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30 January 2012

Dear Mr. Dr. H

**REVIEW OF DELTARES REPORT ON RESTORATION MEASURES IN THE WESTERSCHELDE**

Thank-you for your letter dated 19 December 2011 and the various attachments that were sent subsequently (as detailed in Attachment 1 to this letter). You asked me to consider “whether the measures proposed in the Deltares report can be expected to result in the effects also described in the report”. In subsequent exchanges it was made clear that this should focus on the scientific merit and that this should be done with regard to the conservation objectives as they are currently stated. The advice provided below is therefore focussed on the Deltares report, as scoped, and this advice should not be interpreted as providing any view on the adequacy, or otherwise, of the measures in the context of the Habitats Directive and in particular the restoration of favourable conservation status.

The removal of the Hertogin Hedwige polder had been proposed as a measure to contribute to the restoration of the estuary by providing 295 ha of estuarine nature. More specifically this contributed directly to the conservation objective for estuaries (H1130) which is to “Extend surface area and improve quality”. In response to public concerns about the flooding of this and other polder areas in agricultural use around the estuary, alternatives were sought and the Deltares report considers measures that might be adopted both inside and outside the dikes. These fall broadly into three types of option:

- (i) Removal of dikes to flood areas that are currently protected and so extend the area of the estuary;
- (ii) Process focussed measures to reduce the impact of the tides;
- (iii) The adjustment of the balance of eco-morphological areas (referred to as ecotopes) within the estuary.

It is clear that the first of these contributes directly to the conservation objective by extending the surface area of the estuary. The other two measures rely on their contribution to the structure and function of the estuary in the determination of whether these do indeed constitute positive measures in preventing the deterioration of natural habitats (Art 6.2).

For the second option it is shown that such measures could have a beneficial impact on the tide but it is concluded that because the approach entails major interventions and there are currently a great many uncertainties, this option would take a long time to promote. This is considered to be inconsistent with the requirements of Art 6.2 of the Habitats Directive to provide a more immediate response. I would also suggest that to determine the adequacy of such measures requires a clear (process based) understanding of what constitutes favourable conservation status (or a suitable contribution to favourable conservation status of this Natura 2000 habitat within the context of the



bio-geographic region) that would avoid (or limit) any further deterioration of the natural habitats that the estuary supports. However, as these measures do not form part of the Government's current proposals, I have not examined them in detail. I simply note that the initial investigations are well founded and that I agree that more detailed studies are needed to establish (a) the viability of such measures and (b) the contribution they might make to the Natura 2000 site.

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Although ecotope areas provide a useful starting point, it is not the case that they necessarily provide a suitable basis for judging deterioration within an estuary. This is because changes in ecotope areas are to be expected as part of the natural response to changes, such as sea level rise, that underpin the genesis of an estuary. Hence, one cannot consider the structure and function of an estuary, in eco-geomorphological terms, without due consideration of the dynamics of the system. Whilst the long-term genesis and present day dynamics of the system are considered in some detail (Annex A to the main report) there is no link made to the extent of different habitats that the estuary should or could support. Without this foundation, the basis for making such judgements is the change in areas relative to some arbitrary point in time. In the context of the Habitats Directive, this is taken to be when the site was proposed as a Site of Community Importance, which I understand was 2004. This is therefore the basis on which the Deltares report examines the measures for the third option noted above and the basis I have used for my own evaluation, as requested.

The Suitability Of The Measures Proposed Under Options (I) And (Iii).

Option (i) – Removal of dikes.

Over the course of the Holocene, the estuary has evolved from a drowned coastal plain to funnel shaped macro-tidal estuary, as summarised in Appendix A. The Deltares report notes the importance of the network of channels as a characteristic feature of the estuary. Some of this complexity derives from the side channels that were part of the estuary as recently as 1800 but have now largely been reclaimed from the estuary. There are five such areas that are notable in their contribution to the estuary form, namely Sloe, Braakman, Hellegat, Kreekrak and Vedronken Land van Saeftinghe (Fig 2.5 in Annex A). It is reasonable to assume that the partial or complete reinstatement of any of these areas would contribute to maintaining some of this complexity, as well as quite obviously extending the areal extent of the estuary. Whilst the Hertogin Hedwige polder scheme sought to extend the last of the five areas noted, the measures proposed in the Deltares report are located in three of the other four areas (no extension of estuary area is proposed in the vicinity of Hellegat). These are therefore likely to be of wider benefit. In the context of the wider estuary, they are also of a relatively small size (maximum extents of 0.4% at Appelzak; 0.6% at Sloe; and 1.9% at Braakman) and it should be possible to minimise any negative impacts on the estuary as part of the detailed design.

