore. However, the high velocity discharge phase only lasts a matter of hours until the head difference between the creeks, or ICOLs, has equalized with the ocean tidal conditions, which then take over dominance of entrance flows (Gordon, 1981). On the NSW coast breakouts of creeks and ICOLs are usually initiated by intense rainfall runoff which raise the levels in the water bodies to a point where they either overtop the beach berm and start cutting a channel across the beach, or the threat to the low lying assets around the water body necessitates a channel being mechanically dug across the berm to alleviate the problem (Gordon, 1981,1990).

Breakouts naturally occur, or are induced during weather conditions that also coincide with onshore wind and elevated wave conditions. In NSW breakout conditions tend to be associated with storms generated by either High or Low pressure cells that move off the coast; Lows in the northern Tasman and Highs in the southern Tasman. The pressure systems typically persist for days after the breakout, albeit they progressively move further out east into the Tasman, producing waves from a southeasterly direction.

The storm induced wave conditions generate a short-term northerly littoral drift of sand in the surfzone that, in turn, produces a northerly deflection of the breakout channel, both initially and again 2 to 3 hours after initiation of breakout, as the high energy outflow subsides (Gordon, 1981). The deflection results in a period of increased erosion of the beach and dunes, and a threat to natural and built assets on the northern side of the entrance. It is these intermittent periods of threat that drive political pressure to “manage” the location and behaviour of breakout channels.

The exception to the northerly movement trend is in the southern corners of embayments sheltered by major headlands, where the wave diffraction around the headland can result in a localized southerly littoral transport, and hence the entrances being deflected south.

After a breakout is complete the entrance channel tends to meander at the behest of the prevailing surfzone drift directions at the time. This meandering becomes increasingly less active as the entrance is throttled by sand moved into the entrance from the surfzone and beach. The flood tide input of sand dominates any ebb tide scour because of the enhanced sand entrainment due to wave stirring (Gordon, 1990).

This was the situation at Dee Why lagoon where, in the 1974 storms (Foster et al, 1975) the northward trending deflection of the entrance allowed the storm waves to not only devastate the beach and dunes, but also to threaten the Long Reef Surf Clubhouse. The erosion at the surf club started to undermine the foundations and to damage the door of the boat shed; an almost inconceivable situation given the current (2016) 60m of dune formation and wide beach berm in front of the clubhouse. The situation by the late 1970s was such that, for a time, consideration was given to permanently closing off access to Long Reef Beach, however as it is a very popular surf and surfboard riding location the decision was taken to undertake a reinstatement of the beach, and the associated dunes and car park.

Understanding natural entrance behaviour and controls

Examinations of natural beaches, that have not experienced human intervention, indicate that the location of creeks and ICOLs breakout channels historically "anchor" themselves on "hard points". Where an entrance has had the opportunity to anchor itself, the geometry of the water body tends to adjust its configuration to reflect its stabilized entrance location. Hence creeks and ICOLs take on a back of beach shape that is deflected towards its intermittent entrance location. "Hard points" can include headlands, clay substrates beneath, or behind beach berms, indurated sand outcrops or rocky outcrops on beaches.

During an event the initial breakout channel may start to form some distance away from the "hard point", in a location where the beach berm is, for some reason, lower than elsewhere. As the channel scouring develops there is usually a subsequent deflection and migration of the channel towards its "normal" anchor point. However, more often than not, the hard point focus results in the berm being generally lower in that vicinity and hence the concentration of initiation is near the hard point.

Typically smaller creeks and ICOL entrances, once open, display the characteristics of an unstable shoaling mode (Nielsen and Gordon, 2015) resulting in development of flood tide shoals in the entrance. Therefore these smaller water bodies tend to progress towards closure. The time to closure depends on the prevailing littoral drift conditions and whether or not there is follow-up rain causing re-scouring. At Dee Why Lagoon the mean time to closure is approximately 18 days, but depending on circumstances this has been observed to range from 2 to 44 days (Gordon, 1981).

Intervention management of meandering entrances

Conventional thinking for anchoring, and therefore limiting the meandering of the location of lake and river entrances, is the construction of major structures such as rock breakwaters and training walls. These large-scale structures can significantly impact on the hydrodynamics of the water body (Nielsen and Gordon, 2015) and on overall coastal alignment (Nielsen and Gordon, 2016). Such structures are inappropriate for the smaller creek and ICOL entrances as they are out of scale with the management needs of such entrances.

