Results framed in relation to the questions of Botten Levinson Lawyers

Given all the theory and background information on coasts in general and on the Semaphore-Grange Coast in particular presented above, it is now possible to answer the questions posed by Botten Levinson Lawyers in a systematic, rational and substantive manner. The answers below thus draw on information presented above but with additional question-specific substantiation.

1) What are the natural physical and ecological features of the Land as a whole and in particular the parcels identified as "I", "J" and "L" in the attached alignment plans ("the Re-Dedicated Parcels")?

The terrain of the dunes of the Semaphore-Grange Coast, in terms of its natural physical features, is comprised of dune core abutted to the west by a series of shore-parallel beach ridges which are variably terminated along the shore by a sea cliff. The beach ridges are separated by swales that are shore-parallel and parallel to the beach ridges. The base of the sea cliff often is blanketed by a ribbon of sand that forms foredunes. The contact of the dune belt with residential areas is a 6-m wide cleared buffer zone vegetated by a carpet of herbs and grass; immediately to west of this buffer zone is a sharp contact with the dune terrain that is marked by ingressing dune sand, or by a buried sea cliff, or by earthworks, and by plantings of exotic species such as *Tamarix*.

Ecologically, the vegetation of the dunes of the Semaphore-Grange Coast is variable in terms of condition and diversity. There is clear zonation of plants across the dunes reflecting height of dune, distance from wind and sea spray, age of vegetation assemblage, and depth to watertable. However, there have been impacts on the vegetation ecologically in terms of alien species, the creation of artificial dunes (the relatively long, moderately wide, and smooth-topped 'dune'), pathways, and earthworks.

Land Parcel "I" adjoins a road and is separated from it by a fence and artificial road-parallel gutter up to 2 m deep. From the gutter there is 15 m of dune sand, vegetated by *Spinifex hirsutus, Olearia axillaris, Scaevola crassifolia* (a Priority species), *Atriplex cinerea* and *Carpobrotus rossii*. The dune terrain consists of domal dunes that are vertically accreting due to the trapping/fixing ability of *Spinifex hirsutus* separated by conical to linear depressions. Westward of the dunes is a slope of slumped sand and then a low beach ridge. In this location, from north to south, the most landward beach ridge splits into two ridges. The most significant parts of this Land Parcel are the ecological zonation from dune crest to floor of depressions, and form and the occurrence of domal dunes in action.

Land Parcel "J" adjoins a residential block and is separated from it by a 6-metre wide buffer zone of low herbs and lawn. West of the buffer zone is wide and broad of beach ridge, 2-3 m high, and vertically-accreting domal dunes (vegetated dominantly by *Spinifex hirsutus* and some marram grass *Ammophila maritima*). The main beach ridge vegetation is floristically mixed and consists of *Olearia axillaris, Rhagodia candolleana, Atriplex cinerea,* and *Scaevola crassifolia* (Priority species). Westward of the dunes is sea cliff that has largely slumped to form a slope. The most significant parts of this Land Parcel are the ecological relationship of the dune types and vegetation floristics (from actively accreting domal dunes with *Spinifex hirsutus*, to the mixed floristic assemblages that inhabit the beach ridges); also important is the form and occurrence of domal dunes in action.

Land Parcel "L" adjoins a long stretch of residential blocks separated by a 6-metre wide buffer zone of low herbs/lawn. West of the buffer zone is a sharp topographic 5-m drop, or a narrow linear gutter; these separate the buffer zone from a broad series of three beach ridges, 2-3 m high. The beach ridge vegetation is floristically mixed, consisting of *Olearia axillaris, Rhagodia candolleana*, *Atriplex cinerea*, and *Scaevola crassifolia* (Priority species). There is a strong relationship between vegetation and habitats, with ridge floristics different to swale floristics. In this Land Parcel, and *Lepidosperma gladiatum* (a Priority species) begins to make its appearance in the swales. The total diversity of the vegetation on the ridges and swales is more complex and

diverse than the native vegetation assemblages in Land Parcels "I' & "J". The most significant parts of this Land Parcel is the ecological relationship of dune types and vegetation floristics, and that it has the most mixed floristic assemblages that inhabit the beach ridges and swales.

2) Please assess the biodiversity value to the local coastal area and on any broader regional basis of the natural vegetation or other natural features of each of the Dedicated Parcels ("Identified Features")? Please identify whether it is likely that such biodiversity value will increase over time and if the contribution of the Re-Dedicated Parcels to biodiversity is self-contained or cumulative with other adjacent parcels of land?

