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Department for Economy and Infrastructure



Llywodraeth Cymru
Welsh Government

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) Scheme 201-

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) (Amendment) Scheme 201-

The London to Fishguard Trunk Road (East of Magor to Castleton) Order 201-

The M4 Motorway (West of Magor to East of Castleton) and the A48(M) Motorway (West of Castleton to St Mellons)(Variation of Various Schemes) Scheme 201-

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the M48 Motorway (Junction 23 (East of Magor) Connecting Road) and The London to Fishguard Trunk Road (east of Magor to Castleton) (Side Roads) Order 201-

The Welsh Ministers (The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the M48 Motorway (Junction 23 (East of Magor) Connecting Road) and the London to Fishguard Trunk Road (East of Magor to Castleton)) Compulsory Purchase Order 201-

The M4 Motorway (Junction 23 (East Of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East Of Magor) Connecting Road) (Supplementary) Scheme 201-

The Welsh Ministers (The M4 Motorway (Junction 23 (East Of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East Of Magor) Connecting Road) and The London to Fishguard Trunk Road (East of Magor to Castleton)) Supplementary Compulsory Purchase Order 201-

Proof of Evidence

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Welsh Government, Tidal Flooding

Document Reference: WG 1.16.1

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M4 CORRIDOR AROUND NEWPORT

Proof of Evidence, Tidal Flooding

1. Personal Statement

1.1 My name is Dr Paul Canning. I am employed by Atkins Limited as a Principal Consultant. I am a Chartered Civil Engineer with 20 years of experience in research and consultancy related to tidal flood risk.

1.2 My qualifications consist of:

- a) BEng (Hons) Civil Engineering 2:1. Received from Surrey University in 1996.
- b) PhD thesis on 'Wave breaking on fixed impermeable and mobile permeable beaches'. Received from University of Brighton in 2002.
- c) Member of the Institution of Civil Engineers (MICE), since 2009.
- d) Chartered Engineer (CEng). Registered with Engineering Council since 2009.

1.3 My employment has consisted of:

- a) Atkins Limited, 2002 to present day. Assistant Engineer progressing to Principal Consultant. Responsible for technical delivery of a range of coastal management plans, strategies, schemes; and associated design and assessment to support infrastructure proposals.
- b) University of Bristol, 2009-2011. Visiting Lecturer. I gave lectures to post-graduates on the Water and Environmental Management course, covering Tidal Barrages and Shoreline Management.
- c) University of Bristol, 2000-2002. Research Assistant. I undertook research work covering physical modelling of beaches, design of new single layer armour units, and design of coastal schemes.

- 1.4 My experience, of direct geographic relevance to the M4 Corridor around Newport (M4CaN), consists of:
- a) Severn Estuary Flood Risk Management Strategy (SEFRMS), 2008-2015. I was the Project Manager and Technical Manager for Atkins Ltd, commissioned jointly by Environment Agency South West, Midlands and Wales (now Natural Resources Wales (NRW)). The SEFRMS sets out the technical (economic, engineering, environmental) justification for how to manage the flood risk management assets around the Severn Estuary (and particularly the Wentlooge and Caldicot Levels) over the next 100 years, in response to climate change and increasing wave and tidal flood risks. I managed and/or undertook the following technical streams of work: numerical modelling of hydrodynamic processes, geomorphology, asset performance and design, costing, economic appraisal, funding, environmental assessment, engagement, and option assessment.
 - b) Cardiff Tidal Lagoon, Environmental Impact Assessment (EIA) Scoping Stage: Hydrology, Flood Risk and Flood Consequence Assessment themes, 2014. I was the Project Manager and Technical Manager for Atkins Ltd, commissioned by Tidal Lagoon Power Ltd.
 - c) Cardiff Erosion Risk Overview, 2013. I was the Project Manager for Atkins Ltd, commissioned by Cardiff Council. This project included field assessments of coastal assets and erosion, historic mapping of coastline, analysis of future erosion risk, and conceptual design and costing of possible engineering responses.
 - d) Severn Estuary Shoreline Management Plan 2 (SESMP2), 2008-2010. I was the Coastal Expert for Atkins Ltd, commissioned by the Environment Agency on behalf of the Severn Estuary Coastal Group (SECG). The SESMP2 was agreed by Welsh Ministers in 2014 and sets out the preferred policy for managing flood and coastal erosion risks over the next 100 years. I undertook the numerical modelling of flood risk, and asset assessment and design.

- e) Rumney Great Wharf Tidal Defence Scheme, 2003-2004. I was the Project Engineer for Atkins Ltd, commissioned by Environment Agency Wales (now NRW). The Scheme was designed to manage the erosion and flood risk occurring along the Rumney Great Wharf embankment. I undertook design of the rock armouring and polder solution.
 - f) Gwent Levels Foreshore Management Plan, 2002-2004. I was the Project Engineer for Atkins Ltd, commissioned by Environment Agency Wales (now NRW). This study set out the technical assessment of options to manage the foreshore along the Wentlooge and Caldicot Levels, assuming that the preferred policy was 'Hold The Line'. I undertook the geomorphological assessment, interpretation of numerical modelling of wave and tide climate, predicted change to intertidal habitats, and recommended options to manage the foreshore. The above Rumney Great Wharf Tidal Defence Scheme was one of the recommended schemes.
- 1.5 My evidence is being given on behalf of the Welsh Government. The Atkins-Arup joint venture were appointed by the Costain-Vinci joint venture to undertake the design of the proposed Scheme. The work was undertaken during 2015 to 2016. It is in this context I have written this Proof of Evidence.
- 1.6 I am a member of the project team who are responsible for the delivery of the M4CaN. I supported this project by providing information and advice on the findings and recommendations of the SESMP2, SEFRMS, and the related tidal flood risk to the Wentlooge and Caldicot Levels.
- 1.7 This evidence represents my true and professional opinion and is given in accordance with the Institution of Civil Engineer's Rules of Professional Conduct.
- 1.8 This Proof of Evidence addresses tidal flood risk relating to the M4CaN Project.

2. Scope of Proof of Evidence

- 2.1 My evidence addresses the tidal flood risk aspects relating to the M4CaN proposals. My evidence covers:
- a) Consideration of hydraulic modelling of the Wentlooge and Caldicot Levels, including the River Usk. These models have been used to predict the tidal flood risks now and into the future, and the impact of the M4CaN on tidal flood risk.
 - b) Consideration of recommended improvements to the tidal flood defences now and into the future, and how these improvements would influence the impact of the M4CaN on tidal flood risk.
 - c) Queries, issues and objections that appear to cover three themes: TAN15 compliance in relation to tidal flood risk; general existing and future tidal flood risk; and tide levels in the vicinity of the River Usk and climate change.
- 2.2 I have relied in my Proof of Evidence upon the work and information noted in the references section, and from Mike Vaughan BEng (Hons) Exon CEng CWEM MICE MCIWEM, in relation to River Usk tidal flood risk modelling.
- 2.3 I have also been assisted by my understudy witness, Mr Andrew Wareing BSc (Hons) MSc CEng MICE.
- 2.4 My evidence is presented in the following structure:
- a) Personal Statement.
 - b) Scope of Proof of Evidence.
 - c) The M4CaN in terms of tidal flood risk.
 - d) Consideration of hydraulic modelling relating to tidal flood risk.
 - e) Consideration of recommended improvements to the tidal flood defence now and into the future.

- f) General responses to queries and objections received in relation tidal flood risk.
- g) Summary and conclusion.

