DRAINAGE AND WASTEWATER MANAGEMENT PLANS (DWMP)

INTEGRATED DELIVERY ALLIANCE (IDeA)

BASELINE RISK AND VULNERABILITY ASSESSMENT (BRAVA) METHODOLOGY

Intended Use

For reference by technical staff involved in undertaking and checking/reviewing the Baseline Risk and Vulnerability Assessment (BRAVA) process within the DWMP framework. It should be noted that the methodology to be followed to assess hydraulic model results from the BRAVA process is included within the Problem Characterisation Methodology

Version	Date	Description/Amendment	Prepared by (Author)	Checked by	Reviewed by
01	Feb 2019	Draft issue for NWL review	A Tweddle	G Moralee	A Lee
02	June 2019	Updated draft issue following methodology updates	G Moralee	T Soppitt	A Lee
03	July 2019	All guidance docs combined to one document. Responses to Adrian Lee and Steena Nasapen-Watson's comments.	T Soppitt	G Moralee	-
04	October 2019	Updated following NWL review.	T Soppitt	G Moralee	G Hare
05	December 2019	Third issue for NWL review.	T Soppitt	G Moralee	G Hare
06	January 2020	Fourth issue for NWL review.	G Moralee	G Moralee	G Hare
07	February 2020	Update to boundary condition section.	A Tweddle	G Moralee	G Hare
08	May 2022	Updated to reflect updated Problem Characterisation methodology	AT	GM	GH
09	May 2023	Inclusion of additional Climate Change estimate	GM	EH	GH

Contents

PURPOSE OF GUIDANCE DOCUMENT

Background

This guidance document will summarise the processes to be undertaken for an L3 planning area that has been identified as requiring a Baseline Risk and Vulnerability Assessment (BRAVA) following the Risk Based Catchment Screening (RBCS) and Stakeholder Engagement processes.

The objective of the BRAVA process is to assess the current performance of drainage and wastewater systems, and projected performance as a result of future catchment changes and pressures. Furthermore, the BRAVA process is intended to highlight any system resilience concerns.

Methodology Evolution

Decisions taken to make modifications and updates to this methodology will be logged in the master DWMP Collaboration Tool document, which is saved on SharePoint at the following location; https://NWLcloud.sharepoint.com/sites/TD0096/management/Forms/AllItems.aspx?id=%2Fsites%2FTD0096%2Fmanagement%2F00%2E01%20Collaboration%20Tool&newTargetListUrl=%2Fsites%2FTD0096%2Fmanagement&viewpath=%2Fsites%2FTD0096%2Fmanagement%2FForms%2FAllItems%2Easpx.

Input Data Provided by NWL

The following table documents the input data that is required to be provided as a minimum to enable the BRAVA process to be undertaken. All of the data in the following table is to be provided by Northumbrian Water Group (NWL).

Input Data	Source	Details
RBCS analysis	Asset Strategy	Output from the RBCS process for L3 BRAVA prioritisation.
Regional datasets used in the RBCS	Various	All input data to the RBCS process to be stored on the NWL SharePoint site.
L3 / L2 growth projections	Developer Services	Short-term (within 5 years) new development information; SHLAA data for long-term (5-15 years) growth projections; Longer term (>15 years) growth projection data, e.g. WRMP population growth forecasts.
Trade and industrial flows (current and future)	Various	Consented trade discharge information – originally prepared during the 2016 Community Action Plan (CAP) studies. It was agreed that this data was the most up-to-date, and that a refresh was not required.
Wastewater treatment works (WWTW) flow information	Production / Treatment	In order to undertake an assessment of where WWTW compliance RBCS indicators have been or are likely to be breached following catchment growth and/or change. The likelihood of this occurring should be provided by NWL as part of the Internal Stakeholder engagement process and/or can be identified during the RBCS review stage.
WWTW inlet works and storm tank configurations	Production / Ops	To ensure appropriate hydraulic modelling of the WWTW inlet controls and storm tanks. None of the process infrastructure will be included in the hydraulic model, and an outfall should be modelled downstream of the final inlet control at each location.

Input data at the L3 level should be provided in accordance with the BRAVA and Problem Characterisation order of prioritisation.

HYDRAULIC MODELLING APPROACH

Use of Hydraulic Models

A hydraulic model may not be required in all cases and will depend on the particular requirements indicated from the RBCS analysis and the triggered Planning Objectives for an L3 area.

Where a model is available, the requirements for model enhancements will be judged on an individual L3 basis to make the approach suitable to the demands and pressures of the L3 area.

In instances where there is no existing model for an L3 area, innovative modelling techniques may be used, such as direct rainfall or hydrological approaches. Following the RBCS review and stakeholder engagement activities, an assessment of risk against cost to build a new hydraulic model should be undertaken to determine whether there is value in building a new hydraulic model. This will be particularly pertinent where there is no existing model, but also in cases where the existing model would require significant investment to upgrade it. For some systems, the ability to represent surface water management, source control and residual flood risk and overland flow routes will be required, using advanced 2D modelling techniques.

The modelling approach and decision making process for each L3 will be agreed with NWL and documented for auditing and reporting purposes.

Model Confidence

It is envisaged that the need for increased model confidence, and therefore the detail of modelling requirements, will differ with the demands of each individual L3 DWMP. Model confidence will be assessed and noted in a consistent manner for each L3 for auditing and reporting purposes.

A methodology for assessing model confidence in line with the wider water industry has been developed. The methodology is in line with the CIWEM Urban Drainage Group (UDG) proposals and satisfies the OfWAT reporting requirements. The confidence assessment is to be applied on the updated base models, developed as part of the DWMP programme. A confidence assessment is not proposed to be undertaken on the existing hydraulic model library.

The Model Confidence tool is located on the DWMP SharePoint site.

Model Library

Model requests must be completed for all DWMPs via the standard NWL Hydraulic Models Library procedure.

The identified master model will be used as the basis for the DWMP. There is an opportunity to supersede all completed scheme models that have not already been included in the master model. The hydraulic modeller should estimate the time demand in the scoping phase and agree the extent of updates with the project manager. The hydraulic modeller should update the model library tracker accordingly once complete.

For ongoing capital schemes, the hydraulic modeller should seek the latest existing system model updates for incorporation into the current day model. If appropriate, represent the latest option model in the DWMP Baseline Model.

For other ongoing schemes, the hydraulic modeller should take a judgement as to whether to include the scheme in the models being prepared for use in the DWMP. Agreement to be sought with the technical lead and a record of the decision taken should be included in the QA documentation.

HYDRAULIC MODEL UPDATES

The extent of model update will need to be proportionate to the level of interest and risk within the drainage area. The following sections include guidance for specific updates that will need to be completed and should be documented accordingly in the QA documentation. The guidance provided in this document does not supersede the 'Technical Policy E0703 Specification for Wastewater Modelling V1.1' document and should be used to supplement existing guidance.

Modelling Software

Any model-build to be undertaken as part of the DWMP programme should be completed using appropriate modelling software.

All hydraulic model databases should be compatible with InfoWorks ICM v9.5, and all hydraulic model simulations undertaken for the preparation of the PR24 DWMPs should be completed in this version of the software.

RBCS Indicators and Stakeholder Issues

A high level of confidence will not always be required across the whole hydraulic model area. However, it is essential that existing issues/opportunities and/or assets identified as problematic in the RBCS exercise, and any additional stakeholder issues that have been raised, are adequately represented in the hydraulic model.

To achieve this, additional data collection and appropriate model updates should be considered where necessary. For example; an asset identified during the RBCS as problematic should be modelled with high confidence data. In this case, additional data collection, either in the form of survey or the gathering of existing data held by NWL, may need to be carried out to improve the model confidence.

Data Flags

All hydraulic models downloaded from the NWL Model Library must be updated to the NWL default flags list using the NWL re-flag tool, or the "Find and replace flags" tool within InfoWorks ICM.

Default NWL flags and the Flag Tool can be found on SharePoint located here: https://NWLcloud.sharepoint.com/sites/TD0048/HML/Forms/AllItems.aspx?csf=1&e=OioLF6&cid=e95ad5bb%2D0fcf%2D4bbc%2Da794%2Dec8f3ef87642&FolderCTID=0x012000A3F2860CD7F1E642960A8BFAA5734165&id=%2Fsites%2FTD0048%2FHML%2FWastewater%20Modelling%20Specification%5F%20Tools%5F%20Audit%20and%20Guides%2FTools%2FFlagging%20Tool.

Display Units

It is important to display consistent units in the model and especially for exporting results. In all representation of hydraulic models and simulation results, flows are to be displayed in *l/s* rather than *m^3/s*.

Network User Defined Defaults

Network user defined defaults do not describe individual elements within the model, they are the default parameters for the whole model. They are not to be mistaken, for example, for individual pipe roughness, headlosses, etc. A check should be completed to ensure the following parameters are set.

- Subcatchments
  - Area measurement type: Absolute;
  - Soil Type: The Wallingford Procedure maps should be used;
  - Inflow: Base flow and additional flow set to $0m^3/s/km^2$, unless changed for verification purposes;
  - Land Use Index: New_UK1 should be set, unless changed for verification purposes;
- Conduit
  - Link ends: Headloss type upstream and downstream set to normal;
  - Cross section roughness: Type CW, bottom 3mm and top 3mm;
  - Sediment: Depth 0mm;
- Node
  - Flood Type: Stored;
  - Levels: Flood 1(m) – 0.1. Flood 2(m) – 0.2m;
  - Cross sectional areas: Flood 1 50%, Flood 2 100%;

- Simulation Parameters
  - Simulation parameters will be the default values in ICM, except for the volume balance for both initialisation and simulation which must be set to 0.01. The “use full area for headloss calculations” box should also be ticked.

Modelled Population

All hydraulic models should be checked against the latest available address points data, saved on the DWMP SharePoint site (NWL Address Points 2019), to ensure that modelled drainage area populations are up to date in the DWMP Baseline Model. The address points layer used to update the hydraulic model should be documented in the supporting audit documentation and returned to the NWL Model Library along with the model database.

Wastewater Profile

In catchments that have not been verified against flow survey data, the default diurnal variation should be applied using the flow profile from Table 7.2 in CIRIA Report 177, “Dry Weather Flow in Sewers”, with a per capita flow of 138l/h/d applied across all planning horizons. A flat dry weather flow profile should be applied for design storms, with a multiplying factor of 2.

Partially verified hydraulic models should retain the verified wastewater profile and the per capita consumption rate for the part of the catchment that has been verified, with the remainder of the catchment assigned the default diurnal profile and a per capita consumption rate of 138l/h/d.