ICOL and creek entrances require a solution that limits the deflection and meandering tendency during breakout but which effectively "disappears" into the beach and is buried for most of the time while the entrance is closed. Observation of the behaviour of creeks and ICOLs on unmanaged natural beaches gave rise to the concept of a low profile shore normal wall with a crest slightly below the normal beach berm level. In order to be effective, but not intrusive, such a structure needs to extend far enough across the beach to prevent the channel meandering along the beach, without the structure having to extending all the way across the beach.

The “tripper wall” modifies the mechanism of breakout so that as the lagoon/creek starts to overtop the beach level and flow towards the sea, any initial meandering is arrested when the channel scour exposes the “tripper wall” at which point the channel is deflected along the alignment of the wall and continues to develop adjacent to the wall until the water level in the creek/lagoon becomes tidally dominated.

As the entrance closes the sand build up in the entrance and on the beach berm again buries the wall and the beach returns to an apparently “natural” configuration. Hence the wall is only uncovered for a relatively short time, and simply acts as an anchor point and a "tripper" for redirection of the, initially meandering, breakout channel.

The Dee Why trial of the “tripper wall” concept

The 1974 storm had caused so much damage in the Long Reef Beach region that it took till 1977 for the decision to be taken to restore the area. During 1977 and 1978, a management plan was developed that included the re-building of a dune field buffer in front of the surf club and the car park to ameliorate the potential threat. A prerequisite was that the lagoon entrance be prevented from meandering north and destroying the dune field.

During 1977 and 1978, the development of the Long Reef management plan provided the opportunity to progress the initial concept of the “tripper wall”. A small moving bed model was constructed at Manly Hydraulics Laboratory so as to test the likely response of the breakout channel to the imposition of a “tripper wall”. While moving bed models can be very useful they do have limitations. Importantly, it is not possible to meaningfully model sand size; the smaller the sand diameter the more it behaves like a cohesive material. However, with experience, it is possible to select material that will allow qualitative indications of the likely performance of a design. Hence a range of options can be tested and the results compared and contrasted. Given the limitations of the modelling it was recognised that, despite some very useful indicative results, the actual “tripper wall” was going to be a full-scale experiment, and hence an adaptive philosophy, combined with a conservative approach was required; the structure was designed so that it could be removed, or augmented, if necessary.

The landward end of the wall was located at the point of maximum landward channel erosion that had occurred in the past. Allowance was made for a landward extension should outflanking become a problem. Shortly after construction there was one occasion when the landward end was threatened by outflanking. This was addressed by the judicious placement of a small number of rocks, rather than a formal landward extension.

Initial thinking was that the wall should be at right angles to the local coastal alignment so that the wall could be as short as possible. However the moving bed model results suggested this might encourage outflanking at the landward end due to the sudden change in direction at the northern end of the lagoon. The modelling indicated that ideally the “tripper wall” would be a curved structure allowing a progressive change of direction from the lagoon to the sea. However, as this was to be a “temporary” “experimental structure” the simple expedient was to adopt a straight wall configuration, but to compromise by deflecting the wall 20 degrees to the north, thus making it a slightly longer wall but providing a less severe transition between the lagoon exit and the breakout channel alignment.

The determination of the location of the seaward end of the wall was somewhat problematic so a heuristic approach was adopted. It was initially considered that the seaward extent should be just landward of the seaward crest of the beach berm (the top of the swash zone), with the crest of the wall being approximately 0.5 metres below the "normal" (modal) berm level. The seaward berm crest was selected in order to limit the tendency for the breakout channel to outflank the wall head. Taking into account the state of recovery of the beach in 1978 the decision was taken to locate the seaward end of the wall 80 metres out from the landward end. With the design completed by late 1978, construction of the wall was undertaken during 1979.

By 1986, and following the successful reconstruction and vegetation of the dune field to the north of the wall, between 1979 and 1983, it became apparent that the modal location of the beach berm-crest had moved a further 20 metres seaward. Hence, in 1986 a 20 metre extension was added. Since 1986 there have been periods of beach accretion that have resulted in the berm-crest being a further 20 to 30 metres seaward at times. However outflanking of the head has not proven a concern as the dune field is now 60 to 80 metres wide and the berm just north of the entrance is typically 40 metres wide, so some meandering can be tolerated. A further reason for not extending the wall is to ensure it is not overly exposed to direct storm wave attack, as it is principally a "light weight" structure. Given that the "storm bite" for a 1% event can be up to 225 cu m/m of beach (Gordon, 1987), there is now sufficient sand in the berm alone to accommodate storm erosion, and should elevated water levels allow waves to directly attack the dunes, again there is sufficient sand to readily withstand storm erosion from a major event. The wall has created an environment that has fostered this build up of an adequate buffer.