In terms of biodiversity, the vegetation and floristics of the dunes of Semaphore-Grange Coast stand alone. When comparing other vegetated coastal dunes that have been described in the literature in South Australia and south-eastern Australia, the dune barrier of the Semaphore-Grange Coast is not comparable to the others and stands as significant.

The dunes of Semaphore-Grange Coast are not comparable to other coastal native vegetation in the region or in the State because of the style of dune formation and landforms and habitats generated. As discussed above in earlier sections, the coastal dunes in South Australia can be categorised into several types, *viz*., landward transgressing barrier dunes dominated by parabolic dunes (the Younghusband Peninsula), landward ingressing dune belts abutting Precambrian rock or Pleistocene limestone, dominated by parabolic dunes (the Coffin Bay area), beach ridge belts abutting Tertiary sediments (and these are mostly compromised by pasture lands), and the Semaphore-Grange Coast comprised of a core barrier with seaward beach ridges both barring a former river-estuary system.

Beach ridge complexes are not so common in South Australia, and those that do exist, commonly have been compromised by other land uses.

The 'nearest neighbour' to the Semaphore-Grange Coast in terms of vegetation and floristics is the Younghusband Peninsula, *viz*., the dune barrier of The Coorong, but there the dune terrain (that will generate habitats) is parabolic-dune-dominated, with dune ridges and intervening bowls oriented transverse to the barrier – a markedly different system of habitat to that of the Semaphore-Grange Coast, and even though there is an overlap in species between the two areas floristically, the different types of habitats will result in structural, physiognomic, and phenotypic, and reproductive-strategic differences in the species and the vegetation.

Ecologically, the vegetation of the dunes of the Semaphore-Grange Coast is variable in terms of condition and diversity. There is clear zonation of plants across the dunes reflecting height of dune, distance from wind and sea spray, age of vegetation assemblage, and depth to watertable. However, there have been impacts on the vegetation ecologically in terms of alien species, the creation of artificial dunes (which is the relatively long, moderately wide, and smooth-topped 'dune'), pathways, and earthworks. In an overview, it is likely that the biodiversity values of the entire dune system as well as the specific Land Parcels will increase over time: dunes left to progress/evolve will, in time, become more complex as the terrain passes from simple freshly-accumulated dune sand to sand with incipient soils to sand with well-developed soils (*cf*. Semeniuk & Meagher 1981). The work of Semeniuk & Meagher (1981), Searle *et al*. (1988), and C A Semeniuk (2007) show that vegetation habitats and vegetation assemblage evolution can take several thousand years to develop and, as such, habitats and assemblages need to be not disturbed in order for them to progress naturally to their next stage of development (evolution).

Thus the question 'whether it is likely that such biodiversity value will increase over time' relates to whether the diversity of floristics will increase due to natural dune processes, soils-forming processes, encroachment into the habitat by adjoining (native) plants, and on-going ecology processes. The answer is 'yes', because if left alone to follow natural ecological

processes the vegetation and floristics will progress into different assemblages and will naturally increase in biodiversity. The increase in biodiversity in relation to age and development of habitats is already evident spatially – newly formed dunes with cover of *Spinifex* and marram grass have low diversity; thereafter, with time, these new dunes are further colonised by *Isolepis nodosa*, *Rhagodia baccata* dunes, *Scaevola crassifolia* (Priority species), and the oldest of the beach ridges have a rich and mixed floristic assemblage related to ridge crest, ridge slope, and swale, with the swales having the greatest biodiversity. In other words, the transition from simple biodiversity to a complex and rich biodiversity occurs with time.

It is also important to have a mixture of species in the regional species pool so that when habitats evolve (with soil development and slope amelioration), or revert to their earlier less-mature form (*e.g.*, natural burial by aeolian sand), or species need to be introduced as the assemblage progresses towards community climax, there are species to draw from in the region to colonise these later-developed habitats. That is, the biodiversity of the dunes needs to be viewed site by site and also in a regional context where adjacent parcels of land can contribute to the biodiversity of a site when necessary.

In the Semaphore-Grange area there is variable development of these habitats and soil development, and correspondingly, a mosaic of floristic/vegetation types. The entire suite of the variable mosaics of floristic communities is what is of biodiversity significance. Moreover, in this area, the swales and the oldest part of beach ridge system, as outlined generally for dunes earlier in this report, are the most mature, geochemically complex, and will have the oldest and most diverse vegetation – as such, they will be (floristically) the most significant part of the dune system.