Infiltration Flows

Foul/Combined Sewer Networks

WWTW flow data, including the 80th percentile (typical DWF) flow, has been received for all WWTWs where there is a flow monitor measuring incoming flows. This data should be referenced and checked against the modelled predictions for dry weather flow volume arriving at the works. If required, additional infiltration (base) flows should be applied to the hydraulic model to ensure that the daily DWF arriving at the WWTW is comparable to the measured data. Any infiltration flows applied during a model verification exercise will need to be retained.

The following steps should be taken to apply infiltration flows;

- Confirm the correct application of components of dry weather flow in the hydraulic model, i.e. population, trade flow;
- Compare modelled dry weather flow against the observed 80th percentile flow data for the WWTW (data provided by NWL);
- Where additional baseflow is identified as being required, apply to the upstream network pro-rata based on subcatchment area.

A calculation template has been prepared and is saved on the DWMP SharePoint site.

Care should be taken in catchments where there is a known issue such as tidal inflow to the combined sewer network or significant point infiltration sources to ensure that these are captured in the hydraulic model updates.

In some instances, the modelled flow arriving at the WWTW may be higher than the observed 80th percentile flow, indicating that no additional infiltration flow should be applied. In these cases, a check should be completed on the correct modelling of the aspects of wastewater flow and network connectivity. Additionally, a check on the quality of the observed data should be completed, which may require liaison with the WWTW manager/team lead.

Surface Water Sewer Networks (Separately Drained Areas)

Unless a hydraulic model has been through a verification exercise, the guidance provided in *NWL Design Guidelines: Population, Flows and Loads Wastewater Treatment* should be followed for the application of infiltration flows to surface water sewers that do not drain to an WWTW. That is to say that an infiltration flow should be applied based on a seed count and a calculation of 50% domestic flow.

Trade Flows

Consented industrial/trade flows shall be modelled based on the trade flow figures provided by NWL as part of the CAP studies in 2016;

- Trade discharge will be applied using a dummy contributing area named as follows, “NWL TRADE Ref_Business Name”;
- Trade flows will be applied as a flat profile based on daily volume rather than peak flow;
- Efforts should be taken to ensure an appropriate trade flow profile is applied. In instances where it is not possible to determine the trade profile to be applied, a 40-hour working week will be assumed.

Runoff Modelling

Any unverified hydraulic models that are setup to use the Wallingford runoff model should be converted to New UK and the standard NWL runoff surfaces used. A simplified approach to updating the subcatchment runoff areas may be adopted to avoid the need for a new ATO;

- Runoff Surface 1 (road) to be retained as is;
- Runoff Surface 2 (roof) to be retained as is;
- Runoff Surface 3 (permeable) moved and split as follows;
  - Runoff Surface 4 (x% - depending on catchment assessment of impermeability);
  - Runoff Surface 12 (20%);
  - Runoff Surface 3 (remaining x%).

Foul only subcatchments that have Runoff Surface 1 areas applied following a verification exercise should be retained as is; however, the percentage value applied should be moved to Runoff Surface 4.

Area Take Off

A new area take-off (ATO) may not always be required, and should only be undertaken, utilising the Area Take Off tool or an appropriate substitute, in instances where the previously completed ATO has been highlighted as a concern during the model review process.

Paved Proportion of Gardens (A4)

The Technical Policy E0703 ‘Specification for Wastewater Network Modelling’ document outlines that as part of the ATO, an area of additional impermeable response should be applied to subcatchments to take account of the paved proportion of garden areas not defined in the OS MasterMap layer.

In recent hydraulic modelling studies that have included a model verification exercise using flow survey data, it has been found that the volume and peak response of impermeable surface runoff has in some cases been over-estimated. In some cases, the area applied to runoff surface 4 (Paved Proportion of Gardens) has been reduced to a very small percentage or removed completely.

The following table provides examples of recently completed model verifications and the percentage that was applied to A4.

Scheme Name	Predominant Property Type	Percentage Applied to A4
Durham Road, Spennymoor	Semi-detached, medium density	5%
Alum Waters, New Brancepeth	Semi-detached, medium density	1%
Monks Wood, North Shields	Detached, low density	5%
Belford Street, Peterlee	Terraced, high density	10%
Middleton St. George	Semi-detached, medium density	10 – 42%
Seahouses	Semi-detached, medium density	6 – 10%
The Peth	Semi-detached, medium density	0 – 19%
Bedlington	Terraced, high density	28.5 – 36%

The values shown in the table demonstrate the variability of the additional impermeable area that has been applied when undertaking hydraulic model verification against flow survey data.

As part of the DWMP hydraulic model updates, a review of the additional impermeable area applied in each hydraulic model should be completed and modified, if necessary. A record of the percentage applied should be kept in the hydraulic model QA documentation.

Modelled Node Cover Levels

Hydraulic models that have not previously utilised LiDAR data for modelled nodes cover levels should be updated using the latest available LiDAR data. Modelled node cover levels will be compared against the most up-to-date ground model data available for an L3 area. Nodes that are modelled with high confidence data flags (e.g. survey data, as-built data) will not be updated, and the existing model values retained. It is not recommended to update every L3 model and modelling judgement should be used to consider if the remaining nodes are to be updated.

Additional work has been carried out to understand the extent and the benefits of updating existing models with current LiDAR data.

- It was considered to update cluster areas of nodes where there is a difference between the modelled and ground model values greater than 1.0m, and within areas of triggered RBCS indicators;
  - It was found that updating these cluster areas generated a considerable amount of work to clean up the cluster areas to tie-in with the non-updated areas;
  - In cluster areas where LiDAR had been updated, it was found that the surrounding areas that were not updated had significantly higher/lower ground levels that could potentially cause overland flows to pond in the lower levels and flow paths to be blocked by surrounding higher ground levels (particularly in the 2D version of the model);
- Consideration has been given to updating the entire model due to the issues created from updating only cluster areas;
  - Investigations showed that updating the entire model would take a considerable amount of time and is dependent on the confidence of the existing model. As to be expected, a model with higher confidence flags would be quicker to update than a model with lower confidence flags;
  - Approximate times to update entire models;
    - 1,000 node, low confidence model – on average ten hours;
    - 1,200 node, high confidence model – on average six hours;
    - 5,000 node, high confidence model – on average three days.
  - Due to the number of L3 catchments that are to be carried through the BRAVA stage, it is not recommended to carry out a blanket update on every model due to programme constraints;
- Modelling Results: A selection of models have been simulated before and after doing the cover level updates to understand the impact on predicted results;
  - It was found that predicted flood volumes were similar (less than 10m^3 difference in total);
  - In some instances, the flooding locations moved slightly from one manhole to the adjacent manhole but overall the changes were insignificant.

The overall quality of the existing data compared to current LiDAR data should be considered when deciding if a model is to be updated.

Note – during any updates, it is critical that any depth or level information held within the hydraulic model from high confidence sources (e.g. GIS, survey) is retained. For example, sewer invert depths that have been updated using GIS depth information will need to be updated in line with any updates made to the connected manhole cover level. Other examples where this will apply include (but is not limited to) pumping station switch-on/off levels, storage arrays, weir levels etc.

2D Modelling

2D models will be used in the DWMP programme. The guidance provided in the ‘NWL Specification for Wastewater Network Modelling - 2D Modelling Guide’ should be followed. As a minimum;

- Buildings from the latest OS MasterMap dataset must be included in the model as voids;
- 2D Zone parameters as follows;
  - Maximum triangle – 100m^2;
  - Minimum triangle – 25m^2;
  - Boundary type – dry;
- Flood type of all manholes within the 2D mesh currently set to Stored or Lost to be updated to 2D;
- Flood type of foul manholes in separately sewered catchments to be updated to Gully 2D and use the standard head discharge table as detailed in the NWL 2D Modelling Guide (Issue 01, October 2013).

Property Threshold Levels

Unless better information is available (e.g. from flooding schemes and/or PLP investigations), a global 150mm threshold value will be applied to all property types when calculating property flood risk using DREAM2D or Data Manager.

Model Enhancement using Asset Survey Data

Asset data collection will be proportional to the requirements of the L3 DWMP, and the quality of the existing hydraulic model. Existing hydraulic models will need to be brought up-to-date using the latest NWL GIS records and projected to the base year of 2020. Any significant gaps in data will result in data collection being required, and data collection strategies will relate to the different demands of each individual L3 DWMP. Efforts will be taken to ensure that existing data sources are exhausted prior to commissioning new data collection, e.g., NWL Model Library, eSCADA, Hawkeye, LiveLink, SharePoint.

Wastewater treatment works Representation and Processes

A representation of the drainage area WWTW inlet, storm tanks and return should be included in the hydraulic model to ensure an assessment of inlet capacity can be completed. Furthermore, this is to ensure an assessment of the future impacts of catchment pressures on factors such as flow to full treatment, overflow spill frequency and volume, storm tank operation etc can be completed.

Where concerns have been raised during the stakeholder engagement activities with regards to the processes within an WWTW, outputs from the hydraulic model such as typical dry weather flow, flow to full treatment etc can be provided to NWL to support internal process calculations.

HYDRAULIC MODEL REGISTER

For the DWMP, the following models will need to be referenced/created;

Network	Purpose
NWL GIS	Latest download of the NWL GIS information for updating the baseline hydraulic model.
Existing Baseline Hydraulic Model(s)	Latest drainage area and scheme model(s) to be compiled to create the DWMP Baseline Model.
Existing Verified Hydraulic Model(s)	Any verified or partially verified networks to be incorporated into the DWMP Baseline Model.
DWMP Baseline (2020)	Base year of assessment for the DWMP.
2025 Planning Horizon	Five-year planning horizon model, updated for projected growth, urban creep and infiltration.
2030 Planning Horizon	Ten-year planning horizon model, updated for projected growth, urban creep and infiltration.
2045 Planning Horizon	25-year planning horizon model, updated for projected growth, urban creep and infiltration.
2060 Planning Horizon	40-year planning horizon model, updated for projected growth, urban creep and infiltration.
DWMP Option Model(s)	Where required, option models created to test the impact of and analyse the benefits of proposed interventions

HYDRAULIC MODEL DATABASE

The InfoWorks ICM model database should be setup with the following Model Groups and Sub Model Groups;

