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WEYMOUTH FLOOD RISK MANAGEMENT STRATEGY

FINAL REPORT – June 2010

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WEYMOUTH FLOOD RISK STRATEGY REPORT

Final Report – June 2010 v5

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These reports are not intended to be exhaustive; normally they provide an initial estimate of the costs and benefits associated with an option to address the identified problem. The viability of a preferred option is also indicated. It is important to note that a limited number of options are considered at Strategy stage.

Please note that no guarantees can be given at this stage that a scheme or works will ultimately be undertaken by the Environment Agency.

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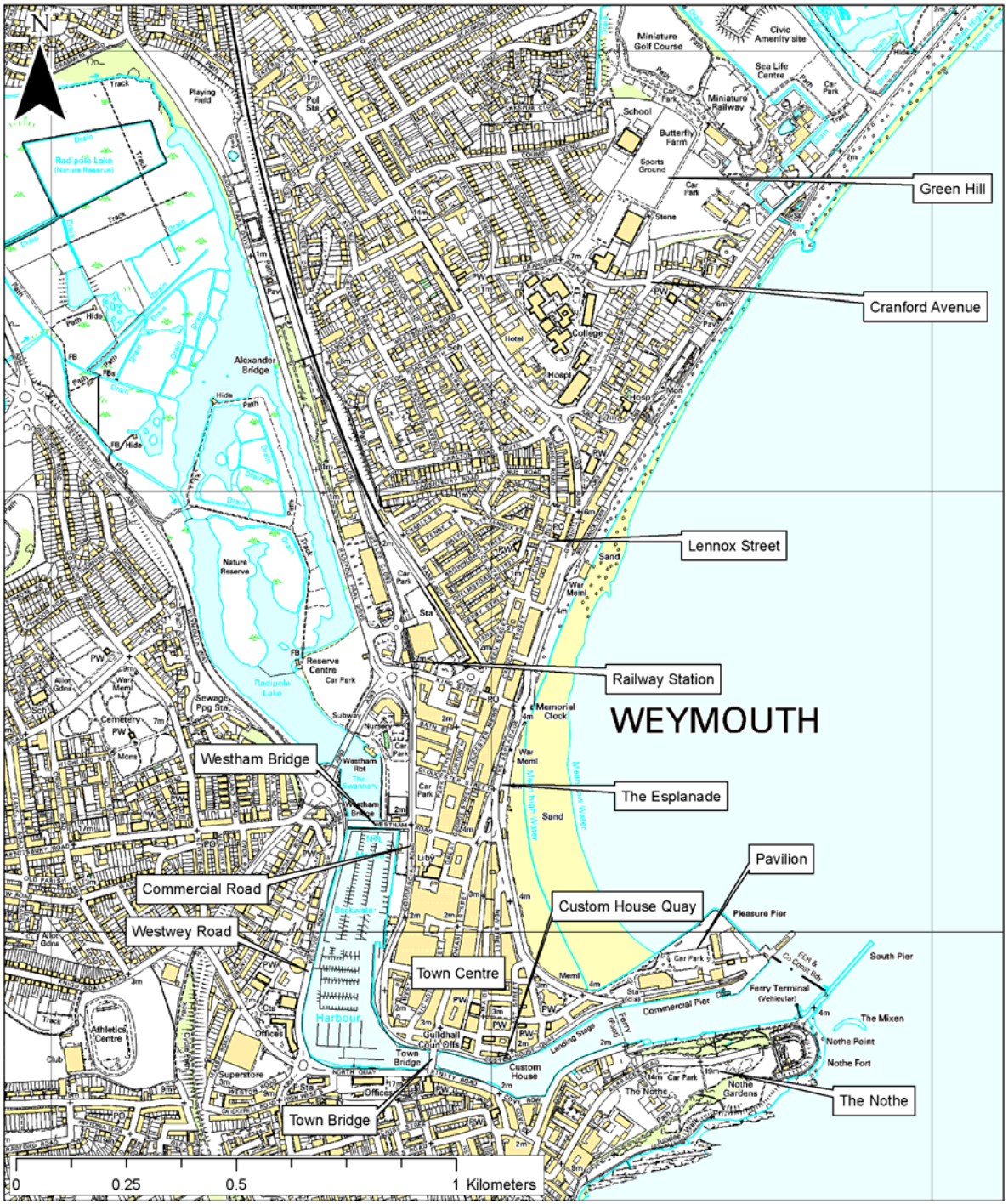


1 EXECUTIVE SUMMARY

This study of Weymouth Town Centre has been produced in collaboration between the Environment Agency and Weymouth & Portland Borough Council. It is a strategic review of the flood risk management measures that are required now and in the future and in relation to development planning needs required for the town centre of Weymouth. The flood risk covers tidal flooding on the Esplanade and in the harbour area, including wave action, both now and for 116 years into the future. This period is 100 years from the end of the next planning Core Strategy which ends in 2026.

Weymouth Town Centre has a history of being an important administrative and commercial centre in an essentially rural area. There are also a large number of Listed Buildings and Environmental Designations in the area and tourism is a major element of the economy. This means the historic character of the area needs to be carefully considered when looking at any of the options in this strategy and any future strategies.

This Flood Risk Management Strategy has been agreed between the Environment Agency and Weymouth & Portland Borough Council. It demonstrates that there is an option which is technically and economically viable based on the current assessment criteria linked to Defra and Treasury Guidance. All reference to damages or benefits within this report relate solely to flood damages to property, based on this guidance, it does not include other aspects important to the local economy such as tourism and retail.

The strategy considers a number of potential options for the management of flood risk over the next 116 years. The importance of maintaining a dynamic and thriving town centre in a uniquely attractive historic setting is recognised. To ensure that a full range of options are considered, a number of more radical long-term options are also discussed, highlighting the significance of the flood risk to the town's future.

Weymouth & Portland's emerging Core Strategy covers the period up to 2026. When considering future development within the Core Strategy the requirements of Planning Policy Statement 25: Development & Flood Risk (PPS25) must be met. To do this Weymouth & Portland Borough Council needs to ensure that any development, and the occupants, are safe for the lifetime of the building.

Current guidance from Defra suggests that sea levels could rise by up to 1.26m by 2126. The indicative standard of protection for coastal areas is 1 in 200 years as specified by Defra guidance. For this strategy we have established that significant flood risk management measures will be required to provide a 1 in 200 year standard of protection to the whole area in 2126.

Recent modelling for the Weymouth & Portland Strategic Flood Risk Assessment (SFRA) Level 2 study, completed in December 2009, highlighted that there are currently approximately 450 properties at risk from flooding from a 1 in 200 year event in Weymouth town centre and that this number will increase significantly in the future due to sea level rise. Work is therefore urgently required to reduce the flood risk to the existing properties.

The SFRA showed that the harbour area of Weymouth currently has a standard of protection of just above 1 in 100 years. Due to wave overtopping, areas alongside the Esplanade are also at risk from a tidal event of 1 in 10 years in combination with a 1 in 1 year wave. The SFRA and previous Areas Benefiting from Defences (ABD) study took this as a 1 in 10 year event. For consistency, the same approach has been used here, but it should be noted that the true joint probability would probably be in excess of 1 in 25 years. Based on historic records flooding from overtopping the Esplanade has not occurred in the last 40 years, although sea levels are rising which will have a large impact on the frequency of flooding due to overtopping. For the current standard of protection an estimate of 10 – 25 years is therefore thought to be sensible based on the assessment undertaken.

Currently 447 properties are at risk from a 1 in 200 year tidal event with wave overtopping. This is predicted to increase to 1007 for the same event in 2035, and then 4042 properties in 2126. This equates to a current present value damage for damage and loses from flooding of approximately £0.32 million, and a total of approximately £145 million by 2126.

In addition to the tidal flood risk, water is known to percolate through the underlying granular ground. This will get worse with sea level rise. Surface water drainage is also an issue due to the low lying nature of parts of Weymouth.

The current flood risk management infrastructure for the area constitutes tidal defences in the form of walls, whilst surface water is managed through a pumping station. With sea level rise resulting from climate change the height of flood defences required to maintain the standard of protection will become so significant as to change the nature and character of some areas, making it no longer possible to enjoy the harbour views. There will also be increased requirement for pumping of groundwater and surface water drainage. For these reasons it is suggested that a significant change in the management of long-term flood risk is required.

The current and future sources of flooding in Weymouth vary depending on the location being considered within the town centre. Flooding can occur due to the overtopping of the flood walls along the quay, whilst other areas are at risk from overtopping of the Esplanade. Once water is in the town centre area then the low lying topography of the area allows the flooding to easily spread across the whole town centre, particularly when sea level rise is taken into account. The study area has, therefore, been split into discrete cells to determine the potential measures required to protect that particular cell. It does not look into the specific effects of fluvial or surface water flooding although the potential impact of these is considered in the development of options.

A wide range of strategic options for the study area, together with the costs and sustainability issues have been considered. The options investigated included continuing the current measures and alignment, the provision of a tidal barrier, providing a wave-return structure on the Esplanade, providing groundwater cut-off structures, raising ground levels and even staged relocation of the town centre. The advantages and disadvantages of each option are then highlighted and general recommendations for the future provided. Where possible, social, environmental and economic factors have been considered in the assessment of each option.

The potential flood defence benefit for the area is just under £145 million by 2126, whilst present value costs for the various options have been identified at between £52 million and £113 million, giving benefit / cost ratios of between 2.2 and 1.3. This shows that all of the options have a positive benefit / cost ratio and therefore could be economically viable provided funding can be secured.

RECOMMENDED ACTIONS:

Commitment to the following actions is important to plan and deliver strategic flood risk management measures at the right time, place and with appropriate funding. A **partnership approach** is essential as assets and infrastructure from various operating authorities and utilities are involved.

Much of the study and data gathering identified below is anticipated to be within the scope of the forthcoming **'Weymouth Bay and Portland Harbour Strategy Study'** which will be funded from Flood and Coastal Risk Management Grant in Aid, led by the Environment Agency, working in association with West Dorset District Council and Weymouth & Portland Borough Council.

Option 4b: involving the phased delivery of a raised Esplanade sea wall and cut-off wall, tidal barrier, limited quay wall raising and stabilising other harbour walls should go forward for more detailed appraisal within the Weymouth Bay and Portland Harbour Strategy Study, other options within this report will also be further developed to allow comparison and ensure the optimum business case is found. **Option 4b will be the foundation for the development of a core strategy policy for dealing with flood risk in spatial planning terms.**

The modelling shows that currently the standard of protection within the harbour is less than 1 in 200 years and therefore works are required now to improve that standard of defence. A more detailed study looking at the tidal barrier is therefore required as soon as possible to ensure that the barrier is put in place before the standard of protection reduces further due to sea level rise. Likewise, the modelling has shown that wave overtopping currently puts the Park District at risk from at least a 1 in 25 year event. Investigations are therefore required now into raising the Esplanade, including a wave return wall. These investigations should also include a cut-off to prevent percolation. Work then needs to be undertaken on the Esplanade as soon as possible to provide the recommended 1 in 200 year standard of protection to the Park District. The raising of the Esplanade is also required to help to provide safe access and egress to parts of Weymouth Town Centre e.g. the Pavilion site.

<u>Urgent flood defence works</u>

- **Custom House Quay wall repairs** – undertake the repairs as recommended in the *Weymouth Harbour Flood Wall Condition Assessment Report, March 2010*, provided in Appendix F.
- Extensive corrosion has been observed on a number of the sections of **sheet piling around the harbour**, in particular the section along Custom House Quay and two sections on the Nothe Parade. This deterioration may soon start to affect

the structural integrity of the defence in these locations. Design and implementation of remedial works is therefore urgently required.

Emergency Planning

- Review and keep up to date emergency flood response plans for the Town Centre.

Data gathering

- **Annual inspection of the assets** should be undertaken so that we have an accurate and up-to-date picture of all of the assets in the area. This will help determine when replacements are needed and highlight any urgent works. These works should then be undertaken at the earliest opportunity. Due to the poor condition of some of the sheet piles these should be a priority for the inspections and replacements.
- Pumping is already undertaken and is likely to need to be increased in the future. **Monitoring of the pumping** undertaken is recommended to determine how the demand changes over time. In addition, there is a need to engage with Wessex Water to consider the impact on the existing and future surface water pumping requirements.
- **A wave buoy in Weymouth Bay** would also help to provide additional information for analysis when looking at the options in more detail. These would be particularly helpful as data for the larger Environment Agency Strategy for Weymouth Bay that is to commence this year and be completed over the next few.
- Undertake a **threshold survey** of the properties within the 2126 flood outline to allow a more detailed economic assessment to be undertaken.

Further studies

- **Esplanade wave-return wall and cut-off** – Undertake an investigation into the work required along the esplanade to reduce the risk of wave overtopping and provide a cut-off to prevent percolation. This work will allow for the continued development of sites in the town centre and provide protection from overtopping for a residential area.
- For the cut-off wall an investigation is required to give a more detailed picture of the **ground water and hydrogeology** for the area. We would recommend the installation of an array of boreholes with peizometers that can be used to record ground water levels. These boreholes will also allow detailed soils investigation to be carried out. The data will be used to indicate the permeability of strata overlying the bedrock by carrying out pumping tests.
- Further investigations are required into the **design of a tidal barrier** across the harbour, including modelling with the barrier in place. As part of that investigation we recommend that work is undertaken to determine the most efficient / effective improvements to the harbour walls for both now and in the future when combined with a tidal barrier. For example, if the walls are raised slightly then the barrier can remain open for longer periods of time.
- Undertake **a socio-economic study** to provide more information regarding the possible impacts of the options, including an assessment of the benefits related to commerce and tourism from securing appropriate standards of defence from flooding and continued development and regeneration.

- Undertake a more **detailed economic assessment** including depth-damage calculations and breach analysis.

Engagement & consultation

- **Develop a public consultation strategy** through the development of the Weymouth and Portland Core Strategy and a Flooding Contributions Supplementary Planning Document. This may lead to the preparation of a public information leaflet, meetings, a website etc.
- To use the River Wey Report and this Flood Risk Management Strategy to provide evidence in support of the shared Core Strategy and Weymouth and Portland Community Plan vision. While in the future, incorporate the findings of the wider Weymouth Bay Study to provide evidence for the Town Centre Area Action Plan, its associated vision, objectives and programmed consultation.

Planning

- The approach recommended in this study supports the objectives of the Core Strategy, subject to the agreement between the Environment Agency and Weymouth & Portland Borough Council on some of the specific requirements to address flood risk.
- Upon adoption of this strategy by Weymouth & Portland BC, the Agency will withdraw its 'objection in principle' to development in the tidal flood zones in Weymouth, subject to the Borough providing planning guidance in the form of a Supplementary Planning Document (SPD) or similar which:
  - sets out the management requirements of the residual flood risk
  - sets out a contributions mechanism toward the delivery of the 'preferred option' over the Core Strategy plan period to 2026.

- The Borough will develop a core strategy policy for delivery of the preferred option. The policy will have three strands.

- Strand 1: detailing the key FRM infrastructure required within the 2026 plan period – costs, funding delivery etc. (PPG12 Para 4.9)
- Strand 2: setting out the general direction of travel to deliver the balance of the flood risk management infrastructure identified in the preferred option or other options that may emerge, over successive plan periods.
- Strand 3: contingency planning – showing how the objectives will be achieved under different scenarios. i.e. 'plan B' (PPG12 Para. 4.10)

2 KEY FLOODING ISSUES

2.1 Overview

The River Wey is classed as a main river; the course of which has shaped the physical layout of the town of Weymouth. The town centre lies between the harbour area of the River Wey and the sea, resulting in a high level of flood risk.

There are two distinct sources of flood risk to the town centre area of Weymouth; still water tide levels in the harbour and waves overtopping the Esplanade. Wave heights within the harbour are much smaller than those affecting the coastal Esplanade that runs along the crest of the shingle spit/beach. In particular it is the easterly waves that are thought to cause the most flooding to the town centre.

Figure 2.1 shows the extents of flooding expected from a 1 in 200 year flood event in 2010, 2035, 2060, 2086 and 2126 including wave overtopping. This provides an indication of how the flood risk to Weymouth Town Centre could develop in the future due to sea level rise.

In the Defra *Flood Risk Assessment Advice for new Development, FD2320* document the speed of onset is related back to risk through the use of low, medium and high categories. Low risk covers areas where the onset of flooding is very gradual (over many hours), medium risk is where the onset is generally over a couple of hours, whilst high risk is for area where there is a rapid risk of flooding. Using this definition the area is thought to be at medium risk based on the speed of onset due to the flooding mechanism being mainly from tidal water levels and therefore generally spread over a couple of hours.

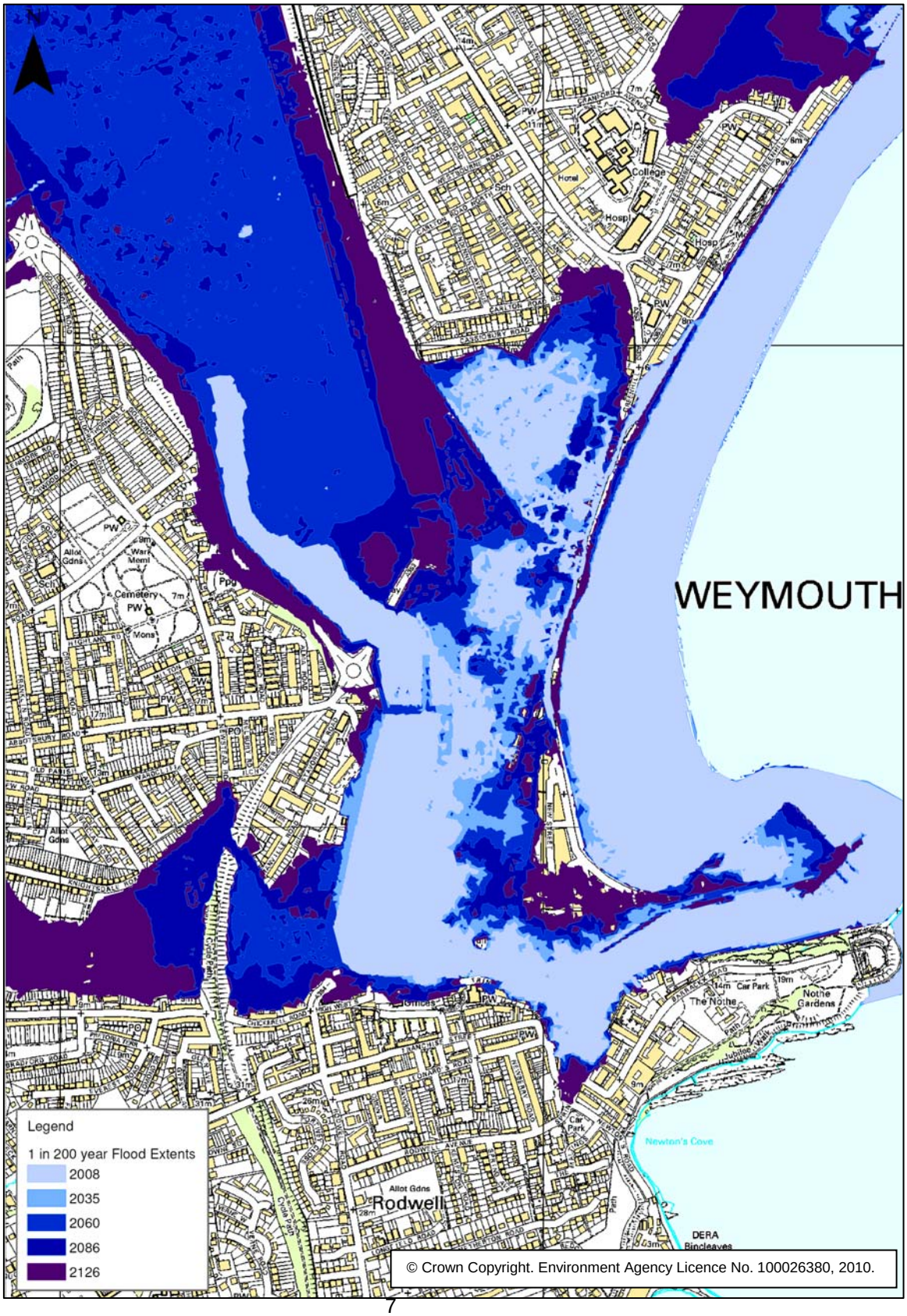
The duration of flooding varies dependent on the tidal cycle, although for higher return period events the SFRA showed that once an area becomes flooded it can remain inundated for over 2 days. This is due to the topography of the area and a lack of adequate drainage for this size of event.