For the more specific parcel of dedicated land-use, the question of whether it is likely that their biodiversity value will increase over time is outlined below. Note that the oldest, most mature, geochemically complex part of the dune complex with the oldest and most diverse vegetation either will be closest to path or under or close to the proposed boardwalk. Also note that the swales in the eastern and oldest part of the Semaphore-Grange Coast dune system generally are intact, and are floristically the biodiverse part of the dunes.

Land Parcel "I" ecologically consists of a patch of dune sand (habitats of domal dunes and conical to linear depressions) with *Spinifex hirsutus*, *Olearia axillaris*, *Scaevola crassifolia* (Priority species), *Atriplex cinerea* and *Carpobrotus rossii*. Westward of the dunes is a slope of slumped sand and then a low beach ridge. The most significant parts of this Land Parcel are the ecological zonation and community succession from dune crest to floor of depressions, *i.e.*, the ecological zonation from dune crest to floor of depressions, and form and the occurrence of dune types. The ecological assemblages, with ongoing dune evolution and soil development, can be expected to increase its biodiversity.

Land Parcel "J" ecologically consists of a broad of beach ridge and vertically-accreting domal dunes with their accompanying vegetation of *Spinifex hirsutus* and some marram grass *Ammophila maritima*. The beach ridge vegetation is floristically mixed and consists of *Olearia axillaris, Rhagodia candolleana*, *Atriplex cinerea*, and *Scaevola crassifolia* (Priority species). Westward of the dunes is the sea cliff that has largely slumped to form a slope. The most significant part of this Land Parcel ecologically is the relationship of the dune types and vegetation floristics (from actively accreting domal dunes with *Spinifex hirsutus*, to the mixed floristic assemblages that inhabit the beach ridges). These assemblages, with ongoing dune evolution and soil development, can be expected to increase its biodiversity.

Land Parcel "L" ecologically consists of a broad series of three beach ridges with floristically mixed vegetation, consisting of *Olearia axillaris, Rhagodia candolleana*, *Atriplex cinerea*, *Scaevola crassifolia* (Priority species) and *Lepidosperma gladiatum* (Priority species). There is a strong relationship between vegetation and habitats, with ridge floristics different to swale

floristics. The total diversity of the vegetation on the ridges and swales is more complex and diverse than the native vegetation assemblages in Land Parcels "I' & "J". The most significant part of this Land Parcel is the ecological relationship of dune types and vegetation floristics, and that it has the most mixed floristic assemblages that inhabit the beach ridges and swales. Again, these assemblages, with ongoing dune evolution and soil development, can be expected to increase its biodiversity.

At one level each of these Land Parcels is self-contained, and they contribute to the subregional biodiversity through seed transport mechanisms, but from a cumulative perspective they are individually contributing as fragments or as a patchwork of mosaics to the total biodiversity of the dune system.

3) Is it likely that the natural coastal ecosystems including the natural vegetation will be destroyed, damaged or altered as a result of the construction and existence of any part of the Path on the Land (whether in a Dedicated Area or otherwise) ? Describe how and where this would occur and the likely impact on the local ecology and local or regional coastal biodiversity?

The ideal situation is that there should be a natural mosaic of habitats and associated floristic assemblages so that these can form the 'source' for seeds and rhizomatous extensions to colonise newly formed dunes, further evolving and maturing habitats. On the parts of the dunes which will be bordered by a path, or traversed by a boardwalk, the infrastructure will fragment existing mosaics or traverse the mosaics. The natural coastal ecosystems, including the natural vegetation, will be destroyed (they will die), damaged or altered as a result of the construction and existence of a path and boardwalk. This will particularly be the case along the edge of the concrete path or under and alongside the boardwalk The dune terrain that will be impacted by path and boardwalk will be domal dunes, conical swales (with incipient soils), dune crests of beach ridges, swales of beach ridge systems (with more fully developed soils).

There are several ways in which this can occur:

For the concrete pathways: (1) direct destruction of the dunes by path emplacement; (2) no recharge of soil water because of the concrete paving; (3) sheet wash of water during rain from the pathway into the adjoining dune and vegetation thus creating a border zone of overwatering; and (4) potential of weed invasion from the path (the edge effect; *cf*. Pauchard & Alaback 2006).