Master Model Group	Sub Model Group(s)	Contents	Example Naming Convention (01-D35 Berwick)
01 Hydraulic Models	01 Model Build and Verification	NWL GIS; Verification (if required).	01-D35 NWL GIS
	02 Planning Horizon Models	Baseline (2020); 2025 Planning Horizon; 2030 Planning Horizon; 2045 Planning Horizon; 2060 Planning Horizon.	01-D35 2020 Needs_N01 01-D35 2025 DH_Fa01 01-D35 2030 DH_Fb01 01-D35 2045 DH_Fc01 01-D35 2060 DH_Fd01
	03 Option Models	Option Model 1; Option Model 2, etc.	01-D35 2030 DH_Op1 01-D35 2030 DH_Op2, etc.
02 Rainfall	01 Design Rainfall	FEH13 Design Rainfall; FEH13 Design Rainfall plus climate change.	'WWTW ID' FEH13 M1s 'WWTW ID' FEH13 M5s 'WWTW ID' FEH13 M1w 'WWTW ID' FEH13 M5w 'WWTW ID' FEH13 M1s_20% 'WWTW ID' FEH13 M5s_20% 'WWTW ID' FEH13 M1w_20% 'WWTW ID' FEH13 M5w_20%, etc.
	02 Timeseries (TSR) Rainfall	Ten Year Series Rainfall; Typical Year Rainfall; Ten Year Series Rainfall plus climate change; Typical Year Rainfall plus climate change.	'TSR ID' Ten-Year TSR 'TSR ID' Typical-Year TSR 'TSR ID' Ten-Year TSR_CC 'TSR ID' Typical-Year TSR_CC
03 Simulation Files	01 Trade Waste Group	Trade Waste Generator File	01-D35 Trade Waste
	02 Wastewater Group	Wastewater Generator File	01-D35 WWG
	03 Level Group	Boundary Condition Level File	01-D35 Level
	04 Ground Model Group	Ground Model from latest LiDAR	01-D35 GM (1/2m)
	05 Ground Infiltration Group	Ground Infiltration File	01-D35 GI
04 Model Simulations	01 2020 Baseline	Baseline BRAVA Simulations	01-D35 Baseline 1D 01-D35 Baseline 2D 01-D35 Baseline TSR10 01-D35 Baseline TSR1
	02 2025 Planning Horizon	2025 Planning Horizon BRAVA Simulations	01-D35 2025 1D 01-D35 2025 2D 01-D35 2025 TSR10 01-D35 2025 TSR1
	03 2030 Planning Horizon	2030 Planning Horizon BRAVA Simulations	01-D35 2030 1D 01-D35 2030 2D 01-D35 2030 TSR10 01-D35 2030 TSR1
	04 2045 Planning Horizon	2045 Planning Horizon BRAVA Simulations	01-D35 2045 1D 01-D35 2045 2D 01-D35 2045 TSR10 01-D35 2045 TSR10_CC 01-D35 2045 TSR1 01-D35 2045 TSR1_CC
	05 2060 Planning Horizon	2060 Planning Horizon BRAVA Simulations	01-D35 2060 1D 01-D35 2060 2D 01-D35 2060 TSR10 01-D35 2060 TSR10_CC 01-D35 2060 TSR1 01-D35 2060 TSR1_CC

Master Model Group	Sub Model Group(s)	Contents	Example Naming Convention (01-D35 Berwick)
	06 Short/Medium Term Options	2025/2030 Planning Horizon Option Model(s) Simulations	01-D35 2025/2030_Op1 1D 01-D35 2025/2030_Op1 2D 01-D35 2025/2030_Op1 TSR10 01-D35 2025/2030_Op1 TSR1, etc.
	07 Long Term Options	2045/2060 Planning Horizon Option Model(s) Simulations	01-D35 2045/2060_Op1 1D 01-D35 2045/2060_Op1 2D 01-D35 2045/2060_Op1 TSR10 01-D35 2045/2060_Op1 TSR10_CC 01-D35 2045/2060_Op1 TSR1 01-D35 2045/2060_Op1 TSR1_CC, etc.
05 ICM Group	01 Layer Lists	Layer Lists for Mapping and other GIS Layers	*N/A*
	02 Selection Lists	Selection Lists of Assets, Added Development etc.	*N/A*
	03 Themes	As required.	*N/A*
	04 SQLs	As required.	*N/A*
06 Existing Models (temporary)	Temporary store of existing hydraulic models downloaded from the NWL Model Library. Should not be returned to the NWL Model Library with the final DWMP submission.		

Notes

Appropriate notes must accompany models in the commit history within the model build software following import/validation/updates. As a minimum, a brief description of updates made to hydraulic models should be included in the Notes tab, with a link to the location of the model build QA documentation provided.

Infoworks ICM Template Database

A transportable database containing an ICM template is held on the DWMP SharePoint site.

Hydraulic Model Returns

Upon completion of the hydraulic modelling exercise for each L3 drainage area, a hydraulic model database should be returned to the NWL Model Library following the standard approach.

As a minimum, the InfoWorks ICM Transportable Database should contain all of the hydraulic model networks used for analysis during the DWMP and the ancillary files required to undertake simulations. Care should be taken to ensure that only the final version of each hydraulic model network is returned in the final database, and any interim 'under development' models are not included. This will ensure that the size of the database is kept to a minimum and that any redundant networks are not stored on the model library.

In addition to the hydraulic models and associated files, the following items should be returned to the NWL Model Library;

- Any asset survey data collected;
- Address points extract used in the modelled population update;
- Ground models developed for use in the DWMP;
- FEH13 Rainfall Catchment Parameters;
- Any updated flood risk layers;
- Any other supporting GIS layers created for the DWMP;
- CSV export of nodes and conduits, including data confidence flag information;
- Updated 1 in 20 year return period flood risk output (DART/DREAM2D) for all PRNs in CSV format for the Baseline (2020) and Long Term (2045), including climate change design horizons

– it is noted that the assessment should be an overland flow and surcharge assessment, and not the simplified approach proposed in this methodology for the undertaking of BRAVA (and Problem Characterisation);

- Peak DWF and peak 1 in 20 year return period event flows and volume at all WWTW, SPS and CSO locations.

REPRESENTATION OF RESIDENTIAL GROWTH

Information Provided by NWL

Growth data will be provided by the Developer Services team within Northumbrian Water (NWL). For each L3 drainage area, the following information will be provided;

- Excel spreadsheet containing the developments for inclusion in the hydraulic models for the current day, DWMP Baseline (2020) and DWMP Planning Horizon models (up to the 2045 Planning Horizon);
- Polygons from/based on the Local Authority's Strategic Housing Land Availability Assessments (SHLAA) showing the location of development sites. It is important that only the developments shown in the final Excel spreadsheet are included in the hydraulic models. Additional sites shown in the SHLAA dataset that are not included in the Excel spreadsheet have been assessed by NWL Developer Services and are not expected to be realised within the planning period.

Current Day Model

Surface Water Flows

The existing system model should represent the drainage system at the time of completion. This is especially relevant while verifying or calibrating a model.

If a development is part completed during model build (and verification), efforts should be made to understand the layout and drainage details of the development from NWL Developer Services and/or the Local Authority. Information can generally be accessed from the Local Authority planning portal website. As a minimum, this must include;

- Actual control rates, flow control devices and storage provision;
- The sewer network will be added into the model;
- Contributing areas will be added to the model network to represent the progress of the development, with area take-off estimated from site reconnaissance, or using the latest OS MasterMap layer. Area take-off and runoff modelling will be applied in accordance with latest modelling guidance;
- An allowance of 2%[1] of the permeable area should be applied as area 4 (realised creep), unless areas are measured from site reconnaissance or available plans;
- Infiltration should be applied to both foul and surface water subcatchments, based on 10% of the average dry weather flow figure, as per latest modelling guidance – it should be noted that a total of 20% dry weather flow will ultimately be applied;
- Selection lists should be created in the hydraulic model database to identify sites that have been added to the model.

Foul Flows

Population should be added to the model as an estimate of residency in the fully or partially completed development and distributed in appropriate foul subcatchment areas. No allowance should be made for surface water response in the foul system, unless other information to contradict this is available.

A consumption rate of 138 l/h/d should be applied, unless better information is available, with the CIRIA default diurnal profile applied in relation to the spreadsheet below:

https://NWLcloud.sharepoint.com/sites/TD0096/BRAVA/Forms/AllItems.aspx?id=%2Fsites%2FTD0096%2FBRAVA%2FCore%20data&newTargetListUrl=%2Fsites%2FTD0096%2FBRAVA&viewpath=%2Fsites%2FTD0096%2FBRAVA%2FForms%2FAllItems%2Easpx.

[1] Confirmed as an appropriate value during a meeting with NWL Developer Services on 24/01/2019.

DWMP Baseline Model (2020)

Surface Water Flows

All developments that are known to have commenced on site or are expected to be completed in the near future, should be represented in the DWMP Baseline Model. These developments should be represented in the hydraulic model as per the Current Day Model approach, detailed in the previous section.

For committed developments on greenfield sites, a simplified representation should be modelled where it is perceived to be of interest to the study (developments with discharges direct to watercourses may be omitted);

- A subcatchment should be defined which represents the extents of the proposed development;
- A new 1D node, referenced 'ND_XXXX' should be added, suffixed with an indication of the development name or reference and system type, e.g. ND_19NO415862_S;
- The new node will be 1D and have a stored flood type, and zero floodable area applied;
- A limited discharge orifice will connect the node to the connection point in the existing system – either as confirmed in a Pre-Development Enquiry (PDE), or by engineering judgement. Caution should be taken to ensure that an appropriate diameter orifice is modelled, capable of passing forward the required flow. If there are no surface water systems or watercourses within 200m, then the connection should be made to the combined system. The control rate should be, in order of selection:
    1. In accordance with correspondence between NWL and the developer/Local Authority. In instances where the proposed flow rate appears excessive, and is likely to cause detriment to the performance of the existing sewer network, the proposed flow rate should be confirmed with NWL;
    2. A minimum flow rate of 5l/s should be applied;
    3. Thereafter, a greenfield rate of 3.5l/s/ha based on the total modelled contributing area of the development site, i.e. sum of all of the impermeable and permeable areas, not the total development area;
- Allocation of impermeable area should be applied in the following order of selection:
    1. In accordance with available development plans;
    2. As a representative sample of the development type proposed and in accordance with other developments of the same type in the catchment;
    3. Roughly as per NWL guidance, i.e. 20% paved (Area 1), 20% roof area (Area 2), 48% as non-contributing (Area 3) and the remaining 12% applied as the permeable surface (Area 12);
- Selection lists should be created in the hydraulic model database to identify sites that have been added to the model.

For committed developments on brownfield sites, it is the intention to improve existing site drainage and therefore, the model should be setup with 50% of the impermeable area as per the existing area take-off (0.5 x Area 1, 0.5 x Area 2), unless better information is available. If a development control rate is defined, the brownfield development can be represented in accordance with the greenfield approach, with the control rate used at the existing system connection.

Foul Flows

Foul flow should be represented by including a total population for the completed development and for partially completed development areas.

For committed developments, populations should be applied to represent the development size – house count multiplied by 2.4 in the first instance, unless better information is available. No allowance should be made for surface water response in the foul sub catchments.

A consumption of 138l/h/d should be applied to the foul area with a multiplying factor of 2 in the wastewater generator, unless better information is available in accordance with the below spreadsheet:

https://NWLcloud.sharepoint.com/sites/TD0096/BRAVA/Forms/AllItems.aspx?id=%2Fsites%2FTD0096%2FBRAVA%2FCore%20data&newTargetListUrl=%2Fsites%2FTD0096%2FBRAVA&viewpath=%2Fsites%2FTD0096%2FBRAVA%2FForms%2FAllItems%2Easpx.