Should tidal flooding occur with wave overtopping as a result of a storm then it is likely that the River Wey will also respond to the event and could exacerbate any flooding upstream of Westham bridge. The risk of fluvial flooding upstream of Westham Bridge as well as surface water in the town have not been considered within the scope of this strategy, however, the effects of a combined event are likely to compound the problem of tidal flooding and should be taken into consideration when developing access and egress routes.

Formal and informal defences exist with variable standards of protection, as detailed in Section 3. Information is available for many of the more recent defences; however, older defences have much less information available about them. The defences are shown in Figure 3.1.

Previous modelling detailed in section 6 has shown that the existing defences currently do not protect the town to the required 1 in 200 year standard and vary in standard of protection. The existing defences will not be effective in the future when considering the effects of climate change on tidal flooding; this would include adding over 1.26m sea level rise to the current flood levels. The result of this is that all of the town centre would be inundated with water, causing an extreme flood hazard. In addition this rise in sea levels will also increase the frequency of flood events.

Figure 2.1 – Modelled 1 in 200 year tidal flood extents (inc. wave overtopping) for various horizons



The flood risk detailed above is causing two particular problems for Weymouth. Firstly there are a large number of properties that are currently at risk and this will increase significantly due to sea level rise. Secondly, PPS25 states that development which takes place must be safe for its lifetime, in particular with safe access and egress routes during times of flood. Modelling has shown that by 2126 the majority of the town centre is at risk of permanent inundation from tidal flooding and therefore there are no safe access / egress routes available. As a result, this Strategy Study is aiming to provide a strategic view of how the existing properties could be protected, possible access routes and what work is required to enable development to go ahead in the area.

The highest points of the beach vary between approximately 2.4 and 2.6mOD, therefore currently even at high tide the beach is not entirely covered. Based on a MHWS currently there will be a beach with a width of approximately 30 – 70m visible at high tide. This reduces slightly by 2060. By 2086 the visible width at high tide is between 10 and 50m, whilst by 2110 there are sections where no beach remains and only up to 30m at the southern end. Finally by 2126 the entire beach is expected to be covered at high tide. This also means that areas of the beach will be covered for increasingly prolonged periods of time, therefore impacting on its use as a tourist attraction.

The beach is currently thought to be relatively stable in terms of movement of material. As sea levels rise and waves increase there could be more loss of material from the beach and only limited influx of material from the cliffs to the north. As the beach cannot fall back due to the presence of the Esplanade and influx of material from the north may not be significant then beach recharge may be required to maintain the beach. Further investigation would be required into sediment movements, quantities and timescales before the extent of the beach recharge required can be determined. This will also depend on how quickly sea levels rise in the future. Monitoring of the current situation is therefore required.

2.2 Summary of model results

Modelling has shown that if no further work is undertaken to defend the town centre of Weymouth then the number of properties and resulting damage from tidal flooding will significantly increase into the future. Table 2.1 below shows the number of properties at risk from a 1 in 200 year flood event with wave overtopping at various time horizons in the future (extents shown in Figure 2.1 above). These numbers assume a basic threshold level above the adjacent ground level of 100mm for commercial properties and 300mm for residential properties. These were the agreed threshold levels assumed for this overview economic assessment. They would need to be substantiated by local inspection as part of a more detailed assessment should any flood risk management works progress further.

Table 2.1 – Number of properties at risk from a 1 in 200 year tidal event assuming continuing maintenance of the existing defences but no improvements

Year	Number of properties	Depth of flooding (m)			Hazard rating
		Min	Max	Average	
2008	447	0.04	1.3	0.35	Moderate to Significant, Extreme in places
2035	1,007	0.06	1.5	0.5	Significant, extreme in places
2060	1,858	0.10	1.7	0.85	Extreme, moderate in places
2086	2,777	0.08	2.0	1.2	Extreme
2126	4,042	0.13	2.7	1.6	Extreme

The depth of overland flooding and the hazard rating is included in the table to highlight the impact of the increased flooding to risk to life. Note that the modelling assumes the defences are maintained to their current level. If maintenance is not undertaken, as for the No active intervention option, then the risk of breach would be increased and therefore the overall flood risk and risk to people would also increase from that detailed above.

As a result of climate change and sea level rise flooding will not only affect more properties, the frequency of the flooding will also increase significantly. For example, the current 1 in 200 year water level is equivalent to the predicted MHWS in 2120 meaning that the water levels that are currently considered to be a significant event would occur roughly once a month.

Currently, the model has shown that once the waves have overtopped the Esplanade the water ponds in the Park District area. Due to the topography of the area there is no obvious route for the water to drain from this area and therefore the depth keeps increasing as additional water overtops the Esplanade. This impacts on the drainage system for the area.

3 EXISTING SITUATION

3.1 Existing Defences

There are various flood defence structures protecting the town, as shown in Figure 3.1 and detailed below.

- Along the sea front, the Esplanade and beach form a relatively high barrier but there are no formal flood defences.
- The Pavilion area at the eastern end of the shingle spit is entirely surrounded by sheet piling.
- The river banks through the town centre are formed by a combination of sheet piled, concrete and masonry quay walls. The quay walls vary in age and condition.
- The river banks upstream of Westham Bridge are protected from tidal flooding as the bridge forms a tidal barrier.
- The flood protection to the town from the tidal reaches of the river is provided by concrete flood walls which are founded on the quay walls.

A scheme, the Weymouth Harbour Tidal Defence Scheme, was completed in 2001 by the Environment Agency in the harbour area with the aim of providing a 1 in 200 year standard of protection from tidal flooding from the harbour. This work included local raising of defences, piling and grouting. Generally, the concrete flood wall was placed on top of the existing quay walls (either masonry or piling). Figure 3.1 below shows the main structure of the wall and therefore where masonry or piling is shown there is also a concrete flood wall on top in most places. An example of this is shown in Photo 3.1.

Figure 3.1 – Existing defence line frontage materials

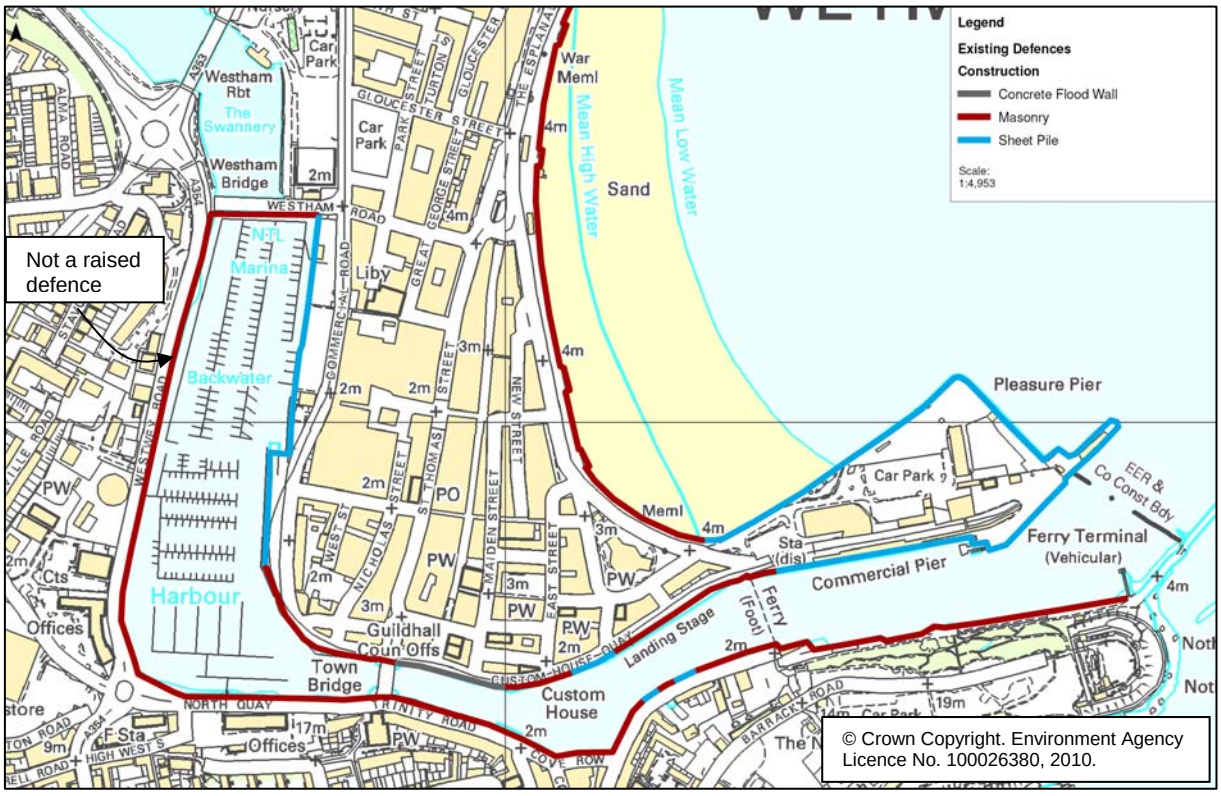


Photo 3.1 – Example of the concrete flood wall on top of a masonry wall

The defence was set at two levels due to the limited cost/benefit ratio. Along Commercial Road up to the slipway the crest is at 2.5mODN, whilst past Town Bridge to Custom House Quay the crest is at 2.3mODN. Since this construction the predicted still tide water levels have been revised. The 1 in 200 year water level for 2010 is 2.40mODN; therefore lengths of this tidal defence scheme are below the current 1 in 200 year standard.

3.2 Existing Asset Condition

There are several types of construction within the existing defence line, which have been constructed at various stages in the last hundred years. Many of the earlier assets are now reaching the end of, or have exceeded their design lives.

The defences can be split into three groups

- Concrete Flood walls
- Sheet piled Quay walls
- Masonry Quay walls

Most of the flood walls were recently constructed (2002) as detailed in section 3. These walls are generally in good condition, although as a result of their age and construction method, there are some defects that have been highlighted in high tidal events around Town Bridge. These defects are being assessed in a separate report as part of this project and are included in Appendix F. The heights and construction of these walls are recorded in the NFCDD database and on as constructed drawings held by the Environment Agency and Weymouth & Portland Borough Council.

The masonry quay walls were originally constructed to provide a working quay area for the port, which was very active in the early 20th century. As a result these walls were not designed to act as a flood defence for the town and are not water retaining structures. Over time, when some of the masonry walls have failed they have been replaced with sections of sheet piled wall.

The sheet piled quay walls have been constructed at various stages during the development of the town. The main area of sheet piling is surrounding the pavilion and ferry port. As stated in the brief report based on Jacobs Babtie condition survey 2005, written by John Davison, this sheet piling is thought to be in serviceable condition but is suffering from accelerated low water corrosion (ALWC). The second large section of sheet piling is along Commercial Road. The length bordering the marina is privately owned whilst the section towards Town Bridge is Council owned and is also thought to be suffering from ALWC.

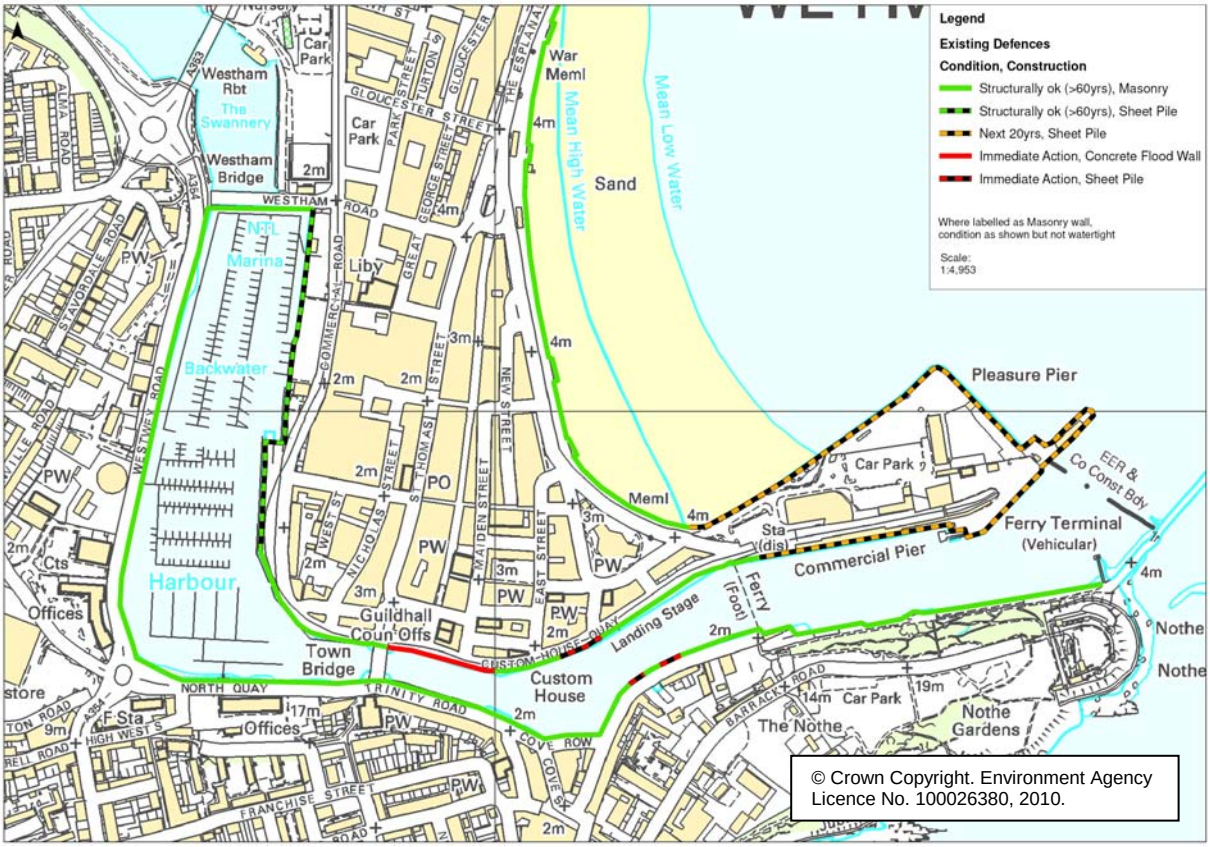
The remaining sheet piling comprises several short lengths between stretches of masonry wall. This is where either sections of masonry has failed or where sheet piling was required for an alternative use of the asset. The sheet piling in these lengths is of varying age and condition, although most is thought to be suffering from ALWC. The area in the poorest condition is a section on the right bank between Hope Cove and The Nothe; this section has been given an expected residual life of 5-10 years in a report issued 5 years ago. This section also forms the foundation of a short road bridge crossing a private slipway.

The condition of the walls is based on reports produced by, and on behalf of, Weymouth & Portland Borough Council following a detailed condition assessment of the quay side structures. In particular the walls along Westwey Road are known to have cracks and be porous. Based on the condition assessment report the walls are not thought to be at risk structurally but they are currently not acting as a flood defence. Work may therefore be required to make the walls in this area water-tight.

Figure 3.2 classifies the maintenance / replacement requirements for the existing assets into 3 groups. Red represents immediate action is required i.e. in the next 5 years, amber suggests work is required in the next 20 – 30 years, whilst green shows the asset is expected to last for more than 50 years. Note that the masonry walls are thought to be structurally sound but are not water tight therefore work may be required to address this issue.

Westham Bridge and Town Bridge are both significant structures in the area which are between 80 and 90 years old. They are therefore both likely to need replacing in the short to medium term. Any replacements will depend on the flood defence work undertaken in the harbour and the required use of the bridges in the future. Currently Town Bridge is performing well, particularly since the pumps were installed in 2002. The sluices in Westham Bridge were refurbished recently although it is the actual bridge structure that is showing signs of deterioration. Once the flood defence strategy is agreed for the harbour area then further investigation should be undertaken as to the possibilities for Westham Bridge.

Figure 3.2 – Maintenance / replacement requirements



4 STRATEGY DRIVERS

A Flood Risk Strategy is written to provide a plan and cost estimates for the defence of an area against flooding over a set period of time. In this case the strategy is being prepared to provide costs and plans for the flood risk management of the town of Weymouth over the period of implementation of their core strategy and for the following 100 years, i.e. until the year 2126.

There are three main drivers behind the construction or replacement of flood defence assets:

- Strategic development planning
- Strategic harbour management
- Flood Defence

4.1 Strategic Development Planning

This is the requirement to construct new defences that will enable the regeneration and development of an area in accordance with a planning strategy.

The main drivers for this are the South West Regional Spatial Strategy (RSS), the Shoreline Management Plan (SMP) and Planning Policy Statement 25: Development and Flood Risk (PPS25).

As part of the July 2008 version of the South West RSS Development Policy A states that the primary focus for development in the South West will be the Strategically Significant Cities and Towns (SSCTs). Weymouth is classed as one of the SSCTs for the South West and the development is specifically focussed on the town centre.

The RSS highlights that Weymouth is known to be an area of regionally significant flood risk. It also highlights the need to enhance its role as a major tourist resort and strengthen its service centre role through the provision of retail, leisure, education, recreation, health and community facilities, particularly in the town centre. Management of the flood risks is therefore required. This is then confirmed in the SMP which states that the policy for the harbour area and the Esplanade is 'hold the line' for all epochs i.e. short, medium and long term.

PPS25 is the Government Guidance for development and flood risk in England. This states that any development should be allocated in a sequential approach, focusing on low risk areas first. PPS25 also states what types of development are acceptable in the different flood risk areas. The requirements of this therefore need to be combined with the RSS requirements when considering the strategic plan for development in Weymouth the Local Authority need to adopt the flood risk management strategy.

4.2 Strategic Harbour Management

As a result of Weymouth heritage and its function as a port, there are extensive lengths of existing structures forming the town's flood defences. The coastal and river frontage in the town is an important asset to its economy, which is primarily centred on tourism.

The physical condition of the existing assets has been assessed together with the environment in which they are located to determine their estimated **residual life.**

The data for the condition of the existing assets has been taken from reports previously prepared for Weymouth and Portland Borough Council and from some visual assessments of the structures. A full independent survey of the whole area was not included in the scope of this study, although a small study was undertaken to investigate one area of the quay wall that is known to leak during high tides. The report produced as part of that investigation can be found in Appendix F.

More detail on the condition of the existing assets can be found in section 3. In summary, some of the assets around the harbour are coming to the end of their design life within the next 5 – 15 years e.g. large proportions of the sheet piles. Investment therefore needs to be focused on the repair or replacement (where necessary) of the harbour walls to ensure the structural stability of the flood walls.

4.3 Flood Defence

The town of Weymouth has a combination of exposed coastline fronted by beaches and harbour walls. The flood defences providing protection to the town are quay walls that are exposed to a combination of tidal water levels and wave overtopping from a storm event. These will be subject to changes in magnitude and frequency over time which will greatly reduce the standard of protection provided by the defences. More detail on the flood risk to the town can be found in section 6.

5 BACKGROUND

5.1 Location

Weymouth is a coastal town in Dorset, with the town centre situated on a low lying area at the mouth of the River Wey. The area covered by this Strategy covers the coastline of Weymouth Bay from Cranford Avenue / Greenhill to Nothe Point which includes Weymouth harbour to Westham Bridge, see Figure 1.1.

The coastal frontage of the town is a sandy beach which is considered to be stable over its central and southern frontages, but becoming less stable to the north. The town was historically a port and the river frontages through the town are a mix of modern marina and historic quay.