For the boardwalk: (1) direct local destruction of the dunes by pile emplacement during construction phases; (2) alteration of local dune environment by the piles; (3) sand excavated during pile emplacement likely to be left as a halo around the piles altering the local soil properties; (4) shading of the dune ground by the boardwalk resulting in changing of the floristics (to those more shade-tolerant species); and (5) changing the rainfall pattern and hence hydrology under the boardwalk by creating run-off, rain-sheltered zones, and drip-lines, and preferred infiltration along the interface of the pile and the parent sand.

The impacts will be linear and along the edge of the path and the boardwalk, and of course under the boardwalk. The ecological effect will extend or likely to extend for a metre beyond the edge of the path or the margin of the boardwalk.

Though these impacts will be at the local scale, they will impact on a dune-vegetation of regional to State-wide significance. In terms of regional coastal biodiversity, since the dunes and vegetation of the Semaphore-Grange Coast is distinct from other coasts in South Australia and south-eastern Australia, the floristic degradation/loss of dune vegetation of the Semaphore-Grange Coast will diminish the store of biodiversity elements regionally, that is, the biodiversity of dune vegetation of South Australia resides in different locations with differing habitats characteristics (though there is species overlap) and each is a portion of the whole regional species spool – what is present regionally in the species and their community assemblages is expressed differently structurally, physiognomically, phenotypically, and reproductive strategically in different localities, and loss or degradation of the vegetation of the Semaphore-Grange Coast impacts on the variable expression of the coastal vegetation in the State.

4) What information regarding the Identified Features identified in (2) and generally, is necessary to identify: (a) whether the Path would be likely to preserve and protect the Identified Features and in particular the existing coastal vegetation? (b) The biodiversity value of land comprising the Re-Dedicated Parcels?

Assuming the path will be concrete paving along the east margin of the dune landscape, or a boardwalk along a beach ridge swale (partly Land Parcel "L"), the path is not likely to preserve and protect the Identified Features as identified in (2) because it will be traversing a variety of dune types and, in particular, the existing coastal vegetation – but to be answered more specifically, the question needs site-specific information, locality by locality, on where the path is to be located, aspects that were beyond the scope of this study. However, generally, the system of dunes and its ecosystem are important enough in all their gradations form incipient newly-formed dunes to older dunes and swales to the oldest dunes and swales, and their corresponding vegetation, to conclude that the path will have adverse impacts in all areas (areas I, J & L) where the path or boardwalk will be placed or adjoin. At any rate, as outlined in (3), the path also will have a range of impacts on the vegetation along its periphery and dune forms such as evolving domal dunes and their associated swales

In relation to the biodiversity value of land comprising the Re-Dedicated Parcels, as stated in (3) above, all the vegetation on natural dune landforms is significant because it is not just the richly biodiverse vegetation that is important but the entire range of vegetation community types, viz., the low diversity community on newly formed dunes to moderately diverse communities on older dunes, to the rich fully-diverse communities on the oldest beach-ridge-and-swale habitats. In this context, biodiversity value of land comprising the Re-Dedicated Parcels is significant because each Parcel contributes a different type of fragment to the entire mosaic of the dune vegetation complex, and the entire mosaic (composed of differing assemblages) is significant as a totality. Again, it is stressed that the area of swale where the boardwalk is proposed to be located has the oldest and most diverse vegetation of the dune system.

In regard to whether the path will protect the dunes or the biodiversity, the answer is 'no'.

5) Will the Path be protected from coastal recession and storm erosion in the event of sea-level rise of 0.3 - 1 metres anticipated over the next 100 years?

No. If sea level rises by a matter of centimetres or a decimetre because of 'global warming', larger orbitals of the incident wave trains will arrive at the Semaphore-Grange Coast. A sea level rise of 0.3-1 m will cause massive coastal erosion to as far back as the residential boundary. This is a wave-dominated and wind-dominated coast and natural coastal erosion has been part of this coast for the past several thousand years. Altering the oceanographic setting by raising sea level by even a decimetre will change the wave dynamics.

6) What information would be required to identify whether the Path could be protected from coastal recession in the event of sea level rise 0.3-1 metre anticipated over the next 100 years?

In the light of the discussion in (5) above, there is no way of protecting the path if massive coastal erosion were to occur.

7) In the event of the assumed sea level rise identified in questions 5 and 6, would the Path be at risk of damage or destruction? If so, please identify the nature and extent of the risks of damage or destruction posed to the Path.