2.5 My evidence does not address the following matters:

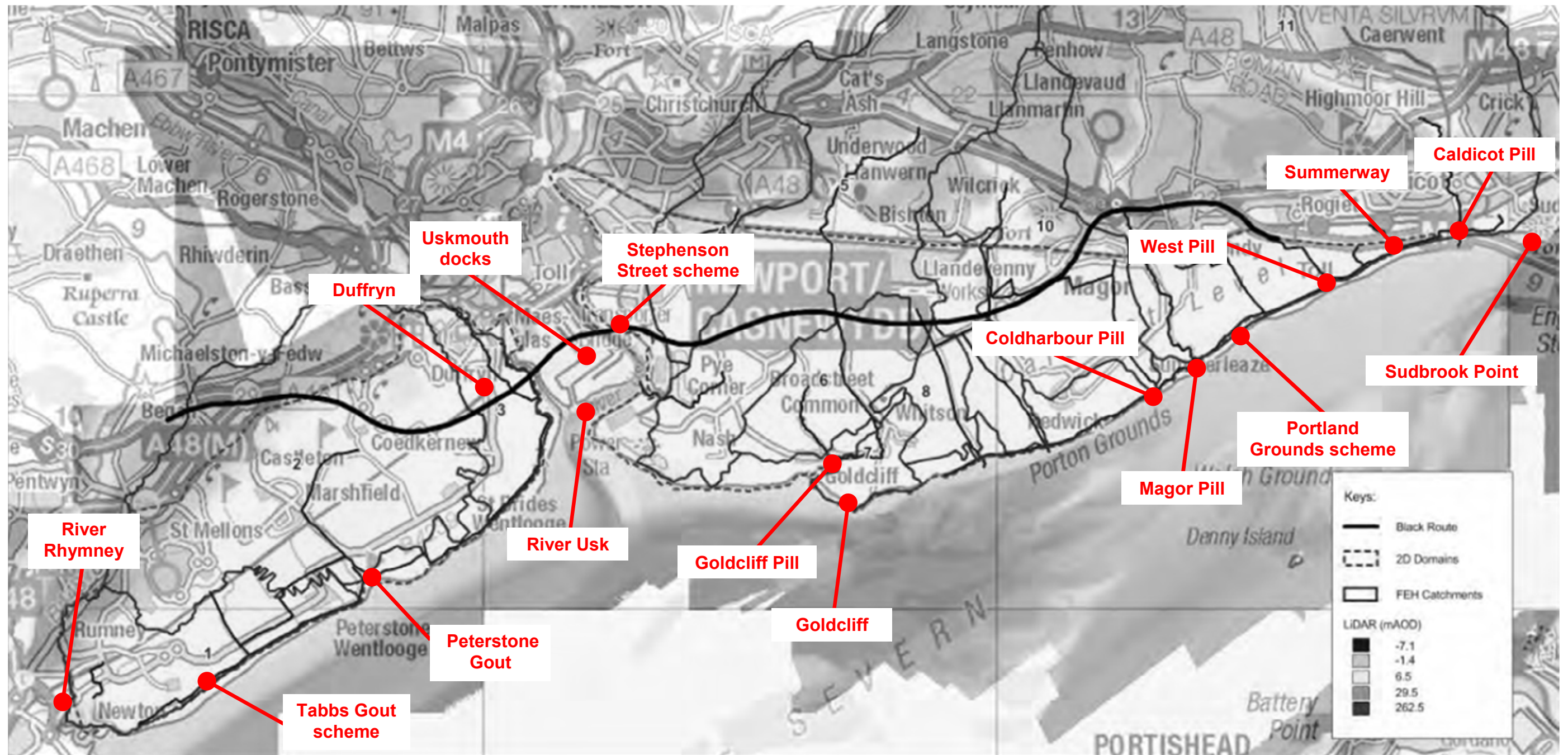
- a) Fluvial flooding. This specialist area will be addressed by Mr Michael Vaughan (WG 1.17.1).
- b) Planning and Sustainable development. This specialist matter will be addressed by Mr John Davies MBE (WG 1.23.1).
- c) Shipping. This specialist matter will be addressed by Mr Jonathan Vine (WG 1.22.1).

3. The M4CaN in terms of tidal flood risk

- 3.1 The M4CaN involves the construction of a new dual three-lane motorway between Junction 29 at Castleton in the west and Junction 23 at Magor in the east.
- 3.2 East from Junction 29 at Castleton and to the east of the mainline railway, the alignment passes on a low embankment across the Wentlooge Levels; an area identified as floodplain and reported as such by NRW.
- 3.3 The new section of motorway would then cross the River Ebbw and pass to the south of the Docks Way Landfill site, leading in a north easterly direction towards Newport Docks and the River Usk.
- 3.4 The River Usk Crossing would cross the Newport Docks between the South Dock and North Dock, before straightening out over the main bridge crossing of the River Usk.
- 3.5 To the east of the River Usk Crossing, the alignment would follow a general left hand curve across the Caldicot Levels. The highway would be supported on a low embankment as it runs eastwards over an area identified as floodplain and reported as such by NRW.
- 3.6 It is forecast that construction of the M4CaN would start in 2018 and be completed by 2022. National guidelines on flood risk (TAN15; Document 17.2.2) require that, *“the development meets an acceptable standard of flood defence for the design life of the development.”* The lifetime of the development could be considered to be 75 years. In fact the assessment has used a 100 year design life. As such the assessment has used a precautionary approach for flood risk assessment purposes.
- 3.7 In my opinion the primary issue relating to tidal flood risk for the M4CaN is that it has the potential to hold back tidal flood water originating from either a) the south, due to overtopping and/or breach of defences from along the Severn Estuary shoreline of the Wentlooge and Caldicot Levels; and b) from the north and south, due to overtopping and/or breach of defences from along the River

Usk. As stated in the Flood Consequence Assessment (Document 2.3.2) and Supplement Report (Document 2.4.4), this primary issue is dependent on whether tidal flood risk improvements are undertaken both now and in the future.

- 3.8 Figure 1 identifies the location of the M4CaN and the various locations and place names that are referred to in the subsequent sections.



Note: Diagram sourced from Figure 1 of Document 2.3.2. Annotation by Dr Paul Canning.
Figure 1. Location plan of M4CaN and relevant locations and place names.

4. Consideration of hydraulic modelling relating to tidal flood risk

- 4.1 This section describes previous hydraulic modelling studies, the predicted tidal flood risk accounting for predicted future sea level rise (SLR), with and without future improvements to the tidal defence system, both with and without construction of the M4CaN. The justification for future improvements to the tidal defence system is described in section 5.
- 4.2 A summary of the previous hydraulic modelling studies, and how they inter-relate and describe the tidal flood risk now and into the future, with and without the M4CaN, is given in the Flood Consequence Assessment (Document 2.3.2) and Supplement Report (Document 2.4.4). These studies provide an assessment of the present day and future flood risk management position on the Wentlooge and Caldicot levels, with and without the M4CaN.
- 4.3 The previous hydraulic modelling studies, due to when and why they were undertaken, applied differing:
- a) Tidal defence crest levels, due to whether tidal defence schemes had been completed, assumed to be completed, and/or further topographic detail was available.
 - b) Extreme water levels (EWLs), inclusion of extreme wave climate, and climate change predictions; due to the study purpose, year and guidance current at the time.
 - c) Representation of how the tidal defences respond to extreme events; covering wave overtopping only (intermittent splash from waves), tidal overtopping only (continuous flow of water over the crest of tidal defences), breach only (structural damage of tidal defences to the point that they lose their function, due to excessive wave and/or tidal overtopping, and

pipings due to seepage), and/or combined wave overtopping, tidal overtopping and breaching.