The town of Weymouth has grown around the River Wey, and the port area on the shingle spit forming the mouth of the river. Historically the town has been a port used for fishing and pleasure cruising. The town grew following an increase in cross channel trade. Since the 1960's the town's commercial port activities have reduced significantly with only the Channel Isles ferry route remaining, along with a much smaller fishing fleet. The port area between Westham Bridge and Town Bridge is now a marina for pleasure craft with the quay areas downstream being used by the fishing fleet and pleasure craft. The reclaimed Pavilion area is a ferry terminal for passenger crossings to the Channel Islands.

The tidal extent of the Wey is formed by Westham Bridge, which crosses the river at the upstream end of the marina. Upstream of this bridge is Radipole Lake, a Site of Special Scientific Interest (SSSI). The bridge is a combined tidal barrier and road bridge that retains freshwater and prevents sea water from progressing further upstream into the river and SSSI. It contains eight culverts; four of which have tidal flaps and four have electronically controlled penstocks which were recently replaced. These culverts, along with a timber drop board, maintain the minimum water level in Radipole Lake as specified by RSPB. They also help to maintain the freshwater habitat of the SSSI, although saline water can pass over the penstocks during high tides. There is also known to be some saline intrusion through the tidal flaps.

In December 2009 the RSPB updated their Water Level Management Plan (WLMP) for Radipole Lake. This looks only 15 years in advance but states that the wish is to maintain the lake as a freshwater habitat. A tidal barrier at Westham Bridge would need to be maintained to meet this requirement. Westham Bridge is approximately 90 years old and showing some signs of deterioration. It is likely that either remedial works or a replacement bridge and barrier will therefore be required in the future to meet the WLMP requirements.

5.2 Heritage, context and character

The built heritage of Weymouth Town Centre is most clearly defined by its geography, geology and the landscape it has created in its peninsula relationship with the sea. The sense of place it creates provides local distinctiveness that is attractive to residents and visitors with a wide range of interests.

Designated as a conservation area in 1974, Weymouth Town Centre contains over 600 listed buildings, a combination of which has been recognised as 'outstanding' in the past.

The recognised exceptional quality of the built environment has justified significant investment by English Heritage over many years and currently the Heritage Lottery Fund. The unique character of Weymouth Town Centre derives from the close relationship of five distinct areas – Weymouth Harbour; Melcombe Regis; The Esplanade; Greenhill; Park Street and the high architectural quality of the buildings and the groups of buildings, many of which are included in the statutory list of buildings of historic or architectural importance.

The outer harbour and its associated buildings are visually immensely important and are a major tourist attraction. There are numerous buildings of 17th century and earlier origins, though 18th and 19th century replacements, conversions and refacing have occurred in many instances. The unique character of the area is formed by the close spatial relationship between tightly packed groups of buildings, individual buildings and an intricate network of narrow confined streets which create a variety of street scenes with a distinct sense of closure. The Esplanade provides an almost unparalleled example of late 18th Century and early 19th Century seaside architecture which follows the sweep of Weymouth Bay. The Esplanade is essentially Georgian in character and is of significant historical and architectural importance in a national, regional, local context.

The protection of the historic and built natural environment is currently extensive and generally well managed by Weymouth & Portland Borough Council. Regional and local policies emphasise the importance of the development and regeneration of the town centre and the Esplanade. In line with the RSS, it is considered essential that at the beginning of the 21st century the Borough should strengthen the role it has for tourism and enhance its role as an employment service centre by providing for improvements to and expansion of retail, service and leisure facilities and the public realm in the town centre.

Controlled management of the town centres main assets including buildings, open spaces, and the beach are paramount to ensuring a sustainable future economy. Weymouth, identified as a strategically significant town by the Regional Spatial Strategy must continue to play an important role in the context of wider Dorset. Securing its economic wellbeing through continued regeneration is crucial within the plan period to 2026 and beyond.

Research has shown that locals hold the harbour in high esteem and it is thought that the environmental ambience of the area is a key element of the town's prosperity and tourism industry.

5.3 Physical characteristics

The commercial centre of the town is located on a shingle spit which forms the mouth of the River Wey. The route of the river is natural and has been fixed over the many centuries by the construction of quay side for port activities. The area has therefore formed due to infill and encroachment. As a result of its location the town is low lying and the ground beneath the town is highly permeable.

Figure A1 in Appendix A shows the topography of the area. This has been produced using LiDAR data (Light Detection and Ranging) which is a Digital Terrain Model (DTM). The figure shows that there is high ground (>5mOD) to the North, East and South of the town centre, whilst the houses between the railway and Lennox Street are especially low i.e. the Park District which is between 0.5 and 1.0mOD. This is below the current level of the Mean High Water Springs (1.2mOD as shown in Table 6.2). The area is currently drained by a pumped combined drainage system operated by Wessex Water. The impact

of sea level rise on this system will form part of the discussions to be had with Wessex Water. Additional pumping capacity may be required.

The esplanade is generally higher at between 3.5 and 4.5mOD. This therefore partly protects the Park District, although overtopping due to wave action is likely to occur, causing flooding of properties. Other areas of Weymouth Town Centre are generally between 1.5 and 3.5mOD.

5.4 Previous Studies

There have been a number of studies investigating the flood risk to the Weymouth area over the last few years. These include:

- **Weymouth & Portland Strategic Flood Risk Assessment (SFRA) Level 1** – this is an overview of the flood risk to the whole borough and provides background information regarding the historic flooding, current and future flooding, topography and geology. This was originally produced in July 2006 and then updated in December 2009 to meet the requirements of PPS25. This involved planners and engineers from Weymouth & Portland Borough Council along with representatives from the Environment Agency.

- **Weymouth & Portland SFRA Level 2** – this study, produced in December 2009, used the information collected during the Level 1 Study to look in more detail at a number of possible development areas as identified by Weymouth & Portland Borough Council. This included Weymouth Town Centre where hydraulic modelling was undertaken to provide a more detailed picture of the current and future flood risk to the area. In particular modelling was undertaken to determine the 1 in 200 year tidal flood risk (with wave overtopping) for 2086 and 2126. These time horizons were chosen to match with the Core Strategy and the expected lifetimes for commercial and residential development (60 and 100 years respectively). As for the Level 1 study this involved representatives of both Weymouth & Portland Borough Council and the Environment Agency.

- **Wessex Tidal Areas Benefitting from Defences (ABD)** – this study, produced in October 2008 for the Environment Agency, looked at the impact of the defences along the Wessex coastline, including Weymouth. Wave overtopping was calculated and then input into a 2-dimensional hydraulic model of Weymouth. The model was run with and without the defences in place and then the areas benefitting from defences for the 1 in 200 year tidal event with overtopping were determined.

- **South Wessex Tidal Flood Zone Compliance Study** – this study for the Environment Agency also used the 2-dimensional hydraulic model to determine the flooding for various return period tidal flood events.

All of these studies, except the Level 1 SFRA, used a 2-dimensional TUFLOW hydraulic model with wave overtopping calculated using AMAZON and SWAN modelling. The results have been utilised as part of this strategy study. More details of the modelling undertaken can be found in the various modelling reports.

To provide more information regarding the phasing of any proposed defences additional modelling was undertaken as part of this Strategy Study. This included the 1 in 200 year flood event for 2035 and 2060, therefore, providing information on the predicted flooding at approximately 25 year intervals. The 1 in 1000 year flood event in 2126 was also modelled to aid emergency planning. Figures showing the modelling results can be found

in Appendix A, whilst the details of the modelling work undertaken are provided in Appendix B.

For all of the modelling work mentioned above a variety of waves were tested for two locations to determine the worst case scenario along with the tide levels, shown in Table 6.2. The easterly waves were found to be the most significant and therefore were utilised for all of the model runs. AMAZON was used to determine the overtopping volumes due to the waves and tide and then the TUFLOW modelling determined the overland flow routes and areas of ponding.

5.5 SMP Policy

The South Devon and Dorset Shoreline Management Plan 2 (SMP2) is currently being produced by Halcrow and a draft is out for consultation. For the extensively developed area of Weymouth, including both Weymouth Harbour and the open coast frontage along Weymouth Bay, the SMP2 states that for all three epochs considered i.e. short, medium and long-term, the plan is to continue to protect the commercial, social and tourism features of this area against the increasing risk of flooding as sea levels rise. The short, medium and long term policy is therefore to hold the existing line of defence up to and including Westham Bridge.

The implications of this are that the inner walls of the harbour need to be strengthened and upgraded, the esplanade needs to be raised and beach recharge should be considered.

5.6 Stakeholders

The Dorset Coast Forum (DCF) was established in 1995 to look at long term issues facing the Dorset coast with regards to the management, use and development of the Dorset coastal zone.

The Environment Agency are keen to enhance the involvement of industry and the public in the decision making process for flood and coastal erosion management. A project has therefore been set up, jointly commissioned by the DCF and the Environment Agency, to engage locals who have an interest in the coastline and find out more about what they want for their area. The River Wey, from its source to Weymouth's outer harbour, is one of the areas involved in the project. The aim of the River Wey Project was to look at the historically context of how the river has been managed and constrained, present issues and then exploration of possible flood resilience ideas for the area.

The key findings of the study are presented in *The River Wey Project, February 2010*, which will be shortly published on the Dorset Coast Forum website. Some of the main points from the report have been included in this study, particularly the public reaction to possible ideas for the future use of the harbour area.

Generally this has shown that the whole harbour and Radipole Lake area are held in high esteem with the local people. It is felt that the character of the town is defined by the presence of the river and therefore the locals want to see both the river and harbour maintained into the future.

6 FLOOD RISK

6.1 Current flood risk

The Weymouth & Portland Level 2 SFRA demonstrated that approximately 450 properties are at risk from tidal flooding with wave overtopping during a current 1 in 200 year event (see Figure 6.2).

According to the Environment Agency's Flood Reconnaissance Information System (FRIS) significant incidents are recorded to have occurred in and around the town centre in 1955, 1977, 1979, 1983 and 2008 from a mixture of tidal, fluvial and surface water sources. Given the location of the town centre, tidal flooding represents the main flood risk combined with the effects of wave overtopping. This is supported by the designation of the town centre by the Environment Agency, as 'tidal' Flood Zone 3, see Figure A2 in Appendix A. More recently, high tide levels in March 2008 caused flooding of the road beneath Town Bridge as shown in Photo 6.1 below.

Photo 6.1 – Flooding of road beneath Town Bridge

The SFRA identified that the residential area (known as the Park District) between Lennox Street and the railway station forms a natural basin, being at a lower elevation than the rest of the town centre. Based on the results of numerical modelling, this area was identified as at risk of flooding as a result of waves overtopping the beach from Weymouth Bay during a 1 in 10 year tidal event. This assessment was based on wave data from an event in October 2004, which was thought to be roughly a 1 in 1 year wave event. The extent of the flooded area was shown to increase with increasing return period, such that a large proportion of the town centre became at risk of flooding by the 1 in 200 year event.

Flooding from groundwater, due to percolation, is also an issue in this area. The Town Centre is entirely constructed on a sand and shingle spit on top of Oxford Clay with land elevations only slightly above mean sea level. The sand and shingle is highly permeable

and tidal and saline water is known to enter trenches during construction during high tides. This issue is likely to increase with sea level rise.

Wessex Water currently pumps water out of the Town Centre. Due to the increases with sea level rise the pumping requirements are expected to increase. Formal monitoring of the pumping undertaken could provide information about the demand and therefore the available capacity. This will then highlight whether or not the current arrange can be maintained into the future.

6.2 Future flood risk

Over the last 150 years an increasingly comprehensive and accurate record has been kept of wave climates and still water levels; these show that changes are happening to the natural environment and that further change can be expected in the future. Regardless of the cause of these changes, they must be anticipated in order that appropriate plans can be put in place.

It is reasonable to recognise that sea levels are rising when estimating future extreme coastal water levels. Relative sea levels along the south coast of England are known to have been rising for millennia, and there is no evidence to suggest that this will stop. Monitoring over the last 20 years has shown a global annual rate of sea level rise of 3.4mm which is twice as fast as the previous 90 years. There is also a broad consensus amongst scientists who observe and model ocean dynamics that global sea level rise will accelerate. Moreover, we are required by Defra to account for rising sea levels.

Increased sea level rise is one of the more certain effects of climate change, because the physical explanation for it is quite simple. Rising atmospheric temperatures (regardless of their cause) gradually heat the oceans. Any substance that becomes warmer expands. Because the oceans are so deep (the Atlantic is around 3.3 km deep on average) even a small increase in volume causes a significant increase in sea level (e.g. 1% increase in volume would derive a rise of around 33 metres). In addition warmer atmospheres melt glaciers and ice caps, currently on land, which then flow into the sea further raising its level.

Current Government Guidance regarding sea level rise is provided in Planning Policy Statement 25 (PPS25): Development and Flood Risk. The values for the South West are shown in Table 6.1.

Table 6.1 – Predicted sea level rise per year in the South West

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
South West	3.5	8.0	11.5	14.5

Source: Table B.1 Planning Policy Statement 25: Development and Flood Risk

The predicted water levels for this area have been taken from the Environment Agency South West Extreme Tide Level Report, produced in 2003 by Posford Haskoning. These are shown in Table 6.2 below. Based on the current sea level rise guidance as shown in Table 6.1 above, the predicted extreme tide levels for 2010 and selected years up to 2126 have been calculated and are also shown below.

Figure 6.1 shows the modelled depths of flooding for the 1 in 200 year tidal event with wave overtopping in 2126. To indicate how this flood risk develops over time the flood

extents for the 1 in 200 year tidal flood risk including wave overtopping for 2010, 2035, 2060, 2086 and 2126 can be seen in Figure 6.2.

Weymouth only has a small tidal range and therefore based on the current predictions the increases due to sea level rise mean that extreme events today will soon become much more common. For example the current 1 in 200 year event will be equivalent to a 1 in 50 year event in 2035, a 1 in 10 year event by 2060, a 1 in 1 year event by 2086 and less than MHWS by 2126. Note that this does not account for any wave action.

Table 6.2 – Predicted future Extreme Tide Levels for Weymouth

Return Period (yrs)	Predicted water levels (mOD) for various horizons						
	2002	2010	2035	2060	2086	2110	2126
MHWS	1.17	1.20	1.33	1.55	1.85	2.20	2.43
1	1.77	1.80	1.93	2.15	2.45	2.80	3.03
5	1.95	1.98	2.11	2.33	2.63	2.98	3.21
10	2.03	2.06	2.19	2.41	2.71	3.06	3.29
25	2.13	2.16	2.29	2.51	2.81	3.16	3.39
50	2.21	2.24	2.37	2.59	2.89	3.24	3.47
100	2.29	2.32	2.45	2.67	2.97	3.32	3.55
200	2.37	2.40	2.53	2.75	3.05	3.40	3.63
500	2.47	2.50	2.63	2.85	3.15	3.50	3.73
1000	2.55	2.58	2.71	2.93	3.23	3.58	3.81

As a result of the effects of climate change over the next 116 years, tidal flood risk to the town centre is expected to increase owing to a predicted rise of mean sea level of 1.26m. This will put approximately 4000 properties at risk compared to approximately 450 under current conditions.

The main sources of flooding within the town centre is from overtopping of the town quay flood defence wall during high tides, as well as wave overtopping along the Esplanade. The SFRA showed that the harbour defences are overtopped during approximately the 1 in 100 year tidal event whilst wave overtopping occurs during the 1 in 10 year tidal event with approximately a 1 year wave. Both of these flooding mechanisms are expected to occur at an increasingly frequent basis in the future. The town is also at risk from surface water and fluvial flooding which has not been assessed as part of this strategy.

As detailed in the ABD guidance a joint probability analysis of the extreme water level and waves was not required. Modelling without wave overtopping was also presented in the SFRA Level 2 for Weymouth to highlight the flood risk purely from still tide water levels. This showed that the Park District area is protected by the Esplanade from greater than a 1 in 200 year tide level. This confirmed that the flooding of the Park District is heavily dependent on the wave conditions during the tidal event.

The lowest point on the Esplanade is approximately 3mOD. This means that in theory the Park District area is protected from still tide water by the Esplanade in the short term. Overtopping is expected by at least 2086, although there are also possible flow routes from the harbour area and therefore flooding of the Park District could occur before the Esplanade is overtopped. This shows that irrespective of wave action the Esplanade will need to be raised before 2126 to provide a 1 in 200 year standard of protection.

Figure 6.1 – Modelled depth of flooding for the 1 in 200 year tidal event with wave overtopping in 2126