Again, the issue of sea level rise is not just that sea level will be at a higher level but rather that more of the wave energy locked in the wave orbitals will reach the shore. Increased wave energy will result in shore erosion. The extent of shore erosion that can take place when sea levels rise was described by Semeniuk (1996a) for an early Holocene record of rising sea level along a bathymetrically complex coast in south-western Australia; a temporary still-stand at 2 m below present sea level resulted in development of a sandy cuspate foreland, and a rise in sea-level from this temporary still-stand to the next higher still-stand completely destroyed the sandy deposit. This example from south-western Australia mimics the sandy terrain of the Semaphore-Grange Coast and provides a model of what can transpire with a sea rising into a sandy coast.

8) What are the risks of damage or destruction to the Path in storm events even if assumed sea level rise were not taken into account?

Storms will occur annually and inter-annually, depending on oceanographic factors. This will be a prevailing factor on a short term and medium term basis. If sea level does not rise over the next decades or within this century, but there is an increase in global temperatures, then it may be anticipated that warmer sea temperatures will drive an increase in storms (Semeniuk 1994, 2012).

If storms erode the dune terrain and remove sand up to the position of the pathway, damage and total destruction of the path cannot be avoided. If storms erode the dune terrain and remove sand up to the position of the boardwalk, damage to the boardwalk and its supporting piles cannot be avoided.

If the storms of previous years were to re-occur in intensity (Figure 30), the concrete path and the boardwalk will be eroded.

9) What likely effect would the potential destruction of the Path have on further coastal erosion and the coastal dune system?

Rocky shores are reflective shores (as discussed earlier in this report). Sandy shores deepening on the steepness of the shore may be dissipative or 'reflective'. If storm and otherwise any other wave action erodes into the concreted pathway, the concrete will break up into slabs perhaps 50 cm to 75 cm in size. Within the shore zone these slabs will act like small-scale mirrors, and while there will not be a concrete wall that the waves will impinge on (from which they would be reflected) the slabs will present themselves as a multitude of smaller reflecting surfaces which will increase the wave energy along the shore (the wave energy being a combination of the incoming wave and part wave energy coming with the partly reflected wave) and increase the shoreline turbulence. The increased wave energy and increased turbulence would keep sand in suspension, which under the effect of longshore currents during the storm, or the effect of wind driven currents, the sand in suspension would be carried out of the eroding area. In brief, the break-up of a concrete pathway would increase the severity of coastal erosion during the storm.

10) Is the proposed construction of the Path in its proposed location, consistent with the Ecologically Sustainable Development ("ESD") principles as set out in the attached City of Charles Sturt Ecological Sustainability Policy? In your views what considerations or risks are relevant to the application of the ESD principles to the proposal?

In the light of the information above, the answer to this question is 'no, the proposed construction of the Path in its proposed location, is not consistent with the Ecologically Sustainable Development principles as set out in the City of Charles Sturt Ecological Sustainability Policy. It particularly does not meet the requirement of (1) Precautionary Principle: acting to avoid serious or irreversible potential environmental harm, despite lack of scientific certainty as to the likelihood, magnitude or causation of that harm; (2) inter-generational equity: meeting the needs of the current generation whilst planning for and not compromising the needs of future generations to meet their needs; and (3) Biodiversity: protecting and enhancing biodiversity.

The loss of dune functions along the pathway edge, or the small-scale impacts on the dunes through the boardwalk, and the alteration of dune floristics by alteration of water regimes and shading will impact and alter a dune/vegetation complex that is of regional to State-wide significance. These factors also relate to inter-generational equity, in that future generations will not be able to experience, or research or learn from a dune/vegetation complex if there has been an increase in its alienation.

A specific conclusion in relation to this question of whether the proposed pathway (of concrete path and boardwalk) conforms with Council policy is that the location of the concrete path and boardwalk, and particularly the boardwalk, is in oldest, most diverse habitat where the vegetation is in good condition and the terrain show the best example of this vegetation. Thus, the answer to whether the proposed pathway conforms to Council policy is 'no'.

There is another perspective that should be presented: that is, that the dunes comprise a physical side (*i.e.*, the dune types, and their interrelations and evolution), and a biological side (*i.e.*, the range of floristic communities that reflect the various developing habitats as the dunes and soils evolve). Coastal dune protection needs to address both the variety of dune types and the variety of vegetation types.

To many non-scientific personnel, the dunes of the Semaphore-Grange Coast are seen as 'just sand dunes' and there would not be an appreciation that the dunes and vegetation of this Coast is geomorphologically and ecologically different from that of the Younghusband Peninsula. To the geomorphic scientist and to the ecologist, these dune systems are distinctly different (as discussed earlier), and the State-wide distinct assemblages of dune types of the Semaphore-Grange Coast even though fragmented are significant and need to be protected. This is particularly the case as this dune system is so proximal to Adelaide.