Description of extreme water levels guidance

- 4.4 The variation in EWL estimates is a fundamental influence on the prediction of tidal flood risk, and is therefore given in Table 1.
- 4.5 EA (2011a) notes that the Annual Exceedance Probability (AEP) attached to EWL values are a measure of the likelihood of EWLs being exceeded in any given year. EWLs given in EA (2011a) are the mean estimate (50%ile). As a measure of uncertainty, Confidence intervals are quantified in EA (2011a) for the 95% confidence bounds (being the 2.5%ile to 97.5%ile estimate of EWLs). Positive application of Confidence Intervals to EWLs therefore results in a 97.5% probability that the EWL would not be greater for the relevant AEP. Accordingly, EWL values with Confidence Intervals are always higher than EWL values without Confidence Intervals.
- 4.6 NRW (Document 17.3.6) re-assessed the EA (2011a) EWLs and Confidence Intervals along the Wentlooge and Caldicot Levels, applying new tide gauge data between 2009 and 2014 from tide gauges at Mumbles, Newport and Avonmouth. NRW (Document 17.3.6) found that at Newport the 0.1%AEP EWL had increased by 0.01m, and the 0.1%AEP Confidence Interval had decreased to 0.4m. Interpolation between Newport and Mumbles by NRW (Document 17.3.6) found that at Cardiff the 0.1%AEP EWL had increased by 0.17m, with no statement on Confidence Interval. In December 2016 and January 2017, NRW advised the M4CaN team that the NRW (Document 17.3.6) EWLs without Confidence Intervals should be used as the core scenario for assessing flood risk for the purposes of TAN15, and that EWLs with Confidence Intervals should be used as a sensitivity test for the purposes of TAN15.

Location and reference			0.1% AEP EWL dataset in 2008-2014				
Approximate location	EA (2011a) chainage reference	SEFRMS reference	SEFRMS (Document 17.2.16)	EA (2011a)		NRW (Document 17.3.6)	
				Without CI	With CI	Without CI	With CI
River Rhymney	408	JPA2	9.0	8.5	9.0	8.6	9.0
Peterstone Gout	402	JPA3	8.9	8.6	9.1	8.7	9.1
River Usk	396	JPA4	9.0	8.8	9.3	8.8	9.2
Goldcliff	392	JPA5	9.1	8.9	9.4	9.0	9.4
Magor Pill	384	JPA6	9.5	9.2	9.7	9.2	9.6
Studies using EWL datasets			SEFRMS (Document 17.2.16)	SEFRMS (Document 17.2.16), Arup (Document 17.2.14), NRW (2016b)		NRW (Document 17.3.6)	

Note: EWLs are in metres Above Ordnance Datum (mAOD).

Table 1. Application of EWLs in previous studies.

Description of climate change guidance

- 4.7 Welsh Government (2016) provides guidance on the climate change allowances to be applied for the purposes of TAN15 (as of 1st December 2016). WAG (2007) (replicated in Defra, 2006a) is the existing guidance on climate change allowances to be applied for the purposes of TAN15. Welsh Government (2016) and WAG (2007) state the same quantitative climate change allowances as regards SLR.
- 4.8 Welsh Government (2011) and EA (2011b) also provide guidance on the application of climate change predictions, for Wales and England respectively. Welsh Government (2011) notes that its guidance is for the purpose of informing all Flood and Coastal Erosion Risk Management (FCERM) projects (schemes) or strategies, and notes it is not tailored for the planning system. Defra (2006a), WAG (2007), Welsh Government (2011) and EA (2011b) are discussed herein as they were used in relevant modelling studies.
- 4.9 Welsh Government (2011) and EA (2011b) set out the climate change predictions for a range of emissions scenarios, drawing from UK Climate Projections (UKCP09). The variation in SLR

predictions is a fundamental influence on the prediction of tidal flood risk into the future and is therefore given in Table 2. In relation to SLR, the emissions scenarios consist of:

- a) Low 50%ile emissions scenario. This is a scenario used to test the sensitivity of FCERM schemes and strategies.
- b) Medium 95%ile emissions scenario. This is the core scenario that is applied to inform and design FCERM schemes and strategies.
- c) Upper end. This is extremely similar to the previous Defra (2006a) and Welsh Government (2007) guidance, and the recent Welsh Government (2016) guidance i.e. effectively for the purposes of TAN15. It is also a scenario used to test the sensitivity of FCERM schemes and strategies.
- d) Upper end plus surge. Surge in this context is the predicted change in storm surge due to climate change, additional to the SLR applied to mean sea levels. It is therefore relevant to EWLs. This is a scenario used to test the sensitivity of FCERM schemes and strategies.

- 4.10 Welsh Government (2016), Welsh Government (2011) and EA (2011b) provide no quantified guidance on the change in extreme wave heights due to climate change. WAG (2007) and Defra (2006a) do provide guidance on this, advising a cumulative 5% increase up to 2055, and a cumulative 10% increase up to 2115. NRW (Document 17.3.6) also applied a 10% increase to offshore wind speed for 2115.

Year	Sea level rise from base date of 2010				
	WAG (2007), WG (2016)	Scenarios from EA (2011b)			
		Low 50%ile from UKCP09	Medium 95%ile from UKCP09	Upper end	Upper end plus surge
2030	0.09	0.06	0.11	0.10	0.30
2060	0.35	0.17	0.31	0.35	0.70
2110	1.00	0.39	0.72	1.02	1.72
Studies using climate change guidance	SEFRMS, Arup (Document 17.2.14), NRW (17.3.6)	SEFRMS	SEFRMS, NRW (2016b)	SEFRMS	SEFRMS

Note: SLR is in metres. Values are given to 2 decimal places solely to clarify differences between guidance and scenarios.

Table 2. Application of climate change guidance in previous studies.

Description of previous hydraulic modelling studies

- 4.11 A summary is given of the differing inputs used for each study below, in chronological order.
- 4.12 The SEFRMS (Document 17.2.16) undertook modelling of tidal flood risk with the 2010 tidal defence geometry and form. At the time this included particular low spots at Tabbs Gout, Stephenson Street and Portland Grounds; and provided the supporting information for the recommended improvements at these locations as discussed later in section 5.
- 4.13 An EWL dataset was generated, specific to the purposes of the SEFRMS and its location (column 4 of Table 1). In addition to this, the extreme wave climate, and the joint probability of extreme waves and EWLs occurring concurrently, was defined at six representative points along the Wentlooge and Caldicot Levels. Analysis of the tidal defence response to EWLs and extreme waves was undertaken using industry standard guidance, to determine the Standard of Protection (SoP) of the tidal defences to breach (from excessive wave overtopping or tidal overtopping) and the initiation of tidal overtopping. Tidal inundation from tidal overtopping and

breach was modelled using industry standard TUFLOW software. Tidal flood risk (i.e. the tidal defence SoP) through to 2110 was assessed using the then current WAG (2007)/Defra (2006a) climate change guidance (column 2 of Table 2), and provided the supporting information for the recommended improvements to keep pace with climate change (discussed later in section 5).

- 4.14 The SEFRMS modelling was subsequently re-run with the EA (2011a) EWL dataset (column 5 and 6 of Table 1) and EA (2011b) climate change guidance (consisting of the low 50%ile, medium 95%ile, upper end and upper end plus surge emissions scenarios, representing the range of SLR that may occur in the future; column 3 to 6 in Table 2) as a sensitivity test to determine whether the findings on tidal flood risk would change significantly. The sensitivity test found that the SEFRMS recommendations remained robust; any changes would be limited to the detailed crest level and form of improvement schemes, and their timing.
- 4.15 Arup (Document 17.2.14) undertook modelling of tidal flood risk at M4CaN Key Stage 2 (KS2, January 2014), to assess the flooding implications on the M4CaN and the flooding impact of the route on surrounding areas. The modelling work applied the Wentlooge and Caldicot Levels tidal defence geometry and form including the, by then constructed, Tabbs Gout and Portland Grounds schemes, and excluding the Stephenson Street scheme. This was undertaken both with and without the M4CaN present (in its geometry as of KS2). The national EA (2011a) EWL dataset was applied, without Confidence Intervals for 2013, and with and without Confidence Intervals for 2113 (column 5 and 6 of Table 1). The initiation of tidal overtopping and subsequent tidal inundation was modelled using the industry standard software TUFLOW. Tidal flood risk from 2013 through to 2113 was modelled by applying the WAG (2007) climate change guidance (column 2 of Table 2).