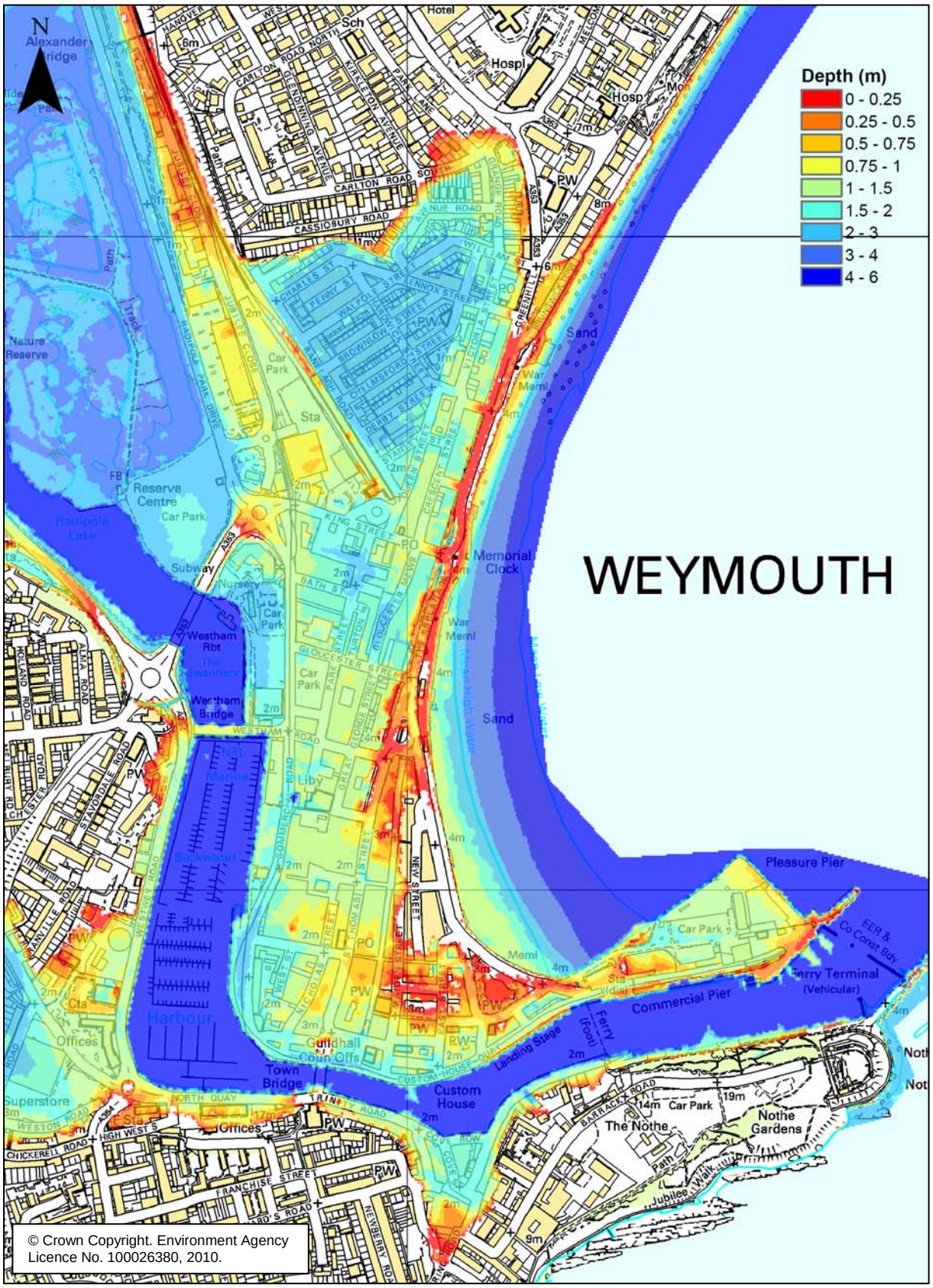
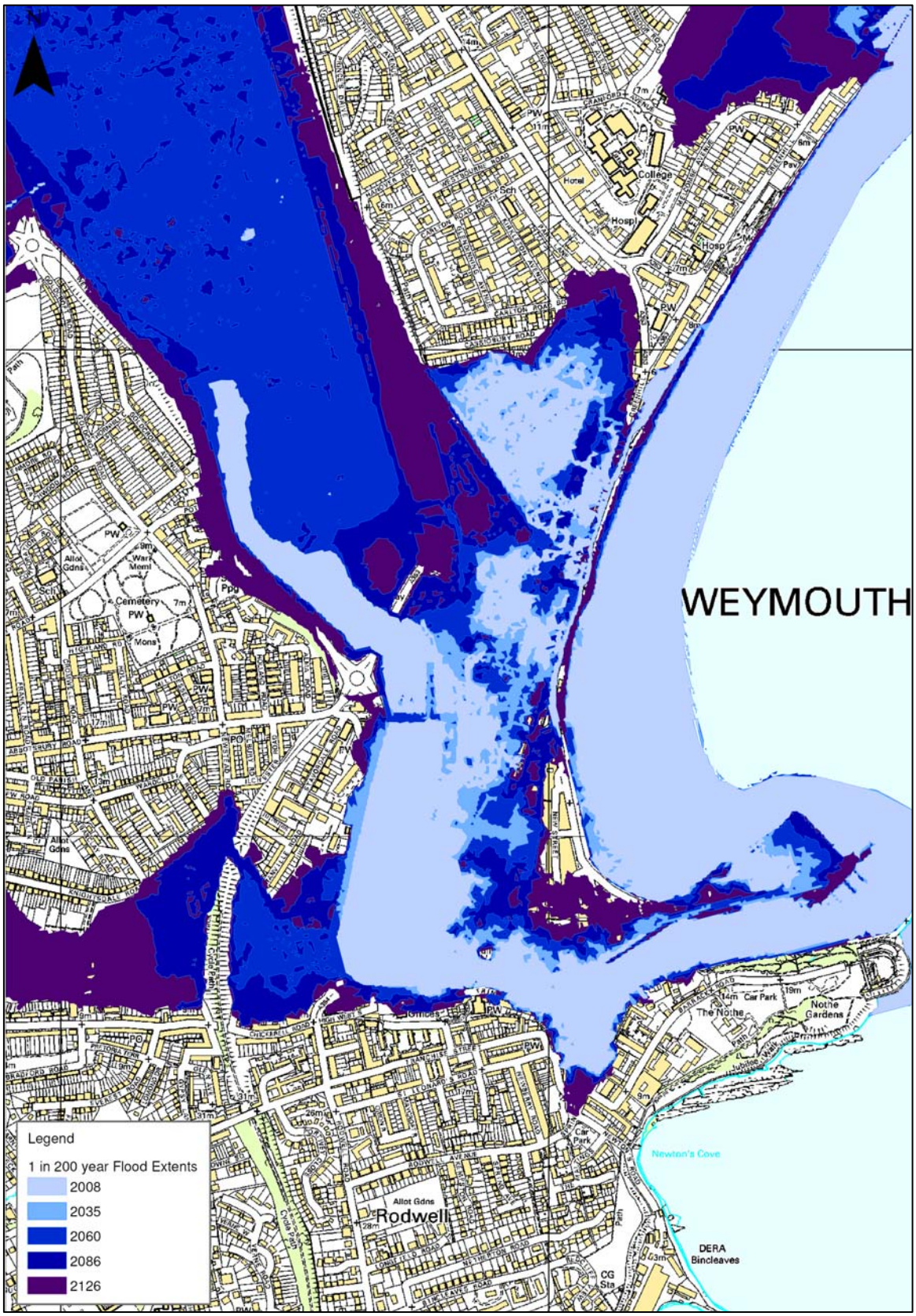


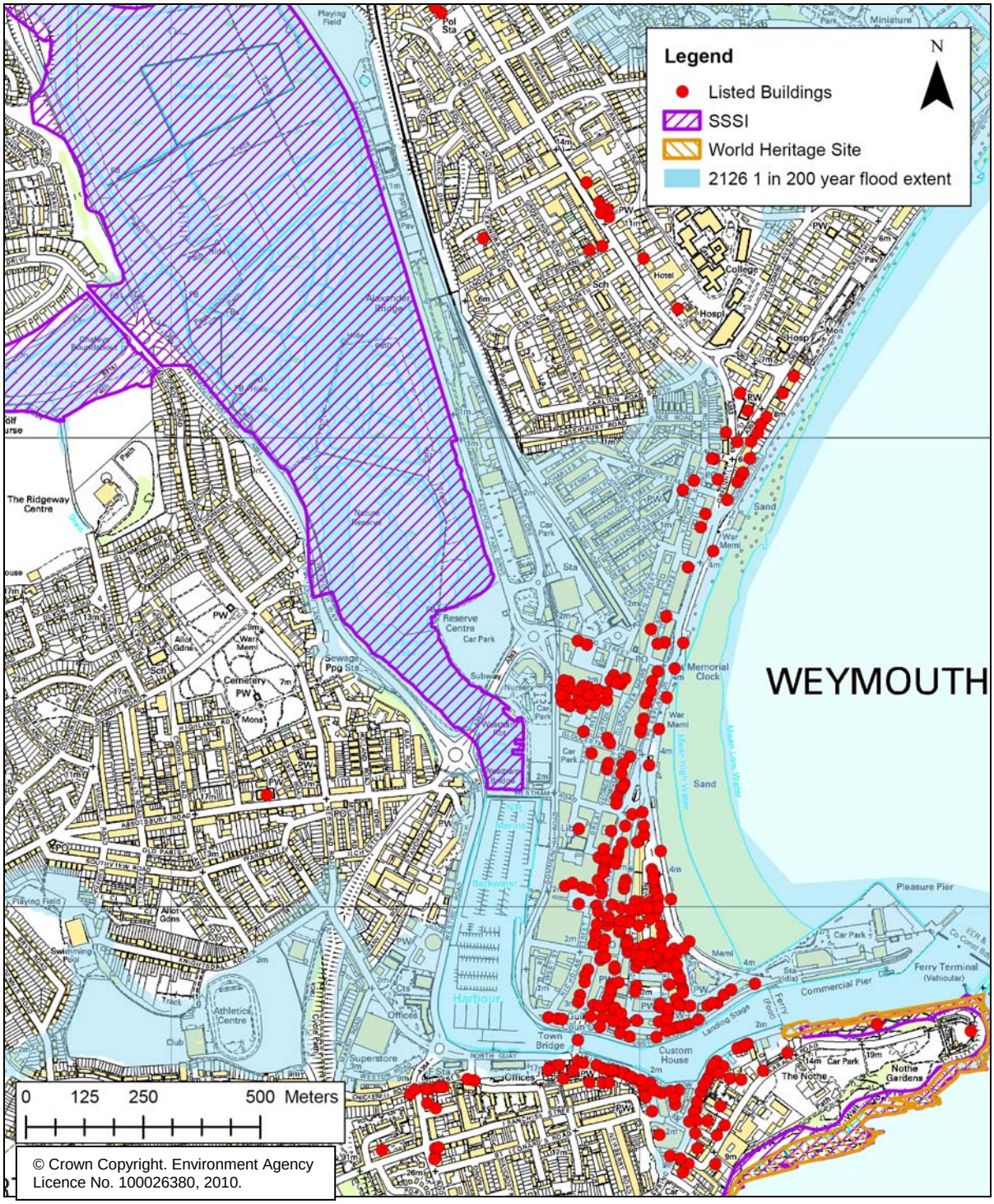
Figure 6.2 – Modelled 1 in 200 year tidal flood extents (inc. wave overtopping) for various horizons



7 ENVIRONMENTAL AND PLANNING CONSIDERATIONS

7.1 Environmental considerations

Figure 7.1 – Environment designations



The environment designations in the Weymouth area are shown on Figure 7.1. There are currently no SACs, SPAs, NNRs, or RAMSAR sites in the area but there are a number of SSSI, Listed Buildings and a World Heritage Site.

Radipole Lake lies adjacent to the town centre along with River Wey. It is classified as a freshwater SSSI and currently Westham Bridge controls the water levels in the lake. With sea level rise there is an increasing risk of tidal intrusion in the future which will alter the habitat of the area.

The area around the Nothe is classed as a core area of World Heritage Site as well as part of the Portland Harbour Shore SSSI.

There are a large number of listed buildings in the Weymouth area, most of which are Grade II. Currently 86 of these are within the 1 in 200 year tidal flood extent with wave overtopping. By 2126 this could increase to 282. Careful consideration is therefore required as to what changes are made to the area and how those changes could impact on these listed buildings.

7.2 Planning considerations

In terms of planning there are three main drivers, PPS12(Local Spatial Planning), the Regional Spatial Strategy (RSS) and Planning Policy Statement 25 (PPS25). PPS12 sets out the requirements for Local Planning Authorities to undertake spatial planning, including infrastructure planning. The RSS provides guidance on where development should be focussed, whilst PPS25 aims to direct development to the areas of lowest flood risk. Weymouth is an example of where these two documents can sometimes lead to conflicts. The RSS designates Weymouth as a Strategically Significant City / Town (SSCT), as explained in Section 4.1, and therefore recommends that development should be directed towards the Town Centre to aid regeneration. The modelling has shown that the Town Centre is at high risk of flooding in the future and therefore PPS25 requires the flood risk is managed and accounted for in planning policy.

This Flood Risk Management Strategy has been produced and agreed by the Environment Agency and Weymouth & Portland Borough Council.

Without the investment in the Town Centre regeneration is very unlikely to occur. It could therefore be suggested that flood protection is not just needed to protect the existing properties, but it is also necessary for supporting the economic growth of the area.

If work is not undertaken to protect the Town Centre in the future, resulting in development moving elsewhere, then Weymouth should no-longer by classified as a SSCT. This demotion of status would result in fewer homes, fewer jobs and reduced investment, the consequences of which would be felt by neighbouring Local Authorities and possibly the South West region as a whole.

For a development to gain planning permission the developer must meet the requirements of PPS25. This involves undertaking the sequential test and then the exception test if required. The sequential test helps to ensure that development is located in areas of lowest flood risk first. Due to the high flood risk in the town centre area (Flood Zone 3) any development here must show that it cannot be placed elsewhere in a lower flood risk zone.

Once the sequential test is passed any developments classed as more vulnerable by PPS25 e.g. residential properties, or essential infrastructure must then meet the requirements of the exception test (Refer to PPS25 Table D3).

The Core Strategy covers the period of 2006 – 2026 but it is recognised that due to certain pressures, for example flood risk, there is a need to look beyond this horizon. In preparation of their Core Strategy, Weymouth and Portland Borough Council prepared Level 1 and 2 Strategic Flood Risk Assessments (SFRAs). These documents aim to highlight both the current and future flood risk, using the climate change guidance from PPS25. Horizons of 2086 and 2126 were therefore considered to take into account the lifetime of developments, (non-residential and residential respectively).

One of the main focuses of the Level 2 SFRA was Weymouth Town Centre. The Level 2 SFRA identified the significant flood hazards facing the community in the future from increased sea levels when climate change was assessed. The elevated sea levels contained in the SFRA were shown to overtop and outflank existing flood defences and extend into areas not currently subject to inundation, resulting in potential major flooding within large parts of Weymouth. See Section 6 for more details.

Without major investment in upgrading and extending current flood defences, flooding will occur with increasing regularity within the lifetime of the new commercial and residential development. While it may be feasible to mitigate the risk to new development by raising floor levels above future flood levels, this will not in itself make the development safe for occupants. These occupants may be forced, in certain circumstances, to vacate their property during a flood. Should this happen, then they would need to travel through significantly flooded areas to reach safe locations outside the tidal flood plain.

PPS25 advises that in certain circumstances, to meet the wider aims of sustainable development, it may be necessary to permit development that requires the provision of flood risk management, including defence and mitigation works. Such provision will generally be funded by the developer although this is dependent on the scale of the mitigation works required and who will benefit from the defences. Mitigation works will only be acceptable provided they are consistent with the relevant flood risk management policies for the area. Funding is less clear when there are a large number of existing properties at risk and therefore more significant mitigation works are required for the whole area rather than just the new developments, as is the case for Weymouth. Developer contributions should then be collected to help fund a larger flood risk management scheme.

The Core Strategy aims to give adequate consideration to all infrastructure needs of potential sites. This is particularly important when considering the future access / egress routes from the sites to areas outside the future flood risk zone. The Core Strategy therefore highlights the appropriate policies required and indications of possible funding routes.

The Shoreline Management Plan (SMP) which is a strategic document that sets out polices for the management of our coastline and our response to coastal flooding and erosion risk management over the next 20, 50 and 100 years has been advanced. The recommended contingency allowances for net sea level rise as set out in PPS25 have been included within the SMP evaluation process.

The SMP provides a large-scale assessment of the risks to people and to the developed, historic and natural environment. It addresses risk in a way that does not tie future generations to costly and unsustainable management, and attempts to balance potential conflicting interests along the coastline.

SMP policies reflect preferred options. While the SMP provides the framework for future decisions, the implementation of the policy relies on the availability of funding.

For the area of Weymouth the preferred policy is ‘Hold the Line’. This policy proposes that defences are maintained and upgraded or replaced in their current position where funding permits. It should be noted that although the policy is identified in the SMP, that does not mean it will be resourced out of central funding or implemented unless works have already been committed.

In general the Environment Agency would support a Local Authority who wishes to fund works envisaged within a SMP or Catchment Flood Management Plan (CFMP) or Strategy Study via a wider infrastructure levy as part of their Local Development Framework.

In line with the RSS, the historical nature of the area also needs to be considered. As mentioned in Section 7.1 there are a large number of listed buildings in the area and much of the town centre and quay area in Weymouth is of great historical importance. The character of the area is also one of the main drivers in terms of the economy of the area i.e. as a tourist attraction. If regeneration does not occur then the character of the area is likely to change.

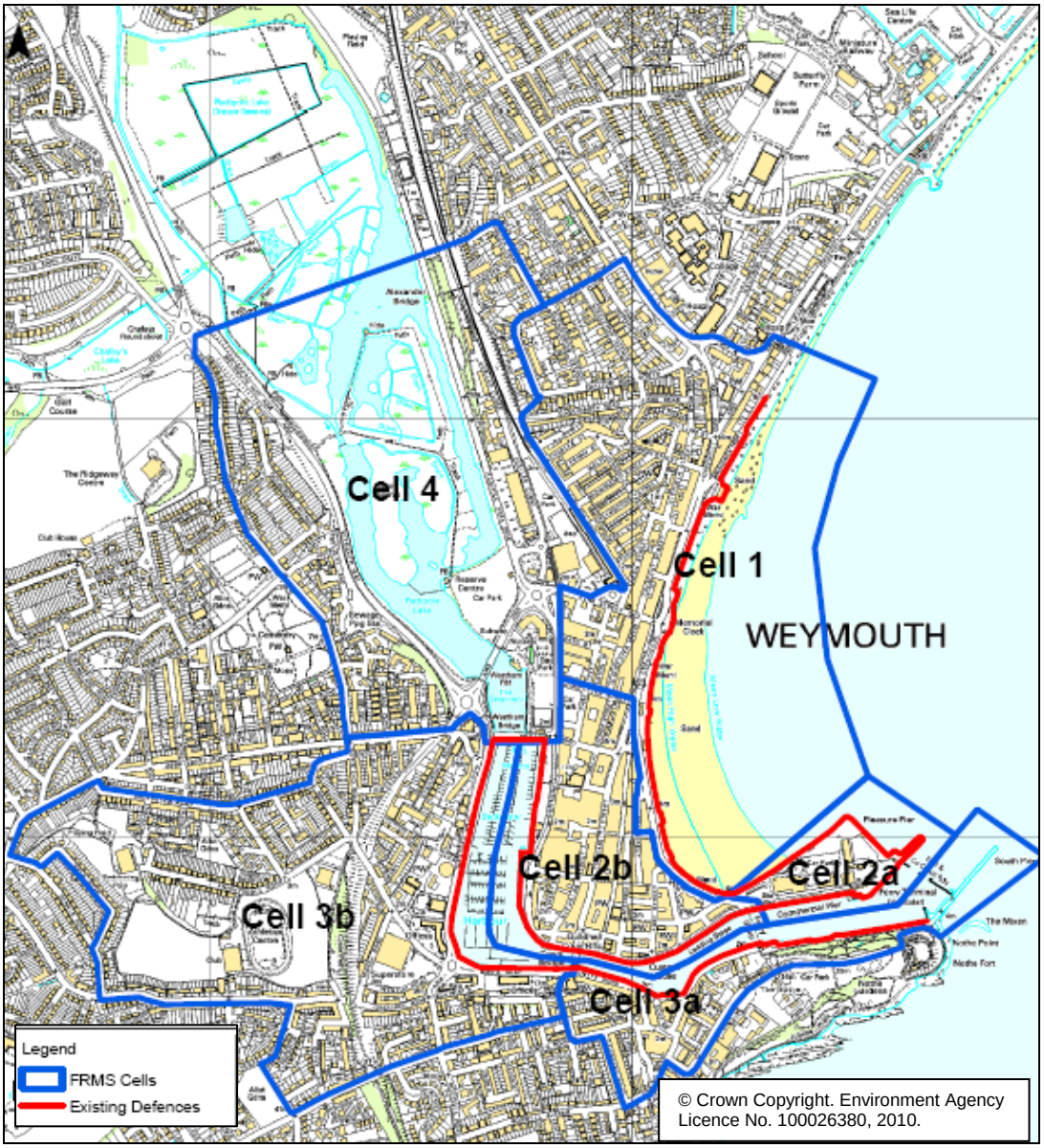
8 GENERAL OPTION ASSESSMENT METHODOLOGY

8.1 Splitting study area into independent cells

To investigate the options in more detail the area has been divided up into cells. Each cell acts as an independent unit. The defence options for each cell have then been investigated. The combined strategy is made up of the most appropriate option for each cell.

Figure 8.1 shows how the area has been split into cells and sub-cells where needed.

Figure 8.1 – Cell Divisions



The strategy covers the centre of Weymouth, including both banks of the River Wey, the southern end of Radipole Lake and the coastal frontage of Weymouth Bay as far north as

Greenhill. Modelling has concluded that there is no flooding to the town centre from flood cells associated with Preston Beach, even by 2126.

Flooding in the town occurs in discrete locations under current conditions. These locations remain as the main sources of flooding with future water levels however the extent, depth and frequency of flooding increases.

The area has been split into six flood cells. Each cell is independent in terms of present day flood extents and these divisions remain important for later flood extents as the original source of flooding is within the cell boundaries.

The cells are

1 Esplanade
2a Pavilion
2b Town Centre
3a The Nothe
3b Westwey Road
4 Radipole Lake

The division of the area into cells that act independently not only acts as a method for the assessment of the flood risk and existing defences. The way the area has been split also ensures that within each cell a continuous line of defence can be suggested and designed.

8.2 Cell Descriptions

1. Esplanade
This is the Eastern side of the town centre, extending west into an area of residential housing. The residential area is low lying and forms a 'basin' with the lowest point being 0.5mODN. The area is fronted by the Esplanade and a promenade which is high relative to the housing. The promenade is approximately 0.5m above the beach level and there is currently no formal sea defence along the promenade. The southern end of the Esplanade has the highest ground levels within the town and a large beach in front of the promenade. There is a masonry sea wall in front of the promenade. The frontage here comprises public promenade areas and commercial properties.

2a. Pavilion
The pavilion area is entirely constructed on made ground behind anchored sheet piled walls. There is a timber pier at the end of the sheet piled ground. The area was due for some form of redevelopment however this has since fallen through. The ferry terminal is located on the Southern edge.