11) Would any impacts identified above be avoided or mitigated by the construction of a path from different materials, or in a different location?

The answers to 'different materials, or in a different location' is provided below.

Some of the impacts noted above can be avoided if the pathway were to be constructed of consolidated (packed) limestone rubble. If a storm were to erode into this type of material, the path would break up into pebbles and coarse sand instead of concrete slabs, effectively removing the function of a series of "small mirrors" and reducing the effect of reflected waves and the increased turbulence. The break-up of a consolidated path to the beach during a storm is illustrated in Figure 46.

Figure 46: Storm damage at coast at Hillview St 2009; the consolidated path to the beach has been broken into slabs, each acting like a mini rocky shore.

In relationship to the boardwalk, it would be best *if it were not to be located through a swale* of a beach ridge system because, as described above, with the beach ridge and swale system, the swales support of the vegetation with the greatest biodiversity.

If the pathway is to be constructed, it would be best located along the herb-and-grass buffer zone at the edge of the residential area, and it would be best constructed of consolidated (packed) limestone rubble. There should be no boardwalk.

On Sheet map #5 Coast Park Path Alignment, the proposed path passes in front of residential blocks, then through the Tennyson Reserve, and returns to bordering the residential blocks in Land Parcel "L". If there has to be a path or boardwalk constructed in the coastal sector of Land Parcel "L" then the most reasonable place for the path (or boardwalk) geomorphically, habitat-wise, and ecologically is against the edge of the residential blocks. However, the entire length of Land Parcel "L" is not suitable for this construction because some parts of it are too narrow, *i.e.*, there is not enough space between the residential blocks and the linear swale for the width of the path – it would require land modification such as landfill along the western edge of the existing path to accommodate the proposed path.

Where the terrain is too narrow for the proposed pathway, the path itself could be constructed in a narrow form and this would entail signage to alert users to this matter.

The engineers, in designing this path, will need to know the width of terrain available, dune dynamics, and micro-relief of the terrain before decisions on location and type of path are made.

12) Set out the current nature and condition of the coastal dune System (in terms of their soils and substrate, shape and formation) and the coastal vegetation in the following areas:
12.1) the area commonly known as the Tennyson Dunes Reserve ("TDR") (which area is situated between the areas proposed to accommodate the coastal path the subject of these proceedings); and 12.2) the areas to the north and south of the TDR which are proposed to accommodate the coastal path the subject of these proceedings, and in particular in the area where the boardwalk is proposed to be constructed.

In the of the area of the Tennyson Dunes Reserve the shape and formation of the dunes is variable depending on the location – (a) the high-relief dune core is a linear ridge whose crest is hummocky and undulating, with sand slopes and local mounds of sand (dome dunes); its soils/substrates are sand with no soil development, or very weakly developed humic soil; its vegetation is dominated by a range of shrubs and heath and is floristically diverse; (b) the beach ridge system consists of ridges of sand (that are hummocky to undulating along the crest, again with soils/substrates that are sand with no soil development, or very weakly developed humic soil) alternating with swales (linear depressions) of sand that are hummocky to undulating along the trough, with soils/substrates of weakly developed humic soil; its vegetation is dominated by a range of heath plants and is floristically diverse but less diverse than the high-relief dune core; (c) the seaward beach ridge and the foredune comprise a linear ridge whose crest is hummocky and undulating, with sand slopes and local mounds of sand (domal dunes); its soils/substrates are sand with no soil development, or very weakly developed humic soil; its vegetation is dominated by a range of scattered heath plants and grasses, and floristically is of relative low diversity.

The coastal dune belt to the south of the Tennyson Dunes Reserve has had its high-relief dune core developed for housing and, as such, has been destroyed. However, two to three beach ridges and a foredune in this sector of coast that conform to the description of (b) and (c) above, with the caveat that the swales appear to be floristically more diverse than those in the Tennyson Dunes Reserve (this was the impression obtained by the reconnaissance survey, but there was no quantification of the plant diversity to substantiate this preliminary observation).

The area to the north of the Tennyson Dunes Reserve is a markedly different system: its high-relief dune core has been developed for housing and has been destroyed, and its most eastward part has remnants of the original beach ridge and swale (one ridge, or half a ridge and portion of a swale). In this context, the remnant has the morphology, soils, and vegetation of the landward parts of (b) above; however, its central and seaward portions have been perturbated. The central and seaward part commonly is a man-structured dune system consisting of a broad, low, and even-surfaced ‘dune’ inhabited by *Spinifex hirsutus* and marram grass, bordered to the east by a depression (an artificial depression where the man-structured constructed dune meets the former dune terrain), and to the west by active modern accreting dunes and a foredune; the substrate on the man-structured dune is soil-free.