- 4.16 I have inspected the differences between the KS2 and January 2016 design road levels, where they are spatially and vertically within the Zone C1 tidal floodplain. This identifies that:
- a) The road horizontal alignment has not changed in any material sense that would affect the assessment of tidal flood risk.
 - b) In the Wentlooge Levels, the January 2016 design road levels are lower by 0.1-4m (broadly 1m on average) for approximately 0.9km between 'Church Lane' Overbridge and Duffryn Railway Underbridge along the landward extent of Zone C1; and are variably different (1.8m higher to 0.7m lower, broadly similar on average) for approximately 1km around Lighthouse Road Overbridge to the Duffryn embankment.
 - c) In the Caldicot Levels, the January 2016 design road levels are higher by up to 1.2m for approximately 1.1km east of the River Usk between the railway and 'Nash Road' Overbridge; and moving east, are then virtually constantly lower by 0.4-0.5m for approximately 6.3km; and again moving east, are then higher by between 0.2-1.0m for approximately 0.2km as the M4CaN exits the landward extent of Zone C1 towards Magor.
- 4.17 The Stephenson Street scheme appraisal report (NRW, 2016b) undertook modelling of the more localised tidal flood risk along the east bank of the River Usk. This applied the tidal defence geometry with and without the Stephenson Street scheme in place. The national EA (2011a) EWL dataset was applied without Confidence Interval (column 5 of Table 1) for the year 2014. The initiation of tidal overtopping (defining the SoP) and subsequent tidal inundation was modelled using the industry standard software ESTRY-TUFLOW. Tidal flood risk through to 2114 was modelled

by applying the EA (2011b) climate change guidance, using the medium 95%ile emissions scenario (column 4 of Table 2).

- 4.18 NRW (Document 17.3.6) undertook assessment and modelling of EWLs, Confidence Intervals, offshore wave transformation to the coastline, joint probability of extreme waves and EWLs occurring concurrently, wave overtopping, breach (from tidal overtopping, wave overtopping and piping), and flood inundation extent. The modelling work applied the Wentlooge and Caldicot Levels tidal defence geometry and form including the completed Tabbs Gout and Portland Grounds schemes, and excluding the Stephenson Street scheme. The updated NRW (Document 17.3.6) EWL dataset was applied, with and without Confidence Intervals (column 7 and 8 of Table 1). The initiation of tidal overtopping and subsequent tidal inundation was modelled using the industry standard software TUFLOW. Tidal flood risk from 2014 through to 2115 was modelled by applying the WAG (2007) climate change guidance (column 2 in Table 2).
- 4.19 Combined consideration of the above studies, and interpretation of their findings, can be used to estimate the overall SoP of the tidal flood defence system as it would be in the current situation (with Tabbs Gout and Portland Grounds schemes completed), additionally as it would be with the Stephenson Street scheme completed, and how the overall SoP would reduce over time if the subsequent SEFRMS recommended programme of improvement (discussed in section 5) through 2030-2110 did not occur. I note that this is my informed qualitative interpretation based on quantified information.
- 4.20 The following sections describe the tidal flood risk that would occur with or without the recommended programme of improvements from the SESMP2 and SEFRMS. As the various studies have used different EWLs and climate change scenarios, the following sections interpret all the studies to a common basis of the NRW

(Document 17.3.6) EWLs (with and without Confidence Intervals) and Welsh Government (2016) climate change guidance, so as to form an assessment of tidal flooding consequences in accordance with TAN15 requirements. This primarily requires reference to future years to be translated (with the actual amount of SLR to one decimal place added in brackets to provide a clear reference). Whilst the studies have varying years of interest I note that the Welsh Government (2016) guidance indicates that for the years 2010-2022 (often referred to as 'present day' in previous studies) the maximum difference in SLR would be 0.04m, and for the years 2110-2122 the maximum difference would be 0.2m. Interpretation of the previous studies indicates that the discussion below would still provide a reasonable description of the tidal flood risks, and any expected programme of improvement works.

Description of tidal flood risk between 2018 and 2030 without Confidence Intervals

- 4.21 This section is given to provide information on the EWLs without Confidence Intervals, being the core scenario in relation to TAN15, as advised by NRW.
- 4.22 The Wentlooge and Caldicot Levels are protected from tidal flooding by a range of earth embankments, revetments, rock armouring and walls. The SEFRMS (Document 17.2.16), Arup (Document 17.2.14) and NRW (Document 17.3.6) indicated that the Wentlooge and Caldicot Levels tidal defences would generally provide a 0.1%AEP Standard of Protection (SoP) against breach through to 2030. Exceptions to this, relevant to the M4CaN, are:
- a) A low spot at Stephenson Street. The forthcoming flood risk management scheme at Stephenson Street is described in NRW (2016b) and explicitly recommended by the SEFRMS (Document 17.2.16).

- b) A low spot at Goldcliff Pill where tidal overtopping could occur in the 0.5-0.1%AEP events (Document 17.3.6).
- c) Between Coldharbour Pill and Sudbrook Point, where piping breach could occur in the 20-0.5%AEP events, and wave, tidal overtopping and/or breach could occur in the 0.5-0.1%AEP events (Document 17.3.6).
- d) Small-scale works (Document 17.2.16) where tidal defences are only slightly lower (generally of the order of 0.1m) than recommended and/or over a short length (generally of the order of 10-100m), subsequently referred to as small-scale works.

4.23 NRW (2016b) indicates that currently without the Stephenson Street scheme present, tidal flooding to the immediate east of the River Usk (Caldicot Levels) would begin to occur in the 10%AEP event (with reference to actual observed flooding in January 2014); this was confirmed by the modelling in Arup (Document 17.2.14). NRW (Document 17.3.6) indicates that in the 0.1%AEP event in 2014, without the Stephenson Street scheme present and including wave and tidal overtopping from the tidal defences (but no breach), 1,995 (residential) and 502 (commercial, other) properties would be at risk. Overall, the above discussion identifies that without the Stephenson Street scheme in place there would be significant flooding of over 2,000 properties (to the north and south of the M4CaN alignment) and regionally significant infrastructure, to the immediate east of the River Usk in 2014 in the 0.1%AEP event. This would occur with or without the M4CaN in place.

4.24 NRW (Document 17.3.6) and Arup (Document 17.2.14) differ in their analysis of future tidal flood risk due to differing EWLs, wave and tidal overtopping and breach analyses, and property definitions. However, analysis of the output of the Arup (Document 17.2.14) study with the M4CaN in place enables the magnitude of

possible betterment and detriment caused by the M4CaN to be defined. Mr Kambiz Abyoukhani has provided me with updated property number information, from further analysis of the output of the Arup (Document 17.2.14) study. This is given below for the year 2013, quoted to one significant figure in recognition of the differing analyses noted above:

- a) In the Wentlooge Levels, no change in flood depths to properties for the 0.5%AEP and 0.1%AEP events.
- b) In the Caldicot Levels, no change in flood depths to properties for the 0.5%AEP event; and betterment for no properties, and detriment for 10 (0-0.2m increased flood depth) properties to the north of the M4CaN in the 0.1%AEP event.