It is also worth noting that for an estuary subject to sea level rise and therefore undergoing landward migration (marine transgression), the accommodation space available will influence the dynamics of the system (Townend et al, 2007). Estuarine accommodation space is the volume available for sediment or water storage in an estuary. Detailed geological analysis in other estuaries suggests that during periods of limited accommodation space, extensive sparsely vegetated sand or mud flats are a characteristic feature of the estuary, and salt marshes are uncommon. In contrast, where the accommodation space is increasing with time, the conditions are more conducive to a stable channel alignment with the potential for intertidal areas to develop marsh vegetation. All of the schemes proposed under this option serve to expand the accommodation space and, following this concept, should help to stabilise intertidal areas.



It is noted that no detailed design has been done on any of the schemes proposed and that what is being considered in the report is the potential feasibility of the various sites. Some indication of the main risks to successful implementation is however provided.

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#### Appelzak Scheme

This scheme has the merit that the area is fronted by an extensive shallow area and is away from the apex of the channel meanders, although a secondary channel does run relatively close to the shore. As the intertidal (mud flat as defined in the report) is a narrow linear strip, any landward extension of this area is likely to be beneficial, although this will require the removal of the dike along the entire length. Given the rapid necking of the estuary immediately upstream, providing additional accommodation space in this area is likely to be beneficial. A number of risks are noted and these, together with local concerns (golf course etc) may make this option difficult to promote. Nonetheless, from a scientific point of view, a suitably designed scheme is likely to contribute positively to the conservation objectives of the site.

#### Western Scheldt Container Terminal Compensation Site

The details of the scenarios considered are not given in the report but it is noted that if the Schorer and Welzinge polders are opened up to tidal exchange about 151 ha of intertidal habitat would be added. This would be a valuable contribution in terms of estuary area and accommodation space. However, if a regulated tidal exchange scheme<sup>1</sup> were to be adopted, this would only contribute to the extension of habitat area and, as such, would be much less valuable. The biggest risk at this site would appear to be the fact that the site is already identified as potential compensation for the WCT. Finding alternatives in reasonable proximity may present the port owners with a major challenge, so the successful negotiation of an agreement would appear to be main obstacle for this site. Again, from a scientific point of view, a suitably designed scheme is likely to contribute positively to the conservation objectives of the site.

#### Braakman-Noord Scheme

This scheme offers the greatest potential to increase accommodations space within the estuary, if full tidal exchange is re-established, through a tidal creek of some form. As for the

WCT scheme, options for regulated tidal exchange, whilst extending the area of saline influence, would have considerably less value in terms of the eco-morphology of the estuary. The risks identified appear significant; in particular the interaction with other conservation designations and the need to address the interests of the local community (see Scott et al, 2011 for a summary of comparable UK experience). Nonetheless, as the Deltares report concludes, the complete removal of the Braakman-Noord polder (allowing unrestricted tidal access) would make the largest contribution to process restoration. I would concur that, of the schemes considered, this measure is the preferred alternative on the basis of eco-morphological criteria.

#### Option (iii) – Adjusting the balance of ecotopes within the estuary.

An evaluation of these options is more difficult because there is no direct contribution to the conservation objective to extend the area of the estuary. The measures rely on the assumption that maintaining ecotope areas is consistent with a positive contribution to the structure and function of the site. The limitations of this assumption have already been outlined.

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<sup>1</sup> Also referred to as Controlled Reduced Tide (CRT).



Working with this assumption it is necessary to understand what is changing. The data provided in Figure 3.8 allows the changes in the different ecotopes at a broad scale (decadal and estuary wide) to be identified. Having reviewed this carefully (working notes available on request), I concur with the interpretation set out on p32 of the report, which I would summarise as follows for each of the main ecotopes:

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Salt marsh	Decline to 1977, explained by developments in the estuary. Area has since been relatively stable, with some expansion of the pioneer species.
Sand bars	Increase in area to 1977 with a subsequent (accelerating?) decline. The rate of loss is greater in the low-dynamic area, although over the last time interval this can be explained by the expansion of salt marsh on the top of the sand bars.
Mud flats	Decline to 1977, explained by developments in the estuary. Since 1977 the area has been relatively stable, albeit with a small progressive loss of low-dynamic area being almost matched by an increase in high-dynamic area. In the last interval (2004-08) there is then a marked increase in the switch between low and high-dynamic areas.
Shallows	Having decreased in area over the interval to 1996, this area has been relatively stable and over the most recent interval exhibited almost no change.
Deepes	Steady increase in area over the entire period, at a rate that has varied between 15 and 45 ha/yr for the various time intervals mapped.

