

NON-REAL TIME HYDRAULIC MODEL REVIEW



Type of review

Display all sheets

Project	Bognor Regis Golf Club	Job Number	70088068	Required coastal standard (if applicable)	
---------	------------------------	------------	----------	---	--

Model Type	1D/2D	Software	Other	2nd review	3rd review	4th review
Revision	1	Date	08/07/2022	08/09/2022		
Area Client	EA	Reviewer	B Watson	P Sale		

REVIEW SUMMARY/CONCLUSION

Is the model suitable for intended use?	<u>Follow on review 08-09-2022</u> Please see the outstanding comments on the model below. Further detail can be found in subsequent sections of this review workbook 1. Only the design event (100+25%CC AEP) has been included in the Infoworks Transferable database. Results for other AEP scenarios are not included within the supplied model. Site A contains residential land use (more vuln uplift allowance for the 2080s epoch (+25%)) is the correct uplift to use based on the site vulnerability classification. Would it not be sensible to also test a 20 year scenario to check that the proposed development (particularly Site B) is suitable? 2. 2 DTMS included within the model network; Updated GM 01022022.asc and Baseline GM.asc. The reporting mentions that the model used the most recent Lidar at the time of the model build. Comparisons were undertaken v Baseline GM.asc. There are differences between the Baseline Ground Model (Baseline GM.asc) and the Updated Ground model (Updated GM 01022022.asc) which extend outside of the proposed redevelopment areas (see worksheet 2D Model Build). Levels should be consistent outside of the areas to be redeveloped? Please ensure ground models (and hence the resultant meshes) are consistent in areas where no changes are proposed 3. Some of the differences between the baseline and proposed model results could be driven by the difference between the baseline ground model and the updated ground model as noted in item 7.3 (worksheet 2D Model Build). Please ensure a wider range of AEP scenarios and present the results in the reporting 4. A check run was undertaken as part of this follow on review using Infoworks ICM version 2021.9 for the 100 year +25% baseline scenario (100yr 10.25mm/hr +25%CC). This results in slightly more extensive flooding when compared to the baseline scenario (see worksheet 2D Model Build). Please check these differences. Are they likely to have any influence on the proposed development? Please find the following 2d results: 5. The reporting mentions that the 27.5hr storm duration was also tested. This is referenced in the reporting but it is not clear whether this is referring to the JBA original modelling (2014) or this modelling? Please make this clear in the modelling report. The reporting suggests that both the 27.5hr and 10.25hr storm durations have been used <u>Previous review 08-07-22</u> This is a 1D fluvial - 2D surface water flood model for the Bognor Regis Golf Course proposed development. The model is based on the 2015 Aldingbourne model that was developed for flood risk mapping and has been updated to be suitable for use, with some considerations to be made to improve the level of detail such as the representation of buildings in the 2D domain whilst also improving the schematisation of the 1D/2D link at structures. The model requires justifications to be added.
---	--

MODEL REVIEW PROCESS

Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by a

Hydraulic model reviews are an essential component of the hydraulic modelling quality assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by a client or requested externally.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document and the review of the model, if required, completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all the amendments have been completed satisfactorily, will the model be approved and

It is recommended that the reviewer makes good use of the fluvial design guide chapter 7 and the user manual/help guides for the appropriate modelling software.

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be deleted. On completion of the review the reviewer may choose to use the following colour coding system to alert the modeller to the

Colour coding used (RAG):

- Green** – Good practice – not strictly necessary in this case but good practice for future studies.
- Amber** – Useful – please follow recommendation if time allows.
- Red** – Must do.

erable development) and Site B contains water compatible development (golf course). The central e A) does not sit within functional floodplain?

with EA composite 2020 Lidar DTM data. There are differences although these are generally not Updated_GM_Minus_Baseline_GM within the attached workbook). It would be expected that ground

of this model review. Please investigate this. It would also be prudent to assess detriment across a

nsidering the submitted results (see worksheet Model_Run_Sensitivity_Test within the attached

r as results for the 27.5hr storm duration test have not been provided within the ICMT and are not

to make the model suitable for a site specific flood risk assessment (FRA). The model is generally orting is lacking detail on the choices and assumptions made during the model update process and

xternal parties and hence all reviews should be written with an expectation that they could be read

normal parties and hence all reviews should be written with an expectation that they could be read

It does not automatically constitute model approval. Once the suggested changes have been the quality assured by the reviewer.

priority of the actions required (if any).

PROJECT BACKGROUND AND APPROACH

PROJECT DESCRIPTION & REQUIREMENTS

The proposals for the Bognor Regis Golf Course development scheme include re-development of the Bognor Regis Golf Course (Site A) into a residential development scheme and relocation of the Bognor Regis Golf Course to a site in Middleton south of the A259 (Site B)

The Environment Agency 2015 Aldingbourne direct rainfall model has been updated / developed to reflect the baseline and post development scenarios for both sites in order to assess the flood risk of the proposed development. The model user report states that the scheme has some limited off site impacts to the south-east of Site A. The impacts have been assessed by the consultant, determining that there will be no significant detriment to offsite areas due to flooding being contained along roads or mitigated by recent developments that are not represented within the model.

MODEL APPROACH & SUMMARY

Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
1.1	What model approach has been adopted? Is it appropriate? (e.g. new 1D/2D build, existing model truncation, 1d only?).		Existing 1D/2D 2015 Aldingbourne model has been updated to improve 1D and 2D domain representation including enhancement of the ground model through topographic survey	No Action		
1.2	Software used, including versions?	Amber	InfoWorks ICM version 8.5. This was not the latest version of InfoWorks ICM at that time as 2021.1 was available.	Consider updating to InfoWorks ICM latest release version 2023.0	This model is based on an existing model. The version of the software was therefore maintained to avoid any additional stability issues or changes to assumptions in the wider model area.	A check run was undertaken as part of this follow on review using Infoworks ICM version 2021.9 for the 100 year +25% baseline scenario (100yr 10.25mm/hr +25%CC). This results in slightly more extensive flooding when considering the submitted results (see worksheet Model_Run_Sensitivity_Test). Please check these differences. Are they likely to have any influence on the proposed development?
1.3	Model Version Reviewed	Red	"Aldingbourne Rifles and SWS_updates_WSP_100yr+25% CC 10.25hrs 1.2m SLR- Base" Has been reviewed. No run log or description of simulations has been provided, as such this scenario is concluded to be the baseline simulation	Simulation log to be provided detailing what each simulation represents	Simulation log has been updated.	Model simulation log spreadsheet provided (Bognor Regis Golf Club_Model Simulation Log). No further action required
1.4	Are all model files provided?		Yes	No Action		
1.5	Does the model run?		Yes	No Action		

EVENTS & SCENARIOS

Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
----------	--------------	-----	---------------------	--------------------	----------------------------	---------------------

2.1	What events have been simulated (Q5, Q100, Q100CC, Q1000)? Are they sufficient to meet the project requirements?	Amber	Model results and report refer to Q100+25%CC event only. The report appendix states that "the model will be simulated for a range of return periods" but these simulations have not been provided or reported on.	Provide justification for simulating Q100+25%CC only or provide all return periods for next review	The focus of the FRA is the design event i.e the Q100+25% CC. That is therefore the event that has been reported on. Results for the other return periods are included within the model for information but do not impact on the findings of the FRA.	Only the design event (100+25%CC AEP) has been included in the Infoworks Transferable database (see screen shot within the comment for this cell). Results for other AEP scenarios are not included within the supplied model. Site A contains residential land use (more vulnerable development) and Site B contains water compatible development (golf course). The central uplift allowance for the 2080s epoch (+25%) is the correct uplift to use based on the site vulnerability classification. Would it not be sensible to also test a 20 year scenario to check that the proposed development (particularly Site A) does not sit within functional floodplain?
2.2	Is a development being modelled? If so are appropriate scenarios modelled to assess the impact?	Red	Yes, post development scenarios have been modelled. Two scenarios have been provided for development scenario and have been reviewed: Aldingbourne Rifes and SWS_updates_WSP_100yr+25% CC 10.25hrs 1.2m SLR - Updated GM - concluded to be the Site B scenario although no simulation log or description of simulations has been provided Aldingbourne Rifes and SWS_updates_WSP_100yr+25% CC 10.25hrs 1.2m SLR - Updated GM with Sub - concluded to be the Site A scenario although no simulation log or description of simulations has been provided	Simulation log to be provided detailing what each simulation represents	Simulation log has been updated.	Simulation log has been included which describes the post development scenarios (Bognor Regis Golf Club_Model Simulation Log). No further action required
2.3	Flood Mapping scenarios?		Defended Q100+25%CC event provided only. Purpose of model is to inform FRA and so defended and undefended scenarios have not been carried out	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)
In the interests of a speedy approval process the model has been re-run in the latest version. This does not show any influence on the proposed development, please see attached plans for the design event.				

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

Additional scenarios are now provided.				