4.25 Considering the above property numbers in light of the differences between the KS2 and January 2016 design road levels, and the Arup (Document 17.2.14) and NRW (Document 17.3.6) analyses, the betterments and detriments would change. Qualitatively:

- a) In the Wentlooge Levels, for the 0.5%AEP and 0.1%AEP events in 2013, the betterment/detriment predictions would remain the same. This is because the M4CaN does not interact, or only extremely marginally interacts near Duffryn, with the predicted tidal flood extents.
- b) In the Caldicot Levels, for the 0.5%AEP event in 2013, it is unclear whether the betterment/ detriment predictions would increase or decrease. This is because within the flood extent (sourced from the Stephenson Street area) the January 2016 design road levels are variably higher and lower. Flooding sourced from Goldcliff Pill, and Coldharbour Pill to Sudbrook Point, does not interact with the M4CaN.
- c) In the Caldicot Levels, for the 0.1%AEP event in 2013, it is unclear whether the betterment/ detriment predictions would

increase or decrease. This is because within the flood extent the January 2016 design road levels are variably higher and lower than for KS2, and the NRW (Document 17.3.6) study identifies further flooding than that identified in Arup (Document 17.2.14).

- 4.26 The above predicted property betterments and detriments would be identified as being avoided, if quantitative modelling was undertaken with the following works in place: Stephenson Street scheme, Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements, and small-scale works. This is because the flood risk and extent would be reduced and not interact with the M4CaN.

Description of tidal flood risk between 2018 and 2030 with Confidence Intervals

- 4.27 This section is given to provide information on the EWLs with Confidence Intervals, being a sensitivity test in relation to TAN15, as advised by NRW.
- 4.28 NRW (Document 17.3.6) also assessed the tidal flood risk if Confidence Intervals are included with EWLs (raising EWLs by 0.4m). Under these conditions, tidal flooding in the 0.1%AEP event extends into the majority of the tidal floodplain in both the Wentlooge and Caldicot Levels. NRW (Document 17.3.6) notes in 2014 that 3,765 (residential) and 1,091 (commercial) properties would be at risk in the Wentlooge Levels, and 8,411 (residential) and 1,178 (commercial, other) properties would be at risk in the Caldicot Levels.
- 4.29 Inspection of the 0.1%AEP event flood extents in the Wentlooge Levels identifies that the M4CaN would not interact with the predicted tidal flooding.

- 4.30 However, inspection of the 0.1%AEP flood extents in the Caldicot Levels identifies that the M4CaN would interact with the predicted tidal flooding; this may cause betterment and/or detriment.

Description of tidal flood risk without the SESMP2 and SEFRMS recommended programme of improvements between 2030 and 2110

- 4.31 The SEFRMS (Document 17.2.16), Arup (Document 17.2.14) and NRW (Document 17.3.6) set out how the wider SoP of the Wentlooge and Caldicot Levels would reduce over time in response to climate change beyond 2030, assuming that the existing tidal flood defence system is maintained and not improved in the future. This identifies that by 2110-2122 (1.0m-1.2m SLR), the majority of the Wentlooge and Caldicot Levels tidal defences would not provide a SoP against breach of 0.1%AEP, and that the SoP against breach across the tidal flood defence system would vary between 100-1%AEP.
- 4.32 NRW (Document 17.3.6) assessed the flooding that would occur, assuming that the existing tidal defences are not improved over time; and that the Stephenson Street scheme, Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements, and small-scale works, are not in place. NRW (Document 17.3.6) estimated that by 2115 extensive flooding would result in up to 11,999 properties in the Wentlooge Levels, up to 15,025 properties in the Caldicot Levels, and also nationally significant infrastructure, would be at flood risk in the 0.1%AEP event (with Confidence Interval).
- 4.33 The above regular and extensive flooding of the vast majority of the Wentlooge and Caldicot Levels, and the properties and infrastructure present in the floodplain, would occur with or without the M4CaN in place.
- 4.34 NRW (Document 17.3.6) and Arup (Document 17.2.14) differ in their analysis of future tidal flood risk due to differing EWLs, wave

and tidal overtopping and breach analyses, and property definitions. However, analysis of the output of the Arup (Document 17.2.14) study with the M4CaN in place enables the magnitude of possible betterment and detriment caused by the M4CaN to be defined. This is given below for the 0.1%AEP event (with Confidence Interval) in 2113, quoted to one significant figure in recognition of the differing analyses noted above:

- a) In the Wentlooge Levels, betterment for 3,000 (0-0.2m reduced flood depth) properties; no change for 1,000 properties; and detriment for 600 (0-0.2m increased flood depth) and 40 (0.2-0.4m increased flood depth) properties.
- b) In the Caldicot Levels, betterment for 10 (>1m reduced flood depth), 20 (0.4-0.6m reduced flood depth), 100 (0.2-0.4m reduced flood depth) and 3,000 (0-0.2m reduced flood depth) properties to the north of the M4CaN; no change for 13,000 properties; and detriment for 2,000 (0-0.2m increased flood depth), 600 (0.2-0.4m increased flood depth), and 10 (0.4-0.6m increased flood depth) properties to the south of the M4CaN.
- c) However, Arup (Document 17.2.14) states that without the M4CaN the flood depths would be up to 1.2m (Wentlooge Levels) and exceed 3m on average (Caldicot Levels), rendering the above betterments and detriments relatively small.

4.35 Considering the above property numbers in light of the differences between the KS2 and January 2016 design road levels, and the Arup (Document 17.2.14) and NRW (Document 17.3.6) analyses, the betterments and detriments would change. Qualitatively:

- a) In the Wentlooge Levels, for the 0.5%AEP and 0.1%AEP (without or with Confidence Interval) events in 2113, it is

unclear whether the number of properties affected by betterment/ detriment predictions between KS2 and January 2016 design would increase or decrease. This is because the January 2016 design road levels are variably higher and lower than for KS2.

- b) In the Caldicot Levels, for the 0.5%AEP and 0.1%AEP (without or with Confidence Interval) events in 2113, the number of residential properties affected by betterment and detriment would be expected to reduce. This is because within the flood extent the January 2016 design road levels are predominantly lower, and flooding to the north or south of the M4CaN would be less constrained and able to continue through to the north or south of the M4CaN.

- 4.36 The above property numbers would be expected to reduce if quantitative modelling was undertaken with the Stephenson Street scheme; Goldcliff Pill, Coldharbour Pill to Sudbrook Point improvements; and small-scale works in place, since the flood risk and extent would be reduced. Therefore, the Arup (Document 17.2.14) work can be considered to be a precautionary assessment, based on the Stephenson Street scheme, Goldcliff Pill, Coldharbour Pill to Sudbrook Point improvements, and small-scale works not proceeding.

Description of tidal flood risk with the SESMP2 and SEFRMS recommended programme of improvements between 2030 and 2110

- 4.37 With the programme of improvements recommended by the SESMP2 (Document 17.2.6) and SEFRMS (Document 17.2.16), the tidal flood defence system would provide a 0.1%AEP SoP against breach through to 2110. The recommended programme of improvements are independent of the M4CaN and are recommended whether the M4CaN is present or not.

- 4.38 I note that the SESMP2 (Document 17.2.6) and SEFRMS (Document 17.2.16), and NRW (Document 17.3.6) applied differing EWL and climate change guidance current at the time. However, as noted earlier the SEFRMS (Document 17.2.16) assessed a wide range of climate change scenarios, which would encompass the NRW (Document 17.3.6) analyses. Accordingly, the SEFRMS (Document 17.2.16) recommendations would remain robust.
- 4.39 Implementation of the improvements programme would result in only localised and temporary flooding occurring due to wave overtopping, and limited tidal overtopping that would not cause breach. Under these conditions the M4CaN would not be expected to cause any betterment or detriment to properties within the Wentlooge and Caldicot Levels.