DWMP Planning Horizon Models (2025 to 2045)

Growth shall be applied in accordance with the DWMP Baseline Model approach, with the following notes;

- Build-out rates identified in the information provided by NWL Developer Services should be applied as follows;
  - 0 – 5 Years – 2025 Planning Horizon Model;
  - 6 – 10 Years – 2030 Planning Horizon Model;
  - 11 – 15 Years and 15+ Years – 2045 Planning Horizon Model;
- Infiltration should be applied to both foul and surface water subcatchments, based on 10% of the average dry weather flow figure, as per latest modelling guidance – it should be noted that a total of 20% dry weather flow will ultimately be applied; NWL Developer Services should be engaged as early as possible to collect and confirm the growth figures in the catchment area for the required time horizon of the scheme;
- All developments, irrespective of size, should be included in the hydraulic model;

DWMP Planning Horizon Models (2060)

The 2060 planning horizon is beyond the available data for projected development sites. The following approach, consistent with WRMP population growth estimates, should be followed to define the modelled population in the 2060 Planning Horizon model;

- Assume all future surface water areas are connected to watercourses, or surface water systems draining directly to watercourses – no updates required to the hydraulic model;
- Identify the drainage area within the 'Drainage Area Populations PR19' Excel spreadsheet, located on the DWMP SharePoint site at https://NWLcloud.sharepoint.com/:f:/r/sites/TD0096/inputs/01%20Developer%20Services/WRMP%20Growth%20by%20DA?csf=1&e=kdD4kQ;
- Obtain the modelled population in the 2045 Planning Horizon model;
- Calculate the 2060 Planning Horizon model population by uplifting the 2045 Planning Horizon model by the '% rate of increase' value;
- Apply the uplift to the existing modelled subcatchments pro-rata based on the 2045 Planning Horizon modelled population.

2060 Planning Horizon – Worked Example

DA	2045 Modelled Population	% rate of increase	2060 Modelled Population
05-D25	8,000*	9.7#	8,776

**Note – this figure is to be taken from the 2045 Planning Horizon hydraulic model, not the WRMP spreadsheet.*
#Note – value taken from WRMP spreadsheet.

REPRESENTATION OF NON-RESIDENTIAL GROWTH

Information Provided by NWL

Non-residential growth data will be provided by the Developer Services team within NWL in the same data pack prepared for the residential growth.

Surface Water Flows

For non-residential sites, surface water runoff should be applied to the existing system following the guidance outlined in the earlier sections of this document, depending on the timing of the development completion.

Foul Flows

To represent the foul flows generated by a non-residential development site, an appreciation of the proposed land-use is required. The following table outlines the typical development classes and proposed flows *(based on NWL Design Guidelines: Population, Flows and Loads Wastewater Treatment and Networks and British Water, 2013. Code of Practice. Flows and Loads – 4. Sizing Criteria, Treatment Capacity for Sewage Treatment Systems).*

Development Class	Description	Flow Rate (litres per person per day, unless stated)
A1	Office / Factory without canteen	50
A2	Office / Factory with canteen	100
A3	Shopping / Retail centre	400 (per 100m2, per day)
B1	Hotels	550 (per room, per day)
B2 & B3	Restaurants / Public House	30 (per cover, per day)
C1	Schools	50
C2	Boarding Schools	175
D1	Health Club / Sports Centre	50
D2	Caravan Site	100 (per plot, per day)
D3	Campsites	75 (per plot, per day)
E1	Retirement / Nursing Home	350
E2	Hospital	450 (per bed, per day)

In the absence of data required to calculate foul flows, an allowance should be made in line with the Flows and Loads document, which specifies;

- 0.1l/s/ha for light industry;
- 0.5l/s/ha for heavy industry.

Foul flows from proposed non-residential developments should be included in the hydraulic model as follows;

- A foul subcatchment covering the development area should be digitised, and connected to the existing system based on information provided, or using engineering judgement;
- A trade flow should be calculated based on the Development Class and the total development area, using the values shown in the table;
- Trade flows will be applied as a flat profile based on daily volume rather than peak flow and unless better information is available, it should be assumed that flows are discharged at a constant rate over a 40-hour working week (09:00 – 17:00), with a peaking factor of 3.

REPRESENTATION OF SIGNIFICANT NON-RESIDENTIAL DEVELOPMENTS

A list of significant non-residential developments was received from NWL on 1st March 2019, as shown in the following table. The details of each of these developments will need careful consideration, and will likely require liaison with NWL Developer Services to determine any discharge agreements that have been made.

Development Name	Description
Blyth	Information available in Northumberland Local Plan on type of proposals.
International Advanced Manufacturing Park (IAMP)	Adjacent to Nissan; various plans available online detailing proposals.
Follingsby Max, Gateshead	Distribution facilities
Newcastle Airport Expansion	Proposals included in NIA Masterplan document
Former SSI Site, Redcar	South Tees Development Corporation Masterplan
Tees Valley Airport	Purchased by Tees Valley Combined Authority – possible new proposals to emerge as a result.
Bowburn Integra 61	Large-scale logistics and manufacturing development
Wooler Distillery	Possible process water requirements and resulting effluent – currently unknown.

APPLICATION OF URBAN CREEP

The information and guidance provided in this section follows the statistical method recommended in UKWIR's study "The Impact of Urban Creep on Sewerage Systems".

Urban creep is the loss of permeable areas creating increased runoff during rainfall events, which has the potential to increase the loading on a sewer network and can contribute to flooding and other issues. Water industry research from the study above concluded that whilst urban creep values vary with drainage system type, development type and density, it typically applies to all residential areas where property boundaries allow for extensions or other additional impermeable surfaces.

Urban creep is to be applied to the following planning horizon models;

- 2025 (five-year projection from baseline);
- 2030 (ten-year projection from baseline);
- 2045 (25-year projection from baseline);
- 2060 (40-year projection from baseline);

Standard Northumbrian Water Runoff Surfaces

As specified in 'Technical Policy E0703 Specification for Wastewater Modelling v1.1', urban creep is typically applied to runoff surface 5 (Future Urban Creep). Values applied are determined using the Urban Creep Calculator spreadsheet, which has been developed based on the UKWIR guidance document.

Runoff Surface	Description
1	Paved
2	Roof
3	Gardens
4	Assumed paved contributions from gardens
5	Future Urban Creep
6	New development/unclassified land
11	Permeable surfaces (used for Ground Infiltration module only, during verification)
12	Permeable surfaces from New UK Runoff model

Where the ATO has been calculated using standard NWL guidance using runoff surfaces 1 to 12, as detailed in Table 1, urban creep values are to be deducted from runoff surface 3 and runoff surface 12. There will be a split in accordance with the standard ATO, with 80% to be deducted from runoff surface 3 and 20% to be deducted from runoff surface 12.

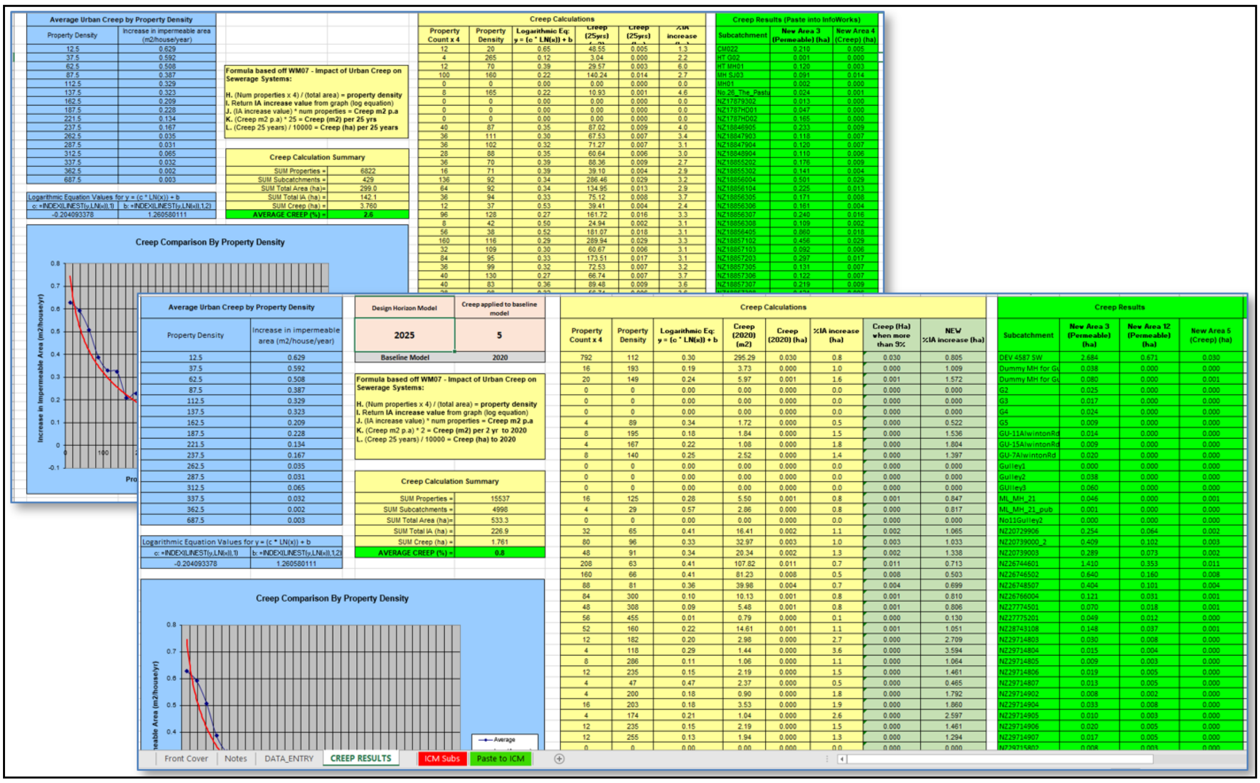
Converted Wallingford Models

If the subcatchment runoff surfaces have been calculated using the older Wallingford Runoff Model specification, the runoff surfaces should be updated as detailed in this methodology and urban creep applied using the same approach as Standard Northumbrian Water Runoff Surface hydraulic models.

Methodology for the Application of Urban Creep

A DWMP creep calculator spreadsheet has been developed, which is based on the standard UKWIR spreadsheet and is located on the DWMP SharePoint site.

A step-by-step methodology for the DWMP creep calculation spreadsheet can be found in the "Notes" tab of the spreadsheet. The following screenshot shows the urban creep calculator spreadsheet elements.



Each planning horizon hydraulic model will require an urban creep calculation spreadsheet to be prepared.

Urban creep should not be applied to foul subcatchments, only to the surface water and combined subcatchments.