1D MODEL BUILD

1D NETWORK						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
3.1	Model overview: Node Summary 1d length		267 River Reaches ranging in length from 1.9m to 1291.1m 885 conduits ranging in length from 1m to 244.3m	No Action		
3.2	Have appropriate distances between sections and/or nodes been used (dx)?		Yes	No Action		
3.3	Are out of bank flows represented in 1d? If so, how has it been done and is		No, out of bank flows are represented in 2D	No Action		
3.4	Is the model geo-referenced?		yes, coordinate system used is British National Grid [EPSG 27700]	No Action		
3.5	Do the cross sections and bed profiles look reasonable?	Red	Cross-section 1.019!! Appears to show a parapet / headwall structure rather than the channel bed. Review against topographic survey has not been requested	Verify schematisation of Cross section 1.019!! Against topographic survey	Cross section 1.019!! is outside of the area of interest for this assessment and therefore no alterations made from the existing model. Refer to section 2.3.4 in technical note.	This cross section is upstream of the B2233 on the Barnham Rife in Barnham. This cross section is over 3.5km upstream of the proposed development area. No further action is deemed necessary given the distance from the development site.
3.6	Chainage – compared to surveyed sections		Survey not provided for comparison. No new cross-sections have been added to the model since 2015 Alginbourne model review	Review against topographic survey has not been requested	No additional sections added in from topographic survey from the existing model	
3.7	Does conveyance look appropriate?	Amber	Poor conveyance in following sections: 1.019!! 1.013!!-3-1.012!! To 1.012!!-1-1.01!! 4.001! 5.005! 3.004!!!!ds 1.003!!!!-3-1.002!!!!us 1.014_ds to 1.013!_u 1.013_0_1.012! To CPW_US CPW_DS to 1.011!-1-1.010! 3.009 to 3.008 7.037 21.007_ds 20.028 19.019-19.018 7.021 7.017DS-0-7.016 1.007 to 1.006DS	Correct poor conveyance through the implementation of panel markers	No updates to the conveyance made from the existing model. Sections identified are outside of area of interest for this assessment. Refer to section 2.3.4 in technical note.	These sections fall outside the development area and inflections in the conveyance curves are generally minor. On this basis no further action is required

3.8	If gauged flow is available, is there good flow reconciliation between the statistical estimates and the modelled,		Direct rainfall has been applied over the 2D domain and no flow reconciliation conducted	No Action		
3.9	Bank Markers. Are they used and if so, are they suitably located?		Not applicable	No Action		
3.10	What approach to channel roughness has been used?	Amber	Varying channel / bank roughness has been applied within cross-sections with appropriate panel markers. Justification for roughness values has not been provided	Provide justification for channel roughness values	Roughness values maintained from original model. Info from roughness zones applied to the 1D model reaches where the values were missing. This was the only available information for the areas outside of the site.	The adopted mannings values appear reasonable based on an inspection of aerial photography. Mannings values are retained from the original modelling. No further action required
3.11	What manning's n value(s) have been used for the channel? If it is 1d only what values and how have they been applied in the flood plain?	Amber	Generally 0.040 bed and 0.060 on bank.	Provide justification for channel roughness values	Roughness values maintained from original model. Info from roughness zones applied to the 1D model reaches where the values were missing. This was the only available information for the areas outside of the site.	
3.12	What method has been used to estimate roughness (USGS, Chow, etc. based on survey, photographs)? Are they appropriate	Amber	Justification for roughness values has not been provided. 0.040 and 0.060 reflects a sluggish / weedy channel with medium dense brush on banks	Provide justification for channel roughness values	Roughness values maintained from original model. Info from roughness zones applied to model reaches. Generally the watercourses within the site were all heavily vegetated and so the values are appropriate.	



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

1D BOUNDARY CONDITIONS

1D BOUNDARY CONDITIONS

Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
4.1	1d boundary model domain; is there glass walling anywhere in the modelled reaches?		No, all channels are linked to the 2D domain to prevent glass walling	No Action		
4.2	How have the boundaries been applied?		NA no 1D inflow boundaries applied	No Action		
4.3	How is the downstream boundary(s) applied?		Tidal HT applied at 5 1D nodes along coastal boundary	No Action		
4.4	If tidal - how has the boundary been derived?	Amber	MHWS time-series has been applied with an uplift of 1.2m as per EA climate change Higher Central scenario. No details are provided on how the MHWS has been derived	Provide details of MHWS data and justificaion for using MHWS	Maintained MHWS boundary from the original model. Climate change uplift applied in line with latest guidance. Uplift added (mAD) to the provided level files	Mean Higher Water Spring tide for the higher central scenario peaks at 4.35mAOD and for the Upper scenario at 4.75mAOD. Mean High Water Spring tide for the closest Coastal Flood Boundary node (chainage _4578) is 2.67 (base year 2017). On this basis the adopted values appear reasonable
4.5	Have appropriate locations been chosen for the downstream model extents?		Yes, applied at outfalls	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

1D STRUCTURES

1D STRUCTURES						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
5.1	Are all structures represented? If not have explanations for structures not modelled been given in the Log/report?	Amber	Report states "no localised structures have been incorporated as they are not believed to be restricting flow". Unclear which structures this refers to. Review against topographic survey has not been requested Bridge at Charles Purley Way (CPW_US) has been added	Provide details of which structures have been ignored and justification	Structures not represented were small crossings of ditches within the existing golf course. The ditches were represented within the 2D ground model and not using river reaches. No 1D structures were added in to the model in these locations.	This is considered reasonable. There are some small drainage ditches across the 2d zone in the vicinity of the Golf Course
5.2	Are invert levels correct compared to survey data?		Review against topographic survey has not been requested	No Action		
5.3	Do bridges surcharge? If so has orifice flow been enabled?		Yes. An orifice flow is not required in ICM	No Action		
5.4	Are there spills around the structure or over the top represented appropriately?	Red	Irregular weirs used to represent overtopping of culverts over decks Where overtopping is represented in 2D, storage areas have been added but no inline bank	Add inline banks at structures where storage areas are in place to prevent glass walling	No changes were made to the model outside of the area of interest.	Locations where inline banks have not been used when the structure deck is represented in 2d are outside of the area of interest. On this basis no further action is required in relation to this assessment
5.5	If there are any movable structures have they been modelled correctly?		NA - no RTCs are present	No Action		

5.6	Structure coefficients - Have they been changed from default values?	Amber	User report states "updates to 1D coefficients made where appropriate" Culvert inlet and outlet units have been derived using CIRIA guidance. Pipe roughness values are user defined and appropriate Discharge coefficients remain default for flap valves, orifices and sluices despite statement in report that these have been updated Bridge discharge coefficients and losses are default irregular weir discharge coefficients are user defined but no justification provided in report. Some values are particularly low e.g. 0.6	Provide justification for structure coefficients where kept as default or where user defined Consider updating the report to reflect that discharge coefficients remain default for flap valves, orifices and sluices	Refer to section 2.3 in modelling tehcnical note for justification on coefficients. Irregular weir coefficients remain from the exisiting model.	This is considered reasonable. In additionl, the location of irregular weirs with discharge coefficients of 0.6 is outside of the area of interest. On this basis no further action is deemed necessary
-----	--	-------	--	---	--	--



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

--	--	--	--	--

1D RUN PARAMETERS

1D RUN PARAMETERS						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
6.1	What time step has been used for the 1D model? Is it appropriate?		A 1 second timestep has been used, which is deemed appropriate.	No Action		
6.2	What initial conditions have been used? Steady state, hotstart file?		No initial conditions have been applied	No Action		
6.3	Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified?		No change to default parameters. Link 1D and 2D calculations at minor timesteps has been used as is appropriate	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

2D MODEL BUILD

DIGITAL TERRIAN MODEL					
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)
7.1	Number of domains?		Single domain	No Action	
7.2	Area of 2d domain/s		98km2	No Action	
7.3	What dataset has been used to define the DTM elevations? LiDAR, Photogrammatic DTM?	Amber	LiDAR DTM has been used to represent the 2D elevations. However, date of DTM is not provided in the report or the model itself.	Provide details of the source of the DTM within the report	2m LiDAR provided as per the existing model. No new LiDAR was downloaded. Surface to be included in next review of model.
7.4	What grid resolution has been used? Is it suitable to accurately represent flow paths, e.g. between buildings?		2D domain uses variable mesh sizes via the use of mesh zones. Min triangle area is 25m2, maximum triangle area is 1000m2	No Action	
7.5	Has the DTM been rotated to optimise flow route representation?		NA variable mesh	No Action	
7.6	Obstructions to flow (or not an obstruction to flow)?	Red	Various mesh zones have been used to represent roads and other topographic features. No justification is provided for raise/lower value applied to mesh zone	Provide justification for mesh zone adjustments to ground model	Mesh zones were left unchanged from the original model. There was one small mesh level zone added for the post development model to represent a speed table at the junction between Golf Links Road, Shirley Drive and Downview Road. This was raised 125mm above the surrounding ground level.
7.7	Has additional site specific topographic survey data been used?		The report states that "enhancements have been made by incorporating the topographic survey data within the ground model" Review against topographic survey has not been requested	No Action	