5. Consideration of recommended improvements to the tidal flood defences now and into the future

The Severn Estuary Shoreline Management Plan 2 and Flood Risk Management Strategy

- 5.1 Management of the shoreline and tidal flood risks in England and Wales is broadly considered in a hierarchical manner, consisting of Shoreline Management Plans (now at their 2nd version, and therefore referred to as SMP2), strategies, and schemes.
- 5.2 SMP2s were undertaken by groups of operating authorities (such as maritime local authorities, the Environment Agency, and Internal Drainage Boards) and other relevant organisations. The SESMP2 was undertaken during 2008 to 2010 by the Severn Estuary Coastal Group, consisting of Natural Resources Wales, Environment Agency, Natural England, Cardiff Council, Monmouthshire County Council, Newport City Council, Vale of Glamorgan Council, Bristol City Council, Forest of Dean District Council, Gloucestershire County Council, North Somerset Council, South Gloucestershire Council, Stroud District Council, with Welsh Government and Defra as Observers.
- 5.3 SMP2s assess four generic policies for managing the shoreline, consisting of: Hold the line; Advance the existing defence line; Managed realignment; and No active intervention.
- 5.4 The SESMP2 sets out preferred policies for managing the shoreline, and associated flood and erosion risks. The SESMP2 was agreed by Welsh Ministers on 26th November 2014. The agreed SESMP2 preferred policies for the Wentlooge and Caldicot Levels shoreline are 'Hold the Line' for the next 100 years.
- 5.5 The definition of 'Hold the Line' is set out in the Defra publication 'Shoreline management plan guidance. Volume 1: Aims and requirements' (Document 17.2.3). The definition is:

“Hold the existing defence line by maintaining or changing the standard of protection. This policy should cover those situations where work or operations are carried out in front of the existing defences (such as beach recharge (see the glossary), rebuilding the toe of a structure, building offshore breakwaters and so on) to improve or maintain the standard of protection provided by the existing defence line. You should include in this policy other policies that involve operations to the back of existing defences (such as building secondary floodwalls) where they form an essential part of maintaining the current coastal defence system.”

- 5.6 From the above definition it is apparent that the strict wording of the policy of ‘Hold the Line’ refers to either maintaining or improving the SoP over time.
- 5.7 The draft SEFRMS was also prepared by the Environment Agency (South West and Midlands Regions in England, and South East Wales Area; the South East Wales Area is now part of NRW). The SEFRMS was undertaken in parallel with the SESMP2. The SESMP2 states that *“studies that have been carried out to feed into the SEFRMS have also been used to inform the SMP2. Many of these studies are of a greater level of detail than might normally be carried out for an SMP2. The development of the Severn Estuary SMP2 has benefitted from these more detailed studies.”*
- 5.8 One of the aims of the SEFRMS was to define the optimal SoP of tidal defences over the next 100 years, on balanced engineering, economic and environmental grounds. It has not been approved yet, but nevertheless is actively being used by NRW and the Environment Agency to guide investment in flood risk management infrastructure around the Severn Estuary in Wales and England.
- 5.9 The broad scale economic analysis within the SESMP2 found that the Benefit Cost Ratios (BCR) of applying the ‘Hold the Line’ policy were 23 and 19 (relevant to the Wentlooge Levels), and 31

(relevant to the Caldicot Levels). There are two BCRs for the Wentlooge Levels as the River Ebbw acts to separate it into two units (to the west between the rivers Rhymney and Ebbw, and to the east between the rivers Ebbw and Usk). This economic analysis conceptually included the cost of increasing future maintenance and construction, and the benefits of avoiding flooding up to the 0.1%AEP event, accounting for climate change predictions in WAG (2007), being similar to Welsh Government (2016).

- 5.10 I have reviewed the SMP2s relevant to Wales (South Wales SMP2, West of Wales SMP2, North Wales and North West England SMP2), and the BCRs for the Wentlooge and Caldicot Levels are in the top ten of in excess of two hundred shoreline units (used to determine BCRs). Whilst the SMP2s in detail applied varying methods of economic analysis, part of the purpose of SMP2s is to provide consistent shoreline management across England and Wales. However, it is noted that SMP2s do not provide certainty of funding, and that future decisions by Welsh Government will be required to ensure compliance.
- 5.11 Subsequent to the SESMP2, the SEFRMS found that the optimal SoP, applying the Flood and Coastal Erosion Risk Management Appraisal Guidance (EA, 2010) economic decision rule for Wales, would be 0.1%AEP over the next 100 years. The economic justification for this is robust, with BCRs of 169 and 31 (relevant to the Wentlooge Levels) and 66 (relevant to the Caldicot Levels).
- 5.12 The variations in BCR between the SEFRMS and the SESMP2 are due to different scales of assessment, differences in the geographic areas (as the SESMP2 included geomorphological linkages as well as tidal flood risk), and differences in climate change guidance.

- 5.13 The reason for the robust BCRs is primarily the extensive property and infrastructure present in the tidal floodplain of the Wentlooge and Caldicot Levels. In total there are over 22,500 properties; care homes, hospitals and schools; the mainline railway between Cardiff and the Severn Tunnel, the existing M4 and M48 motorways, the A48 and B4239; major power transmission lines (275kV/400kV), a power station and numerous electricity sub-stations; the docks at Newport and major sewage treatment works. The tidal flood risk to all this development and infrastructure is managed by the tidal defences along the Wentlooge and Caldicot Levels.
- 5.14 Tidal flood risks to this infrastructure would increase as described in section 4, if Welsh Government did not fund the 'Hold the Line' policy in the SESMP2.
- 5.15 Further to the SEFRMS recommending a 0.1%AEP SoP over the next 100 years, the SEFRMS identified three Priority Schemes of relevance to tidal flood risk to the M4CaN (Tabbs Gout along the Wentlooge Levels; Portland Grounds and Stephenson Street along the Caldicot Levels). These three Priority Schemes were recommended to address clear, strategically important low spots along the Wentlooge and Caldicot Levels tidal defences. The SEFRMS recommends that the three Priority Schemes occur within five years; this would be by 2019.
- 5.16 I note that the findings of the NRW (Document 17.3.6) study indicate that there are further low spots, relevant to the M4CaN, at Goldcliff Pill and Coldharbour Pill to Sudbrook Point. As noted previously, the SEFRMS assessed a range of climate change scenarios, ranging from the low 50%ile emissions scenario to the upper end plus surge scenario. The SEFRMS found that across all these climate change scenarios, the recommendation for a 0.1%AEP SoP over the next 100 years, and the BCRs, along the Wentlooge and Caldicot Levels remains robust. This range of climate change scenarios encompasses the NRW (Document

17.3.6) analyses and therefore the SEFRMS recommendation and justification for 0.1%AEP SoP over the next 100 years would remain robust.

Status of the recommended priority schemes from the SEFRMS

- 5.17 NRW confirmed in their letter of 4th May 2016 that of the three Priority Schemes, the Tabbs Gout scheme is completed and Portland Grounds was expected for completion in summer 2016. NRW subsequently stated at a meeting on 22nd September 2016 that both the Tabbs Gout and Portland Grounds schemes are now completed, and that as and when the three Priority Schemes were completed, the Wentlooge and Caldicot Levels would have a 0.1%AEP SoP through to 2030.
- 5.18 Information received from NRW in August 2016 (NRW, 2016b) confirmed that the Stephenson Street scheme is currently at the appraisal stage, and identified that the existing SoP is approximately between 10%AEP and 3.3%AEP.
- 5.19 The economic justification for the Stephenson Street scheme was also confirmed to remain robust, with further analysis within the appraisal stage determining that the Benefit Cost Ratio (BCR) was estimated as 24.8. The SEFRMS estimated the BCR as 66. The differences between the BCR's used in the two studies can be mostly attributed to the more detailed scheme level analysis, and the scheme level choice of the improvements being a combination of sheet-piled wall, reinforced concrete wall and embankment, which are more costly than the assumptions in the SEFRMS. The significant impacts on existing development and infrastructure used to calculate the BCR's remain similar between the two studies.
- 5.20 In August 2016, Welsh Government published 'Coastal Risk Management Programme – Guidance Notes for Local Authorities' (Welsh Government, 2015). This document states on page 2 that

“Welsh Ministers have made a commitment to assist local authorities meet mounting revenue pressures and enable prudential borrowing to support an aggregate £150 million investment in coastal flooding and erosion risk management projects. This programme provides a one-off opportunity for local authorities to implement transformational projects for our coastline and coastal communities with Welsh Government contributing 75% of project costs.”, and also that “The programme is intended to help local authorities to implement coastal flooding and erosion risk management projects aligned with the policy options recommended within the Shoreline Management Plans.”.