2b. Town Centre
The main part of the town centre is currently protected by an Environment Agency flood wall that extends around the town centre. The entire river bank here is quay wall made of masonry, concrete or sheet piling. Some areas of the sheet piling have been noted as being in poor condition. The area is primarily made up of offices and commercial properties.

3a. The Nothe
The Nothe forms the southern river bank. The area has commercial properties along the front and has residential properties behind these. The frontage is mainly quay wall made of masonry, concrete or sheet piling. Once again, some areas of the sheet piling have

been noted as being in poor condition. There is one slip way crossed by a privately owned highway bridge, supported on the quay walls. There are proposals to install a boat lift at this location that would extend out beyond the bridge and across the highway. The raised defence line terminates at a road ramp upstream of the slipway bridge. The highway here is directly on the edge of the water with residential properties immediately behind.

3b. Westwey Road

This section covers the right hand bank of the channel between Westham Bridge and Town Bridge. Westwey Road runs along the top of a Portland stone masonry quay wall. There is one access point to marina berths from this bank. This area is higher than the town centre and has both commercial and residential property behind the road.

4a. Radipole Lake

Radipole Lake is a freshwater RSPB reserve. The lake is fed by the River Wey and is non tidal. The levels within the lake are controlled by 4 valves on Westham Bridge which have recently been replaced. Westham Bridge is included within this cell; the bridge itself is due for repair or replacement although there is no plan currently in place.

8.3 Freeboard Allowance

A freeboard allowance has been applied to the water levels determined by modelling. The extreme tide level data used for the modelling includes no allowance for overtopping but gives the values of uncertainty separately. Surge levels are included for in the extreme tide levels.

The freeboard is calculated based on the uncertainty in modelling results for water levels and the effect of site specific conditions such as land use. A detailed analysis of the required freeboard can be found in the note in Appendix C.

In addition to this note the freeboard along the harbour walls has been set to 0.5m with an additional 0.2m to account for settlement. This value has been used in this area because the wave climate within the harbour is much calmer than that along the coastal frontage. Note that this means the walls required now to provide a current 1 in 200 year standard of protection are much higher than the existing walls.

A freeboard allowance was included in the design of the 2001 scheme, although due to the changes in extreme tide level predictions there is no remaining freeboard with the scheme and in some places the current crest level is below the required 1 in 200 year standard of protection.

9 STRATEGIC SCHEME OPTIONS

The strategic options to be assessed for the protection of the town of Weymouth are discussed below. The options are:

- No active intervention
- Do Minimum
- Flood warning
- Raise the walls along the existing defence line to protect against a 1 in 200 year flood level in 2126.
- Raise ground levels up to at least the 1 in 200 year flood level in 2126
- Relocate the existing town centre to higher ground
- Raise ground levels and reduce the defence line by reclaiming land from the harbour

Note that these options apply to all of the 6 flood cells.

9.1 Options 1 – No active intervention

The No active intervention option means that no work is carried out, including further maintenance of the existing defences. This option would lead to the eventual collapse of the quay walls and associated flood defences along the harbour frontages of the River Wey. This would lead to damage to the public quay side areas and the eventual prevention of their use. The quayside areas could be unaffected if the quay walls were maintained/replaced without replacement of the flood defences. Failure to carry out maintenance or to increase the height of the existing flood defences will mean that, over time the town is put at a progressively higher risk of flooding.

As sea levels rise the available time for the drainage system to drain will be reduced and eventually gravity drainage will fail. Pumping is already undertaken. This will need to be increased in the future to deal with increased sea levels and a higher ground water table.

9.2 Option 2 – Do Minimum

The Do Minimum option means that the current defences are maintained but no improvements are undertaken; this will mean that the walls will be overtopped on a progressively more frequent basis. The cost of maintenance of the existing flood defence assets will increase as the assets age and the standard of protection of the defences will reduce as sea levels rise.

Some assets, in particular some of the steel sheet piled quay walls have little or no residual life and will suffer structural failure in due course. These structures would only be replaced to the existing defence standard as part of this option.

This option includes:

- Replacement of the existing walls to the current (2010) level

This option does not include:

- Construction of any additional assets

This option is one of minimum maintenance to maintain the current standard of defence. As the defence wall is situated on top of the quay wall maintenance of the defence would require the maintenance of the quay wall. Due to the poor condition of much of the quay wall this would incur considerable costs with no increase in the defence standard. This is therefore not thought to be an economically viable solution.

9.3 Option 3 – Flood Warning

Flooding in the town is mainly as a result of tidal action and it is, therefore, possible to provide reasonable warning of a potential flood event.

This strategy covers the next 100 years and predictions indicate the level of flooding will be substantially greater than that currently experienced and would become increasingly more frequent.

Flood warnings would help to ensure people can get to safety prior to a flood event but this will not prevent flood damage. In addition, flood warnings will be issued on an increasingly frequent basis and would need to be issued at earlier stages in the tide cycle and for longer periods of time. This may lead to greater inaccuracies in the predictions, thus potentially having more 'false alarms' and occasions when a warning is not issued when flooding actually occurs. People will also need to be out of their homes for increasingly long periods of time.

This suggests that flood warning is not a viable option on their own although should be included with other developments within the area.

This option includes:

- Replacement of the existing walls to the current (2010) level

This option does not include:

- Construction of any additional assets

9.4 Option 4 – Raising Defences to 1 in 200 year standard for year 2126

This can be done in a number of ways although any option needs to consider the permeability of the ground in the Weymouth area. The ground in Weymouth is highly permeable and therefore allows tidal water to affect ground water levels and consequently increase the risk of flooding in the town. This is expected to be a particular issue as sea levels rise. Just "above ground" work i.e. raising the Esplanade, is therefore not sufficient on its own. A cut-off is also required to ensure that the Park District in particular is not at risk due to percolation as sea levels rise.

The construction of a cut off wall along the 1.3km frontage from the Pavilion area as far north as the college and hospital would prevent tidal water levels from affecting ground water levels in the town.

Caution should be taken when considering this option. The hills to the north comprise mainly chalk which can have a high permeability; as a result there may be a large flow of ground water from the hills in the direction of the sea. A cut off wall could, in this situation cause a rise in ground water levels in the Town which may in turn increase flood risk landward of the cut off wall. Therefore it may be inappropriate to construct a cut off wall in this location. This option would require detailed investigation of the groundwater

processes as well as detailed soils investigation to determine the depth of any impermeable layer and therefore the depth of cut off wall required.

To begin the process of this investigation we would recommend the installation of an array of boreholes with peizometers that can be used to continuously record ground water levels. The data would need to be recorded over a period of around 5 years or long enough that the effects of a significant rainfall and tidal event can be recorded. This data would need to be assessed in relation to rainfall data from surrounding hills as well as with tide level data. These boreholes will also allow detailed soils investigation to be carried out. The data will be used to indicate the permeability of strata overlying the bedrock by carrying out pumping tests.

Based on anecdotal evidence there is assumed to be a clay layer some 7-8m below the ground level along the Esplanade; a cost has been indicated for the construction of a driven sheet pile wall along this length. The wall is assumed to be 10m deep to achieve a minimum embedment of 2m into the clay layer.

These sheet piles would need to tie into the base of any other flood defence structure along the Esplanade to provide an effective cut off.

Options for raising the existing defences are detailed below.

9.4.1 Option 4a - Construction of new walls on the existing alignment together with construction of a scheme to prevent wave overtopping along the esplanade.

This scheme involves replacing the existing assets to a height that would provide protection from a 1 in 200 year flood event in 2126. This may also involve extending the walls to join up with higher ground, particularly along the Esplanade. This option would, in the short term, allow the town to continue with development within the existing area. In the long term however this option would lead to a substantial change to the character of the town; as walls reach a height where by most people would be unable to see over them. The increasing water levels outside the walls would also lead to a greater risk to life should a breach of the walls occur.

The town would become increasingly reliant on the use of pumped drainage systems for all rainfall as tide levels would increasingly prevent the use of gravity drainage systems.

This option includes:

- Replacement of all quayside structures and other raised flood defences to the 1 in 200 year level in 2126
- Raising of the Esplanade and construction of a wave return wall along its length to prevent overtopping
- A cut-off wall along the Esplanade to prevent percolation

This option does not include:

- Maintenance of any existing structures
- Maintenance of any new structures
- Work to any drainage systems
- Any additional pumping requirements

9.4.2 Option 4b - Construction of a tidal barrier and replacement of the existing downstream walls and quayside, together with the construction of a scheme to prevent wave overtopping along the esplanade.

To minimise the height of raising of the walls along the river quayside, a tidal barrier could be constructed near the entrance of the river, at a location that would not affect the operation of the ferry terminal. This would be used to prevent the tide level in the harbour area exceeding the height of the existing quay walls.

This option would still require the ongoing repair and replacement of the quay walls and the existing flood walls as they come to the end of their useful life, but would allow the existing wall heights to remain as they are and thus not alter the character of the town. This would potentially mean that the existing drainage network may be somewhat less affected by increasing mean sea level, although the higher ground water table could still be a concern.

This option could be delivered in a phased approach:

Phase 1
- Replacement of all quayside structures and other raised flood defences to a current 1 in 200 year level
- Raising of the Esplanade, a cut-off wall along the Esplanade to prevent percolation and construction of a wave return wall along its length to prevent overtopping

Phase 2
- Construction of a tidal barrier at the mouth of Weymouth Harbour

Phase 3
- The opportunity to adapt the barrier to form a tidal lock gate to allow the continued use of Weymouth Harbour.
- Incorporation of a more extreme option elements, e.g. ground raising, if required following future monitoring of sea level rises.

This option costing does not include:
- Maintenance of any existing structures e.g. cleaning, patching etc
- Maintenance of any new structures
- Work to any drainage systems
- Operation and maintenance of a tidal barrier

A detailed investigation would be required to determine the optimum location of the tidal barrier taking into account cost, heritage, environmental considerations (via an EIA), maintenance, future plans for the harbour etc. This study should also look into finding the optimum wall height within the harbour when considering how often the barrier will need to be closed both now and in the future. The barrier will also need to be connected to the raised Esplanade. A plan of this option can be found in Appendix D

9.5 Option 5 – Raise Ground Levels of the Town Centre Area

This option would involve re-building and maintaining a similar alignment to the existing defences, along with raising the entire ground level of the existing town centre and adjacent low lying areas to cope with flood levels in the year 2126. A wave return wall would also be required along the esplanade to reduce the impacts of waves overtopping.

This would affect the commercial centre of the town from the ferry terminal up to the railway station and including the low lying residential area (Park District) affected by overtopping of the Esplanade.

Assumptions for this option are:

- Generally, reveted slopes would be constructed to replace the existing vertical masonry and sheet piled quay walls, except where needed to maintain the ports trade activities, as this will provide the most sustainable and the most cost effective 'defence' system. This would, however, result in the loss of either river channel area and/or developable/usable land area.
- The locations for keeping vertical quay walls can be identified. Longer lengths of vertical wall would increase both the construction and future maintenance cost.
- It is anticipated that the ground raising would be carried out in stages and may, therefore, require that some areas/properties are developed earlier than currently expected.
- The ground would be raised to the level indicated by modelling for the 1 in 200 year flood event plus a freeboard allowance in the year 2126. This will allow a direct comparison to be drawn with the other options.
- Should the rate of sea level rise exceed the current forecasts, then some small flood defences would need to be constructed around the periphery of the developed land. However, the decision for the need to construct any additional defences could be delayed for a number of decades and follow detailed monitoring of sea levels.

The cost of this option will include:

- Raising of the Esplanade and construction of a wave return wall to prevent overtopping.
- Construction of revetment or other retaining structures along the alignment of the river banks.
- Reconstruction of all public areas including promenade, roads and pavements
- Construction of new raised core infrastructure, utilities and drainage. A 50% contribution from the utilities has been included as it has been assumed that many of the utility assets are reaching the end of their service life and would, therefore, need replacing anyway.
- Some special consideration of the 'heritage' area facing the river downstream of the Town Bridge would need to be made. For example it may be possible to retain the frontage of some of the buildings to try to maintain the character of the area.

The cost of reconstructing all new buildings on the raised areas has been assumed to be the responsibility of the land owner / developer and appropriate authority. At this stage we are envisaging that progressively different areas of the town will be sectioned off and raised. A detailed investigation would be required to determine the exact process and the order of the areas to be raised. This will depend on sea level rise, political pressures, along with development opportunities.

9.6 Option 6 – Move the Town Centre to High Ground Inland

The present position of the town centre is low lying and at substantial risk from rising sea levels. There are areas of higher ground immediately inland of the present town centre which could be used as possible relocation sites for the town centre. This option would involve the relocation of the town's current commercial and residential activities from the present low lying areas to higher ground.

The existing defences would need to be maintained to provide protection against flooding during the planning and implementation phases.

A substantial part of Weymouth's economy is tourism mainly as a result of the seaside location and the historic riverside quays. As a result of this the idea of a gradual migration of the entire town centre could have a dramatic effect on the economy of the area. To mitigate this, the areas at risk from flooding, including historic features and seaside resort, could still provide a tourist attraction whilst residential property is relocated. The high risk areas could then be converted to more water compatible uses that support tourism to try to increase the income to the area in the long term. This would have to be a very carefully managed process to ensure that any negative impact on the town's economy resulting from changes in tourism levels is kept to a minimum. It would also incur significant additional costs.

A cost estimate has not been prepared for this option as this process would be a large project in itself.

9.7 Option 7 – Move the Town Centre by Reclaiming Land from the Harbour Area and raising

As outlined in Option 6, the present position of the town centre is low lying and at substantial risk from rising sea levels. This option would require the reclamation of land from the harbour area to a level necessary for the 1 in 200 year flood event plus a freeboard allowance in the year 2126, as indicated by modelling.

The harbour would be filled in and the River Wey directed through open channel or culvert, where necessary, to the sea. Radipole Lake could remain as a fresh water habitat if desired either with Westham Bridge continuing to act as a tidal barrier or a new barrier being constructed downstream, possibly at Town Bridge.

This would provide an area very close to the existing town centre to allow the progressive raising of the ground levels and redevelopment in and adjacent to the existing town centre area.

This option builds on the ideas in option 5 and makes changes to the use and course of the river to minimise flood risk, reduce the lengths of vertical quayside and provides the space required to facilitate the progressive raising of the dense construction in the town centre.

9.8 Alternative Long-term options

Below are two options that are more targeted at the long term flood protection of Weymouth taking into account sea level rise, with the additional element of providing new space for development. They are therefore more radical ideas that would have a significant impact on the nature of the area. Note that they do not fit with the current SMP policy for the area of 'hold the line'.

9.8.1 Option 8a – Advance the line by reclaiming land within Weymouth Bay

This option of advancing the line by building new defences from the Nothe to Greenhill and incorporating a tidal barrier across the harbour could protect the existing town from the rising sea levels. The tidal barrier would provide a more managed water level in the harbour area.

This would also provide development potential in the area of reclaimed land, in particular a modernised sea front with the old town lying behind it. This would be a major scheme that would need detailed investigation into the possible impacts elsewhere, particularly environmentally, as well as a cost estimate. If it is thought that the SMP policy should change to advance the line then this could be investigated as part of the more detailed Strategy due to be completed over the next few years.

9.8.2 Option 8b – Phased approach to change of land use and ground raising, allowing for further development

This option recognises the current flood risk and the fact that moving to a new pattern of land use in this area will take considerable time.

This option is a combination of options 4b, 5, 6 and 7, with the added benefits of providing additional areas for development and ensuring the town can still function whilst the raising work is undertaken. The overall approach is phased to provide areas for the commercial town centre to re-locate to, which then allows the land use of the old town centre to change and adapt to climate change. This option also allows for the coastline to fall back as sea level rise increases therefore helping to maintain a natural beach without significant recharge. Further details are also shown in Appendix D.

Note that the costs for this option are not directly comparable to the other options due to the large difference in developable land that is made available as part of this option. In addition, the in-filling of the harbour is optional depending on how the Council see the quay area developing in the future. Depending on the developer interest phases 2 and 3 could also be reversed. This would bring the option more in line with option 5.

Phase 1

- Replacement of quay walls by the town centre
- Construction of a wave return / overtopping wall along the Esplanade
- This work will allow for the continued development of sites in the town centre and provide protection from overtopping for a residential area. The Esplanade will provide a safe access / egress route which would also assist the development of the ferry terminal car park area.
- Construction of a tidal barrier at Town Bridge (or in Phase 2 depending on economics etc)

Phase 2

- Filling of the Westwey Road side of the channel between Town Bridge and Westham Bridge will provide a defended area suitable for development
- Raising of ground at the Athletics Centre
- Raising of ground at the Marsh Road and superstore area

Phase 3

- This will allow gradual movement of crucial infrastructure and services from the town centre to the eastern side of the river as required. The eastern side of the river will be revetment.
- The low areas of the Town Centre can then be raised and provide space for further development
- More space may be required to set back the esplanade to account for increased storminess and further sea level rise.

More detailed investigations into the raising of ground in all the areas listed above will be required if this option is to progress further. In particular an assessment will need to be

made of the impact on the surrounding area. This is most relevant for the land on the right bank of the River Wey e.g. Athletics Centre and superstore area, as this is known to currently provided flood storage for upstream catchments. The most suitable fill material would also need to be determined to provide a more detailed cost estimate for this work.

9.9 Additional options

The following options have been raised and discussed but have not been progressed in detail.

9.9.1 Breakwater

An offshore breakwater could be constructed to reduce the impacts of wave overtopping on the Esplanade. This could form part of an option but is not a strategic option in itself. This could be investigated as part of the more detailed Strategy due to be completed over the next couple of years.

9.9.2 Artificial reef

An additional advance the line option is an artificial reef to help prevent wave overtopping. This could offer added amenity value to the area and possibly increase tourism. This would only reduce the wave overtopping and therefore would still need to be considered along with works in the harbour, raising of the Esplanade and a cut-off to prevent percolation. This could be investigated as part of the more detailed Strategy due to be completed over the next couple of years.

9.9.3 Demountable defences

This is a moveable flood protection system that is either fully pre-installed and requires operation during a flood event or a system that requires part-installation into guides or sockets within a pre-constructed foundation.

If demountable defences were to be used they would need to be constructed along the full length of the towns existing defences. Alternatively the barriers could be placed on roads entering the town forming a defence in combination with the closest buildings to the quay. Those buildings on the edge would therefore not be protected from internal flooding from their frontage. In Weymouth there are roughly 15 roads from the harbour and 12 roads along the Esplanade which would all need demountable defences.

The decision on whether or not a demountable scheme is appropriate requires a risk-based assessment. This is primarily due to the additional risk of operational failure when compared to permanent defences. Where it is technically, economically and environmentally feasible and locally acceptable permanent defences are therefore preferred over demountable defences.

Demountable defences can also require higher maintenance costs and heavily rely on good flood warning procedures. Due to the high number of properties at risk and the hazards involved this option has not been considered further.

9.9.4 Building resilience

In the immediate term this would help to reduce the damages from any flooding that occurs prior to flood risk management improvements. Some examples of flood resilience are:

- Sealing cracks, joints and brickwork to prevent water entering the building
- Reducing the possible flow routes through joints of windows and doors

- Using flood resilient flooring to help reduce the water entering the building and aid the clean up process
- Raising the levels of services, particularly electricity into the building and ensuring where they enter the building is properly sealed.

This would not prevent flooding and would only reduce the damages from flooding where the depths of water in the buildings are relatively low. Safety would also still be an issue. This is therefore not a viable standalone option but should be considered when designing new developments.

9.10 Options Discussion

All options were considered in light of the requirement to provide a 1 in 200 year standard of protection in 2126. In addition to this it is useful to consider the even longer timescale and how options could be further adapted to accommodate additional potential changes in sea level. Residual flood risk is another consideration as there is always a risk of the design event being exceeded i.e. an event greater than a 1 in 200 year standard of protection.

The options above show that it is possible to protect Weymouth Town Centre both in the short term and the long term in a variety of ways, all of which have both advantages and disadvantages for the area.