7.8	How have buildings been represented within the DTM?	Amber	Buildings have not been accounted for through raising the footprint of buildings within the DTM or applying a high roughness value	Considering raising the footprint of buildings within the DTM or applying a high roughness value to building polygons	Maintained the approach from the original model
7.9	Are defences/embankments/bank crests accurately represented?		Unknown. Report states that scenarios are defended only. No details provided on location of scenarios	No Action	
7.10	If post-development scenarios are required have the proposed ground levels and building been represented appropriately?		Changes between "Baseline GM" and "Updated GM 01022022" can be observed at Site A and Site B that reflect Appendix C from the user report. However, Review against topographic survey has not been requested	No Action	

2D ROUGHNESS					
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)
8	What manning's n values have been used to define floodplain roughness? Have they been applied correctly?	Amber	2D zone uses a general value of 0.06 Mannings which has been justified in the report. 2D roughness zones have been applied with Mannings ranging from 0.025 to 0.10. The majority of these are channels and are covered by 1D river reaches so NA. However, There are a number of roughness zones applied that do not cover channel areas and are not justified in the report	Provide justification for 2D roughness values	Roughness values maintained from the original model
8.1	What methods have been used to estimate roughness?	Amber	Not known	Provide justification for 2D roughness values	Roughness values maintained from the original model
8.2	Is the representation of different roughness areas sufficiently accurate and detailed?	Amber	Roughness is extremely simplified, 0.06 covering majority of 2D domain including roads and buildings.	Consider applying roughness zones for roads and buildings within the 2D zone based on OS MasterMap	Roughness values maintained from the original model



2nd Review Comments	2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
2 DTMS included within the model network; <i>Updated GM 01022022.asc</i> and <i>Baseline GM.asc</i> . The reporting mentions that the model used the most recent Lidar at the time of the model build. Comparisons were undertaken with EA composite 2020 Lidar DTM data. There are differences although these are generally not significant. There are differences between the Baseline Ground Model (Baseline GM.asc) and the Updated Ground model (Updated GM 01022022.asc) which extend outside of the proposed redevelopment areas (see worksheet <i>Updated_GM_Minus_Baseline_GM</i>). It would be expected that ground levels should be consistent outside of the areas to be redeveloped? Please ensure ground models (and hence the resultant meshes) are consistent in areas where no changes are proposed	Both DTMs were developed from the latest LiDAR, however, a discrepancy was brought in when creating the TIN for use in the model with different pixel sizes being used in the export function , in the software prior to import to ICM. This has now been corrected and no discrepancies are observed beyond the site, see revised figure in worksheet Updated_GM_Minus_Baseline_GM.		
Mesh level zone (ID: 1 - area 0.31 Hectares) added as reported at the junction between Golf Links Road and Shirley Drive (495180, 100785). This raises ground levels by 0.125m. This is as reported in section 2.3.3 of the model report. The reporting also mentions that an additional mesh zone was added to the urban area to the south of the model to increase the resolution of the mesh in a key area of interest. This is considered reasonable and no further action is deemed necessary			

This is considered reasonable. Building representation is consistent between the baseline and proposed scenarios.			

2nd Review Comments	2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
Roughness zones have been used in the model to represent woodland, water, and some key roads. The application is fairly simplistic although there is consistency between the baseline and proposed models. The default value for the 2d zone is 0.06 which is considered a reasonable general value. On this basis and considering the consistency between the baseline and proposed scenarios, no further action is deemed necessary			



4th Review Comments	4th Review Response (DATE)

4th Review Comments	4th Review Response (DATE)

2D BOUNDARIES

2D BOUNDARY CONDITIONS						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
9.1	Have any boundaries been used in the 2D domain? If so detail.		2D zone has a normal depth condition applied to the perimeter	No Action		
9.2	Is the model boundary suitably large? i.e. the flood extent should not reach the boundary.		Yes 2D domain is an appropriate extent	No Action		
9.3	Has rainfall been applied directly to the 2d model domain?		Yes, with the exception of buildings. Rainfall has been applied to buildings via subcatchments that are directly connected to the nearest manhole. A fixed runoff coefficient of 0.95 is then applied to rainfall within building subcatchments	No Action		
9.4	Coastal - How has the wave overtopping been applied?		User report states that wave overtopping calculations were not updated. No inflows have been applied at coastal model boundary	Provide details on how wave overtopping has been considered	The tidal flood risk (including wave overtopping) was based on the Eas Emsworth to Littlehampton West Bank Coastal Modelling Study which included wave overtopping. This confirmed that the defences provide the necessary standard of protection and therefore the site is not at risk of tidal flooding. Wave overtopping was therefore scoped out of the assessment for the ERA	This is considered reasonable



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

2D STRUCTURES

2D STRUCTURES						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
10.1	Have any structures been included in the 2D domain? If so how have they been represented?		No	No Action		
10.2	Are invert levels correct compared to survey data?		NA	No Action		
10.3	How have defences been represented? Zline? If there are flood zone scenarios have the defences been excluded adequately?		NA	No Action		
10.4	Have appropriate loss coefficients and roughness values been used?		NA	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

2D RUN PARAMETERS

INITIAL CONDITONS & OTHER RUN PARAMETERS						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
11.1	What time step has been used for the 2D model? Is it appropriate?		A 1 second timestep has been used and this is deemed appropriate.	No Action		
11.2	Have initial water levels been applied? Are they correct?		Antecedant conditions equivalent to 100% saturation of all soils within the catchment have been represented using 2D initial conditons. Report states that these are unchanged from the existing 2015 model	No Action		
11.3	Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default?		The option to link 1D and 2D calculations at the minor timestep has been selected, with all other run parameters set to default.	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

1D/2D MODEL LINKS

MODEL LINKS						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
12.1	How have the 1D/2D models been coupled, is it appropriate?		reaches that are applied from section end elevations.	No Action		
12.2	Is the digitisation of the links acceptable?	Amber	Elevations are informed by cross section ends. Preferred methodology would be for bank lines to be informed by the ground model, although option to adjust bank levels based on adjacent ground levels has been selected	Consider updating bank elevations from ground model	Maintained from the original model	This is considered reasonable. As stated in the previous review option to adjust bank levels based on adjacent ground levels has been selected in the 2d run parameters
12.3	Is the 2d representation of the river channel comparable in width with the 1d model cross sections?		NA - ICM matches width by default	No Action		
12.4	Representation of 1D output in 2D domain		NA - 1D water levels cant be provided in ICM model outputs	No Action		
12.5	Have any default link parameters been changed (i.e. to improve stability)?		No change to drowned bank linearisation threshold. Discharge coefficient of 1.1 has been applied which is appropriate for grass embankments and inline with Innovyse guidance Modular limit kept as default 0.9	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

1D-2D Surface Water

SURFACE WATER MODELLING			
Item No.	Item Checked	RAG	1st Review Comments
18.1	Check the geographical coverage of the model relative to the surface water catchment for the study. Is the model coverage sufficient for the study or project?		Yes surface water catchment is appropriately captured
18.2	Have contributing areas been applied appropriately? Are the subcatchment boundaries geocoded? Do the impermeable area assumptions appear correct?		Direct rainfall applied to 2D zone Subcatchments applied for buildings only with fixed runoff coefficient which is deemed as appropriate
18.3	How has the surface water network been represented, is it suitably detailed?		Surface water drainage network is represented in detail where contributions to the fluvial system are present
18.4	Does the overall model connectivity match the sewer records?		Review against topographic survey has not been requested
18.5	How are receiving watercourses represented in the model? Is this appropriate?		1D channels are represented as river reaches. Review comments included in 1D Model Build tab
18.6	Are there any errors or warnings?	Red	Warning 1053: One or more nodes had their flow limited from the 2d zone
18.7	Has storage compensation been applied? Is this appropriate?		NA
18.8	Are there any backfalls in the model and do these look realistic where they exist?		NA
18.9	Have sediment depths and roughness coefficients been applied appropriately and are they within the expected ranges?		Pipe roughness values are user defined and appropriate
18.10	Are all significant outfalls included in model with appropriate detail?		Yes, outfalls to coastal boundary are represented with tidal boundary conditions
18.11	Are all significant storage tanks included in model with appropriate detail?		Baseline scenario contains 1x storage node. Review against survey has not been requested.

18.12	Are all significant pumping stations included in the model with appropriate detail?		Baseline contains 4x pumping stations. Review against survey has not been requested.
18.13	Has any infrastructure been omitted from the model network? If so what is the justification for this this? Is this appropriate?		None reported. Review against survey has not been requested.
18.15	Is the runoff model appropriate and have the parameters been applied correctly?	Amber	Runoff controlled by infiltration zones in 2D domain. Runoff is defined using Hortonian infiltration parameters. No justification provided in report for infiltration parameters used. A fixed runoff coefficient of 0.95 is then applied to rainfall within building subcatchments and is appropriate
18.16	How has the design rainfall been generated and applied? Is this appropriate?		Methodology for rainfall generation has been reported in detail within Appendix B. Hydrology review has been conducted separately.