- 5.21 A list of Potential Candidate Projects is given in Appendix 1 of Welsh Government (2015). This includes the SESMP2 policy unit of NEW5, which covers the Stephenson Street scheme length.
- 5.22 Whilst the economic decision-making guidance in EA (2010) would still need to be complied with, the inclusion of the Stephenson Street scheme in Appendix 1 of Welsh Government (2015) indicates that greater funding certainty can be expected than other projects without the Coastal Risk Management Programme.
- 5.23 Further to this, at a meeting on the 22nd September 2016, NRW confirmed that Newport City Council are promoting the Stephenson Street scheme, that the Outline Business Case (NRW, 2016b) is with Welsh Government to consider for approval, and the Stephenson Street scheme is part of the Coastal Risk Management Programme. For the Stephenson Street scheme to occur, it would need to go through the stages of detailed design, licencing and permissions, and construction. Based on my experience, advice from Mr Huw Richards and Mr Barry Woodman, I consider that the Stephenson Street scheme would not be completely constructed until 2019.

- 5.24 NRW provided an updated study on flood risk to the Wentlooge and Caldicot Levels on the 25th November 2016. As I have stated previously, this study (Document 17.3.6) indicates that further works would be required, relevant to the M4CaN, at Goldcliff Pill and Coldharbour Pill to Sudbrook Point to meet the SEFRMS recommendation for 0.1% AEP SoP between 2010-2110. I have also previously stated that the SEFRMS recommendation and justification for 0.1% AEP SoP over the next 100 years would remain robust. Accordingly, there would be a strong economic case for the Goldcliff Pill and Coldharbour to Sudbrook Point works to occur between 2010 and 2030.
- 5.25 I have inspected the NRW (Document 17.3.6) findings to determine the broad extent and magnitude of works required. For the Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements to occur, they would need to go through the stages of project initiation, options appraisal and outline design, detailed design, licencing and permissions, and construction. Based on my experience, advice from Mr Huw Richards and Mr Barry Woodman, and project initiation in 2017, I consider that the Goldcliff and Coldharbour Pill to Sudbrook Point works would not be completely constructed until 2025.

6. Planning Policy and tidal flood risk

Objection 0268

Summary of NRW objection

- 6.1 The objection raised by NRW in their letter of 4th May 2016 is summarised on page 2 as:

“In this context we advise that NRW would object to the making of the above named Orders, as from the information provided, we are unable to agree with the conclusions of the Environmental Statement that ... is contrary to Welsh Government’s Technical Advice Note (TAN) 15: Development and Flood Risk”

- 6.2 NRW’s objection is expanded in their letter of 4th May 2016 on page 86 to 88, and notes that:

“Whilst acknowledging the points summarised in this section, we remain of the view that the increase in tidal flood risk which would arise to properties and infrastructure to the south of any new stretch of motorway is contrary to the requirements of TAN 15.

The key issue is lack of certainty that improvements to the coastal defences will be funded, programmed and implemented to keep track with providing a standard of protection which would mean that the Scheme, and properties to the south would remain flood free during a 0.1% (1 in 1000) tidal event throughout the lifetime of the Scheme.”

- 6.3 Subsequent to NRW’s letter of 4th May 2016, Welsh Government published the Flood Consequence Assessment Supplement Report (Document 2.4.4). This described the tidal flood risks now and in the future, with and without future tidal defence investment, and with and without the M4CaN. I have drawn on Document 2.4.4 in sections 4 and 5 of this Proof of Evidence.

- 6.4 A Statement of Common Ground (SoCG) is being prepared with NRW setting out the agreed technical background and policy issues relating to flood risk. It is anticipated this will be completed by the start of the Inquiry.

Acceptability criteria for flooding consequences

- 6.5 The Flood Consequence Assessment (Document 2.3.2) notes that the majority of the M4CaN lies (as defined in the Development Advice Map) within Zone C1; areas at risk of flooding from fluvial or tidal sources (based on EA extreme flood outline for 0.1% annual chance event), but currently developed and served by significant infrastructure, including flood defences. TAN15 sets out the planning policy tests for development proposals within Zone C1, in sections 5, 6, 7 and Appendix 1.
- 6.6 The Flood Consequence Assessment (Document 2.3.2) refers to section 5 of TAN15, and defines the M4CaN as '*less vulnerable development*'. TAN15 states that less vulnerable development can be permitted within Zone C1 subject to justification criteria in TAN15 sections 6, 7 and Appendix 1.
- 6.7 The justification for the location of the M4CaN is considered in the Proof of Evidence of Mr John Davies MBE (WG 1.23.1). I will now consider the technical information required to inform a judgement about flooding consequences.
- 6.8 Section 7 and Appendix 1 of TAN15 set out how to assess flooding consequences in detail, specifically in Appendix A1.12, A1.14 and A1.15.
- 6.9 Of particular relevance to NRW's objection is the fact that TAN15 requires that there are no adverse flood consequences for any existing development resulting from the construction of any new development, tested against a 0.1%AEP event over the lifetime of the development. NRW's objection is on the basis that the

recommended SoP of 0.1%AEP would only be met to the year 2030 on construction of the Stephenson Street scheme (notwithstanding the NRW (Document 17.3.6) findings), and that beyond 2030 there would not be complete funding certainty for further tidal flood defence improvements in response to climate change.

6.10 From consideration of the tidal flood risk information described in section 4 of this Proof of Evidence, I consider that:

- a) With the Stephenson Street scheme in place, the M4CaN would be flood free in the 0.5%AEP event up to 2030. The M4CaN would then meet the requirement of TAN15 Appendix A1.14 (flood free in the 0.5%AEP event).
- b) With the Stephenson Street scheme, Goldcliff and Coldharbour Pill to Sudbrook Point improvements, and small-scale works in place, the M4CaN would not cause detriment in the 0.1%AEP event up to 2030. The M4CaN would then meet the key element of NRW's objection, based on TAN15 Appendix A1.12 (no increase in flooding elsewhere). The M4CaN would also meet the requirements of TAN15 Appendix A1.14 (flood free in the 0.5%AEP event) and A1.15 (limited flooding in the 0.1%AEP event).
- c) With the SESMP2 and SEFRMS programme of tidal defence improvements after 2030 (encompassing the NRW (Document 17.3.6) findings and predicted climate change to 2122), a 0.1%AEP SoP would continue to be provided to the Wentlooge and Caldicot Levels. The M4CaN would then meet the key element of NRW's objection, based on TAN15 Appendix A1.12 (no increase in flooding elsewhere), and also achieve TAN15 Appendix A1.14 (flood free in the 0.5%AEP event) and A1.15 (limited flooding in the 0.1%AEP event) conditions.

- d) Without the SESMP2 and SEFRMS programme of improvements after 2030, the SoP of the Wentlooge and Caldicot Levels would reduce over time. In such circumstances, the M4CaN would not meet the key element of NRW's objection since the objectives in TAN15 Appendix A1.12 (no increase in flooding elsewhere) would not be achieved, and also the objectives in TAN15 Appendix A1.14 (flood free in the 0.5%AEP event) and A1.15 (limited flooding in the 0.1%AEP event) would not be achieved. The Proof of Evidence of Mr John Davies MBE (WG 1.23.1) addresses how this scenario should be viewed by the decision maker in this case.