In this context, the Tennyson Dunes Reserve and the coastal dune belt to the south of the Tennyson Dunes Reserve are the most natural in the region, and the area to the north of the Tennyson Dunes Reserve is largely disturbed and artificially developed. However, it should be noted that the dune terrain adjacent to the west of the proposed path can be relatively intact in terms of dune forms and vegetation.

13) Will the proposed path accord with the objectives of the Council's Community Land Management Plan[1] ("CLMP") to "protect the coastal dune system and coastal vegetation and to provide convenient and controlled public access to the beach and environs"? (Adopted by the Council on 26 April 2016 in agenda item 6.44 [see attached and Brief Tab 8]). In answering this question, particularly consider and address the following matters:

13.1) the effects of the proposed coastal path on the dune soils and substrate and the dune shape and formation;

The proposed boardwalk will not accord with the objectives of the Council's Community Land Management Plan – it will perturbate the landforms and soils of the swales, in an area of swale that is the oldest and most diverse part of the dune system as described above. Its impact will involve 5 m of perturbation as described earlier.

The proposed concrete path, where located on the wide parts of the 'lawn' buffer zone along the edge of the residential area, will have minimal impact on the dunes and soils but where it interfaces with remnants of the old dune system it will affect the landforms and soils vegetation through edge effects and through land-filling; these effects will occur along the oldest most diverse part of the dune system where dune (beach ridge) crests and swales abut the proposed concrete path.

13.2) the effects of the proposed coastal path on the coastal vegetation;

The proposed boardwalk will not accord with the objectives of the Council's Community Land Management Plan – it will perturbate the vegetation of the swales, in an area of swale area that is the oldest and most diverse part of the dune system as described above. Its impact will involve 5m of perturbation as described earlier through construction phase, sand halo of waste material, shading, alteration of rainfall patterns, alteration of recharge, and drip lines.

The proposed concrete path, where located on the wide parts of the 'lawn' buffer zone along the edge of the residential area, will have minimal impact on the vegetation but where it interfaces with remnants of the old dune system it will affect the vegetation through edge effects and through land-filling; the path will alter the edge run-off and alter hydrological recharge, and where there is land-filling to support the path, alter the soils; these effects will occur along the oldest and most diverse part of the dune system where dune (beach ridge) crests and swales abut the proposed concrete path.

13.3) the direct effects of the removal of the plants identified in the report prepared by Kelly Mader dated 20 October 2016 and the associated vegetation assessment mapping;

The direct effect on plants identified in the report prepared by Mader (2016a) is their removal and destruction, thereby decreasing the diversity of the plant community in the local area of the boardwalk or the concrete path.

13.4) the effect of the proposed boardwalks on the relevant sections of coastal vegetation underneath and adjacent to the proposed boardwalk even if that vegetation is not being directly removed;

As discussed above, the effect of the boardwalk along its length will be shading, sand halo effects and changing the soils, altered rainfall paters, and drip lines. These will be experienced soon after emplacing the boardwalk or some years later - at any rate, whether the response is in the short term or in the longer term, the effect will be a fundamental change in the plant community - from one that was exposed to the Sun to another that has to adapt to shade and altered rainfall conditions.

13.5) the importance, condition, age and biodiversity value of the dune and vegetation in all areas affected by the proposed coastal path (including the boardwalk);

To answer this question robustly, one would need to devise a scale of condition appropriately designed for this area, a scale of community importance (similar to the Geoheritage Significance scale shown in Figure 5) also appropriately designed for this area, determine the age of the dune and soil by radiometric dating, quantify the biodiversity of the vegetation, and quantitatively compare it to other vegetation in the Semaphore-Grange Coast and elsewhere. This was not possible within the constraints of this study. However, what can be and has been provided as an answer to this question is an overall assessment of the importance, condition, age and biodiversity value of the dune and vegetation in all the areas that the boardwalk and concrete path are to be placed. It is my opinion that, except for local areas where the dunes and vegetation along the current buffer zone adjoining the residential areas are degraded, all areas of the dunes and vegetation are important, in good condition, and have biodiversity value in the context of the concepts described above on the importance of fragments contributing to the dune-and-vegetation complex as a whole.