When appraising all of the options we need to consider the town's physical and social assets along with the feasibility of each option and the protection provided. In particular, there are a large number of listed buildings in the area which all add to the character of Weymouth. This character, along with the beach, is what attracts visitors and therefore plays a large role in the economy of Weymouth. Where possible the character of the area should therefore remain unchanged. Due to the predicted extent of the flooding in the future this may not be possible, although the options detailed above show varying degrees of impact on the character and nature of Weymouth Town Centre.

The options can be split into three groups. Options 1, 2, 3 and 6 will not provide sufficient protection to the current town centre from flooding in the short or long term. This means that the standard of protection for the existing properties will reduce in the future and new development will not be permitted on flood risk grounds. In particular, Option 6 would most likely result in a significant change to the economy of the area with a reduction in tourism and no regeneration potential. **These are therefore not recommended options for Weymouth.**

Options 4a and 4b are similar but differ primarily by the introduction of a tidal barrier across the harbour entrance (option 4b). Both options would have a visual impact on the existing harbour perimeter and the Esplanade and possibly changes to the day-to-day use of the harbour in the long term. If walls are raised consideration will be needed of how to maintain the historic maritime nature of the quay. This will also impact on the moorings and fish landings, therefore adaption would be required although evidence from the River Wey project suggests that the locals are in favour of raising walls, provided the charm of the harbour is not spoilt. If a barrier is installed then the operations will need to be considered, particularly in the long term, to provide an indication of how often the barrier will need to be closed.

The major advantage of option 4b is that it provides a good standard of protection for the whole period, and being based substantially on the existing alignment of flood defences and high ground, minimises disruption to the functioning of the existing heart of the town.

The tidal barrier in the harbour greatly reduces the visual impact of required defences for much of the marina area.

An additional positive of options 4a and 4b is that raising of the Esplanade also gives the opportunity for regeneration and enhancement of the seafront area hence hopefully improving the tourist attraction.

The main downside of options 4a and 4b is that they are strategies with large capital costs with the need for ongoing maintenance and replacement / improvement works for the foreseeable future. The area will therefore need ongoing and increasing investment as well as the knowledge that the consequences of failure of the scheme will also continue to increase. There is a limit to how high flood walls / a barrier can be built and therefore these options whilst effective over the timescale considered, would probably become unsustainable over the very long term and future adaptations e.g. Option 8a or 8b may also be required. This is common to a great many other areas of the Country.

Ground water levels and the additional pumping requirements also need to be considered when assessing these options.

Option 8a, the advance the line option, is essentially similar to option 4b, but presents the opportunity for significantly increased scope for regeneration of the sea front area. This could act as a catalyst for significant new development whilst providing a major component of the required defences for the rest of the town. However, unless major developer contributions could be secured, this is unlikely to be an economically viable option based on the current assessment.

Options 5, 7 and 8b are more extreme options that will have an impact on the character of Weymouth but also significantly reduce the investment required in flood risk protection is the longer term e.g. after 2126. Even without defences the ground levels will be above the predicted flood level and therefore looking further into the future only minor defence work may be required as sea levels continue to rise.

The character impact of these options could be reduced depending on how the ground raising is undertaken. For example, new buildings could be designed to be sympathetic to the historic character of the town centre.

The RSS also needs to be considered in terms of providing new areas for development. Moving the town or providing new large areas for development directly contravenes the aims and objectives of RSS, which pushes development towards the current town centre areas. Future revisions of the RSS will need to address this issue before any major relocation can occur as it would also impact on the surrounding Local Authorities.

Table 9.1 below details the advantages and disadvantages of each option and provides general comments regarding the options where applicable.

Note that for all of the options above, storage, pumping and the drainage system for the whole area need to be reassessed.

9.11 Preferred Option – Option 4b

Based on the current guidance from the RSS and SMP and the knowledge of the area including its historic maritime character and the local economic drivers, Option 4b (raised Esplanade sea wall and cut-off wall, tidal barrier, limited quay wall raising and stabilising other harbour walls) appears to provide a strategy that will provide the required protection

both in the short and long term with the least disruption and impact on the town. This option also provides the possibility of considering ground raising at a later date if sea level rise exceeds predictions or large areas of the town become available for development. This option would also allow the town centre to continue to develop and regenerate.

A plan of the proposed works for Option 4b is shown in Appendix D.

Table 9.1 – Option advantages and disadvantages

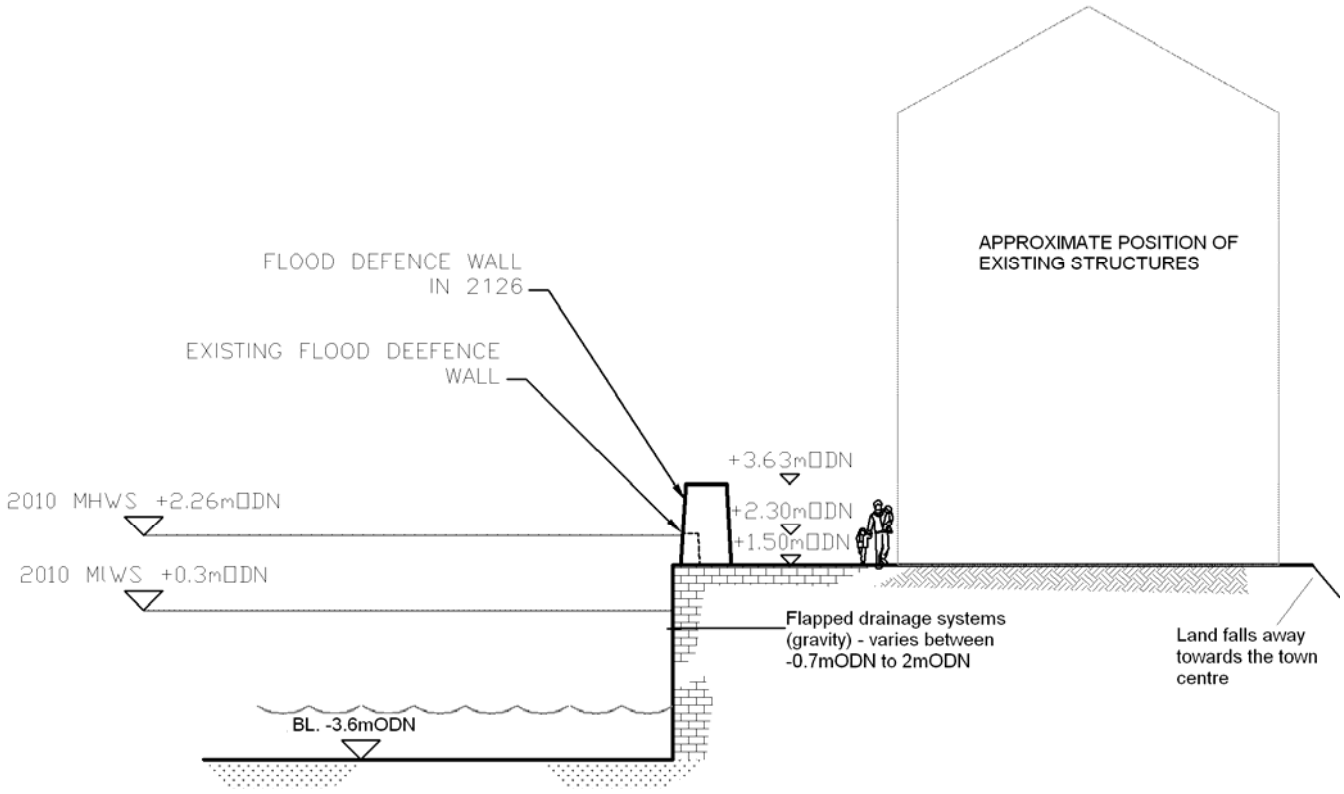
Option	Advantages	Disadvantages	Comments
1. No active intervention	• Eliminates all flood defence spending	• Approximately 450 properties currently at risk. This will increase in the future • Loss of existing assets / investment and failures would increase the health and safety issues.	Not considered further – unacceptable due to the significant risk to life and property.
2. Do minimum	• Maintains the existing defence line	• Approximately 450 properties currently at risk. This will increase in the future • Standard of protection reduces over the years.	Not considered the way forward due to the number of properties at risk currently and in the future.
3. Flood warning	• Maintains the existing defence line • Does not involve a large construction • No disruption to the town	• High maintenance, installation and operational costs • Flood warnings would become progressively more frequent • Residents of the town would have to leave their homes more often and for longer periods of the tide cycle as time passes • Not a fail safe system. It relies on human intervention	Not a viable option on its own, although this could be incorporated into other options for the short term.
4a. Raising of existing harbour defences – walls	• It maintains the existing alignment • Allows the town to continue with development in the area. • Includes a cut-off along the Esplanade to prevent percolation. • In line with SMP policy of hold the line • Raising the Esplanade provides an opportunity for enhancement and regeneration of the sea front	• Walls will become high, affecting the character of the town – see Figure 9.1 • High walls have a greater flood risk which could present a high risk to life should a breach occur • With SLR increased pumping would be required to aid the existing drainage network • High maintenance costs due to walls needing replacing (lifespan depends on materials used, sheet piles ~ 50 – 60 years)	This is certainly an option for the short to medium term although for the long term the wall heights will be significant, therefore altering the character of the area. There is also a limit (in terms of aesthetics and character) on how high walls can be built so this is not an option that can be continued over the long term.
4b. Raising of existing esplanade defences – tidal barrier	• Allows the existing harbour walls to stay at lower level therefore maintaining nature of the harbour • Includes a cut-off along the Esplanade to prevent percolation • In line with SMP policy of hold the line • Raising the Esplanade provides an opportunity for enhancement and regeneration of the sea front • Allows for future adaptation depending on the uses of the harbour and the Town Centre	• Barrier would require considerable maintenance and result in high operational costs • The frequency and duration of closure of the barrier would increase with SLR e.g. by 2126 barrier would need to be closed probably every mean high water spring tide. This would impact on how the harbour is used.	Provides protection for short and long term. Adaptable to changes in sea level rise predictions. Could be combined with other elements e.g. land raising in the future if required.

Option	Advantages	Disadvantages	Comments
5. Ground raising	• Sustainable solution • Allow development to continue • Provides means of safe access & egress for current properties and proposed developments • Flood defences would not be required unless SLR is higher than predicted • No further investment would be required once the raising is complete, only maintenance costs up to the study horizon.	• Highly complex implementation • Could be a considerable negative impact on the economy of Weymouth. • Need to raise services • Need to raise buildings, some of which are listed • It would cause large areas of disruption • Cost of raising ground levels within the town also attracts the cost of raising key infrastructure and services and is therefore an expensive option. A large number of assumptions were required to develop a cost for this option.	Could be considered further for the long term protection of the town although not necessary for the short - medium term where other less disruptive options could provide adequate standards of protection.
6. Move the town	• Guarantee the protection of the town from fluvial or tidal flooding • Opportunity to improve access routes and infrastructure	• Economy would suffer as a result – no further investment / development in the current town centre • Extensive disruption • Viability of existing town centre would be questionable • Funding would be required to maintain tourist areas • Large number of Listed Buildings in the area at risk.	Not in line with the RSS or SMP policy and does not provide protection to any of the current buildings / landowners.
7. Reclaim land	• This would considerably reduce the length of the required flood defences, • It would provide land onto which part/all of the existing town could be relocated	• Some of the marina area would be lost • This will change the nature of the area. • Large disruption • Changes to the character of Weymouth	A new marina could be created so that the income stream is not lost. To be considered further for the long term protection of the town only.

Longer term options			
Option	**Advantages**	**Disadvantages**	**Comments**
8a. Advance the line	• This would provide long term flood protection to the town centre area • It would help to provide new areas for development along with a modernised sea front public realm area. • The beach area could be protected and enhanced.	• The works would be highly costly. • This would be extremely disruptive to the beach area in particular, therefore impacting on the tourist economy • This would be highly complex and require a detailed study which itself would be costly • There could be large environmental impacts therefore mitigation is likely to be required.	This is a possible long term option although a detailed investigation would be required to fully investigate the technical and particularly economic viability of this option.
8b. Hybrid approach inc. ground raising	• This would considerably reduce the length of the required flood defences • It would provide land onto which part/all of the existing town could be relocated without the need to provide large defences along the river banks. • The redevelopment of the town centre could be undertaken in a simpler, progressive manner, due to the availability of new developable land adjacent to the existing town centre. • There would be no need to relocate an extensive area of residential properties. • The town centre would remain close to the beach • Provides additional areas for development • Provides a more sustainable flood risk management approach.	• Expensive due to the amount of ground raising required. • Disruption during construction could put some people off visiting the area. • Large number of listed buildings in the area to be raised. This provides the character of the area which is what attracts visitors • Negative interim impact on the economy of Weymouth • Raising key infrastructure needs to be considered • Complicated process	Would provide protection throughout the short, medium and long term although significant disruption would be caused to the area and major changes to the character and nature of Weymouth, particularly the beach and seafront areas which are fundamental to tourism. Phased approach makes it highly adaptable to climate change.

Figure 9.1 gives an illustration of the heights of the walls required to protect the town from the 1 in 200 year event in 2126. To provide perspective an average adult has been added to the figure, showing that at the required heights most people would be unable to see over the proposed walls. This would completely change the nature of the area. In particular, in areas where the buildings are close to the water side the walls would give a feeling of narrow corridors and present a complete dislocation from the water front and marina. This has been provided to highlight the degree of visual impact and separation from the water-side that would be required if purely option 4a was pursued.

Figure 9.1 – An illustration of the walls required to protect against the 1 in 200 year flood by 2126.



10 COST AND PHASING METHODOLOGY

10.1 Costing

Costs are provided to enable a comparison of the different options and to enable the calculation of cost benefit for each of the options.

To provide a consistent and easily adaptable cost for a flood risk management strategy a cost database spreadsheet has been developed, see Appendix G. The database uses cost assumptions from the Environment Agency Flood Risk Management Estimation Handbook which, where possible, have been verified against recent schemes.

For the database to be used a line of defence must be determined that will provide protection for the entire area. This line can then be split to identify any existing defences and any gaps in the existing defences where new defences are required.

Each defence length identified was then given a unique ID. For each defence length a new database sheet was then created that identified the key dimensions and levels. These were then used to calculate a cost for constructing or raising the defences to the required level for each of the pre-determined time scales. The assumptions used, an example of the database sheet for each defence and the details of existing defences are provided in Appendix G.

The database automatically calculated the total costs including design fees and construction and sum the costs for the defences required for each cell.

This method of costing is appropriate for construction and raising of walls, quayside and embankments and has therefore been used here to show the cost of bring the existing defence line up to the required standard. Further options have been developed as discussed in section 9. The costing of general ground raising and construction of a tidal barrier was carried out separately. The costing of these options has been determined from previous projects and by cost estimation.

Each of the costs assigned to an option has, where possible, been either benchmarked against an existing or completed project or can be supported by a cost breakdown.

The cost for sheet piling is based on a 100 year design life. From experience it is apparent that this design life is often not achieved by steel sheet piles in a coastal environment because of higher than expected corrosion rates and a less frequent maintenance regime than required. It has therefore been assumed that the life of a steel sheet piled wall is 60 years. The cost of the replacement of these piles after 60 years has been included to provide a more conservative cost estimate. Should the sheet piles achieve a longer design life the costs for a second replacement would be delayed.

10.2 Assumptions

For each option certain elements have been omitted from the cost as they could not be accurately determined at this stage. Details of the assumptions made for each option are identified in section 8.

Generally the costs include

- Feasibility studies

- Construction costs
- Design fees
- 60% Optimism bias*

*It is generally accepted that people have a tendency to be over-optimistic about the outcome of planned actions. Optimism bias arises in relation to estimates of costs and benefits and duration of tasks. It must be accounted for explicitly in appraisals if these are to be realistic. The UK government explicitly acknowledges that optimism bias is a problem in planning and budgeting and has developed measures for dealing with optimism bias in government (HM Treasury 2003). It is therefore a requirement to use so-called optimism bias uplifts in order to arrive at more realistic budgets for planned ventures. For this study we have used the recommended value of 60% optimism bias i.e. an additional 60% is added on to the estimated costs of works.

The following are not included in the cost assumptions

- Future maintenance costs
- Interim maintenance or replacement of failed assets during the implementation of a long term strategy

The cost of ground raising includes the raising of the ground level using imported fill material. A cost is included to allow for the raising of services in the ground such as drainage and electricity. The estimate assumes a flat area of ground that is raised to a new level. The cost of demolition of the existing structures has been given a basic estimate whilst the cost of rebuilding those structures is not included for with in the estimate. Therefore the raising / re-locating of individual or private buildings have not been included in the assessment. Ground raising costs do not include for any design or feasibility stage as the scope of these is presently unknown. Due to the uncertainties in this ground raising costs an 80% optimism bias has been used for this part of the cost estimate.

10.3 Phasing

The strategy not only provides options for the defence of the town but also gives an approximate timescale for the implementation of the proposed works.

The date for investment in a particular line of defence is, however, not solely dependent on the height of the existing defence; the other factors that will influence this include the residual life of the existing asset, the potential to obtain developer contributions and the actual rate of sea level rise.

For all of the options sea level rise needs to be monitored and the phasing adapted to match any changes to the sea level rise predictions. Currently the Proudman Oceanographic Laboratory (POL), part of the Natural Environment Research Council, is responsible for measuring sea levels across the globe. They regularly report on their findings, which will be included in the UK Climate Impacts Programme (UKCIP). This is an on-going programme, and the most recent advice is currently detailed in UKCP09. Any changes as a result of this programme should therefore be taken into account when assessing when work needs to be completed in the future.

Typically the design life for flood defence structures is 50 years and this would require the reconstruction of defences before 2126 if they are required before 2076. Ideally structures should be designed to have a longer design life, 100 years or more.

Phasing is achieved by the following activities:

- Comparison of the existing defence levels and the predicted water levels to determine the year in which the existing defence will be overtopped. A freeboard allowance is applied to the water level to account for any uncertainty.
- An assessment of the residual life of the structure, this would preferably be based on a structural inspection however a visual assessment is often the only available information.
- The desired regeneration and development areas

A combination of these factors has been used to determine the most appropriate investment date. These investment dates for each option are shown in Appendix E.

The bodies likely to promote schemes are then able to see when they are likely to require money and can plan there actions and obtain funding.

11 SCHEME COSTS AND CONTRIBUTIONS

11.1 Scheme Costs

The costs presented here are the whole life costs (excluding maintenance) up to 2126, therefore they included the cost of any replacement work required based on the assumed life of the structure. For example piles are known to last at most 60 years, therefore the cost below is for the piling to be replaced in the next 10 years and then replaced again in 70 years. In addition, the do minimum costs are included in the flood warning option. Appendix E provides an indication of when the works for the options would be expected to be undertaken. These timings have then been used during the development of the present value costs.

The costs for each option include all the work elements that would need to be carried out to bring the defences up to a 1 in 200 year standard of protection in 2126 (including sea level rise). Table 11.1 shows the capital costs for each element of work required for the options detailed in section 9 for the future defence of the town and then which work element is required for each option. Note that options 6 and 8a have not been given an estimated cost and are therefore not included in this table. This is because a detailed investigation would be required for these options before any estimates can be provided. These costs are based on the Environment Agency Flood Risk Management Estimation Handbook which, where possible, has been verified against recent schemes. Due to the strategic nature of this study certain elements have been omitted from the costs as they could not be accurately determined at this stage e.g. pumping requirements over the 100 years. Section 10 provides more details on what is included in the costs and the assumptions made during the assessment. Table 11.2 then provides a summary of the capital costs which includes for repeating any of the works due to the structure lifespan. Note that some of the elements e.g. sheet piling are required to be repeated multiple times depending on when the work is undertaken.

Table 11.3 then provides a summary of the present value costs for each option. Due to the uncertainty in the calculations and the assumptions we have had to make, we have provided a cost range for each option rather than a single value.