In addition, I noted that the rate of loss of sand bar and shallows combined more or less matched the rate of gain of deep water until 2004. In the most recent interval, the former was substantially greater and this appears to be due to the recent development of salt marsh areas on top of the sand bars. This is relevant because it suggests that the expansion of deep water has been taking place at the expense of the sand bars and shallows without significantly affecting the mud flats; at least until the most recent interval.

The switch between low and high-dynamic mud flat is visible when comparing the 2004 and 2008 ecotope maps. As noted in the report, several of these occur along the margins of the deep water channel and may reflect a local change in the system dynamics (eg. migrating channels). However, the most extensive loss (at least visually from the plots) would appear to be in the Speelmaansgat and Ijskelder creeks that form part of the Vedronken Land van Saeftinge marsh. Whilst this may be a response to local channel dynamics, it could equally reflect a system adjustment to correct ebb/flood dominance as part of the ongoing marine transgression in response to sea level rise.

The conclusions that are then drawn in the report from this analysis seem a little curious. The report infers that further consideration is not given to restoration of the sand bars because the “decreasing trend is attributed to changes in the Western Scheldt itself” (p34). I would suggest that this line of argument may also apply to the changes in mud flat.

The report goes on to note that “no physical explanation has yet been found for such a substantial conversion of low-dynamic to high-dynamic mud flats”. I completely agree that this finding is entirely dependent on one data point and that the source information should be carefully reviewed before undue weight is placed on this finding. As the report notes, without this data point one would conclude that the mud flat areas have been relatively stable over recent years.



What seems odd is that the report then concludes (last sentence on p34) "that the task of nature restoration is more urgent in the low-dynamic mud flats than for the area of salt marshes and pioneer vegetation". This seems a little bizarre on two counts. Firstly, as already noted, there is a great deal of uncertainty attached to the conclusion about the changes in the mud flat areas and secondly that the conclusion completely ignores the sustained and clear loss of sand bars.

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Within the context of the broader management of the estuary the loss of sand bar area is being addressed through the disposal of dredging. Since 1970 the dredged volume has varied between 8 and 15 Mm<sup>3</sup>/yr and in recent years some of this material is being placed along edges of the sand bars to restore surface area of these features (p42 and Fig 4.2). It is too early to tell whether this will be sufficient to counter the ongoing loss of sand bar area.

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One may therefore conclude that some work is in hand to address the ongoing loss of sandbars and that a comparable effort is needed to address the change in mud flat areas (if this is indeed taking place). The measures outlined in the report seek to do this. Given the conclusions of the report I would consider it essential that, as a first step in developing these proposals, careful attention should be given to confirming the recent changes and, if possible, updating the analysis with more recent data to establish whether this a continuing trend.

The measures proposed are now assessed on the assumption that they are addressing a real need. As with the option (i) schemes, the Deltares report seeks to identify the feasibility of potential sites and associated risks, noting that further studies are need to confirm their viability.

#### Appelzak

The scheme is located a reasonable distance from the main channel but on the line of one of the secondary flood channels. Given the overall area of shallows this extension appears to be feasible. However an extensive list of risks is noted. Of these, the narrowing of the overall channel section at what is in any case a "pinch point" in the estuary, with implications for both the main channel and the Saefinghe salt marsh, are probably the most critical. To this extent, it is worth noting that this scheme is counter to the previous suggestion of removing the Hertogin Hedwige polder, which would have increased the cross-section in this heavily constrained part of the estuary. I would conclude that this scheme is worth considering in more detail, whilst recognising that it may not be viable, or it may only be possible to realise a smaller area without introducing unwanted impacts.

#### Hulst Mud Flats

This site is immediately adjacent to the main channel and opposite the outfall of the (secondary) flood channel. It is therefore likely to be subject to highly dynamic conditions, which mean that stabilising the shore in the manner proposed is likely to require ongoing reinforcement. Some nourishment at this site may have the added benefit of helping to protect the existing dike but without some structural measures it is likely to require ongoing re-nourishment rather than a one off measure.

