Option	Description	Benefit zone		
		North	Central	Harbour
1	**Replace sea wall**	✔	✔	
	A new wall could be built of concrete, steel piles or masonry. This option would seek to replace the existing defence or be built seaward of the existing wall. To adapt to climate change, the wall would need to be taller than the current defence, which may require raising the promenade and footpath area behind.			
2	**Raise existing sea wall**	✔	✔	
	Raising the existing wall would increase the flood protection performance of the defence in the short to mid-term. However, as this option relies on the existing structure it can only practically be raised so far without a complete re-build. In addition, without raising the promenade, sea views could be affected and therefore the wall could only be raised so far. In areas where the existing structures are currently in poor condition a concrete 'shroud' would be used to encase the existing defence to prevent premature failure of the new raised defence.			
3	**Rock armour revetment**	✔		✔
	Rock armour could be installed at the base of the existing sea wall to increase flood protection performance. As this solution does not increase the height of the defence it is only viable in the short to mid-term without the full effects of sea level rise. The rock armour would encroach onto the amenity beach (or into the mooring zone within the harbour), but it would not affect line-of-site from the town.			
4	**Setback walls with flood gates**	✔	✔	
	Flood protection walls could be installed set-back from the existing coastal defences, these would run parallel to the roads and private property boundaries. In some instances, it is envisioned that private properties may require integrating into the defence line to ensure flood wall continuity; this would require waterproofing or shrouding of vulnerable areas. This option would help prevent flooding to the town through a secondary defence line; while it does not help reduce wave overtopping, it would prevent flood water from inundating properties. In the long-term this option will be less effective due to the extreme sea levels expected and it does not seek to improve the condition of existing defences. However, if used in conjunction with other defence improvements it could effectively work into the long-term scenario.			
5	**Offshore breakwater**	✔	✔	
	An offshore breakwater would seek to reduce the flood risk by dissipating wave energy within Stonehaven Bay. The size of the structure (height and width) would determine how much wave energy is dissipated. For this reason, a breakwater may/may not be designed to be submerged such that it is not visible, creating a reef-like structure to break the largest waves offshore. As this option does not increase the height of the existing defences it may only offer limited protection in the long-term, however coupled with other defence options it could aid in reducing the size of other required defences.			
6	**New wall extension with a rock armour revetment**	✔		
	The existing defence could be increased in height with the addition of rock armour installed on its seaward face. The rock armour would serve as protection to the wall whilst also significantly reducing wave overtopping making it an effective coastal flood defence in the long-term scenario. To adapt to climate change, the wall would need to be taller than the current sea wall, which may require raising the promenade and footpath area behind the defence. In areas where the existing structures are currently in poor condition a concrete 'shroud' would be used to encase the existing defence to prevent premature failure of the new raised defence.			
7	**New stepped or sloping revetment**	✔	✔	✔
	The existing defences could be replaced by a new stepped revetment (as currently seen along the Cowie promenade), or by a similar modular blockwork structure or rock armour structure. All solutions could be designed such that their wave overtopping performance is suitable into the long-term scenario. Given the present-day overtopping risk, a higher crest level than existing will be required. To adapt to climate change, the wall would need to be raised further, which may require raising the promenade and footpath area behind the defence.			
8	**Beach recharge + control structures**	✔	✔	
	The beach within Stonehaven could be recharged increasing the beach crest width and height. To prevent the beach mobilising and moving around within the bay, beach control structures would also likely be required. With a large enough beach in both height and width this option could be a solution in the long-term, however it would also require replenishment over time if it is shown that material is lost offshore or the beach migrates shoreward through "roll-over". This option may also require the raising of existing hard defences.			
9	**Foreshore recharge**	✔	✔	
	Similar to beach replenishment, this would look to have large quantities of beach material dumped near the centre of Stonehaven Bay, effectively making a very large beach / sand bar. Over time this material would move around within the bay, replenishing the existing beaches. This option would reduce the water depths within the bay and thus create a large area in which wave action would be dissipated across. This option would be suitable up until the long-term scenario given sufficient material deposition. It is possible that the beach would need replenishing by mid-century.			