Table 11.1 – Details of what is included in each option

Work element	Capital Cost	Option							
		1	2	3	4a	4b	5	7	8b
Wall replacement	£87,000,000		✓✓	✓✓		✓✓			
Wall raising to 2126 levels	£100,000,000				✓✓				
Revetment of the entire harbour	£16,000,000						✓	✓	✓
Pavilion Sheet piling	£12,000,000						✓	✓✓	✓✓
Tidal barrier	£25,000,000					✓			✓
Infill Harbour	£25,000,000							✓	✓
Ground Raising Town Centre	£48,000,000						✓	✓	✓
Esplanade Raising	£21,000,000				✓	✓	✓	✓	✓
Cut-off along the Esplanade	£8,500,000				✓	✓			
Esplanade Link Roads	£2,000,000						✓	✓	✓
Ground Raising playing fields	£26,000,000								✓
Ground Raising superstore	£28,000,000								✓
Ground raising Park District	£49,000,000						✓	✓	✓

Work element	Capital Cost	Option							
		1	2	3	4a	4b	5	7	8b
Ground Raising around park	£55,000,000						✓	✓	✓
Ground raising Pavilion	£14,000,000								✓

* double tick shows that some of the works need to be undertaken more than once in the 100 year time frame (although not all, dependent on when the initial work was completed)

Table 11.2 – Total capital cost for each option (including repeat work where needed)

Option	Description	Details	Approx. Capital Cost
1	No active intervention	No work undertaken	£0
2	Do minimum	Maintenance only. All sheet piles and walls replaced twice	£175,000,000
3	Flood warning	Maintenance only. All sheet piles and walls replaced twice	£175,000,000
4a	Raise walls	Sheet piles and walls replaced twice	£230,000,000
4b	Tidal barrier	Some sheet piling and walls replaced twice	£180,000,000
5	Raise ground	Work only undertaken once. Areas on LB still at risk.	£205,000,000
6	Move the town	Not estimated	Not estimated
7	Reclaim harbour	Sheet piling at Pavilion replaced twice	£235,000,000
8a	Advance the line	Not estimated	Not estimated
8b	Ground raising & change of land use	Sheet piles replaced with revetment so only done once	£320,000,000

Table 11.3 – Present value costs of each option

Option	Description	Present value (PV) costs		
		Low estimate	Best estimate	High estimate
1	No active intervention	0	0	0
2	Do minimum	£40,000,000	£52,000,000	£60,000,000
3	Flood warning	£40,000,000	£52,000,000	£60,000,000
4a	Raise walls	£60,000,000	£74,000,000	£86,000,000
4b	Tidal barrier	£41,000,000	£66,000,000	£78,000,000
5	Raise ground	£83,000,000	£91,000,000	£100,000,000
6	Move the town	Not estimated	Not estimated	Not estimated
7	Reclaim harbour	£103,000,000	£113,000,000	£123,000,000
8a	Advance the line	Not estimated	Not estimated	Not estimated
8b	Ground raising & change of land use	£83,000,000	£103,000,000	£121,000,000

Note that the costs for option 8b is not directly comparable to the other options due to the large difference in developable land that is made available as part of this option. In addition, the in-filling of the harbour is optional depending on how the Council see the quay area developing in the future. The amount and location of developer interest could also have an impact of the phasing, with the option of reversing the order of phases 2 and 3. This would bring the option more in line with option 5.

Note that for option 4b a large proportion of the capital costs are for the replacement of the existing walls, with some areas requiring replacement twice due to the timescales

involved. The cost of the new defence works i.e. tidal barrier and Esplanade works equates to a capital cost of approximately £60 million.

11.2 Contributions

The piecemeal protection of individual regeneration sites is not the preferred approach to future flood risk management as it is unsustainable and will leave key areas with potentially unsafe access as a result of increased tidal inundation. Therefore a holistic and phased approach in line with the timelines raised in the RSS needs to be considered. For the various areas considered in this report, the land has a number of owners. As this is only at the initial strategy stage and as the viability of any proposed works is still uncertain, more detailed discussions have not been held and therefore contributors have not been identified.

Construction of flood risk management infrastructure provides benefits to both existing development and new regeneration areas and therefore if any schemes or works are taken forward, then contributions from all parties should be considered. Additionally, in public areas, contributions should be discussed with the local authority where public areas may be enhanced as part of the works.

The cost of future flood risk management infrastructure could be met through either private or public investment and can be viewed in a similar way to other major infrastructure requirements (such as highways) as they are essential for the development of key areas as identified in the RSS. Due to the costs involved a funding framework may need to be developed as part of a Flood Risk Contributions document.

Private Funding

Contributions from the new development areas are required to achieve the development obligations under PPS25. These can be raised through a variety of sources including Section 106, Community Infrastructure Levy and Community Benefit funds.

The exact method for determining the funding requirements will need to be determined through a future Supplementary Planning Document and will need to take into account economic viability evidenced through the wider Weymouth Bay Study.

Developer contributions will also vary for the different options. For example, it is expected that the ground raising of the athletics track should primarily be paid for by the developer, as they will benefit significantly from the land being made available for development.

As a guide, the areas highlighted in the Core Strategy as potential development sites within the town centre make up approximately 15% of the land area in the town centre that is shown to be within the 1 in 200 year flood outline by 2126. Whilst for the whole borough, the areas highlighted as possibilities for development make up approximately 5% of the total borough area. These figures could be taken into consideration when determining the size of the levy for development within the town centre and the borough as a whole.

Public Funding for Regeneration

Government funding through various regeneration mechanisms such as Homes and Communities Agency, Regional Funding Allocations and capital borrowing could be appropriate to support future regeneration. Key flood risk management infrastructure could be funded in this way.

Public Funding for future flood risk management measures

Flood Defence Grant in Aid (FDGiA) is distributed by the Environment Agency on behalf of Defra. Funding provided from third party sources can alter the priority of FDGiA allocations. Funding is generally aimed at schemes that provide the greatest reduction in flood risk for the lowest public contribution. Table 12.2 gives the benefit/cost ratios for the options identified as part of this strategy. All acceptable options providing a 1 in 200 year standard of protection at 2126 appear to be economically viable with a benefit cost ratio of between 1.3 and 2.9.

An alternative funding route for part of the costs could be the Housing and Communities Agency (HCA) via their Single Conversation process. One of the aims of the HCA is to help to fund works required to provide affordable housing. For example, currently North Somerset Council have submitted an application to HCA for funding for flood defence capital works in the Weston-super-Mare area. These works are required to allow residential developments within the Weston Development Area. This could be an area for further investigation regarding some of the car park sites highlighted by Weymouth & Portland Borough Council as part of their Core Strategy.

Bournemouth, Dorset and Poole have developed a Local Investment Plan for the period of 2010 – 2026. This plan reflects a number of challenges to the area, including dealing with the effect of climate change. This states that Weymouth Pavilion Site and Town Centre is one of the priority areas

12 ECONOMIC ASSESMENT

12.1 Benefit methodology

A number of methods were investigated to assess the economic benefits of various options for flood management within the town centre of Weymouth. It was decided, in view of the level of this study, to modify a method successfully undertaken in other Royal Haskoning projects to estimate flood damage costs. This is based on the Multi-coloured Manual (MCM) (although this is not a full benefits assessment using detailed depth damage information but a basic assessment of the 'do minimum' damage cost, assumptions made in relation to this are detailed below). Note this does not account for any damage to roads or services. It is purely a property based assessment.

Flood damage costs for the do minimum scenario have been estimated using the method outlined below to provide an approximate cost against which to compare the cost of various strategy options described in section 9 of this report. As recommended for Strategy level assessments in the MCM Handbook and owing to the lack of property age and class data, weighted Annual Average Damage (AAD) costs were used to assess flood damage on a basic level. These values were updated to November 2009 using the current consumer price index and applied to the number of properties at risk for each timeframe. For commercial properties AAD values are provided per square metre, therefore mean floor areas were used for each commercial class based on the MCM and Valuation Office Agency Code for each property. It was decided to use the mean floor areas provided by the MCM rather than directly use any floor areas provided with the 2008 National Property Dataset (NPD) in order to maintain consistency in data use and to reduce any error associated with using a small dataset given that floor areas for several properties were omitted (the MCM values are based on a national sample). It was found that there was a variety of floor areas within the NPD for Weymouth indicating that the use of the mean floor areas for each class is appropriate in this case as the areas are not particularly small or larger than the national average on which the mean floor areas provided by the MCM area based. It was also checked that there was no domination of any one particular class of commercial property hence although it is recognised that usage and therefore class could change over time, it is considered that this would make little difference to the overall result. A discount factor was applied to the AAD values for each year, as recommended by the HM Treasury Green Book (3.5% for present day to 30 years time, 3% for 31 to 75 years time and 2.5% for 76 years and beyond), in order to estimate present value damages for each period of time.

In order to identify the number of properties at risk, the NPD was analysed in combination with tidal flood extents. Extents were obtained from the modelling undertaken by RH as part of the Weymouth and Portland Level 2 Strategic Flood Risk Assessment (SFRA). The extent for the 1 in 200 year tidal flood event (including the effects of wave overtopping) was used to assess properties at risk under the current situation. The 1 in 200 year tidal flood extent (with wave overtopping) incorporating the effects of climate change was used to assess the number of properties at risk during a 1 in 200 year event by the years 2035, 2060, 2086 and 2126 (future situations), the latter of which represents the life of Weymouth and Portland Borough Council's Core Strategy plus 100 years for the lifespan of any residential development.

The modified property dataset was then divided into residential and commercial properties for both current and future scenarios. It should be noted that within each period of time, flats account for over one third of the total number of residential properties at risk;

however they have not been excluded from this assessment because it was considered complex to remove from the dataset those not on ground level without conducting an extensive survey. The inclusions of all flats could lead to overestimation of flood damage costs because although only the ground floors of these properties are likely to be directly affected by flooding, residents on higher levels will experience some level of damage due to the loss of access and services during and after a flood event potentially leading to additional temporary housing costs should the flats become uninhabitable. A more detailed study could ascertain the number of ground floor flats via a survey should an in depth cost/benefit assessment be required.

The flood depth grid for the 1 in 200 year event from the Level 2 SFRA was then used to determine whether each property could be expected to flood during this event by identifying whether the flood depth at the property was above or below a threshold identified by the client (100mm for commercial properties and 300mm for residential properties). This was repeated for the 1 in 200 year event 'plus climate change' for each timeframe.

MCM AAD costs vary according to the standard of protection (SoP) assumed to exist for each property or group of properties. For the purpose of this assessment it was assumed that defences currently exist in the study area but are generally of unknown standard and do not protect all properties within the area at risk from flooding. It is also assumed that not all properties at risk will experience flooding during every flood event. A 1 in 50 year SoP was therefore assumed for current conditions during a 1 in 200 year event. This was then reduced for each period of time into the future to represent the effects of climate change where increased storminess and rising sea levels could be expected to put more properties at risk, in addition to increasing the frequency of flooding to properties which already experience flooding under current conditions. By the year 2126, it is anticipated that existing defences will offer no protection. In all cases it was assumed that there will be no flood warning.

12.2 Benefit results

The results from this assessment are shown in Table 12.1 for the various epochs.

Table 12.1 - (Future flood damage costs expressed in present value)

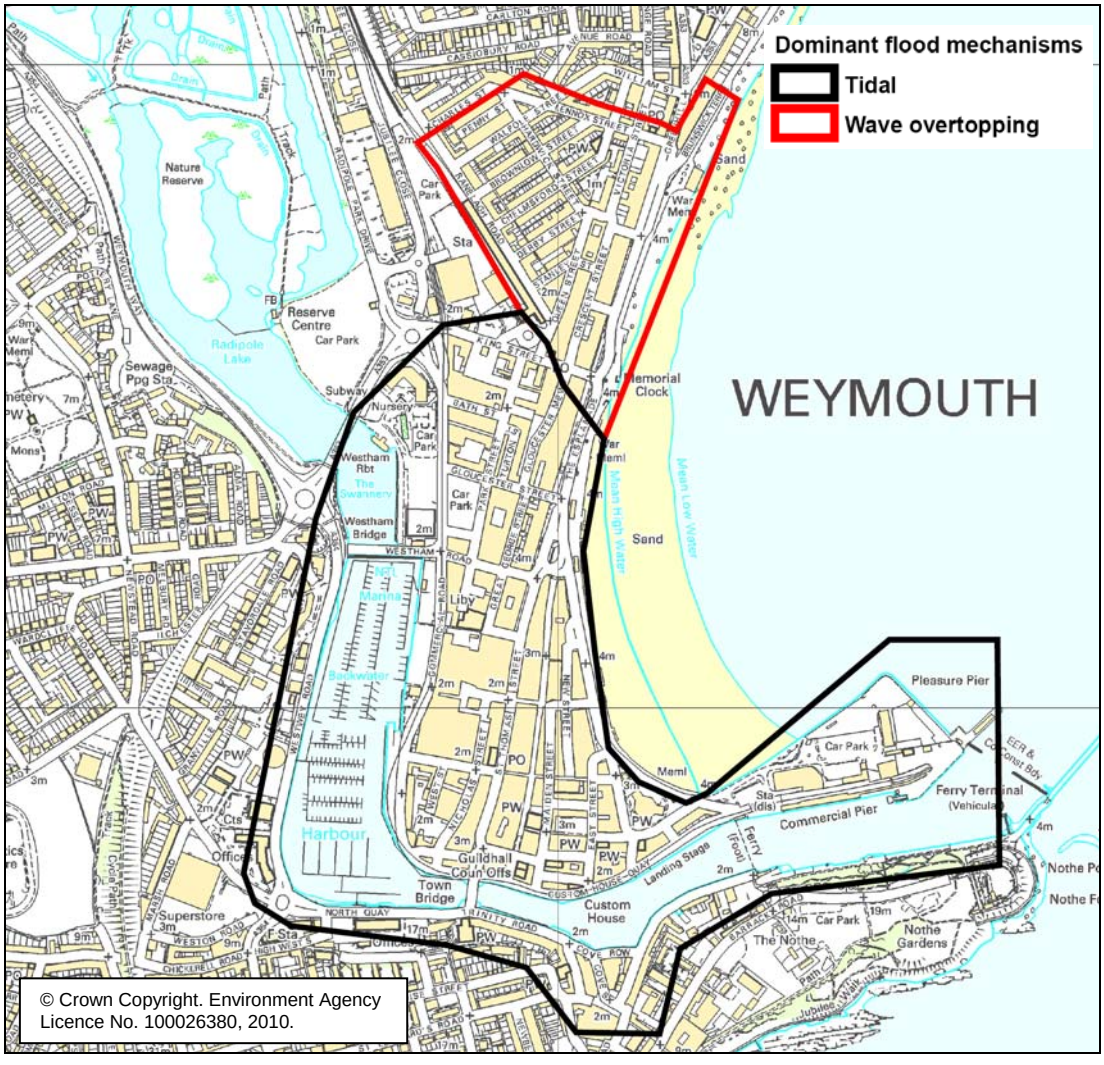
Year	Number of years	Assumed standard of protection		Total number of properties at risk during 200 yr event			Pvd (total for epoch)
		Tidal	Wave Overtopping	Tidal	Wave Overtopping	Total	
2008	27	100	10	288	159	447	£17,400,000
2035	25	25	5	646	361	1007	£33,700,000
2060	26	5	0	1300	558	1858	£43,600,000
2086	39	0	0	2025	752	2777	£49,100,000
2126	1	0	0	3231	811	4042	£880,000
Total	118						**£144,700,000**

When undertaking the benefit assessment a standard of protection has been chosen to represent the general onset of flooding for the area based on the modelling undertaken. This is shown in Table 12.1 for the various time horizons. These assumed standards of protection vary to reflect the different dominant sources of flooding in different parts of the study area as identified by the Level 2 SFRA modelling results. 'Tidal' refers to the

harbour area of the town where the primary mechanism of flooding is tidal. 'Wave Overtopping' refers to the area of town north and east of the railway station where the dominant flood mechanism is wave overtopping which was shown by the SFRA to occur at a much lower return period than tidal flooding due to the influence of waves, hence the lower assumed standard of protection. This is shown in Figure 12.1.

For the areas that are affected by waves the return period stated represents that tide level combined with a 1 in 1 year wave. For example the current onset is from a 1 in 10 year tide level and a 1 in 1 year wave. The SFRA and previous Areas Benefiting from Defences (ABD) study took this as a 1 in 10 year event. For consistency, the same approach has been used here, but it should be noted that the true joint probability would probably be in excess of 1 in 25 years. The resulting 1 in 10 year standard of protection is therefore thought to be a conservative estimate when compared to flooding incidents over the last 50 years due to the actually probability of these two scenarios combining.

Figure 12.1 – Dominant flood risk mechanism



The results show that damages can be expected to increase for each period of time into the future (the results for 2126 are lower because this is based solely on one year as the extents and depths of flooding were not modelled beyond this point). This is expected because as a result of climate change, increased storminess and rising sea level are

likely to put more properties at risk as the extent and depth of flooding increases for each of the timeframes shown in Table 12.1. Results indicate that over the lifetime of the Weymouth & Portland Borough Council's Core Strategy, present value damages from a 1 in 200 year event (including the effects of climate change where applicable) could amount to just almost £145 million. It should be noted that these results are indicative and should be considered in combination with the assumptions detailed below. In addition, at this stage we have not considered capping of damage values. This should be done when a more detailed assessment is undertaken.

12.3 Assumptions

- Properties are assumed not to have basements.
- All flats have been included in the assessment whether they are on the ground floor or higher levels because it was considered problematic to remove non-ground floor flats without extensively surveying the area at risk. Additionally if the ground floor of a property is flooded, services and access are likely to be cut off for residents on higher floors therefore incurring some level of damage.
- November 2009 price base unless otherwise stated.
- Of all the properties at risk not all will experience flooding during every flood event.
- Thresholds are the same for all properties (100mm for commercial and 300mm for residential)
- Commercial Non-bulk class mean floor area information was unavailable therefore the average of non-bulk property floor area has been calculated using the available data in the NPD for the Weymouth area. It is therefore assumed that these are accurate.
- VOA codes in the NPD which did not fit into one of the five MCM commercial classes have been included in the non-bulk class.
- Any listed buildings in the dataset have not been accounted for therefore costs may subsequently be higher than estimated.
- Saltwater damage costs to building fabric are 10% higher than fresh water (source: MCM).
- An extra 10.7% has been added to the total damage cost to account for the cost of emergency services during a flood event (source: MCM).

12.4 Damage vs. costs

Table 12.2 shows the benefit / cost ratio for each of the options outlined in Section 9, based on the best estimate costs from Table 11.2.

Table 12.2 – Options benefit/ cost ratio for 2126

Option	Standard of protection in 2126	Present value benefit	Present value cost	Benefit / cost ratio
1 – No intervention	0	0	0	-
2 – Do minimum	0	0	£52 million	-
3 – Flood warning	0	0	£52 million	-
4a – Raise walls	1 in 200 year	£145 million	£74 million	2.0
4b – Tidal barrier	1 in 200 year	£145 million	£66 million	2.2
5 – Raise ground	1 in 200 year	£145 million	£91 million	1.6
6 – Move town	1 in 200 year	£145 million	Not estimated	-
7 – Reclaim harbour	1 in 200 year	£145 million	£113 million	1.3
8 – Raise & change use	1 in 200 year	£145 million	£103 million	1.4

Table 12.2 shows that all acceptable options to provide a 1 in 200 year standard of protection at 2126 appear to be economically viable particularly if other factors e.g. environmental designations and heritage are taken into account.

There are several factors influencing selection of the preferred option that are not accounted for above due to the assumptions made during the costing process (as detailed in Section 8). This includes:

- Increased maintenance / operational costs e.g. increased pumping requirements
- Environmental acceptability e.g. very high raised flood walls impacting on landscape
- Potential structural instability e.g. high ground water velocity in sands.