Wall design/construction

The trunk of the wall was formed up in sand. On the lagoon channel side a 1 in 2 slope was selected. On the other, northern side, all but the last 10 metres near the seaward head were simply blended into the newly constructed dunes. The seaward 10 metres of the northern side were formed up to a similar configuration as that on the lagoon side, that is, a 1 in 2 slope. Provision was made for a crest 2 metres wide. A heavy geo fabric, similar to Texcel 1200R, was placed on the slope and on the crest as an underlay for the armour layer of Reno Mats; rock filled wire baskets. The Reno Mats were 6 metre by 2 metre by 0.25 metre baskets made of galvanized wire coated in PVC. The baskets were separated into compartments by wire bulkheads. On the channel side the baskets were placed and wired together with the long axis down the slope. On the northern side a similar configuration was adopted for the 10 metres back from the head, to provide protection against possible outflanking. The 2 meter wide crest was made up of the 6 metre by 2 metre by 0.25 metre Reno Mats laid lengthwise along the crest and wire-tied into the baskets on the slopes. This produced a flexible but monolithic structure.

Once in place the Reno Mats were filled with rock. It was vital that the rock was tightly packed so that water and wave action couldn't cause the rock to move and abrade the wire of the baskets. This was achieved by slightly overfilling each compartment, before attaching the lid. The seaward head was constructed before the final Reno Mats were in place. The head was a vertical wall of 2m by 1 metre by 1 metre Gabion baskets, with intermediate bulkheads dividing each Gabion into two compartments. The Gabions were again overfilled with rock, lids sewn in place then next row stacked on top, sewn to the lower row and filled until the top Gabion was at crest height. The triangular infill sections, required to complete the wall shape between the Gabions and the Reno Mat slope, were formed in place by sewing lid mesh, on the required angle, to both sides of the Gabions and then filling these triangular compartments with rock and attaching a lid. Once the head wall was in place geotextile was attached to the inner face and the sand fill of the trunk was extended to meet the vertical head wall. Then the final Reno Mats were placed, sewn to the Gabion head, and filled.

The 20 metre 1986 extension was formed up to a similar configuration as the last 10 metres of the initial wall. The extension Reno Mats were wire-sewn to the “old” head to make a continuous structure and a new head was constructed to a similar configuration to that of the “old” head.

The configuration adopted resulted in the toe of the Reno Mats/Gabions being at -0.5 metres AHD, which is approximately 0.5 metres below Mean Sea Level (MSL). In an open coast situation where a structure can be exposed to direct wave attack, a toe level of approximately -2 meters AHD is normally recommended (Nielsen et al, 1992). However the degree of protection provided by the set back of the structure, given the wide beach berm, and the existence of a stiff clay substrate at the -0.5 level, for much of the length of the wall, has meant that over the 30 years since construction the toe has not shown any appreciable detrimental scour.

Tripper Wall performance

The first stage of the wall was completed 37 years ago, and the extension was completed 30 years ago. Given that it was intended for the wall to be an experimental and possibly “temporary” structure, it is instructive to review its performance in order to gauge the success of the overall concept, and its potential applicability to other sites.

Even after this length of time the wall continues to perform surprisingly well, particularly considering the material used in its construction. The outcomes it has delivered in stabilizing the breakout location, and in providing a protective buffer to assets to the north of the wall, has exceeded expectations. A minor issue on the south bank has arisen as a result of post-breakout meandering. This has necessitated construction of a small training wall on the southern bank. The dune field to the north of the wall is now between 60 and 80 metres wide, and up to 8 metres high, whereas after the 1974 storm there were no dunes remaining and the erosion escarpment was along the line of the landward extent of the current dunes (see figure 1). The beach berm in this area is typically now 30 to 40 metres wide and the surf club is now 60 metres landward of the seaward toe of the dunes. It is sufficiently far inland and obscured by the dunes that an observation platform and equipment shed has had to be constructed near the front of the dunes, 50 metres seaward of the clubhouse.