#### Terneuzen

This site is also alongside the main channel but this time opposite a flood and ebb short-circuit channel, which is likely to have less impact. The site is also in the outer part of an embayment formed by the dikes. By narrowing the channel, this scheme may be a useful counter measure to the main channel deepening that has occurred elsewhere. How stable the outer face will be is probably the most critical issue and will determine the areal extent of any new area. This is recognised and it is suggested that it may be necessary to reinforce the side of the channel with hard material. Whilst this



may achieve the desired result in terms of this measure, this may also artificially fix the apex of the meander which may have repercussions elsewhere in the system.

#### Zimmermanguel Channel

This option seeks to move the channel away from the shore, with the expectation that the near shore area will develop as mud flat at the expense of some high-dynamic sand bar that forms the existing Valkenisse Oost. This scheme has previously been rejected and Deltares remain of the view that this is a high risk option. Whilst moving the channel may be feasible it is not clear what the outcome would be. The wider shore connected intertidal may lead to the development of low-dynamic mud flat. Equally, the presence of the secondary channel may lead to the rapid reversion to high dynamic mud flat or even additional sand bars. So whilst attractive because of its distance from the main channel, further work is needed to confirm what ecotopes would actually be delivered by this scheme.

#### Ossensisse Sand Bars

This scheme seeks to infill a secondary channel and create low-dynamic sand bar, rather than mud flat. Whilst desirable in the context of estuary wide changes (see discussion on what is changing above), this scheme does not contribute to the stated objective of increasing low-dynamic mud flat. Nonetheless, the scheme would appear feasible, although the report notes the scheme is conditional on other plans being developed by the Province of Zeeland.

#### Gat Van Borssele Channel

This site has some similarities with Terneuzen being in a shallow embayment relative to the secondary channel that runs close by. The scheme is also likely to benefit dike safety, as noted, but may require ongoing replenishment or structural reinforcement to limit the impact of wave action. This again leads to some uncertainty over the extent of low-dynamic mud flat that would be created.

#### Summary of Option (iii) Measures

Overall, the schemes proposed all have a range of uncertainties which makes determination of the net benefit difficult to estimate. From the information presented, I would expect that some of these schemes will drop out during the detailed design stage; the measures at Hulst and Zimmermanguel seem to me to be of the most questionable net benefit. I would therefore agree with the conclusion that although, taken together, these measures could increase the low-dynamic areas in the estuary by between 260 and 420 ha, the outcome is likely to be towards the lower bound because of the difficulties inherent in delivering this type of scheme.

Given that three of the schemes were then eliminated on cost grounds, the total contribution is reduced to between 110 and 180 ha. With the difficulties noted, I remain of the view that the outcome is likely to be closer the lower bound. The figures given here relate to the physical areas that would be created. A weighting factor has been applied to these values to take account of (a) the ecological value of the new habitat relative to what is already there and (b) the additional uncertainty at the complex sites. This reduces the areas to 90 and 210 ha for all six schemes and 40 and 100 ha for the three that are included in the Government proposals.

I do not understand the purpose of the weightings, as there are no targets specified, simply a desire to find alternatives to the Hertogin Hedwige polder option (which is not directly comparable because this scheme would have expanded the estuary area in an unspecified manner) and reverse the recent losses in particular ecotopes. If considered in the context of the Habitats Directive, the requirement is for a contribution to the maintenance of the site, or a reversal of any deterioration (Arts 6.1 and 6.2). If the changes over the period 2004-08 are taken as the baseline, this points to a loss of low-dynamic mud flat area of some 650 ha. The proposed measures clearly do not restore what has seemingly been



lost but they do make a positive contribution to their restoration. I therefore conclude that the schemes could deliver an extension of low-dynamic area of around 100 ha. Trying to estimate the

ecological value of this relative to what currently exists is, in my view, a waste of time whilst the conservation objectives are simply framed in terms of areal extent. Only when the measures are related to their influence on the structure and function of system can any worthwhile judgement be made on their ecological value as part of the estuary habitat.

Observations on the Government Proposals and the Exchange with the European Commission.

Scientifically, I consider the advice provided by Deltares to be sound. It is based on a substantial body of background knowledge. The identification of a range of measures is outlined and care is taken to identify the potential risks. The limited scope of the report and the preliminary nature of the findings, particularly in relation to the specific measures, are clearly documented.