1st Review Actions	1st Review Response (DATE)
No Action	
No Action	
No Action	
No Action	
No Action	
Provide justification for warning	Nodes have been retained from the original model and not been altered. Nodes with flow limited from 2D Zone appear to be outside of the 2D Zone.
No Action	
No Action	
No Action	
No Action	
No Action	

No Action	
No Action	
Provide justificaiton for runoff paramterisation in 2D zone	Maintained from original model, comment added to report section 2.3.4
No Action	



2nd Review Comments	2nd Review Response (DATE)
I could not find evidence of this warning within the latest log results. No further action required	

This is considered reasonable. No further action required	



3rd Review Comments	3rd Review Response (DATE)



4th Review Comments		4th Review Response (DATE)	

FORCING PARAMETERS AND JOINT PROBABILITY INCLUDING FOR WAVE TRANSFORMATION MODELLING

PARAMETERS AND JOINT PROBABILITY						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
19.1	Does the approach utilised conform with best practice guidance?	Amber	Report states that no change has been made to MHWS. No details provided on source of MHWS data	Provide details of MHWS data and justificaion for using MHWS	No report was provided for original model. We maintained the boundary as in the original model	Mean Higher Water Spring tide for the higher central scenario peaks at 4.35mAOD and for the Upper scenario at 4.75mAOD. Mean High Water Spring tide for the closest Coastal Flood Boundary node (chainage _4578) is 2.67 (base year 2017). On this basis the adopted values appear reasonable
19.2	Inclusion of up to date data, such as Hindcast?	Amber	Report states that no change has been made to MHWS. No details provided on source of MHWS data	Provide details of MHWS data and justificaion for using MHWS	No report was provided for original model. We maintained the boundary as in the original model	
19.3	Creation of tidal curve created using appropriate source data?	Amber	Report states that no change has been made to MHWS. No details provided on source of MHWS data	Provide details of MHWS data and justificaion for using MHWS	No report was provided for original model. We maintained the boundary as in the original model	
19.3	What Joint Probability method has been used (Defra 2005 or Multivariate) is this suitable for the study?	Amber	Report states that no joint probability anaysis was conducted	Provide justificaion for not carrying out joint probability analysis	The EAs Emsworth to Littlehampton West Bank Coastal Modelling Study confirmed that the site (and Bognor) is protected up to the 1 in 200 year event and the standard of protection will be maintained in the future. Tidal risk to the site was therefore low and so no need to do joint probability assessment. The focus of the study was the fluvial and surface water flood risk	This is considered reasonable. No further action required
19.4	Has the Coast Flood Boundary data (CFB) been applied appropriately within the models?	Amber	Report states that no change has been made to MHWS. No details provided on source of MHWS data	Provide details of MHWS data and justificaion for using MHWS	MHWS was retained from the exisiting modelling, with additional cliamte change scenarios added (mAD)	See above comments

19.4	Has climate change been accounted for appropriately?		MHWS time-series has been applied with an uplift of 1.2m as per EA climate change Higher Central scenario Sensitivity analysis with +1.6m as per upper end EA climate change scenario has also been	No Action		
------	--	--	--	-----------	--	--



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

--	--	--	--	--

COASTAL WAVE TRANSFORMATION MODELLING

MODEL CHOICE						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
20.1	Does the model fit the brief? (Phase averaging/ phase resolving, stationary / non-stationary)		NA	No Action		
DOMAIN						
20.2	Does the boundary cover offshore waves from all relevant directions?		NA	No Action		
20.3	Does the coastline file represent the coastline to a high enough resolution for the modelling required?		NA	No Action		
20.3	Are all required output locations offshore of the chosen coastline?		NA	No Action		
20.4	Does the model extend far enough offshore that computational error close to the model boundary will not effect the required results?		NA	No Action		
20.4	Does the model domain extend far enough offshore so that wave boundary conditions are accurate for the model boundary?		NA	No Action		

20.5	Does the model converge to a reasonable amount in the area of interest?		NA	No Action		
ACTIVE/INACTIVE BOUNDARIES						
20.6	Are ocean and land boundaries set?		NA	No Action		
20.7	Is the spectral shape to be applied to the ocean boundary appropriate given the geographic location and the boundary conditions available?		NA	No Action		
BATHYMETRY						
20.8	Is the input bathymetry of a high enough resolution for the resolution required?		NA	No Action		
20.9	Are bathymetry data available for areas which may dry out at low tide?		NA	No Action		
21	Are boundaries between different bathymetry datasets smooth?		NA	No Action		
21.1	Does the model mesh/grid represent the input bathymetry well?		NA	No Action		
21.2	Are bathymetric features elsewhere within the model domain well represented if they are expected to alter wave propagation (e.g. Offshore sand banks)?		NA	No Action		
WATER LEVEL						
21.3	If the model water level has been set constant across the model domain is this a realistic assumption given the tidal behaviour across the model domain?		NA	No Action		
21.4	For non-stationary models has the underlying tide / surge behaviour been taken into consideration? If not is it justifiable?		NA	No Action		
WIND FIELD						
21.5	If model wind speed and direction has been set constant across the model domain is this realistic?		NA	No Action		

21.6	Are there any datasets available which could be used to construct a spatially varying wind field?		NA	No Action		
21.7	For non-stationary models has an appropriate data set been identified to cover the required model period?		NA	No Action		
WAVE BOUNDARY CONDITIONS						
21.8	If modelled, wave boundary conditions should come from the same model data source as wind data otherwise there may be inconsistency between the two.		NA	No Action		
21.9	Is enough information available to generate a wave spectrum?		NA	No Action		
22	For non-stationary models has an appropriate dataset been identified to cover the required model time period?		NA	No Action		
OUTPUT REQUIREMENTS						
22.1	Model behaviour checked through output of Hs, Tp, Mdir fields for entire model domain.		NA	No Action		
22.2	Water depth at output points checked against real depth (interpolation / lower resolution may result in differing water depth which in shallow water can result in significant change to wave height).		NA	No Action		
RESULTS						
22.3	Do errors at the model boundary disappear further into the model domain?		NA	No Action		
22.4	Does wind growth occur as expected given the fetch length across the model?		NA	No Action		
22.5	Are changes in wave period easily explained?		NA	No Action		
22.6	Is the output wave height within the expected range?		NA	No Action		
CALIBRATION						
22.7	Has the model been calibrated against appropriate quality controlled measured data?		NA	No Action		

22.8	Do the locations of the calibration data allow calibration close to the required output locations?		NA	No Action		
VALIDATION						
22.9	Has the model been validated against appropriate data independent from the calibration process?		NA	No Action		
SENSITIVITY TESTING						
23	Have sensitivity runs been performed in order to test the sensitivity of the model at the output locations to reasonable variations in the model forcing data (for all boundary		NA	No Action		
STABILITY AND CONVERGENCE						
23.1	Have the number of iterations been modified away from the default and is this appropriate?		NA	No Action		
23.2	Has the model achieved the appropriate levels of convergence?		NA	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

MODEL SENSITIVITY

SENSITIVITY TESTING & UNCERTAINTY						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
16.1	Have appropriate model parameters been chosen for sensitivity testing?		Sensitivity towards roughness and downstream boundary condition have not been conducted since model update due to previous analysis on the 2015 model that found the model to be insensitive toward these parameters. Sensitivity analysis has been conducted towards: - Sea level rise (1.2m and 1.6m uplifts have been applied in line with EA higher central and upper end climate change scenarios respectively) - surcharged outfalls in development scenarios to assess outfalls discharging from the development platforms - Discharge from SuDS features from the site into the Lindsey Rife using a constant inflow hydrograph	No Action		
16.2	Do the results of the tests show the models to be particularly sensitive to certain parameters?	Red	Report states that sensitivity tests reveal moderate sensitivity towards parameters tested within the site with negligible sensitivity outside of the development site. However, difference maps presented within Appendix D show depth differences of >0.1m both within and outside of the site polygon for all sensitivity analyses.	Consider providing further summary statistics to support sensitivity analysis. Justify use of "negligible" terminology.	Negligible is used to indicate changes in flood depths that are below 0.01m, which is the tolerance of the model. As discussed in the FRA and added in to the modelling technical note, flood differences outside of the site area are due to differences in the mesh between the pre and post development models. This results in noise generation in areas not hydraulically linked to the site.	Some of the differences between the baseline and proposed model results could be driven by the difference between the baseline ground model and the updated ground model as noted in item 7.3 (worksheet 2D Model Build) of this model review. Please investigate this. It would also be prudent to assess detriment across a wider range of AEP scenarios and present the results in the reporting
16.3	Have confidence limits for model results (+/- mm) been presented? How were they derived and does this seem sensible?	Red	No confidence limits provided	Provide confidence limits	The tolerance of the model is assessed to be 0.01m, which is how the flood difference mapping is presented. Variations of =<0.01m can be apparent where meshing has changed between model scenarios, so this has been assessed as the	No further action required



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)
Both the baseline and proposed ground models have been updated to use the latest LiDAR from 2020 and have been reprocessed, resulting in no more differences between ground models outside of the proposed developments.				