Breakouts, even during major storm events have performed as expected; they overtop the berm and usually deflect northward, under the littoral drift conditions prevailing during storms. A small channel initially developing across the alignment of wall, until the scour in the channel exposes the crest of the wall. Then the flow attaches to the wall and the on-going channel development is confined to the south side of the wall. Any outflanking at the head has been minor and short-lived, and has not endangered the structure or the dune field. Because the wall is located within the beach berm region it is sufficiently protected from storm wave attack, so the Gabion/Reno mattress complex has been able to survive intact.

The major issue with the wall has been the damage to the wire baskets, on their exposed surfaces, particularly on the crest. This has at times led to a loss of rocks and hence the need to undertaken maintenance involving both replacement of rocks and the sewing on of new wire “lids”. Unfortunately some of this damage was initiated during construction of both the initial, but particularly the extension phases of the wall. This was primarily due to vehicular access along the crest to carry stone fill material for the Reno Mats and Gabions. Because this activity was not well managed it led to damage of the PVC coating on the wire and abrasion of the galvanizing. In addition, from time to time, access for tractors and other vehicles used for beach maintenance has been along the crest. Unfortunately, at times of shallow burial of the wall, the beach rake operations have also added to the damage, particularly near the head. A combination of these activities has ultimately resulted in the wires of the mesh of the lids of the crest Reno Mats being unnecessarily abraded and broken, thereby limiting their potential life.

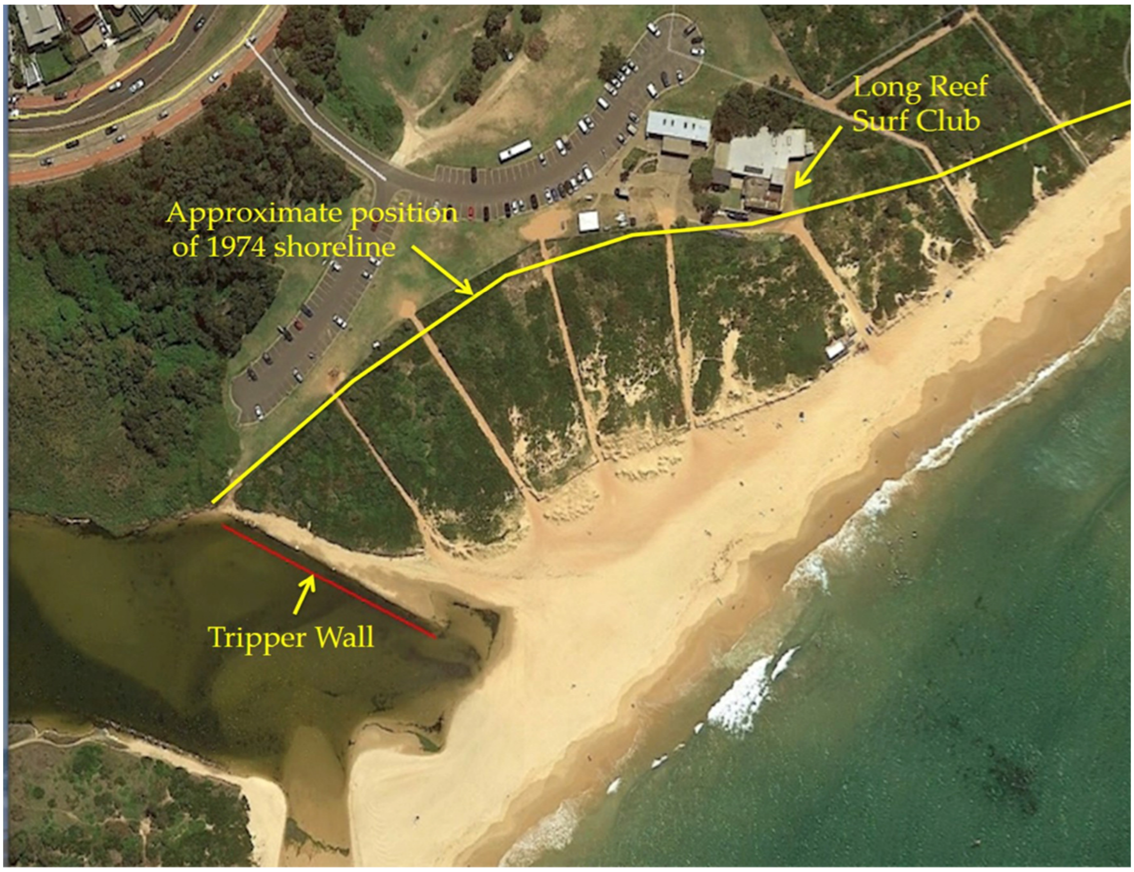

Figure 1 – Dee Why Lagoon Entrance showing 1974 shoreline and the location of the “Tripper Wall” that provided the environment to allow dune and beach recovery.