The Government proposals draw on but do not adhere to the recommendations of the Deltares report, presumably because of the need to take account of a number of other considerations, other than just the scientific advice. Based on my evaluation of the measures that are proposed by the Government, I conclude that, if delivered as outlined in the report, these will contribute positively to the conservation objectives of the site. Whether the proposals of the Government provide sufficient in the face of the requirements is then a matter of judgement and, possibly, legal interpretation. If the objective is deliver an area equivalent to that provided by the Hertogin Hedwige polder, then this would not be achieved by the measures that constitute Phases 1 and 2 but might be achieved through the introduction of further measures in Phase 3.

Regarding the Annex attached to the Commission's letter dated 13 October 2011, I would make three observations.

- 1) The proposals are said to be an alternative to the Hedwige polder. Whilst this may be the case in the context of OS2010, in the context of Arts 6.1 and 6.2 of the Habitats Directive, it seems to me that the Government is simply seeking measures that will contribute to a reversal of the reported deterioration of the natural habitats. Any comparison with the scheme that has now been withdrawn is therefore irrelevant.
- 2) I do not understand the suggestion that the measures at Appelzak will have a negative impact on the marshes (H1310 and H1330). If anything I would expect the measures to potentially be beneficial to the marshes on the Appelzak shore. The risk to the Saeftinghe marsh is noted in the report.
- 3) The proposals to open the Shorer and Welzingen polders are criticised because they are in a different ecological zone. Whilst point (1) is again relevant, it is also the case that such an assertion is on the basis of maintaining or enhancing the distribution of habitats that have largely been determined by where past reclamations have taken place, rather than determining what the estuary can realistically support. A point I have already made in my general comments at the beginning of this letter.



HR Wallingford

The above advice seeks to address the question posed. I would be happy to provide further clarification on any of the points raised, should this be necessary. Whilst drafting this advice, I have inevitably given some thought to the more difficult issue of the long-term restoration of structure and function in the estuary and I would be happy to discuss the issue with you, or your advisors, if considered appropriate.

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Yours sincerely

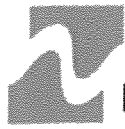
PROFESSOR IAN H. TOWNEND  
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References

Scott CR, Armstrong S, Townend IH, Dixon M, Everard M. 2011. Lessons learned from 20 years of managed realignment and regulated tidal exchange in the UK, In: ICE Coastal Management 2011, ICE, London, pp. 1-10

Townend IH, Wang ZB, Rees JG. 2007. Millennial to annual volume changes in the Humber Estuary, Proc.R.Soc.A, 463, 837-854.





ATTACHMENT 1 - SCOPE OF WORK

NATURE RESTORATION IN THE WESTERN SCHELDT ESTUARY

Review of report 1204087-000-ZKS-0030 Nature restoration in the Western Scheldt: a further exploration of the possibilities

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The requirements for the review are detailed in the letter Mr. Dr. J.P. Hoogeveen to Professor I.H. Townend dated 19 December 2011. The letter sets out a brief summary of the issues to be addressed and requests a review "of whether the measures proposed in the Deltares report can be expected to result in the effects also described in the report." In addition to the main Deltares report a number of other documents have been referred to in the course of the review.

DOCUMENTS EXAMINED IN COURSE OF REVIEW:

- 1204087-000-ZKS-0030 Nature restoration in the Western Scheldt: a further exploration of the possibilities, 2011
- 1204087-000-ZKS-0049 Appendix A: Natural restoration in the Scheldt estuary via the improvement of the large-scale physical processes, 2011
- 1204087-000-ZKS-0036 Appendix B: Ecotopenkaarten, 2011.
- Deltares report, Tidal Phenomena in the Scheldt Estuary, 2010.
- MvEZLI letter to De Voorzitter van de Tweede Kamer der Staten-Generaal, dated 17 June 2011.
- European Commission letter of response dated 13 October 2011.
- Natura 2000 Standard Data Form for the Westerhelde.
- Projects development outline 2010 Scheldt estuary (spreadsheet of projects)
- Conservation objectives Natura 2000 site Western Scheldt & Saefinghe
- 120110 - vragenlijst Townend.doc and 120112 - vragenlijst Townend.doc – response to queries raised in the course of the review.
- A Dutch Ecotope System for Coastal Waters (ZES.1), To map the potential occurrence of ecological communities in Dutch coastal and transitional waters, Report RIKZ/2005.024, July 2005.
- Papers from the published literature.