Baseline Model (2020)

The DWMP Baseline Model will be checked to ensure that any urban creep applied during previous studies has been checked/removed. The model will then be updated with any committed developments and capital schemes, updating it to the 2020 baseline year. As the majority of the model simulations will be undertaken during late 2019/2020, urban creep will not be applied to the Baseline Model.

DWMP Planning Horizon Models

For each planning horizon model, an incremental value of urban creep is to be applied from the baseline year of 2020 to reach the desired planning horizon;

- 2025 = five-year creep contribution;
- 2030 = ten-year creep contribution;
- 2045 = 25-year creep contribution;
- 2060 = 40-year creep contribution.

Key Notes

The UKWIR guidance dictates that a maximum of 9% of the existing subcatchment area can be applied as urban creep. The urban creep calculator spreadsheet has been developed to reflect this maximum limit of urban creep that can be applied.

Attention should be paid to subcatchments with very low values applied to the permeable runoff surfaces 3 and 12, i.e. several decimal places above absolute zero. In some instances, the modelling software may return a value of zero. It is important that the hydraulic modeller checks for instances where this has occurred and corrects the issue.

An ICM configuration file has been created to import the updated urban creep values to ensure consistency of data import, and to reduce the risk of modeller error. The ICM configuration file is located on the DWMP SharePoint site.

BOUNDARY CONDITIONS

Tidal Boundary Conditions

Mean High Water Springs

The mean high water springs (MHWS) values for the available locations within the NWL region have been taken from the National Tidal and Sea Level Facility (NTSLF) website[2]. The data provided on the website identifies the MHWS values for the time period between 2008 and 2026. These values will be used to inform the tidal boundary conditions to be applied in the DWMP hydraulic models.

Port	MHWS
North Shields	2.52m AOD*
Whitby	2.59m AOD**

**Based on a MHWS tidal height of 5.12m and a conversion to relative datum value of -2.60m.*
***Based on a MHWS tidal height of 5.59m and a conversion to relative datum value of -3.00m.*

Based on the above values, a **baseline** MHWS tidal level covering the entire region of **2.56m AOD** is to be applied, which is considered an average between the North Shields and Whitby locations. A level file should be created in InfoWorks ICM, which is to be applied for all outfalls impacted by tide levels. This is to be determined by application of the boundary condition script created by Stantec.

Consideration should be made as to whether an outfall should be modelled with a flap valve to prevent unrealistic excessive volumes of flow entering the sewer network as a result of the application of the level file.

Climate Change Impact

The projected impacts of climate change on MHWS tide levels, which will be referenced when preparing tidal boundary conditions to be applied to all planning horizon hydraulic model design storm simulations (not including TSR analyses), need to be taken into account.

The following guidance is based on information provided by the Environment Agency (EA) at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

Sea Level Allowances

There is a single regional allowance for each epoch or time frame for sea level rise, which is shown in the following table as mm/yr with cumulative increase per epoch in brackets.

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 / metres (m)
East, east midlands, London, south east	4 (140 mm)	8.5 (255 mm)	12 (360 mm)	15 (450 mm)	1.21 m
South West	3.5 (122.5 mm)	8 (240 mm)	11.5 (345 mm)	14.5 (435 mm)	1.14 m
North west, north east	2.5 (87.5 mm)	7 (210 mm)	10 (300 mm)	13 (390 mm)	0.99 m

Source: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

For the Northumbrian Water region, the values for 'North west, north east' are to be used.

The allowances shown above account for slow land movement. This is due to 'glacial isostatic adjustment' resulting from the release of pressure after ice that covered large parts of northern Britain

[2] https://www.ntslf.org/tides/predictions

melted at the end of the last ice age. The northern part of the country is slowly rising, and the southern part is slowly sinking. This is why net sea level rise is less for the north-west and north-east than the rest of the country.

Sea Level Rise Calculation

A calculation spreadsheet has been prepared based on the information provided by the EA, which is saved on the NWL SharePoint site at:

https://NWLcloud.sharepoint.com/sites/TD0096/methodologies/Forms/AllItems.aspx?id=%2Fsites%2FTD0096%2Fmethodologies%2F03%2E02%20BRAVA&newTargetListUrl=%2Fsites%2FTD0096%2Fmethodologies&viewpath=%2Fsites%2FTD0096%2Fmethodologies%2FForms%2FAllItems%2Easpx.

The values to be applied in the hydraulic model are;

- 2025 Planning Horizon – 2.57mAOD;
- 2030 Planning Horizon – 2.60mAOD;
- 2045 Planning Horizon – 2.71mAOD;
- 2060 Planning Horizon – 2.83mAOD.

Outfall Receiving System Impacts

The representation of other catchment influences including rivers and permeable/slow response may be required to adequately model the system performance. Through engagement with the Environment Agency, the following approaches have been agreed in principle and no individual consultation is required or expected for each L3 catchment.

Where there are the interests of flood authority parties, feedback and direction is expected at the RBCS stakeholder review stage, or through knowledge and involvement in other programmes of work, for example, NIDP. This would be the opportunity in the DWMP process to influence the modelling approach. No external auditing of DWMP models is expected, irrespective of catchment requirements.

Non-Tidal River Interaction

The representation of river level data will depend upon the requirements of the particular drainage area. The default position is not to apply level files to surface water and other outfalls. Thereafter, the following approach shall be used, prompted by the nature of the influence:

Case	Description	Application	Climate Change Uplifts
1	No level file	Default	No
2	Top of pipe level	This case would be used where the modeller has evidence that, on a regular basis, the river level influences the discharge condition of the outfall, e.g. where the outfall is below top of riverbank level.	No
3	Typical top water level	If information is available through site reconnaissance, or other means, that a higher than top of pipe water level occurs on a regular basis, this level will be used in the hydraulic model using an appropriate level file.	No
4	River model derived dynamic water levels	If there is the information and justification, dynamic water levels obtained from river models can be aligned to rainfall simulations and durations.	If available/relevant
5	Integration of river model	If the river performance is significant to the performance of the catchment or representation of issues, then the river model shall be integrated, if available, into the ICM model.	If available/relevant

Case	Description	Application	Climate Change Uplifts
6	Creation of river model for integrated model approach	It may be necessary to create a hydraulic and hydrological representation of a receiving watercourse. For these cases, the guidance and methodology formed and agreed for the Strategic Study/NIDP programme should be followed.	If available/relevant

Other Interactions

Other interactions at sewer network outfalls, such as permanent sediment build-up or other restrictions, are likely to be identified during the RBCS review and stakeholder engagement stages of the DWMP process.

In these instances, boundary conditions will be represented based on the information supplied and documented in the supporting QA.

Other Boundary Conditions

The following list, whilst not exhaustive, should be considered when developing the catchment model. The default position is to not include these features.

- Inflows
  - A list of watercourses into combined sewers have been provided by NWL. Allowance should be made in all cases to make a representation of flows into the sewer network, ranging from point source inflows, direct net rainfall hydrology, or full representation of the hydrology and hydraulics of the system. Care must be taken to avoid double counting contributing areas with other parts of the hydraulic model;
  - Culverted watercourses should be represented as prompted by inclusion in existing models or following stakeholder feedback. A similar approach to connected watercourses may be appropriate. Where the representation of culverted watercourses is not deemed necessary, the modeller should refer to the boundary condition table in the previous section. It may be appropriate to use a top of pipe level boundary condition where no other information is available;
- SuDS/SWM/waterbodies – if there are such features in the drainage system, and these have been designed and represented in existing hydraulic models, these must be included in the DWMP catchment model. These features can be in either 1D or 2D form and, in most cases, this will be retained in the DWMP modelling approach. Updates to the default modelling approach may be required, if feedback received from stakeholders or knowledge from other schemes dictates;
- Groundwater response or flooding – no allowance shall be made in this programme. Consideration for representation and inclusion in future cycles of the DWMP will be made;
- Seasonal infiltration – no allowance shall be made in this programme. Consideration for representation and inclusion in future cycles of the DWMP will be made;
- Overland flow or surface water flooding – representation of these features shall be prompted from study level knowledge or from stakeholder feedback. An assessment of smaller scale catchment boundaries should be made (e.g. using software such as ArcHydro) to define the extent of the catchment boundary. These areas can be represented by using the NWL Rural Runoff approach and direct net rainfall, or, especially in smaller areas, a NewUK runoff model on an appropriate scale subcatchment definition;
- Other permeable response – inter-urban permeable areas may be added to the model in ordinarily omitted surfaces. This can be achieved through the addition of traditional catchment areas or an appropriate scale subcatchment definition.

FEH13 DESIGN RAINFALL GENERATION

***Note** – the following sections detail the approach that has been taken to produce FEH13 design rainfall events for all of the L3 areas that have been identified as requiring a BRAVA assessment. The rainfall data will be stored on the NWL Model Library. There will be no requirement to generate any new rainfall for use on the DWMP programme.*

Overview

Design rainfall events have been generated in order to simulate the hydraulic models for wet weather conditions. Understanding the anticipated performance of the sewer network and drainage area during wet weather conditions in the base model and future scenario models is a key element of the BRAVA, Problem Characterisation and Option Development processes.

Approach

As outlined in the CIWEM Urban Drainage Group (UDG) 'Rainfall Modelling Guide 2015' document, the original FEH methodology for the production of design rainfall events, which was developed in 1999, was updated in 2013 to address a number of concerns raised specifically regarding higher return period events. In summary, the FEH13 methodology has been developed using a larger dataset of historical rainfall records, to create a depth/duration/frequency (DDF) model for rainfall that would lead to the creation of more representative design rainfall events for locations within the UK.

The FEH13 approach for the generation of design rainfall events has been applied.

Software

To generate the design rainfall for use in the DWMP studies, the following software has been used;

- InfoWorks ICM;
- ReFH2.

Catchment Parameters

The FEH catchment parameters were extracted from the FEH Web Service[3]. The 1km point depth-duration-frequency (DDF) catchment parameters were exported using the centroid point for the catchment draining to a WWTW. One rainfall series per WWTW catchment has been generated. Large catchments were checked for spatial variation of DDF descriptors and catchment average values used, if necessary.

Catchment parameters used in the generation of the design rainfall will be returned to the model library along with the hydraulic model database.

Catchment Area

An appropriate catchment area has been applied based on the catchment area draining to the WWTW.

Initial Conditions

Antecedent Rainfall Depth

The antecedent rainfall depth has been set to 99mm for all design storms to give a worst-case scenario of depression storage filled, which means no initial losses are applied to the model.

Evaporation

Evaporation in the UK varies between 0mm/day in mid-winter and 3mm/day in mid-summer. To represent a worst-case situation, a value of 1.5mm/day and 3mm/day has been applied for winter and summer design storms, respectively.