WAVE OVERTOPPING

GENERAL CONSIDERATIONS						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
21.1	What is the source of data used?	Amber	Report states "we do not consider any need to remodel the wave overtopping given the findings of this scenario" However, no details are provided on the existing wave overtopping calculations and how this has been considered	Provide details on how wave overtopping has been considered	The EAs Emsworth to Littlehampton West Bank Coastal Modelling Study confirmed that the site (and Bognor) is protected up to the 1 in 200 year event and the standard of protection will be maintained in the future. Tidal risk, including wave overtopping to the site was therefore low. The focus of the study was the fluvial and surface water flood risk	This is considered reasonable. No further action required
21.2	What level of calibration (where data exists) has been achieved?		NA	No Action		
21.3	How appropriate are any assumptions?		NA	No Action		
DEFENCE CONCEPTUALISATION						
21.4	Is it the appropriate resolution?		NA	No Action		
21.5	Are any key low crest levels missed out?		NA	No Action		
21.6	Have the correct crest, toe and slope been used in terms of Neural Network constraints?		NA	No Action		
21.7	Comparison/check against beach profile, AIMS, defence survey, LIDAR and any other data used for schematising.		NA	No Action		
EUROTOP APPLICATION						

21.8	Have correct values been input?		NA	No Action		
21.9	Have the calculations been used within their applicable range?		NA	No Action		
22	How has overtopping been considered when the still water levels rise near the crest/ just above the crest?		NA	No Action		

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

MODEL STABILITY

1D MODEL STABILITY

Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
13.1	Errors/Comments/Warnings?	Red	Various validation warnings that have not been justified within the reporting. Most notably, conduit invert and soffits above ground levels, elements with 0.000m² area, bank connections overlapping 2D mesh Runtime warnings are: - depth exceeds section height - acceptable due to 1D/2D link - Flow reversals on banks - not justified in the report - nodes have had their flow limited from the 2D zone - not justified in the report	Justify validation and runtime warnings	Conduit levels and bank connections have been retained from the existing model. Element area has been inspected and is outside of the area where WSP updates were made, as such is likely to be a artefact of the original model. Bank connections overlapping 2D mesh in void region is where the river reach end points are not snapped to the connecting storage area. This has not been changed from the original model. Flow reversals likely due to the nature of the low lying ground and shallow watercourses. Nodes have been retained from the original model and not been altered. Nodes with flow limited from 2D Zone appear to be outside of the 2D Zone.	This is considered reasonable. No further action required
13.2	Convergence		Convergence achieved.	No Action		
13.3	Does a basic check of animations and graphed outputs give an indication of good model stability?	Red	Significant oscillations present along bank lines due to drowning and recirculation along 1D/2D link. 1D river reach flows are unstable as a result. This is not justified in the report and no attempts to resolve issue	Justify instabilities along 1D/2D link or provide details of model troubleshooting	Few changes were made to the river reaches and errors would have been present from the existing model. As the study area is small in comparison to the model extents, no updates were made to improve the entire model.	This is considered reasonable. No further action required

2D MODEL STABILITY

Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
14.1	Is mass balance within tolerable limits?		The 2D volume balance error for all simulations is less than 1% (max 0.042%) and therefore acceptable. 1D node mass balance error for all simulations is less than 0.001% and therefore acceptable	No Action		
14.2	Are CE and dV values relatively stable and remain so once the run has got going.		NA	No Action		

14.3	Errors/Comments/Warnings?	Red	Same as 1D warnings reported above	Justify validation and runtime warnings	See comment above - carried forward from the original model	See above responses
14.4	Negative Depths		None within the 2D zone.	No Action		
14.5	Does a basic check of animations and graphed outputs give an indication of good model stability?		Yes, basic check of animations is acceptable	No Action		
14.6	2d extents and outputs		2D outputs are available within ICM	No Action		



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)

MODEL OUTPUTS & CALIBRATION

CALIBRATION/VERIFICATION					
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)
15.1	Have calibration runs been completed? Is data for calibration available? Gauge data, extents, anecdotal etc.		No details of calibration provided	Provide justification for calibration not being carried out	This modelling was based on an existing EA model and just the area of interest updated. It was assumed that where calibration was possible that had been undertaken as part of the original modelling.
15.2	Are the simulated hydrograph peaks reasonably similar to the recorded peaks?		No details of calibration provided	Provide justification for calibration not being carried out	This modelling was based on an existing EA model and just the area of interest updated. It was assumed that where calibration was possible that had been undertaken as part of the original modelling.
15.3	Is the shape of the simulated hydrograph and therefore the volume suitably similar?		No details of calibration provided	Provide justification for calibration not being carried out	This modelling was based on an existing EA model and just the area of interest updated. It was assumed that where calibration was possible that had been undertaken as part of the original modelling.
15.4	Are simulated floodplain extents similar to recorded extents? Are flow routes similar?		No details of verification provided	Provide justification for verification not being carried out	See photo below of historic flooding. Blue circle matches with the modelled flood risk in the north of the site where there is no development. Residential then located in the red circle which is shown to be drier
15.5	Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact?		No details of calibration provided	Provide justification for calibration not being carried out	This modelling was based on an existing EA model and just the area of interest updated. It was assumed that where calibration was possible that had been undertaken as part of the original modelling. No additional data was provided to allow any calibration. Photo of historic flooding has however been compared to model results - see below
15.6	If no historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible?	Amber	High level comparison to EA surface water flood maps shows a good likeness	Consider providing comparison to historic data within report	Results are similar to original model with increased detail in the area of interest







2nd Review Comments	2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)
The previous modelling calibration was undertaken using three recorded events, June 2012, November 2010 and December 2012. An extract from the JBA (2015) report is included within the comment for this cell. It appears as though model calibration was reasonable in the previous JBA (2015) modelling. Given that the previous model has been calibrated, additional updates are fairly minor, and comparisons with historical anecdotal evidence, no further action is deemed necessary			
Inspection of historic flood outlines held by the Environment Agency (I\$\\National\\Physical\\Hydrology\\flood_event_outlines.shp) show no historic flood outlines at the development site (although this is not a record of all flooding, only what the EA holds). There are some similarities when comparing the 100 year +25% (applying a depth cutoff threshold of 0.02m) with the existing Flood Zone 3 extent although the 100 year +25% extent is generally smaller.			







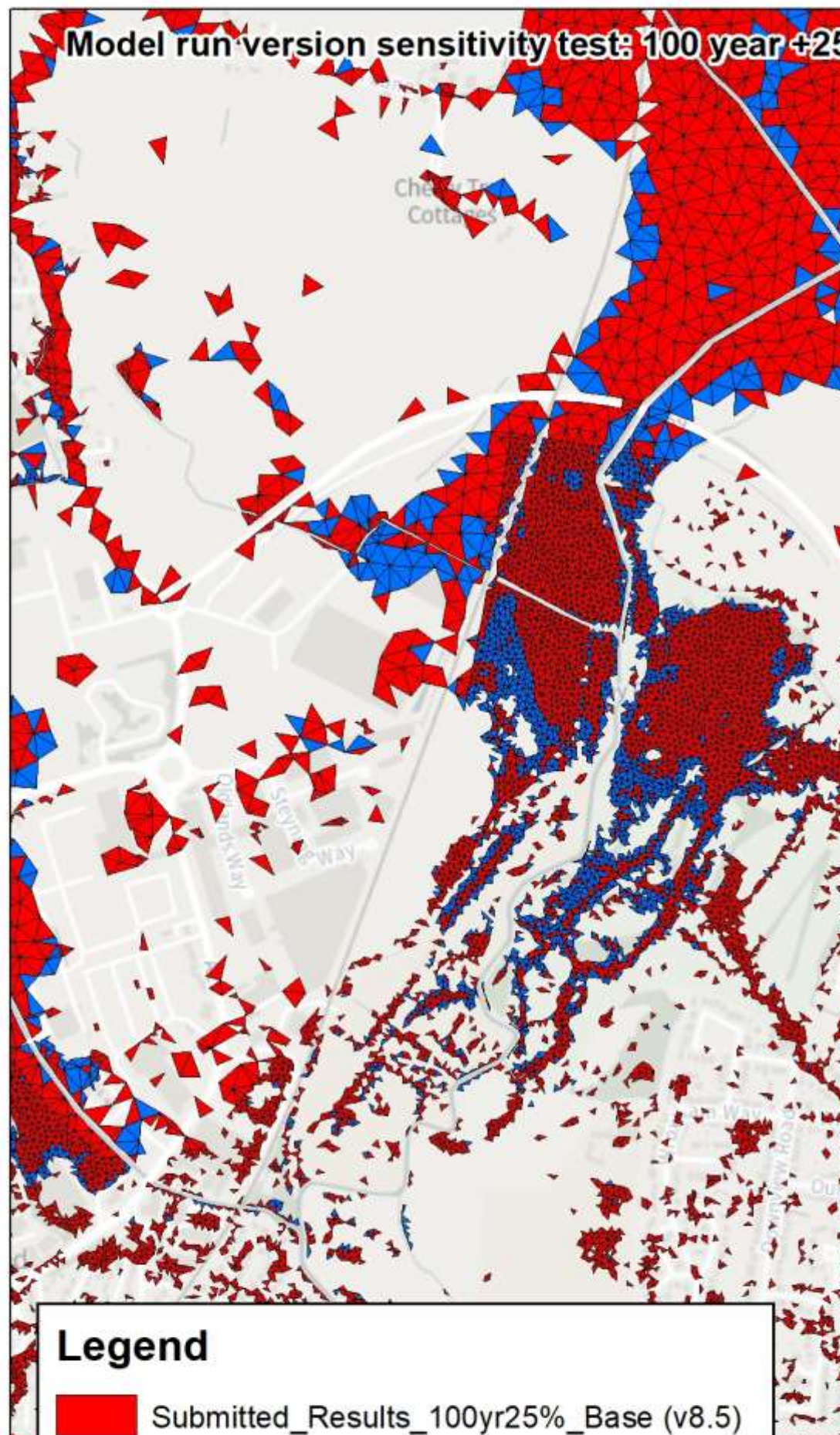
4th Review Comments	4th Review Response (DATE)