10	**Beach and river realignment**		✔	
	Within the central section, the beach could be moved seaward with a view to redirect the Cowie Water south towards the Carron, as it flowed historically. As the beach is moved seaward, it would effectively act as type of breakwater to the hard coastal defences, however this realignment would likely require nourishment along with control structures to make sure the system is stable in extreme events and not breached. This option would be suitable into the mid-term scenario, but exposing the toe of the hard defences for the realigned river may require additional strengthening and repair works to ensure integrity against fluvial and coastal processes.			
11	**Managed realignment - Cowie**	✔		
	Partially realigning the defence in the northern benefit area (Helen Row and Boatie Row) could be considered due to the flood risk and lower number of residential and businesses in this area. Within a partial realignment scenario, a secondary defence, potentially in the form of a vegetated earth bund, would be built set-back from the existing coastal defences; this would be required to prevent flooding to the remaining properties.			
12	**Ground raising**	✔		
	The flood risk in the northern benefit area is a result of the low ground level, meaning that any wave overtopping will flow down and flood this area. An option to consider instead of realigning the defence would be to raise the ground level immediately behind the defences such that flood water can only flow back out to sea. While this option is a large undertaking, it could secure the flood risk beyond the long-term scenario if coupled with repairs or replacements of the existing defences to manage erosion risk.			
13	**Managed realignment - harbour**			✔
	As there is limited development at risk in the south harbour, managed realignment could be considered. This option would likely also require a setback wall with flood gate at the edge of the existing harbour arm to limit wave overtopping into the inner basin.			
14	**River Cowie training wall / groyne extension**	✔	✔	
	The existing concrete structure could be extended further out and southward to shelter the river mouth from waves. The structure could be an extension of the concrete structure or be formed of rock armour. As this defence does not increase the height of the existing river banks, it is only effective to the mid-term scenario, however coupled with existing defence improvements would make it a long-term solution.			
15	**Rock armour revetment extension**			✔
	The existing rock armour structures located to the north of the harbour have very narrow crest widths; extending the rock armour crest width would effectively improve their performance against wave overtopping. In the long-term scenario, with the higher extreme sea levels, it might be that the defence would require a raised parapet wall at the rear of the rock armour profile.			
16	**Advance the line with new vertical wall**			✔
	Within the harbour a new wall alignment could be built at the toe of the existing defence without effectively increasing the footprint of the structure. The defence would likely be made from sheet piles, which could be clad with timber to aid with mooring and improve the appearance of this option. Concrete or masonry would also be suitable materials for construction, though may have a larger footprint. This option would also widen the promenade/road making better access for pedestrians.			
17	**Extension of harbour breakwater arm**			✔
	The existing outer breakwater arm could be extended to further shelter the middle basin from wave overtopping. This defence could be an extension of the concrete structure or a rock armour structure. This option would have to carefully take into account the navigation routes for vessels and might require dredging to maintain the required navigation channel width.			
18	**New breakwater arm**			✔
	A new southern breakwater arm could be built further out from the harbour and connected to the headland. This option would provide additional shelter to the harbour, potentially protecting the inner and outer areas of the harbour and could increase the active harbour space allowing a new mooring basin to be designed by the South Pier and old lifeboat house. The form of this new breakwater arm would likely be of rock armour, but a concrete caisson structure could also be viable.			
19	**Advance the line**			✔
	To maximise the benefits from improving the coastal defences in the south of the harbour, advancing the line with a new defence would create a new area in which additional businesses could be built on. As this option widens the defence it will prevent overtopping flow into the inner basin. This option could re-use the existing rock armour into a new defence, or alternatively an extension of the South pier could be considered in the form of a masonry or concrete sea wall.			
20	**Property relocation**	✔	✔	✔
	Properties at immediate flood risk behind the current coastal defences could be relocated, reducing potential flood damages while also providing additional space for flood protection improvement schemes behind the existing defences. While this option does not seek to reduce wave overtopping it could be coupled with other mid to long-term strategies to reduce flood risk damages.			
21	**Property Flood Resilience and Resistance (PFR)**	✔	✔	✔
	A short-term option to address flooding in less severe storm events, PFR measures could be a valuable option to incorporate into those properties at risk of flooding. For more severe storms and with increasing sea levels, the level of resilience will be limited and is therefore not considered to be a mid-term option, unless coupled with improvements to the coastal defences.			