UCWI

In cases where UCWI is to be used (e.g. a model has been verified and/or there is good justification for not updating the runoff modelling approach to latest NWL guidance), the SAAR value from the FEH catchment descriptors should be used. Justification for retaining the runoff modelling approach should be documented in the hydraulic model QA documentation.

[3] https://fehweb.ceh.ac.uk

NAPI
The NAPI design values have been calculated from the newly created TSR datasets and are detailed in the section describing the generation of the TSRs.

Event Details

Return Periods
The design rainfall has been created for the following return periods; 1 in 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 50, 75, 100, 200. Rainfall has been created for individual return periods rather than a single file comprising of multiple return periods, so that individual events can be used, if needed.

Durations
The design rainfall has been created for the following durations; 30, 60, 90, 120, 180, 240, 360, 480, 960, and 1440 minutes.

Season (Profile)
Both summer and winter profile storm events have been created for use in the model simulations.

Return Period Type
The ‘Peaks over Threshold’ method has been applied for all return period events.

CLIMATE CHANGE

There is a need to understand how changing rainfall patterns and intensities will affect the performance of urban drainage systems with respect to flooding levels of service and storm overflow spill volumes and frequencies. For this reason, inputs to industry standard drainage modelling software need to consider how design storms and time series rainfall, of high temporal resolution, might change under future climates.

In order to provide guidance and a common reference point to WaSCs, OFWAT set out key requirements on how climate change should be considered in developing long term delivery strategies in the publication https://www.ofwat.gov.uk/publication/pr24-and-beyond-long-term-delivery-strategies-and-common-reference-scenarios (Nov 21).

In this guidance document, OFWAT state "We expect companies to use UKCP18 projections for RCP2.6 and RCP8.5 to explore how these different climate futures affect their strategies – including their potential impacts on water resources, wastewater loads, flooding, and biodiversity – and to ensure the strategy is appropriate given these alternative climate assumptions. We consider that using the 50th percentile probability level for each projection offers plausible high and low assumptions for setting common reference scenarios, but companies may consider testing against a wider range of climate scenarios."

OFWAT's guidance states that "RCP2.6 is a 'stringent' mitigation scenario, representing a future in which the world aims for and is able to implement sizeable reductions in emissions of greenhouse gases. For example, carbon emissions begin to decline from 2020 and reach zero by 2100, leading to a global average temperature rise of between 0.3°C and 1.7°C by 2081-2100, compared to the reference period of 1986-2005. RCP8.5 represents a future without additional efforts to constrain emissions, where greenhouse gas emissions continue to grow, leading to a global average temperature rise of between 2.6°C and 4.8°C by 2081-2100."

UKCP18 – Available Tools

As a first step in developing a process to meet the above requirements a review of available UKCP18 tools was undertaken to assess their appropriateness for application to urban drainage analysis. This found that there are six products available from the Met Office;

- Probabilistic projections
- Global projections
- Local projections
- Regional projections
- Derived projections
- Marine projections.

The projections are generated using a variety of climate models and samples. The type of projection chosen depends on what the purpose/use of the data is and what spatial and temporal resolution is required. The following table is taken from the Met Office UKCP18 Guidance (2018). It explains each projection type, the spatial and temporal resolution, and the typical uses.

	Probabilistic Projections	Global (60km) Projections	Regional (12km) and Local (2.2km) projections	Derived Projections
Description	Probabilistic changes in future climate based on an assessment of model uncertainties	A set of 28 climate futures with detailed data on how it may evolve in the 21st century • 15 x Hadley Centre Model variants HadGEM3-GC3.05 (PPE-15) • 13 x other climate model (CMIP5-13)	Two sets of 12 climate futures at high resolution • 12 km over Europe, downscaled from the lobal projections (PPE-15) using Hadley Centre model HadREM3-GA705 • 2.2km for the UK, providing further downscaling from 12km simulations using HadREM3-RA11M	A set of climate futures derived from the global projections for a lower emissions scenario and global warming levels
Period	1961-2100	1900-2100	1981-2080 for 12km 1981-2000, 2021-2040, and 2061-2080 for 2.2km	1900-2100
Temporal Resolution	Monthly, Seasonal, Annual	Daily, Monthly, Seasonal, Annual	Sub-daily for 2.2km, Daily, Monthly, Seasonal, Annual	Daily, Monthly, Seasonal, Annual
Spatial Resolution	25km	60km	12km 2.2km	60km
Geographical Extent	UK & regions	UK & regions Global	UK & regions Europe for 12km	UK
Emission Scenarios	RCP2.6, RCP4.5, RCP6, RCP8.5	RCP2.6, RCP8.5	RCP8.5	RCP2.6, 2˚C world, 4˚C world
Why should you use it?	• Explores emissions scenario uncertainty • Explored uncertainty in key processes in climate models • Helps characterize future extremes in risk assessment	• Long time series • Spatially and temporally coherent • Direct access to ‘raw’ climate model data • Met Office Hadley Centre global climate model HadGEM3-GC3.05	• Enhanced spatial detail • Spatially and temporally coherent • Direct access to ‘raw’ climate model data • CPM projections uses climate model featuring explicit dynamical representation of large convective storms	• Long time series • Spatially and temporally coherent • Explore emissions scenario uncertainty when used with global projections • Explore global warming levels

Suitable spatial and temporal resolution for urban drainage modelling

Suitability of UKCP18 Tools for Urban Drainage Modelling

Of the available UKCP18 products, only the UKCP local (2.2km) model offers the required spatial and temporal resolution required for urban drainage modelling. It is the only model that can represent changes in convective rainfall which will play a critical role in likely changes in flooding and pollution from urban drainage systems.

A key disadvantage of this model is that output is only available for the RCP8.5 scenario.

Additional Climate Tools

To assist WaSCs and other relevant stakeholders in developing climate changed rainfall for Urban Drainage modelling, two projects were commissioned and published in 2021 and 2022. Both are based on underlying climate data from the UKCP Local (2.2km) model and therefore represent RCP8.5 only.

Future Drainage Design Storm Uplifts (2021)

FUTURE-DRAINAGE uplifts are outputs from a Newcastle University-led consortium involving the Met Office, JBA Consulting and Loughborough University, funded by the NERC (UKRI) UK Climate Resilience Programme. The data on future rainfall changes ('uplifts') are designed for organisations who need to allow for an increase to design storm rainfall in sub-daily to daily durations, to account for the impact of climate change projections in the UK. The project used the latest UK Climate Projections (UKCP) high resolution 2.2km data (UKCP Local) to derive robust rainfall uplift estimates using the high greenhouse gas emissions scenario RCP8.5 for 2050 or 2070

UKWIR REDUP Time Series Rainfall Perturbation Tool V3 (2022)

REDUP V3 is a key output from the UKWIR publication "Climate Change Rainfall for use In Sewerage Design - Design Storm Profiles, Antecedent Conditions, Red-Up Tool Update and Seasonality Impacts" (Dale et-al, 2022). This version of REDUP allows the perturbation of time series rainfall from rain gauges with regional (WaSC) perturbation factors derived from the Met Office's Convection-permitting Model (CPM), UKCP local (2.2km) using the high greenhouse gas emissions scenario RCP8.5 for the 2030, 2050 and 2070 epochs. As with previous versions of REDUP, REDUP V3 perturbations are undertaken at an hourly resolution because the 2.2km climate model produces results at an hourly output frequency. The tool undertakes three perturbations: hourly intensity perturbations, fitting to dry period statistics and fitting to total rainfall depth statistics.

Representation of RCP2.6

As discussed above, the only available climate tools that are suitable for urban drainage modelling were produced using just one of the four possible greenhouse gas emission scenarios or 'pathways', RCP8.5. The UKWIR REDUP research output provides a detailed critique of how RCP2.6 could be applied through a technique known as pattern scaling and recommendations are made in the Technical Report with respect to this. Key points from this are included in Appendix A for information. The main conclusions here are that it would take a significant amount of work involving multiple stakeholders (JBA, Met Office, Newcastle University and WaSC PSG) to derive/add RCP 2.6 uplift factors to REDUP and even if added the change in the factors would not be expected to be particularly significant for the time horizon of 2050.

NWL Approach

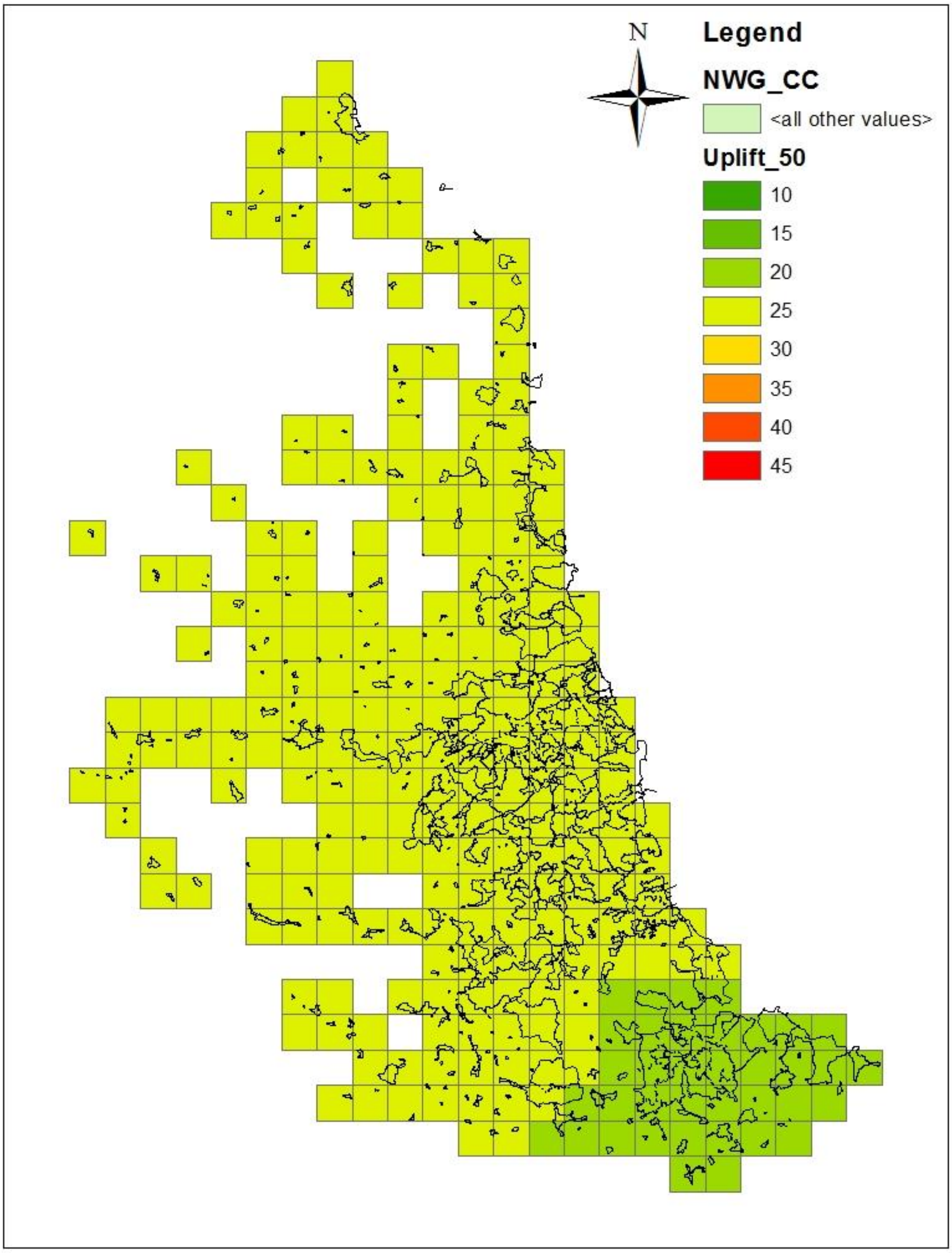
In view of OFWAT requirements and climate tool availability, NWL has taken the following approaches in applying climate uplifts to rainfall for the DWMP.