AUDIT TRAIL

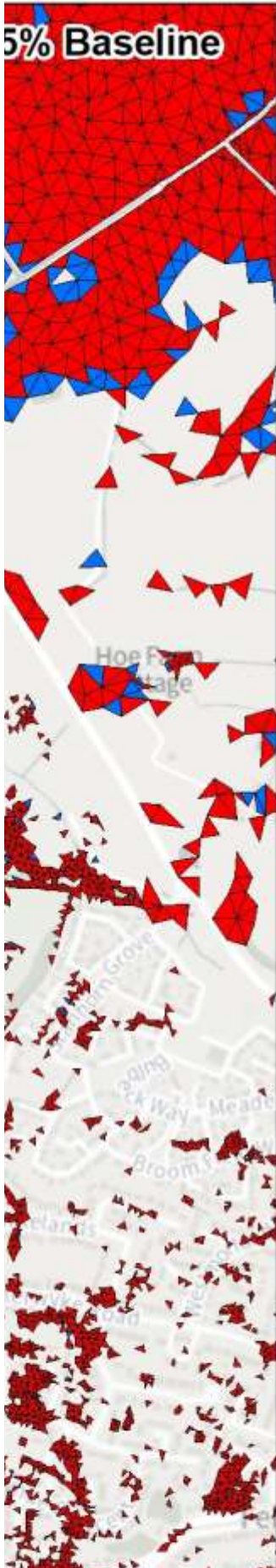
AUDIT TRAIL						
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	2nd Review Comments
17.1	Was a model run log provided?	Red	No	Simulation log to be provided detailing what each simulation represents	Simulation log has been updated.	Model run log has not been provided (Bognor Regis Golf Club_Model Simulation Log). No further action required
17.2	Was a suitable file naming, structure & management system used?	Amber	File naming is ok and all files are stored within ICMT. However, no descriptions have been provided within the properties of the simulations	Provide description of network and simulations within properties tab	All of the naming, structure and management system was carried forward from the original model	This is considered reasonable. No further action required
17.3	Were check files provided?		NA	No Action		
17.4	Were comments provided within the model?	Red	No, comments were not added within the ICMT	Provide comments within properties tab of each file or via user defined flags	Comments were not provided in the original model	This is considered reasonable. No further action required
17.5	Was there good version control? Is the model history detailed where applicable?		Model history prior to updated baseline has not been provided	No Action		
17.6	Were Errors / comments / warnings made available?	Red	No, errors/warnings were not presented or justified within the report	Justify validation and runtime warnings	These were from the original model	This is considered reasonable. No further action required
17.7	Was a technical overview of the model and its background provided	Red	Yes the model report contains detail on the methodology used. However, assumptions and limitations are not presented	Provide modelling assumptions and limitations within the report	Modelling assumtuions and limitations have been included within the modelling report.	Assumptions, limitations, and uncertainty section added to the model report (page 9).
17.8	Were notes on how the model operates under different flow conditions provided?		Yes, commentary is provided on the model results	No Action		
17.9	Was an explicit statement of any concerns about the accuracy of the model or its ability to represent reality provided?	Red	no, assumptions and limitations are not presented	Provide modelling assumptions and limitations within the report	Modelling assumtuions and limitations have been included within the modelling report.	Assumptions, limitations, and uncertainty section added to the model report (page 9). The reporting mentions that the 27.5hr storm duration was also tested. This is referenced in the reporting but it is not clear whether this is referring to the JBA original modelling (2014) or this modelling? Please make this clear as results for the 27.5hr storm duration test have not been provided within the ICMT and are not shown in the modelling report. The reporting suggests
17.10	Is there anything else missing or are there suggestions for additional information or clarification?	Red	Assumptions and limitations should be provided. Justification of validation and runtime warnings should be provided	Assumptions and limitations should be provided. Justification of validation and runtime warnings should be provided	Modelling assumtuions and limitations have been included within the modelling report.	



2nd Review Response (DATE)	3rd Review Comments	3rd Review Response (DATE)	4th Review Comments	4th Review Response (DATE)
The 27.5hr storm duration results are now provided and show no impact.				