Not only has the breakage of the baskets exposed the rock filling allowing it to escape the containment, but it has also resulted in accelerated rusting of the broken wire. This in turn has produced a potential foot injury hazard for people walking along the crest to access the beach. During the times the crest is exposed, people can see the potential danger, however as the crest becomes covered with sand there can be spikes of rusty wire just under the surface. Several attempts have been made to address the damaged crest lids and reduce the potential for injury, including wiring on patches and replacing lids. There was also an attempt to cover the structure with a heavy geotextile to produce a carpet-like surface however it proved too difficult to successfully anchor the geotextile to the mattresses, and so the current and wave action resulted in it becoming detached and ending up as mounds of debris near the landward end of the wall.

Matters for consideration

As has been mentioned, in the early days of the project there was a perceived vulnerability to outflanking of the landward end of the wall, however as the dune field developed to the north of the wall, this area became effectively landlocked and hence there was no need to pursue this matter further. Any future replacement wall would not require the degree of protection incorporated into this end of the existing wall although it would be desirable to provide a more sympathetic curved transition zone between the landward lagoon bank and the wall.

With the “tripper wall” containing northward migration of the channel there was sometimes a tendency under northerly wave conditions for the channel to meander south in the post storm period before closure could occur. From time to time this resulted in some erosion of the toe of the dunes on the south side of the entrance. To limit the southern excursion a training wall was constructed along part of the southern bank. This wall is 70 metres long, is approximately parallel to the “tripper wall” and is 80 metres to the south, thereby providing a wide area for the channel to meander while the entrance is open. The training wall is however quite different to the “tripper wall” in that it is made up of rock which unnecessarily remains exposed at all times. Fortunately it does not extend seaward past the centerline of the dunes and so its visual impact is limited. It is not involved in managing the breakout, but rather limiting the meandering while the lagoon is open to tidal action.

This training wall was not part of the original concept and its form and design are out of keeping with the idea of a minimum impact structure that would only intrude into the environment when required. In addition the crest level of the training wall is unnecessarily high. A far more sympathetic structure could have been used to limit any southward meandering tendency during the relatively short time the entrance is open.

Comment

The “tripper wall” for the Dee Why Lagoon entrance at Long Reef was conceived as an experimental structure, hence the design was a simple straight wall that was made with material that could be removed if the concept was not a success. However, the historical evidence clearly points to the positive outcomes of the concept. The “tripper wall” has delivered a control structure to stabilize the entrance location during lagoon breakout. However, for most of the time, the structure is hidden below beach level. It is believed that application of the “tripper wall” concept is not limited to Long Reef but can be applied to similar situations.

The landward end of the experimental wall was determined at a time when the beach was still suffering from the impact of an extreme erosion event, and hence was located well landward of where it needed to be once the dunes to the north had been re-established and stabilized. Conversely, it could be argued that the successful re-establishment of these dunes was, to a degree, dependent on the building of the wall. Regardless, the inner section of the experimental wall was conservatively designed and hence future applications could examine alternative treatments. It is clear that at the landward end there is a need to transition the direction of flow out of a lagoon into a more shore-normal direction across the beach berm. Preferably this transition section should be curved and have both trunk, and some limited crest armour, so as to manage potential scour.

The crest level selected as 0.5 metres below the modal level of the beach berm proved to be a fortuitous decision. At times, following a long period of lagoon closure, the crest was buried by up to a metre of sand. On such occasions the initial northward meandering of the scour channel at times occupied all of the 40 metre berm-buffer in front of the dunes, before scouring down to the "tripper wall" and being re-directed along the wall. However on a majority of breakouts, when crest coverage was more like the 0.5 metre design of cover, the meandering was more contained. At 0.5 metres below the modal berm level the wall tended to start to be covered with sand within a month after entrance closure. The rate of cover was however dependent on wave overtopping of the berm, particularly during Spring tides. The rate of burial was also enhanced by on-shore wind born sand transport. Experience has shown that, for much of the time, the wall is either fully or partially buried, thereby producing a structural solution to lagoon entrance management that has minimal impact on beach amenity.