Design Storm Uplifts

Design storm uplifts have been applied using published FUTURE DRAINAGE data for the NWL region.

As there is a moderate degree of variability in uplifts across the region, it has been split into the L2 DWMP boundaries. It should be noted that the central and higher estimates represent the 50%ile and 95%ile uplifts derived from the 12-member ensemble of simulations undertaken using the UKCP Local (2.2km) model representing the RCP8.5 scenario.

2050 FUTURE DRAINAGE Uplifts for NWL Region (30Yr RP - 60min Storm)



The uplifts applied are summarised in the following table.

L2	2045 Lower Estimate	2045 Central Estimate	2045 Higher Estimate	2060 Lowe Estimate	2060 Central Estimate	2060 Higher Estimate
Northumberland	11	18	30	12	20	34
Rural Tyne	11	18	30	13	21	34
Tyneside	10	16	30	11	19	34
Wearside	10	16	30	11	19	34
Wear	10	16	29	11	19	33
Teesdale	10	17	29	12	20	33
Teesside	9	15	30	10	17	34

TIMESERIES RAINFALL GENERATION

TSR datasets have been generated in order to simulate the hydraulic models for typical year conditions, specifically to assess the performance of CSOs, WWTWs and other key assets.

Generation of TSR Series

A total of 19 ten-year TSR datasets have been generated based on the location of a number of EA rain gauges at the following locations;

- TSR Series 1 – Berwick
- TSR Series 2 – Seahouses
- TSR Series 3 – Wooler
- TSR Series 4 – Warkworth
- TSR Series 5 – Newbiggin
- TSR Series 6 – Wallington
- TSR Series 7 – Dewlaw
- TSR Series 8 – Fulwell
- TSR Series 9 – Hexham
- TSR Series 10 – Haltwhistle
- TSR Series 11 – Darlington
- TSR Series 12 – Knitsley
- TSR Series 13 – Easby
- TSR Series 14 – East Cowton
- TSR Series 15 – Burnhope Reservoir
- TSR Series 16 – Chirdon
- TSR Series 17 – Kielder Ridge End
- TSR Series 18 – Lartington Filters
- TSR Series 19 – Linbriggs

All of the L3 areas have been assigned a TSR series based on proximity to the nearest EA raingauge.

A regression analysis was completed using the annual mean API30, summer mean API30, winter mean API30 values and the average annual rainfall for each dataset. This enabled the calculation of a design NAPI value to be generated based on annual average rainfall and soil type.

An example of the regression calculation is shown below. The example shows the design NAPI values that have been calculated for a location with Soil Type 1 and an annual average rainfall of 900mm.

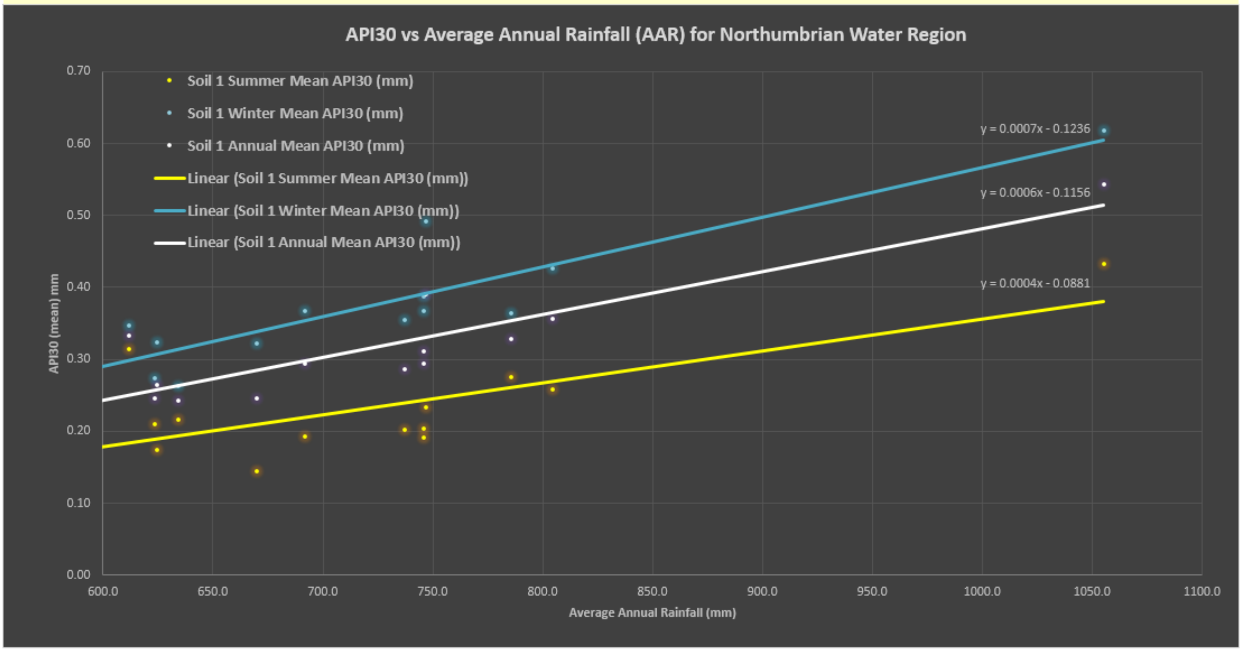
The full QA documentation for the production of the TSR datasets has been uploaded to the NWL Model Library.

API30 Data For Northumbrian Water Region

Select SAAR (mm)	900	Annual Mean API30 (mm)	Summer Mean API30 (mm)	Winter Mean API30 (mm)
Soil 1		0.4	0.3	0.5
Soil 2		2.5	2.0	2.8
Soil 3		5.5	4.4	6.2
Soil 4		18.6	14.7	21.3
Soil 5		52.3	40.9	59.9

Graphical Analysis (Use Dropbox Below to Select Soil Class)

Soil 1



Climate Change

For use in the 2045 and 2060 planning horizons, a 2050 and 2080 TSR dataset has been generated which has been updated for the impacts of climate change using the UK Water Industry Research (UKWIR) climate perturbation tool, ‘RedUP V3’.

Documentation

Each of the newly created datasets is accompanied by a summary report outlining the data that has been used to generate the series, and a statistical overview of the dataset. All of the rainfall files and supporting documentation are stored on the NWL Model Library.

The dataset used in the hydraulic modelling analysis for each BRAVA, Problem Characterisation and Option Development and Appraisal process will be documented for auditing and reporting purposes.

HYDRAULIC MODEL SIMULATIONS

All hydraulic model simulations for the PR24 DWMPs are to be undertaken in InfoWorks ICM (version 9.5).

The following hydraulic model simulations are to be completed to undertake the Standard BRAVA;

- Dry weather flow – 1D model;
- Design rainfall events – 1D and 2D models;
    - 1D model to assess the performance of network assets, e.g. CSO pass-forward flow at first spill;
    - 1D model to assess the 1 in 50 year population at risk metric;
    - 2D model to assess predicted flood risk throughout the drainage area;
- Timeseries rainfall events;
    - Three-year and 'typical' year series for the assessment of asset performance.

The following sections detail the simulation setup to be applied for each of the events that need to be simulated.

Dry Weather Flow – 1D Hydraulic Models

All hydraulic models (base and planning horizons) are to be simulated for a 24-hour dry weather flow period, using a standard diurnal profile applied to the wastewater generator. The model to be used for this simulation will be the 1D network model.

Run Parameters

- Start: 00:00 14/08/2019 (or another suitable weekday);
- Timestep: 10s;
- Results multiplier: 12 (2-minute results timestep);
- Gauge multiplier: 12 (2-minute results timestep);
- Duration: 1 day.

Design Rainfall Events – 1D Hydraulic Models (1 in 5 Year Return Period)

The results from the design rainfall events simulated with the 1D hydraulic models will be used to inform the Problem Characterisation process. In particular, assessments of asset performance using the 1 in 5 year return period events, e.g. CSO pass-forward flow at first spill, peak screened flow and performance of assets against their consent requirements.

The baseline (2020) and planning horizon models are to be simulated with the following design storm events;

- Return Period: 5 year;
- Season: Summer and Winter;
- Durations: 30, 60, 90, 120, 180, 240, 360, 480, 960 and 1440 minutes.

Run Parameters

- Start: 00:00 00/00/0000
- Timestep: 10s;
- Results multiplier: 30 (5-minute results timestep);
- Gauge multiplier: 12 (2-minute results timestep);
- Duration: 2 days (ensure appropriate lag is applied in the Timestep Control dialog, to allow enough time for the network to completely drain down after the end of the rainfall event).

Design Rainfall Events – 1D Hydraulic Models (1 in 50 Year Return Period)

The 1 in 50 year return period event simulations will be used to undertake the 1 in 50 year population at risk assessment.

The baseline (2020) and planning horizon models are to be simulated with the following design storm events (as per the national framework guidance);

- Return Period: 50 year;
- Season: Summer and Winter;
- Durations: 60, 240 and 480 minutes.

Run Parameters

- Start: 00:00 00/00/0000
- Timestep: 10s;
- Results multiplier: 30 (5-minute results timestep);
- Gauge multiplier: 12 (2-minute results timestep);
- Duration: 2 days (ensure appropriate lag is applied in the Timestep Control dialog, to allow enough time for the network to completely drain down after the end of the rainfall event).

Design Rainfall Events – 2D Hydraulic Models

The results from the design rainfall events simulated with the 2D hydraulic models will be used to inform the Problem Characterisation process. In particular, assessments of predicted flood risk within drainage areas, and how this risk changes through the planning horizons, will be undertaken using the results from the 2D hydraulic model. An assessment of pollution risk from manholes predicted to flood within close vicinity of a waterbody receptor will also be undertaken using the results from the 2D hydraulic model.