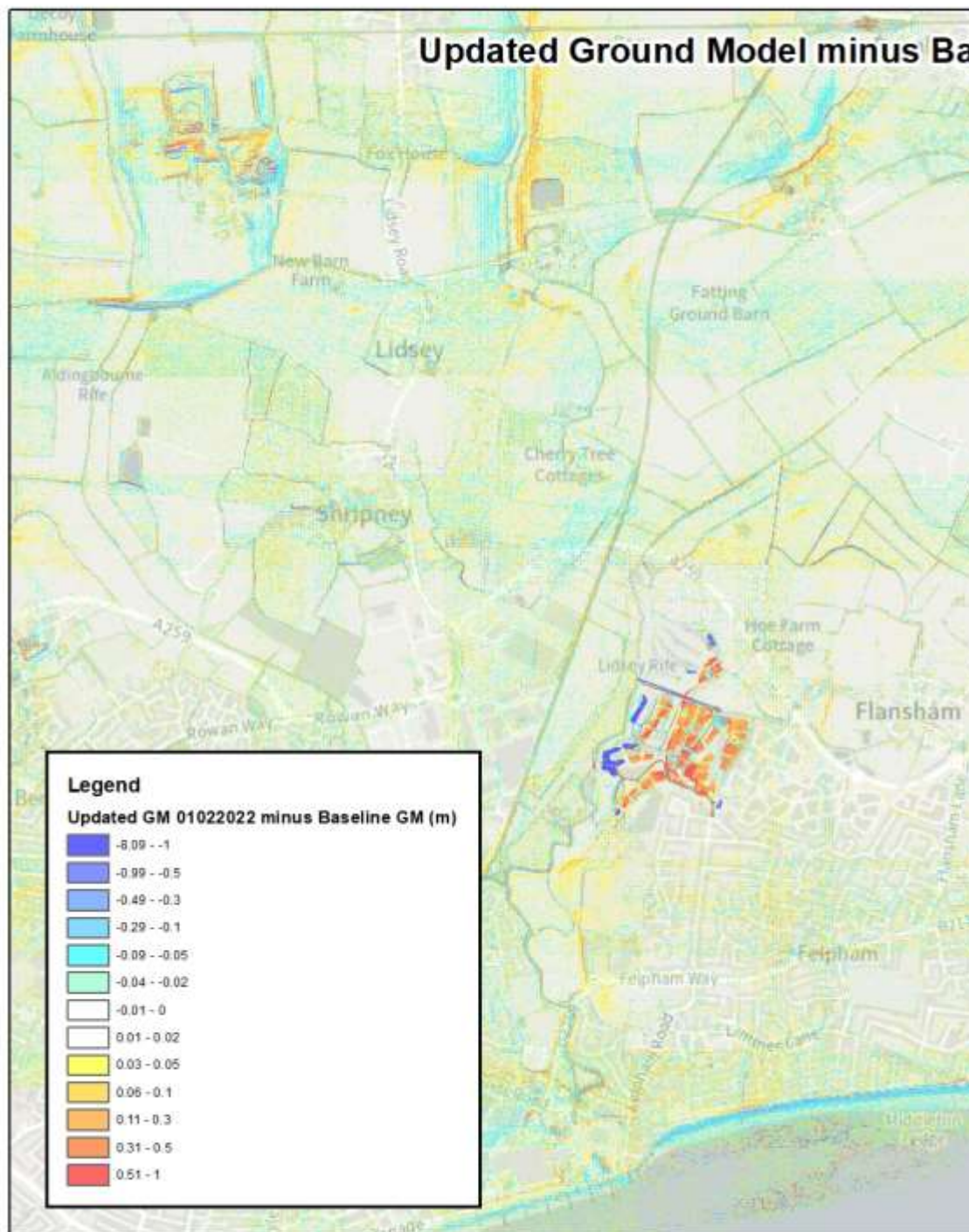


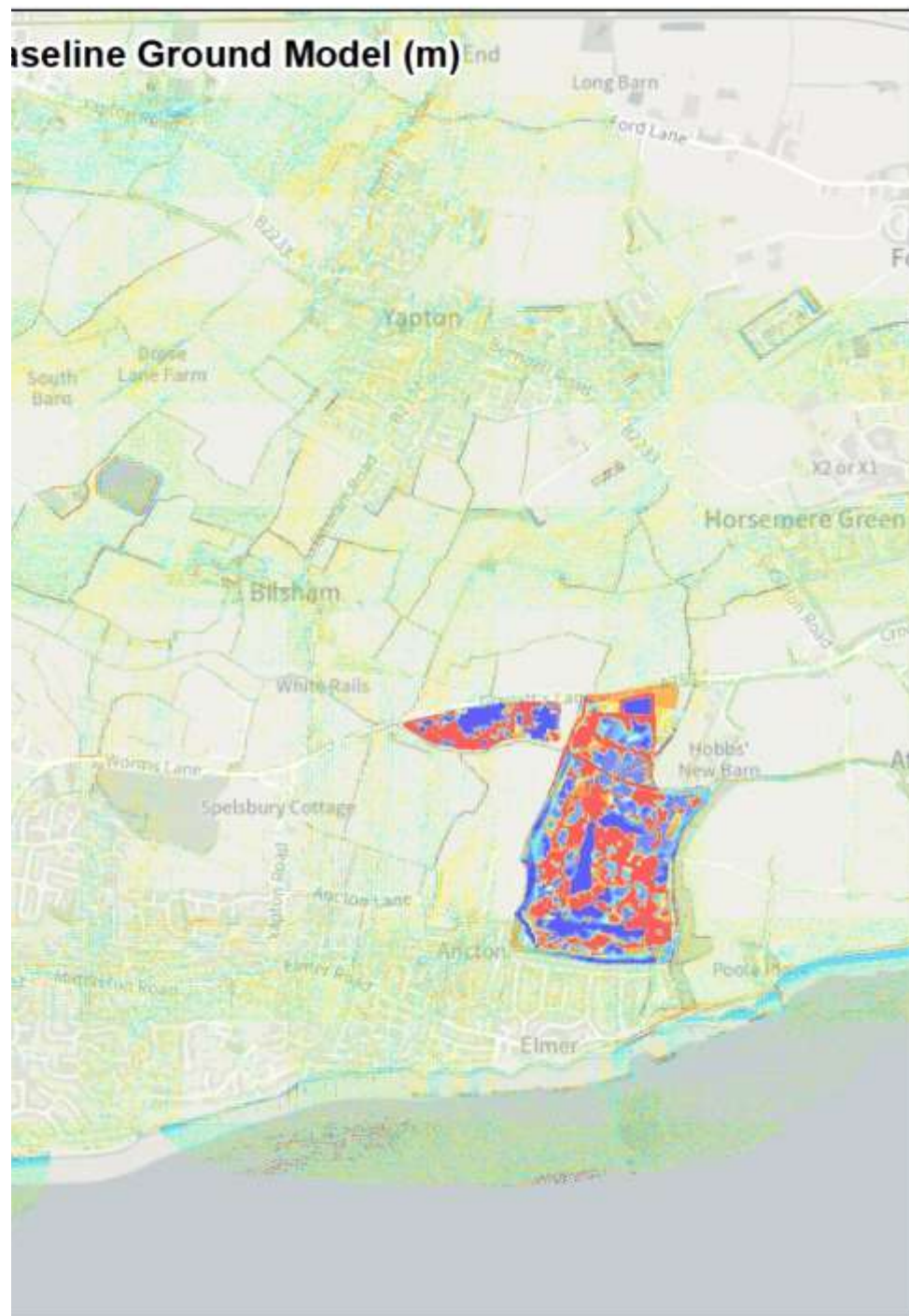




Map comparing model results for the baseline 100 year scenario (100 year 10.25 hr mm/hr +25%CC) based on runs undertaken with Infoworks ICM version 8.5 and version 2021.9. A depth cutoff of 0.05m has been applied to both sets of results ("DEPTH2D">0.05)







The map to
models; Ba
01022022.
differences
developme
the ground
proposed r

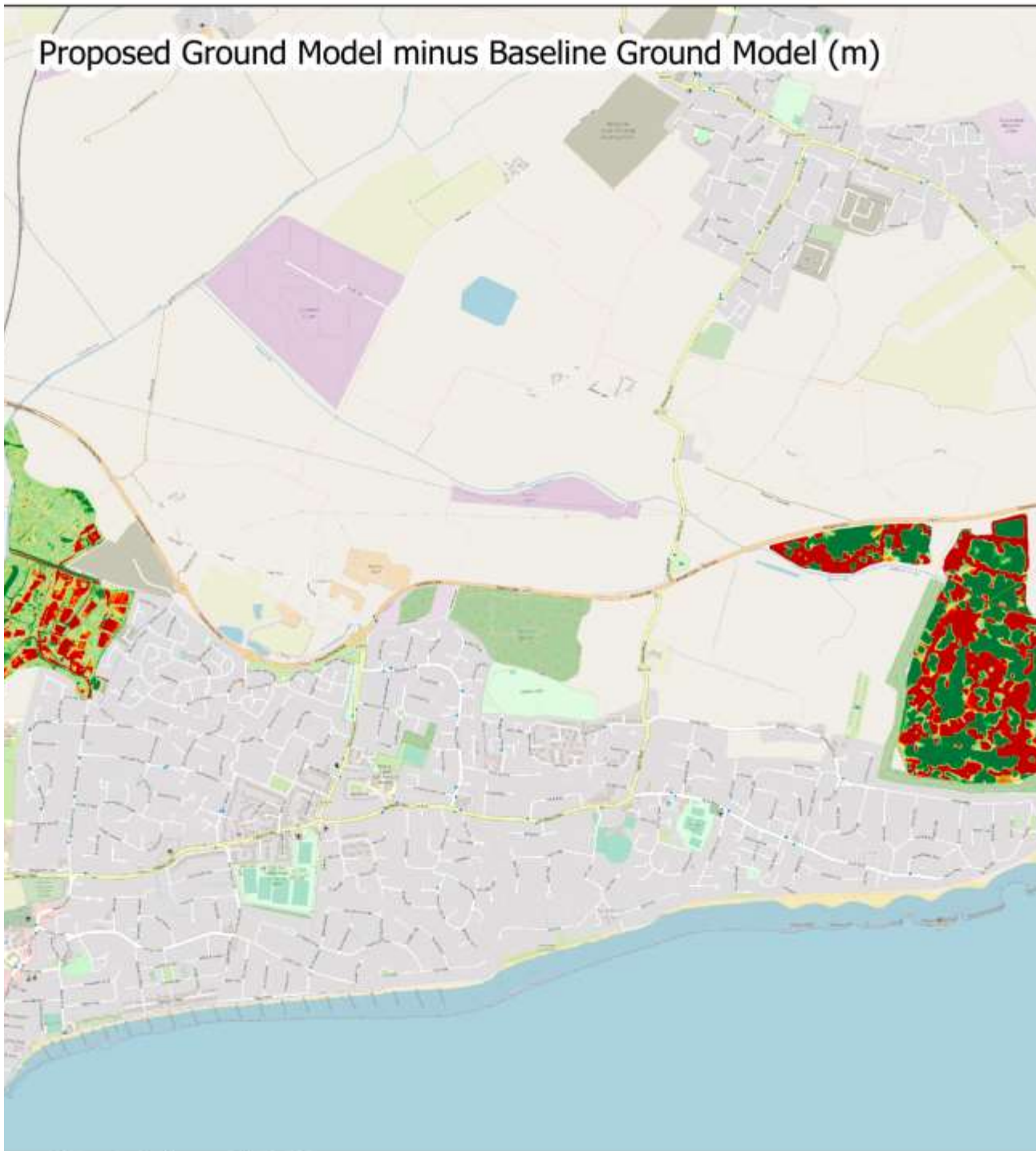
The map to
models; Ba
Proposed_
differences
developme

On the left is a comparison between ground
baseline GM.asc and Updated GM
asc . It appears as though there are
discrepancies in elevation outside of the areas where re-
development is proposed. It would be expected that
the models would be consistent outside of the
development areas

On the right is a comparison between ground
baseline_15092022.asc and
_15092022.asc . There are no more
discrepancies in elevation outside of the areas where re-
development is proposed.