Initially the determining factor for the seaward end of the wall was that it reached the seaward crest of the beach berm; the point of "normal" wave run-up on the beach. Experience however has shown that the seaward end only needed to extend to a point where initial overtopping, and meandering by the incipient breakout channel, could be absorbed within a buffer zone of sufficient width that protected the dune field from the initial breakout channel meandering. At Long Reef for example, in order to protect a 60 metre wide dune, the wall needed to extend 40 metres past the seaward toe of the immediately adjacent dune. Clearly this relationship is dependent on site-specific characteristics, and the wall crest. Hence the particular site considerations need to be taken into account at any other location where the concept is to be considered. However it is felt, from both the field experience and the earlier model testing, that the overall plan geometry of the Long Reef wall and its relationship to the adjacent dune fields should be scalable to differing sites.

The Reno Mat/Gabion type of wall construction was selected on the basis of its ability to be removed if the experiment was unsuccessful. Structures made using these products had been previously trialed as toe protection for sea walls on the open coast at both Cronulla and at Collaroy. The original selection of the type of wall for the experimental structure did not envisage it was going to achieve the extended life it has ultimately enjoyed; the Reno Mat/Gabion structure has performed remarkably well. It is unfortunate, but noteworthy, that the lack of care with respect to vehicle movements along the crest both during the construction and the on-going beach raking operations, has unnecessarily compromised the wire mesh baskets on, and near, the crest. This has resulted in a maintenance issue and the potential for injury to beach users. It does show a latent vulnerability for this type of structure. The performance of the Dee Why "tripper wall" however demonstrate that, with greater attention to construction methods and on-going beach maintenance operations, a life of 40 years is potentially achievable; a reasonable structural life in the marine environment.

The "tripper wall" at Long Reef also provides an opportunity to review the 37 years of operation and consider whether any replacement, or new structure at a different location, should be with the same type of structure or an alternative. Other options that could be considered could include geobags or geotubes instead of Reno Mats and Gabions or armour units such as various types of interlocking concrete blocks. In considering these alternatives, it should be recognised that just as Gabions and Reno Mats have limitations, Geofabric type structures can be vulnerable to damage during construction and later on, to vandalism. Interlocking concrete blocks have limitations unless the interlocking mechanism provides some flexibility to allow for settlement, but at the same time their placement resists actions by vandals to remove individual blocks. Blocks that could be investigated for armouring such a structure could include Seabees and other similar interlocking units as documented by the US Army Corps of Engineers (1981).

Most of these units are likely to have realistic life of 40 to 50 years hence replacement of a “tripper wall” should be factored into any cost /benefit study undertaken to select the desired option. The initial cost of the Dee Why Lagoon “tripper wall” was $166,000 (in 1980 dollars). Unfortunately no figures are available on its maintenance costs over the 37 years.

Finally, “tripper walls” are appropriate to use as a technique where the lagoon or creek has sufficient buffer volume to absorb minor to moderate rainfall events without needing to break out across the beach. However, when a major event causes a breakout to naturally occur, the flow attempts to meander before settling into a short lived energetic event that rapidly produces a deep scour channel through the beach berm. The “tripper wall” provides a constraint that limits the initial meandering tendency of the breakout and “anchors” the main breakout channel as it develops, and in so doing limits the threat to neighbouring assets. However the wall, between breakouts, is normally below beach level and therefore not visually intrusive.

The “tripper wall“ concept is however specifically intended for lagoons and creeks that experience intermittent breakouts on beaches in closed embayments. For example, at Dee Why Lagoon the average time between breakouts has been observed to be approximately 2 months (Gordon, 1981), and the Dee Why/Long Reef embayment is a closed sediment system contained by its headlands. A “tripper wall” option is not considered applicable to situations where creeks regularly flow across beaches, as in these cases the berm tends to be maintained in a lowered state, so any structures aimed at constraining the location of the entrance and any channel development during run-off events needs to take the form of dual training walls, rather than “tripper walls”. “Tripper walls” are also not an effective management option in maintaining the location of lagoon or creek entrances on coasts with a net long-term littoral drift. While a “tripper wall” helps contain entrance meandering in response to short-term littoral drift on a beach that is in a closed embayment, the concept will not prevent the ongoing entrance migration associated with open embayments where shorelines experiencing a net longshore littoral drift trend.

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