13 CONCLUSIONS & RECOMMENDATIONS

13.1 Conclusions

Weymouth has approximately 450 properties at risk of flooding from the 1 in 200 year tidal event currently, which is expected to increase to roughly 4040 properties by 2126. The current Flood Risk Management strategy for the area is raised defences. Our investigations have shown that by 2126 the current provision and extent of flood defence measures may need to be changed due to the following issues:

- Very high raised defences required to provide the specified standard of protection;
- An increasing problem with surface water drainage. This is already pumped therefore pumping will be required on an increasingly frequent basis. This will need to be coordinated with Wessex Water.
- Percolation due to high ground water levels, which could result in potential structural instability
- Increased risk (through increased consequence) of residual flooding, with rapid inundation and water becoming trapped in the defended area.
- Possible blight on development

This therefore highlights the need for a change in the strategic approach to long-term flood risk management for this area away from purely raising defences on the current alignment and towards alternative strategies for flood risk management.

As part of this study we have looked at a number of options to determine a flood risk management strategy that will present a positive future for Weymouth. To allow a comparison of the different options an outline economic analysis was undertaken, as shown in Table 12.2. Due to the assumptions required during the costing stage of the works certain elements were not included in the economic analysis, although they are important factors in the continuing successful development of Weymouth town centre.

Of all the options investigated Option 4b, the tidal barrier with harbour wall improvements and the raising of the Esplanade including a cut-off, appears to be a suitable option to provide short term protection. It also provides the possibility to adapt in the future if required as part of a long term strategy and offers the least disruption to the existing town centre. Possible adaptations in the future may include some of the ground raising detailed in the other options depending on the degree of sea level rise that actually occurs.

Through our assessment, with Option 4b, we have arrived at a scenario for 2126 that could provide protection for the existing properties along with growth and regeneration of the town centre, provided the finished floor levels of any development are above the 2126 1 in 200 year predicted level.

Funding sources particularly for the short term works e.g. tidal barrier and harbour wall improvements will need to be identified. It is likely this will be made up of public funding along with developer contributions. Sea levels will also need to be monitored and any changes to the trends highlighted by UKCIP. Defra will then need to update the Government Guidance based on the UKCIP findings. For example, the current projections are detailed in UKCP09 but the guidance has not yet been updated on how to use these projections. The latest guidance should be taken into account when considering the timing of any of the works.

This assessment has only provided an initial investigation into the possible options for the area to protect the existing town of Weymouth, as well as enabling further development. Due to the timescales and funding available at this stage a large number of assumptions have had to be made and only the initial ideas have been considered. More detailed work is required to determine how the viable options highlighted here could be carried out.

In addition, time and money needs to be allowed for to provide suitable periodic reviews of the current situation, particularly due to possible changes in the extreme tide level predictions and sea level rise predictions.

13.2 Recommendations

Following the assessment undertaken for this study, we recommend:

Urgent flood defence works

- **Custom House Quay wall repairs** – undertake the repairs as recommended in the *Weymouth Harbour Flood Wall Condition Assessment Report, March 2010*, provided in Appendix F.
- Extensive corrosion has been observed on a number of the sections of **sheet piling around the harbour**, in particular the section along Custom House Quay and two sections on the Nothe Parade. This deterioration may soon start to affect the structural integrity of the defence in these locations. Design and implementation of remedial works is therefore urgently required.

Emergency Planning

- Review and keep up to date emergency flood response plans for the Town Centre

Data gathering

- **Annual inspection of the assets** should be undertaken so that we have an accurate and up-to-date picture of all of the assets in the area. This will help determine when replacements are needed and highlight any urgent works. These works should then be undertaken at the earliest opportunity. Due to the poor condition of some of the sheet piles these should be a priority for the inspections and replacements.
- Pumping is already undertaken and is likely to need to be increased in the future. **Monitoring of the pumping** undertaken is recommended to determine how the demand changes over time. In addition, there is a need to engage with Wessex Water to consider the impact on the existing and future surface water pumping requirements.
- **A wave buoy in Weymouth Bay** would also help to provide additional information for analysis when looking at the options in more detail. This would be particularly helpful as data for the larger Environment Agency Strategy for Weymouth Bay that is to commence this year and be completed over the next few years.
- Undertake a **threshold survey** of the properties within the 2126 flood outline to allow a more detailed economic assessment to be undertaken.

Further studies

- **Esplanade wave-return wall and cut-off** – Undertake an investigation into the work required along the esplanade to reduce the risk of wave overtopping and provide a cut-off to prevent percolation. This work will allow for the continued development of sites in the town centre and provide protection from overtopping for a residential area.
- For the cut-off wall an investigation is required to give a more detailed picture of the **ground water and hydrogeology** for the area. We would recommend the installation of an array of boreholes with peizometers that can be used to record ground water

levels. These boreholes will also allow detailed soils investigation to be carried out. The data will be used to indicate the permeability of strata overlying the bedrock by carrying out pumping tests.

- Further investigations are required into the **design of a tidal barrier** across the harbour, including modelling with the barrier in place. As part of that investigation we recommend that work is undertaken to determine the most efficient / effective improvements to the harbour walls for both now and in the future when combined with a tidal barrier. For example, if the walls are raised slightly then the barrier can remain open for longer periods of time.
- Undertake **a socio-economic study** to provide more information regarding the possible impacts of the options, including an assessment of the benefits related to commerce and tourism from securing appropriate standards of defence from flooding and continued development and regeneration.
- Undertake a more **detailed economic assessment** including depth-damage calculations and breach analysis.

Engagement & consultation

- **Develop a public consultation strategy** through the development of the Weymouth and Portland Core Strategy and a Flooding Contributions Supplementary Planning Document. This may lead to the preparation of a public information leaflet, meetings, a website etc.
- To use the River Wey Report and this Flood Risk Management Strategy to provide evidence in support of the shared Core Strategy and Weymouth and Portland Community Plan vision. While in the future, incorporate the findings of the wider Weymouth Bay Study to provide evidence for the Town Centre Area Action Plan, its associated vision, objectives and programmed consultation.

Planning

- The approach recommended in this study supports the objectives of the Core Strategy, subject to the agreement between the Environment Agency and Weymouth & Portland Borough Council on some of the specific requirements to address flood risk.
- Upon adoption of this strategy by Weymouth & Portland BC, the Agency will withdraw its 'objection in principle' to development in the tidal flood zones in Weymouth, subject to the Borough providing planning guidance in the form of a Supplementary Planning Document (SPD) or similar which:
  - sets out the management requirements of the residual flood risk
  - sets out a contributions mechanism toward the delivery of the 'preferred option' over the Core Strategy plan period to 2026.

- The Borough will develop a core strategy policy for delivery of the preferred option. The policy will have three strands.

- Strand 1: detailing the key FRM infrastructure required within the 2026 plan period – costs, funding delivery etc. (PPG12 Para 4.9)
- Strand 2: setting out the general direction of travel to deliver the balance of the flood risk management infrastructure identified in the preferred option or other options that may emerge, over successive plan periods.
- Strand 3: contingency planning – showing how the objectives will be achieved under different scenarios. i.e. 'plan B' (PPG12 Para. 4.10)

APPENDIX A Figures

LIDAR topographic data
Environment Agency Flood Zone Maps

APPENDIX B Details of hydraulic modelling

APPENDIX C Freeboard assessment

APPENDIX D Plan of Option 4b and Option 8b phasing details

APPENDIX E Timing of works for each option

APPENDIX F Harbour Flood Wall Condition Assessment Report

APPENDIX G Costing assumptions, example database sheet and existing defence details

Glossary of terms

Area of Outstanding Natural Beauty (AONB)

Areas of Outstanding Natural Beauty (AONB) were formally designated under the National Parks and Access to the Countryside Act of 1949 to protect areas of the countryside of high scenic quality that cannot be selected for National Park status due to their lack of opportunities for outdoor recreation (an essential objective of National Parks). Natural England is responsible for designating AONBs and advising Government and others on how they should be protected and managed. Further information on AONBs can be found at: http://www.aonb.org.uk

ArcMap

A Geographical Information System (GIS) computer Package produced by ESRI. Further information can be found at www.gis.com and also at www.esri.com.

Benefits

Those positive measurable and immeasurable changes that a plan will produce, including damages avoided.

Catchment

A surface water catchment is the total area that drains into a river. A groundwater catchment is the total area that contributes to the groundwater part of the river flow.

Catchment Flood Management Plan (CFMP)

A large-scale strategic planning framework for managing flood risks to people and the developed and natural environment in a sustainable way.

Core Strategy

This is a compulsory Local Development Document that sets out the policies regarding development and use of land in a Local Planning Authority's area.

Defra

Department for Environment, Food and Rural Affairs. The department of central Government responsible for flood management policy in England.

Digital Elevation Model (DEM)

A representation of the topography of an area and gives the elevation of the upper surface whether it is the ground, vegetation or a building.

Digital Terrain Model (DTM)

A representation of the ground surface with buildings and vegetation removed. With airborne techniques automated filters have been developed which can detect buildings and remove them and fill the gap with interpolated data.

Environment Agency

Non-departmental public body responsible for implementing Government policy relating to the environment and flood risk management in England and Wales.

Flood Defence

A structure (or system of structures) for reducing flooding from rivers or the sea.

Flood Estimation Handbook (FEH)

Provides the current ways for estimating flood flows for the UK.

Floodplain

Any area of land over which water flows or would flow if there were no flood defences. It can also be a place where water is stored during flooding.

Flood Map

The Flood Map is our public map for floodplain information. It shows the Flood Zone extents, which ignore defences, the location of raised defences and the area benefiting from defences. Available on our website, it also provides information on the chance of general areas of land flooding.

Flood Risk

The level of flood risk is the frequency or likelihood of the flood events together with their consequences (such as loss, damage, harm, distress and disruption).

Flood Risk Management

Modifying the frequency or consequences of flooding to an appropriate level (equal to land use) and monitoring to make sure that flood risks remain at the proposed level. This should take account of other water level management requirements, and opportunities and constraints. It is not just about applying physical flood defence measures.

Flood Zones

The zones show the area at risk if there were no defences and are classified in PPS25 as follows:

Zone 1 - annual probability of flooding of less than 1 in 1000 year (0.1 per cent);

Zone 2 - annual probability of flooding between 1 in 1000 year (0.1 per cent) and 1 in 100 year (1.0 per cent) for river flooding or 1 in 200 year (0.5 per cent) for coastal flooding; and

Zone 3 - annual probability of flooding greater than or equal to 1 in 100 year (1.0 per cent) for river flooding or greater than or equal to 1 in 200 year (0.5 per cent) for coastal flooding.

Fluvial

Relating to a watercourse (river or stream)

Geographical Information System (GIS)

A computer-based system for capturing, storing, checking, integrating, manipulating, analysing and displaying data that are spatially referenced.

Geomorphology

The sediment erosion, deposition of transport processes that create the topography and shape of a river and its floodplain.

Groundwater

Water occurring below ground in natural formations (typically rocks, gravels and sands).

Highest Astronomic Tide (HAT)

The highest tide that can occur due solely to the arrangement of the moon, sun and planets.

Historic Flood Map

Shows the mapped extents of known historical flooding.

Hydraulic Model

Software packages that provide a mathematical interpretation of possible depths, velocities and flows that may occur during a flood. It utilises a DTM.

Indicative Standard of Protection

The range of level of protection to be considered for flood defences, based upon how the land being protected is used. They do not represent any entitlement to protection or minimum level to be achieved.

Land Use

Various designations of activities, developments, cropping types, etc for which land is used.

Land Management

Various forms of activities relating to agricultural, forestry, etc and other practices.

LiDAR

Light Detection and Ranging (LIDAR) is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground.

Local Development Documents (LDD)

These documents make up the Local Development Framework (LDF).

Local Development Framework (LDF)

A series of Local Development Documents that outline the planning policy in a Local Planning Authority's area.

Mean High Water Springs (MHWS)

The average of the spring tides which occur every two weeks.

National Nature Reserve (NNR)

National Nature Reserves are designated under the National Parks and Access to the Countryside Act 1949 or the Wildlife and Countryside Act 1981 (as amended) mainly for nature conservation, but can also include sites with special geological of physiographic features. They were set up to protect the most important areas of wildlife habitat and geological formations in Britain, and as places for scientific research. All NNRs are "nationally important" and are best examples of a particular habitat/ecosystem. They are usually owned or leased by English Nature, or managed in accordance with a Nature Reserve Agreement with the landowner or occupier. At the end of March 2000 there were 200 NNRs in England covering 80,533 hectares. NNRs receive SSSI designation under The Countryside and Rights of Way Act 2000 and The Wildlife and Countryside Act 1981 (as amended). Further information about NNRs can be found on English Nature's website site:

http://www.englishnature.org.uk/special/nnr/nnr_search.asp

National Flood and Coastal Defence Database

The DEFRA High Level Targets requires flood and coastal defence operating authorities to develop the National Flood and Coastal Defence Database (NFCDD).

Ordnance Datum Newlyn

Ordnance Datum Newlyn (ODN) is a traditional vertical coordinate system, consisting of a tide gauge datum with initial point at Newlyn (Cornwall) and a Terrestrial Reference Frame observed by spirit levelling between 200 fundamental benchmarks across Britain. Each benchmark has an orthometric height only (not ellipsoid height or accurate horizontal position). This coordinate system is important because it is used to describe vertical positions of features on British maps (for example, spot heights and contours) in terms of height above mean sea level. The word Datum in the title refers, strictly speaking, to the tide gauge initial point only, not to the national levelled bench marks.

Other historic features

English Heritage (EH) is the national body responsible for identifying and protecting historic buildings by recommending the most important of them for "listing". There are three grades of listed buildings depending on their relative importance:

- Grade I buildings are those of exceptional interest;
- Grade II* buildings are particularly important buildings of more than special interest; and
- Grade II buildings are of special interest, warranting every effort to preserve them.

Local authorities have the power to designate Conservation Areas in any area of "special architectural or historic interest", whose character or appearance is worth protecting or improving. These qualities are judged against local and regional criteria, rather than national importance, as with listed buildings. In England, the main sources of information on recorded archaeological remains will be the Sites and Monuments Records (SMR) and the National Monuments Record (NMR). The SMR should contain information about all known archaeological remains. For further information refer to the English Heritage website: http://www.english-heritage.org.uk

Planning Policy Statement 25: Development and Flood Risk (PPS25)

One of a series of Planning Policy Statements issued by DCLG to advise local planning authorities and developers. While Planning Policy Statements are not statutory, planning authorities are obliged to consider them when preparing plans and determining planning applications. PPS25, issued in December 2006 (replacing PPG25 issued (2001), raises the profile of flood risk, which should be considered at all stages of the planning and development process and across the whole catchment. It emphasises the need to act in a precautionary way and to take account of climate change. It provides advice on future urban development in areas subject to flood risk, subjecting proposals to a sequential response (depends on the amount of risk) and promotes the concept of Sustainable Drainage Systems (SuDS) in new development or redevelopment. For further information please refer to the Department for Communities and Local Government website:

http://www.communities.gov.uk/index.asp?id=1504640

Problem areas

Areas within the catchment at risk from flooding.

Probability of occurrence

The probability or chance of a flood event being met or exceeded in any one year.

Property

A property is defined here as one household, such that one building may house numerous properties. Property data has been taken from the National Property Dataset (NPD).

Ramsar Site

The Ramsar Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (1971) requires the UK Government to promote using wetlands wisely and to protect wetlands of international importance. This includes designating certain areas as Ramsar sites, where their importance for nature conservation (especially with respect to waterfowl) and environmental sustainability meet certain criteria.

Ramsar sites receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000 and The Wildlife and Countryside Act 1981 (as amended). Further information can be located on the Ramsar convention on wetlands website: http://www.ramsar.org/

Regional Planning Guidance (RPG)

Planning Guidance issued for the South West by the Government Office for the South West Regional Assembly.

Regional Spatial Strategy (RSS)

This will replace the RPG. It sets out a regional framework that addresses the 'spatial' implications of broad issues like healthcare, education, crime, housing, investment, transport, the economy and environment.

Risk assessment

Considering the risks in a project, which leads to developing actions to control, reduce or accept the risks.

Scenario

A possible future situation, which can influence either catchment flood processes or flood responses, and the success of flood risk management policies/measures. Scenarios will usually be made up of the following: urban development (both in the catchment and river corridor); change in land use and land management practice (including future environmental designations); or climate change.

Scheduled Monuments, Scheduled Ancient Monuments

To protect archaeological sites for future generations, the most valuable of them may be "scheduled". Scheduling gives nationally important sites and monuments are legal protection by placing them on a list, or 'schedule'. English Heritage identifies sites in England, which the Secretary of State for Culture, Media and Sport should place on the schedule. The current legislation, the Ancient Monuments and Archaeological Areas Act 1979, supports a system of Scheduled Monument Consent for any work affecting a designated monument. Further information can be found on English Heritage's website: http://www.english-heritage.org.uk

Shoreline Management Plan (SMP)

Non-statutory plans to provide sustainable coastal defence policies (to prevent erosion by the sea and flooding of low-lying coastal land) and to set objectives for managing the shoreline in the future. They are prepared by us or maritime local authorities, acting individually or as part of coastal defence groups.

Site of Special Scientific Interest (SSSI)

Sites of Special Scientific Interest (SSSIs) are notified under the Wildlife and Countryside Act 1981 (as amended) and the Countryside and Rights of Way (CRoW) Act 2000 for their flora, fauna, geological or physiographical features. Notification of a SSSI includes a list of work that may harm the special interest of the site. The Wildlife and Countryside Act 1981 (provisions relating to SSSIs) has been replaced by a new Section 28 in Schedule 9 of the CROW Act. The new Section 28 provides much better protection for SSSIs. All cSACs, SPAs and Ramsar sites are designated as SSSIs. For further information refer to English Nature's website: http://www.english-nature.com

Special Area for Conservation (SAC)

SACs are internationally important sites for habitats and/or species, designated as required under the EC Habitats Directive. All SACs have now had their former candidate status confirmed.

SACs are protected for their internationally important habitat and non-bird species. They also receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000; and The Wildlife and Countryside Act 1981 (as amended). For further details refer to the following The Joint Nature Conservation Committee website http://www.jncc.gov.uk

Special Protection Area (SPA), Proposed Special Protection Area (pSPA)

A site of international importance for birds, designated as required by the EC Birds Directive. A pSPA is a proposed site, but has the same status as a confirmed site. SPAs are designated for their international importance as breeding, feeding and roosting habitat for bird species. The Government must consider the conservation of SPAs in all its planning decisions.

SPAs receive SSSI designation under The Countryside and Rights of Way (CRoW) Act 2000 and The Wildlife and Countryside Act 1981 (as amended). For further details refer to the European Commission: website: http://europa.eu.int/

And The Joint Nature Conservation Committee website at:

http://www.jncc.gov.uk/ukspa/sites/spalistA-C.htm

Strategic Flood Risk Assessment (SFRA)

A broad scale assessment of flood risk carried out by a unitary authority or district council. These documents are drafted so that proposed developments can be quickly appraised to Planning policy Guidance.

Sustainability

A concept, which deals with man's effect, through development, on the environment. Sustainable development is 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundland, 1987). The degree to which flood risk management options avoid tying future generations into inflexible or expensive options for flood defence. This usually includes considering other defences and likely developments as well as processes within a catchment. It should also take account of, for example, the long-term demands for non-renewable materials.

Sustainable Drainage Systems (SuDS)

Management practices and control structures designed to drain surface water in a more sustainable way than some conventional techniques (may also be referred to as sustainable drainage techniques).

List of abbreviations

AONB	Area of Outstanding Natural Beauty
CFMP	Catchment Flood Management Plan
Defra	Department for Environment, Food & Rural Affairs
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EA	Environment Agency
GIS	Geographical Information System
HAT	Highest Astronomic Tide
LDD	Local Development Documents
LDF	Local Development Framework
LIDAR	Light Detection And Ranging
MHWS	Mean High Water Springs
NFCDD	National Flood and Coastal Defence Database
NNR	National Nature Reserve
ODN	Ordnance Datum Newlyn
PPS25	Planning Policy Statement 25: Development and flood risk
RAMSAR	The Ramsar Convention on Wetlands of International Importance
RSS	Regional Spatial Strategy
SAC	Special Conservation Area
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
SOP	Standard of Protection
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SUDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
W&PBC	Weymouth & Portland Borough Council

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