Contains Ordnance Survey data © Crown



copyright and database right 2022



[Return to 1D model build](#)

[Return to 2D model build](#)

Manning's n for Channels (Chow, 1959)

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools			
b. same as above, but more stones and weeds	0.025	0.03	0.033
c. clean, winding, some pools and shoals	0.03	0.035	0.04
d. same as above, but some weeds and stones	0.033	0.04	0.045
e. same as above, lower stages, more ineffective slopes and sections	0.035	0.045	0.05
f. same as "d" with more stones	0.04	0.048	0.055
g. sluggish reaches, weedy, deep pools	0.045	0.05	0.06
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.05	0.07	0.08
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	0.075	0.1	0.15
a. bottom: gravels, cobbles, and few boulders			
b. bottom: cobbles with large boulders	0.03	0.04	0.05
3. Floodplains	0.04	0.05	0.07
a. Pasture, no brush			
1. short grass			
2. high grass	0.025	0.03	0.035
b. Cultivated areas	0.03	0.035	0.05
1. no crop			
2. mature row crops	0.02	0.03	0.04
3. mature field crops	0.025	0.035	0.045
c. Brush	0.03	0.04	0.05
1. scattered brush, heavy weeds			
2. light brush and trees, in winter	0.035	0.05	0.07
3. light brush and trees, in summer	0.035	0.05	0.06
4. medium to dense brush, in winter	0.04	0.06	0.08
5. medium to dense brush, in summer	0.045	0.07	0.11
d. Trees	0.07	0.1	0.16
1. dense willows, summer, straight			
2. cleared land with tree stumps, no sprouts	0.11	0.15	0.2
3. same as above, but with heavy growth of sprouts	0.03	0.04	0.05
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.05	0.06	0.08
5. same as 4. with flood stage reaching branches	0.08	0.1	0.12
4. Excavated or Dredged Channels	0.1	0.12	0.16
a. Earth, straight, and uniform			

1. clean, recently completed			
2. clean, after weathering	0.016	0.018	0.02
3. gravel, uniform section, clean	0.018	0.022	0.025
4. with short grass, few weeds	0.022	0.025	0.03
b. Earth winding and sluggish	0.022	0.027	0.033
1. no vegetation			
2. grass, some weeds	0.023	0.025	0.03
3. dense weeds or aquatic plants in deep channels	0.025	0.03	0.033
4. earth bottom and rubble sides	0.03	0.035	0.04
5. stony bottom and weedy banks	0.028	0.03	0.035
6. cobble bottom and clean sides	0.025	0.035	0.04
c. Dragline-excavated or dredged	0.03	0.04	0.05
1. no vegetation			
2. light brush on banks	0.025	0.028	0.033
d. Rock cuts	0.035	0.05	0.06
1. smooth and uniform			
2. jagged and irregular	0.025	0.035	0.04
e. Channels not maintained, weeds and brush uncut	0.035	0.04	0.05
1. dense weeds, high as flow depth			
2. clean bottom, brush on sides	0.05	0.08	0.12
3. same as above, highest stage of flow	0.04	0.05	0.08
4. dense brush, high stage	0.045	0.07	0.11
5. Lined or Constructed Channels	0.08	0.1	0.14
a. Cement			
1. neat surface			
2. mortar	0.01	0.011	0.013
b. Wood	0.011	0.013	0.015
1. planed, untreated			
2. planed, creosoted	0.01	0.012	0.014
3. unplaned	0.011	0.012	0.015
4. plank with battens	0.011	0.013	0.015
5. lined with roofing paper	0.012	0.015	0.018
c. Concrete	0.01	0.014	0.017
1. trowel finish			
2. float finish	0.011	0.013	0.015
3. finished, with gravel on bottom	0.013	0.015	0.016
4. unfinished	0.015	0.017	0.02
5. gunite, good section	0.014	0.017	0.02
6. gunite, wavy section	0.016	0.019	0.023
7. on good excavated rock	0.018	0.022	0.025
8. on irregular excavated rock	0.017	0.02	
d. Concrete bottom float finish with sides of:	0.022	0.027	
1. dressed stone in mortar			
2. random stone in mortar	0.015	0.017	0.02
3. cement rubble masonry, plastered	0.017	0.02	0.024
4. cement rubble masonry	0.016	0.02	0.024

5. dry rubble or riprap	0.02	0.025	0.03
e. Gravel bottom with sides of:	0.02	0.03	0.035
1. formed concrete			
2. random stone mortar	0.017	0.02	0.025
3. dry rubble or riprap	0.02	0.023	0.026
f. Brick	0.023	0.033	0.036
1. glazed			
2. in cement mortar	0.011	0.013	0.015
g. Masonry	0.012	0.015	0.018
1. cemented rubble			
2. dry rubble	0.017	0.025	0.03
h. Dressed ashlar/stone paving	0.023	0.032	0.035
i. Asphalt	0.013	0.015	0.017
1. smooth			
2. rough	0.013	0.013	
j. Vegetal lining	0.016	0.016	
	0.03		0.5

Manning's n for Closed Conduits
Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:			
2. Steel:	0.009	0.01	0.013
Lockbar and welded			
Riveted and spiral	0.01	0.012	0.014
3. Cast Iron:	0.013	0.016	0.017
Coated			
Uncoated	0.01	0.013	0.014
4. Wrought Iron:	0.011	0.014	0.016
Black			
Galvanized	0.012	0.014	0.015
5. Corrugated Metal:	0.013	0.016	0.017
Subdrain			
Stormdrain	0.017	0.019	0.021
6. Cement:	0.021	0.024	0.03
Neat Surface			
Mortar	0.01	0.011	0.013
7. Concrete:	0.011	0.013	0.015
Culvert, straight and free of debris			
Culvert with bends, connections, and some debris	0.01	0.011	0.013
Finished	0.011	0.013	0.014
Sewer with manholes, inlet, etc., straight	0.011	0.012	0.014
Unfinished, steel form	0.013	0.015	0.017
Unfinished, smooth wood form	0.012	0.013	0.014
Unfinished, rough wood form	0.012	0.014	0.016
8. Wood:	0.015	0.017	0.02

Stave			
Laminated, treated	0.01	0.012	0.014
9. Clay:	0.015	0.017	0.02
Common drainage tile			
Vitrified sewer	0.011	0.013	0.017
Vitrified sewer with manholes, inlet, etc.	0.011	0.014	0.017
Vitrified Subdrain with open joint	0.013	0.015	0.017
10. Brickwork:	0.014	0.016	0.018
Glazed			
Lined with cement mortar	0.011	0.013	0.015
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.015	0.017
Paved invert, sewer, smooth bottom	0.012	0.013	0.016
Rubble masonry, cemented	0.016	0.019	0.02
	0.018	0.025	0.03

Manning's n for Corrugated Metal Pipe
(AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	
1. Annular 2.67 x 1/2 inch (all diameters)	n
2. Helical 1.50 x 1/4 inch	0.024
8" diameter	
10" diameter	0.012
3. Helical 2.67 x 1/2 inch	0.014
12" diameter	
18" diameter	0.011
24" diameter	0.014
36" diameter	0.016
48" diameter	0.019
60" diameter	0.02
4. Annular 3x1 inch (all diameters)	0.021
5. Helical 3x1 inch	0.027
48" diameter	
54" diameter	0.023
60" diameter	0.023
66" diameter	0.024
72" diameter	0.025
78" diameter and larger	0.026
6. Corrugations 6x2 inches	0.027
60" diameter	
72" diameter	0.033
120" diameter	0.032
180" diameter	0.03
	0.028

<i>Model</i>	<i>Review Type</i>	RAG	Coastal standard	Software
Coastal wave transformation only		Red	Strategic	ISIS/FMP
Coastal 1D inundation		Amber	Appraisal	Estry/TuFlow
Coastal 1D-2D inundation		Green	Design	TuFlow
Coastal 2D inundation		n/a		MIKE11
Fluvial/tidal 1D model				MIKE21 HD
Fluival/tidal 1D-2D model				MIKE21 SW
Fluvial/tidal 2D model				MIKEFLOOD
Surface water model				SWAN
<i>Display all sheets</i>				SWAN/EuroTop/TuFlow
				Other

Model Type

1D only

2D only

1D/2D

Description

Baseline version

Add coastal template to baseline.

Add version control sheet and version number

Add roughness example sheet

Add sheet 'Lists' for maintenance

Update named ranges for RAG status

Add drop down box to select model type and VBA to hide/display relevant sheets

Explicitly reference Model_checks in cell comments

Switch off remove comments as code not yet resilient