13.6) the utility or otherwise of any replanting programs in remedying any likely damage or alteration to the dunes or the vegetation caused by the path;

This is a question that does not have a simple answer. Once the edge of the path and the main part of the boardwalk have altered both the soil and the hydrological properties of the dune terrain, it is probably futile to attempt replication of the community by replanting . Initially, there needs to be a study of which plant species can tolerate the altered condition. Those that cannot tolerate the altered conditions will not survive replanting, and those that can tolerate the altered conditions will be successfully replanted. But at any rate even if replanting is successful, the community that will be replanted will not the community that previously existed along the pathways.

In terms of damage to the dunes, different species of plants form associations or assemblages. Disturbance of an assemblage may disrupt root structures, humus production, and species competition, and as a result of these changes may alter the stability and shape of some areas.

13.7) the extent of damage caused by utilising current informal access paths (which may no longer be used if the path is constructed), compared to the damage likely to be caused by the proposed path;

There are two types of paths in this region: those that are shore-perpendicular and that provide access to the beach from hinterland car parks, and those that have been created by random wanderings. For the former, most people keeping to the shore-perpendicular pathways are creating minimal damage. For the latter, in the context of wind deposition and mobile sand, while there is some damage in the short term from people wanderings, the damage is short term and soon erased. It should be noted, though, in this context, the beach ridge and swale terrain in southern areas, south of the Tennyson Dune Reserve, is generally in good condition.

13.8) any other matter you consider relevant.

I have covered all relevant points.

14) In having regard to the answers in (13), above, is the proposed path in accordance with the following policy/proposal for the management of land in the CLMP, namely to "support measures to protect, stabilise and refurbish the coastal dune system"?

In the light of the information provided throughout this report and specifically the information provided in answers to thee questions 1-13 above, I do not believe that the proposed path is in accordance with the following policy/proposal for the management of land in the CLMP, namely to "support measures to protect, stabilise and refurbish the coastal dune system".

15) Having regard to the answers in (13), above, in your opinion will the proposed coastal path protect the coast in that area marked "J" and "L" on the path alignment plans (as updated)?

If this question means ‘protection of the coast’ from storms, that is, ‘will the proposed coastal path protect the coast from coastal processes’, then the answer is ‘no’. If coastal erosion in the future is so that marked that it encroaches landward to the extent that it removes all the beach ridges (as it has nearly did in the recent past in the northern area), then such erosion will remove the concrete path and the boardwalk.

If this question means ‘protection of the coast’ in terms of its dunes and vegetation, then the answer is ‘no’, though establishing pathways in environmentally acceptable locations will tend to channel random walking and help remove informal accessing of the beaches (*i.e.*, it will manage indiscriminate trampling by people walking across the dunes). As described above, the edge effects of the concrete path, any terrain modifications to support the concrete path, and all aspects of the construction and ongoing existence of the boardwalk will impact on the dunes and vegetation and, in this context, the proposed coastal path will not fully protect the coast in that area marked "J" and "L" on the path alignment plans in terms of its geomorphology and vegetation ecology.

Summary and conclusions

The essence of this report can be summarised into six main conclusions:

1. any excavation or dredging of sand from the southern part of the Semaphore-Grange Coast or south of the Semaphore-Grange Coast for use in replenishing sand for more northern parts will exacerbate coastal erosion; more wave energy of south-westerly derived wave trains will reach the shore of the central beaches;

2. the biodiversity of the dunes is significant and it should not be viewed and assessed in terms of the isolated fragments in the dunes but rather as parts of a holistic sum of the various mosaics;

3. the paths and boardwalk are proposed to be placed in the oldest, most complex, and most biodiverse parts of the dune terrain of the Semaphore-Grange Coast;

4. the proposed concrete path and boardwalk will not protect or preserve the dunes or the ecosystems from coastal erosion;

5. the proposed concrete path and boardwalk will not protect or preserve the dunes ecologically;

6. the boardwalk in the swale will located in the habitat that is more complicated and show more biodiversity than other parts of the dune terrain, that is, the boardwalk in fact will perturbate the dune in one of the most important parts of the system, *viz*., the landward swale which is the oldest most biodiverse part of the dune ecosystem; therefore the boardwalk will have more ecosystem and geomorphic impacts than a path located along the eastern edge of the dune terrain.

Declaration

I have made all enquires that I believe to be desirable and appropriate, and no matters of significance that I regard as relevant have to my knowledge been withheld from the Court.

Dr V Semeniuk
6th April 2017