Future tidal defence investment

- 6.11 I recognise that neither the SESMP2 nor SEFRMS provides absolute funding certainty for improvements to the tidal defence after 2030. However, I note that:
- a) The SESMP2 policies are agreed by Welsh Ministers. Defra (Document 17.2.3) states that on completion of a SMP2, agreement confirms that the procedures for developing an overall understanding, identifying and analysing problems and developing policies have been followed in line with current guidance; and the SMP2 meets the principles of sustainable development.
 - b) The economic justification for both the SESMP2 policy of Hold The Line and the SEFRMS recommended SoP of 0.1%AEP over the next 100 years is robust and strong in comparison to other SMP2 recommendations in Wales.
 - c) The priority schemes recommended by the SEFRMS have already been progressed to scheme appraisal (Stephenson

Street) or have been constructed (Tabbs Gout and Portland Grounds).

- 6.12 On these grounds I consider it reasonable to work on the basis that the SESMP2 policies and SEFRMS recommendations will be implemented between 2018 and 2030 (relevant to the Stephenson Street scheme, Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements, and small-scale works), and more widely from 2030 to 2122.
- 6.13 The SEFRMS is already being used to guide the investment in tidal flood defence infrastructure along the Wentlooge and Caldicot Levels. Priority schemes have been identified and implemented. With only the Stephenson Street scheme in place, and until the Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements, and small-scale works are in place, the property detriments in the 0.1% AEP event in 2018-2025 would likely be much closer to those noted for 2018-2030 than for 2030-2110. With the completion of the Stephenson Street scheme, Goldcliff Pill and Coldharbour Pill to Sudbrook Point improvements as indicated by NRW (Document 17.3.6), and where small-scale works are noted, the M4CaN would not interact with tidal flooding in the 0.1% AEP event up to the year 2030. The M4CaN will then be compliant with TAN15 section 7 and Appendix 1 until this date.
- 6.14 When consideration is given to the assets at risk and the robust economic justification for maintaining the SoP, the case for continuation of investment in the tidal flood defence infrastructure is compelling.

7. General existing and future flood risk

Objections 0020, 0083, 0145, 0149, 0150, 0195, 0206, 0216, 0310, 0314

- 7.1 Individual objectors have raised general concerns as regards the potential effects of climate change on tidal defences and tidal flood risk along the Wentlooge and Caldicot Levels, the existing SoP and condition of tidal flood defences, increased vulnerability to coastal flooding, the cost of works to the tidal defences and how the tidal defences would be managed in the future. These are specifically referenced in OBJ 0020, 0150, 0195, 0206 and 0314. Sections 4 and 5 of my Proof of Evidence deal with the above items in detail.

8. Tide levels in the vicinity of the River Usk and climate change

- 8.1 Associated British Ports (ABP) have stated that the crest level of the existing Newport Docks lock gates is 7.74mAOD. Inspection of the EA (2011a) EWL guidance indicates that the 100-50%AEP events would have tide levels of 7.8-7.9mAOD in year 2016, including for 0.2m Confidence Interval.
- 8.2 ABP have also stated that the crest level of the new Newport Docks 'Outer Lock' gates would be 8.41mAOD. Inspection of the EA (2011a) EWL guidance indicates that in year 2016, tidal overtopping would just begin to occur in the 4-2%AEP event of 8.4-8.6mAOD, including for 0.2m Confidence Interval.
- 8.3 WAG (2007) and Welsh Government (2016) climate change guidance indicates that 0.4m of SLR would occur between 2016 and 2066. Tidal overtopping of the new Newport Docks 'Outer Lock' gates would occur between the 50-20%AEP events of 8.3mAOD-8.5mAOD. Furthermore, WAG (2007) and Welsh Government (2016) climate change guidance indicates that 0.5m of SLR would occur between 2016 and 2076. Tidal overtopping of the new Newport Docks 'Outer Lock' gates would then occur between the 100-50%AEP event of 8.4-8.5mAOD.
- 8.4 The above SLR amounts are closely equivalent to the upper end scenario in Welsh Government (2011). Application of the Welsh Government (2011) guidance would result in the new Newport Docks 'Outer Lock' gates being overtopped:
- a) In the low 50%ile emissions scenario, between the 10-5%AEP event (for both 2066 and 2076).
 - b) In the medium 95%ile emissions scenario, between the 20-10%AEP (2066) and 50-20%AEP (2076) events.

- c) In the upper end plus surge scenario, more frequently than the 100% AEP event (for both 2066 and 2076).

- 8.5 In light of the above discussion I consider that the proposed crest level of the new Newport Docks 'Outer Lock' gates of 8.41mAOD reasonably accounts for predicted climate change, in that overtopping of the gates would occur at a similar frequency in 2066-2076 as for 2016, based on the WAG (2007) and Welsh Government (2016) climate change guidance.
- 8.6 I have reviewed the updated EWLs and Confidence Intervals from NRW (Document 17.3.6), and from inspection note that for the %AEP events noted above, the updated EWLs and Confidence Intervals would not change the findings stated above.
- 8.7 The implications on Shipping of the above discussion are covered in the Proof of Evidence by Mr Jonathan Vine (WG 1.22.1).

9. Summary and Conclusions

- 9.1 My Proof of Evidence provides a detailed description of the existing and future tidal flood risks on the Wentlooge and Caldicot Levels.
- 9.2 My Proof of Evidence includes all facts which I regard as being relevant to the opinions which I have expressed and the Inquiry's attention has been drawn to any matter which would affect the validity of that opinion.
- 9.3 In my opinion, if the SESMP2 and SEFRMS recommendations are funded into the future, this would address NRW's objection relating to Section 7 and the technical information in Appendix 1 of TAN15, specifically in Appendix A1.12 (no increase in flooding elsewhere). I consider there is a compelling case for that future funding to occur.
- 9.4 The evidence of Mr John Davies MBE deals with the planning policy issues in PPW and TAN15 in detail. He demonstrates, referring to the evidence of the other witnesses, that the M4CaN is essential highway infrastructure that is acceptable in principle, as an exception, in this area of flood plain in accordance with paragraph 13.3.2 of PPW, subject to certain requirements. Mr John Davies MBE deals with these requirements and the tests in TAN15 concluding that, on balance, whilst further tidal flood defence improvements as identified above are required in the early years of the M4CaN, the limited short-term conflict with some tests would not outweigh the benefits of this nationally important scheme. He further concludes that once the limited short-term conflict has been removed by the implementation of the identified flood defence improvements, there would be no conflict with national planning policies in the longer term on the basis that future funding does occur to comply with the Welsh Government's 'Hold the Line' policy.

- 9.5 I believe the facts which I have stated in this Proof of Evidence are true and that the opinions expressed are correct.
- 9.6 I understand my duty to the Inquiry to assist it with matters within my expertise and I believe that I have complied with that duty.

10. References

Defra, 2006a. Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities – Climate Change Impacts.

Document 2.3.2. M4 Corridor around Newport Environmental Statement, Volume 3, Appendix 16.1 Flood Consequence Assessment.

Document 2.4.4. M4 Corridor around Newport Environmental Statement Supplement, September 2016, Volume 3, Appendix S16.2 Flood Consequence Assessment supplement report.

Document 17.2.2. Welsh Assembly Government, Technical Advice Note 15, Development and Flood Risk, 2004.

Document 17.2.3. Defra, Shoreline management plan guidance Volume 1: Aims and requirements, 2006.

Document 17.2.6. Severn Estuary Coastal Group, Severn Estuary Shoreline Management Plan, Main Report and Appendices, 2010.

Document 17.2.14. Arup, M4 Corridor around Newport Flooding Assessment, Issue 1, 2014.

Document 17.2.16. Environment Agency, Severn Estuary Flood Risk Management Strategy Appraisal Report (draft), 2014.

Document 17.3.6. Natural Resources Wales, Caldicot and Wentlooge Coastal Modelling, Summary report, Final, August 2016.

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