The baseline (2020) and planning horizon 2D hydraulic models are to be simulated with the following design storm events;

- Return Period: 20 years;
- Season: Summer and Winter;
- Durations: 30, 60, 90, 120, 180, 240, 360, 480, 960 and 1440 minutes.

Run Parameters

- Start: 00:00 00/00/0000
- Timestep: 10s;
- Results multiplier: 0 (no time-varying results to be generated, only max required);
- Gauge multiplier: 0 (no time-varying results to be generated, only max required);
- Duration: 2 days (ensure appropriate lag is applied for enough time to allow the network system to completely drain down after the end of the rainfall event).

2D Parameters

- General: Link 1D and 2D calculations at minor timestep – checked;
- GPU: Always – checked;
    - It is important that the 2D GPU setting is set to 'Always' as software testing has indicated that not using a 2D GPU card for 2D simulations may produce differing results.

Timeseries Rainfall – 1D Hydraulic Models

The results from the TSR simulations will be used to inform the Problem Characterisation process. In particular, assessments of asset spill frequency (CSO, SPS EO, WWTW etc) within drainage areas, will be undertaken using the results from the TSR simulations. The model to be used for this simulation will be the 1D network model. Furthermore, an assessment of WWTW inlet flows during a typical year will be completed using the results of the TSR simulations with the 1D hydraulic model.

- Three years (2016, 2017 and 2018) from the ten-year TSR dataset to be simulated;
- Series to be selected from the 17 rainfall datasets produced for the region.

Run Parameters

- Start: 01/01/2015 (no requirement to run additional time at the beginning of the event as the antecedent conditions will be taken from the rainfall file);
- Timestep: 60s;
- Results multiplier: 0 (gauge file must be used);
- Gauge multiplier: 2 (2-minute results timestep);
- Finish: Time/Date: 31/12/2018;
- Ensure the lag on the timestep control is set to zero.

Spill Assessment Parameters

- Minimum spill volume: 50m3;
- Minimum spill flow: 1l/s.

Simulation Parameters

InfoWorks ICM network default simulation parameters are recommended;

- Tolerance for volume balance;
    - Initialisation: 0.01
    - Simulation: 0.01
- Use full area for headloss calculations – checked;
- Allow re-runs using updated network – checked;
- Read subevent UCWI & evaporation – checked;
- Get start time from rainfall events – checked, unless running the annual TSR events, when this should be unchecked.

HYDRAULIC MODEL SIMULATIONS SUMMARY

The following table summarises the approach to be taken for some of the key modelling components when undertaking the Standard BRAVA process.

Modelling Input	Base (2020)	5 Year Planning Horizon (2025)	10 Year Planning Horizon (2030)	25 Year Planning Horizon (2045)	40 Year Planning Horizon (2060)
Growth	Short-term committed development to be provided by NWL.	Local Plan / SHLAA data to be provided by NWL and used to update hydraulic model.			Long-term growth forecast data provided by NWL and used to inform hydraulic model update.
Urban Creep	No application of urban creep.	To be updated in accordance with the UKWIR methodology.			
Design Rainfall	The following return period storms will be simulated as part of the Standard BRAVA; • DWF • 1 in 5 year; • 1 in 20 year, and; • 1in 50 year return period. ***Note*** – these are the return periods that are required to complete the Standard BRAVA only, and do not represent the full list of design storm events that may need to be simulated in future.				
Time Series Rainfall	A total of 19 ten-year TSR datasets have been produced for the current day and also for the future planning horizons. Ten-year series have been generated; however, only three years (2016, 2017 and 2018) will need to be simulated for the Standard BRAVA.				
Climate Change Uplift	Not applicable.	Not applicable.	Not applicable.	UKCP18 uplift for the design rainfall events relevant to the L2 area. TSR datasets perturbed using REDUP V3.	UKCP18 uplift for the design rainfall events relevant to the L2 area. TSR datasets perturbed using REDUP V3.
Infiltration	Modelled base flows to be calibrated, where appropriate, with MCERTS data. Where no MCERTS data is available, refer to model update guidance.	As Base Model.			
Per Capita Consumption	138l/hd/day, default CIRIA profile to be applied in all of the planning horizon hydraulic model simulations.				
Trade / Industrial Flows	Latest available information (2016) provided by NWL.	As Base Model.			

Modelling Input	Base (2020)	5 Year Planning Horizon (2025)	10 Year Planning Horizon (2030)	25 Year Planning Horizon (2045)	40 Year Planning Horizon (2060)
Boundary Conditions / Tide / River Levels	Applied, where appropriate. Uplifted in line with GOV UK FRA guidance#.	Applied, where appropriate, during design storms only. Not to be applied during TSR events. Uplifted in line with GOV UK FRA guidance#.	Applied, where appropriate, during design storms only. Not to be applied during TSR events. Uplifted in line with GOV UK FRA guidance#.	Applied, where appropriate, during design storms only. Not to be applied during TSR events. Uplifted in line with GOV UK FRA guidance#.	Applied, where appropriate, during design storms only. Not to be applied during TSR events. Uplifted in line with GOV UK FRA guidance#.

#https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

STANDARD BRAVA

Hydraulic Model Simulations

The following table summarises the hydraulic model simulations that will be required to be run to undertake the Standard BRAVA and Problem Characterisation processes.

Model	Per Capita Consumption (l/hd/day)	Growth	Urban Creep	Dry Weather Flow	Design Rainfall	Time Series Rainfall	Boundary Condition
Base PR24 (2020)	138	Committed development	None	24-hour dry weather flow period	Base Rainfall (5, 20 and 50 year RP)	Base TSR	Baseline MHWS and any non-tidal river level restrictions – applied during design storms only
5-Year Planning Horizon (2025)	138	Local Plan / SHLAA development	5-Year Projection	24-hour dry weather flow period	Base Rainfall (5, 20 and 50 year RP)	Base TSR	Uplifted MHWS and any non-tidal river level restrictions – applied during design storms only
10-Year Planning Horizon (2030)	138	Local Plan / SHLAA development	10-Year Projection	24-hour dry weather flow period	Base Rainfall (5, 20 and 50 year RP)	Base TSR	Uplifted MHWS and any non-tidal river level restrictions – applied during design storms only
25-Year Planning Horizon (2045)	138	Local Plan / SHLAA development	25-Year Projection	24-hour dry weather flow period	UKCP18 L2 Uplifted Rainfall (5, 20 and 50 year RPs)	Climate Change Perturbed TSR	Uplifted MHWS and any non-tidal river level restrictions – applied during design storms only

Model	Per Capita Consumption (l/hd/day)	Growth	Urban Creep	Dry Weather Flow	Design Rainfall	Time Series Rainfall	Boundary Condition
40-Year Planning Horizon (2060)	138	WRMP uplifts applied, if required	40-Year Projection	24-hour dry weather flow period	UKCP18 L2 Uplifted Rainfall (5, 20 and 50 year RPs)	Climate Change Perturbed TSR	Uplifted MHWS and any non-tidal river level restrictions – applied during design storms only

PRELIMINARY AND FINAL PROBLEM CHARACTERISATION – SENSITIVITY TESTING

The DWMP framework documents define an approach for determining a 'Strategic Needs Score' and a 'Growth Uncertainty' classification, which is to be used to determine Preliminary and Final Problem Characterisation scores for an L3 area. The problem characterisation approach outlined in the framework documents is generic in form and is intended to inform whether further sensitivity testing is to be undertaken on a L3 area, and the level of detail to be applied during the Option Development and Appraisal phase.

In Appendix C, Section 2.4.2 of the DWMP framework documents, it is advised that water companies undertake sensitivity testing on the 25-year planning horizon model as part of the Standard BRAVA by applying +-30% to the 20% and 30% climate change uplift for future design storms, and to carry out sensitivity testing using varying timeseries rainfall datasets. Sensitivity testing of +-30% of the urban creep values is also proposed to be undertaken with the 25-year planning horizon model.

For the NWL DWMPs, the generic approach suggested by the DWMP framework documents for Preliminary and Final Problem Characterisation will not be followed (although the approach could be applied retrospectively if the industry is required to report on the values generated by the suggested framework approach).

ASSESSMENT OF PLANNING OBJECTIVES

The information gathered during the RBCS and stakeholder engagement, and the model results, will be used to undertake an assessment of the performance of the drainage system against a number of Planning Objectives. The detailed method of assessment, including the thresholds and triggers of assessment to be applied, is covered in the Problem Characterisation methodology.

The following table is intended to provide a high-level overview of the proposed Planning Objectives, and the results required from the hydraulic model simulations that will be needed to undertake the Problem Characterisation exercise.

An overview document has been prepared which outlines the detailed model outputs required from each planning horizon model simulations to enable the Standard BRAVA analysis to be completed. The document is saved on the DWMP SharePoint site at https://NWLcloud.sharepoint.com/sites/TD0096/methodologies/Forms/AllItems.aspx?id=%2Fsites%2FTD0096%2Fmethodologies%2F03%2E03%20Problem%20Characterisation.

Strategic Planning Area	Planning Objective	Required Outputs from Hydraulic Model	Method of Assessment	Key Modelling Considerations
FLOODING	**PO1 Internal Property Flood Risk**	Count of properties deemed to be at risk of internal flooding, assessed using the overland flow results from the 1 in 20 year return period event 2D hydraulic model simulations.	Hydraulic model results to be analysed to determine the number of properties at risk of flooding using an appropriate flood risk assessment tool (e.g. DREAM2D).	In determining a drainage area property flood risk, it is imperative that an appropriate input dataset is prepared. This involves the preparation of a 'cleaned' building polygon dataset, removing buildings that are not inhabited (e.g. garages, outhouses). A global default property threshold value will be set to 150mm.
FLOODING	**PO2 External Property Flood Risk**	Count of properties deemed to be at risk of external flooding, assessed using the overland flow results from the 1 in 20 year return period event 2D hydraulic model simulations.	Hydraulic model results to be analysed to determine the number of properties at risk of flooding using an appropriate flood risk assessment tool (e.g. DREAM2D).	In determining a drainage area property flood risk, it is imperative that an appropriate input dataset is prepared. This involves the preparation of a 'cleaned' building polygon dataset, removing buildings that are not inhabited (e.g. garages, outhouses). A global default property threshold value will be set to 150mm.
FLOODING	**PO3 1 in 50 Year Population at Risk**	Count of properties and sum of affected population deemed to be at risk of flooding, assessed using the results from the 1 in 50 year return period event 1D hydraulic model simulations.	Hydraulic model results to be analysed to determine the total population at risk of flooding. The assessment should follow the guidance provided in Developing and Trialling Wastewater Resilience Metrics, Water UK, November 2017 (https://www.water.org.uk/publication/developing-and-trialling-wastewater-resilience-metrics/)	In determining a drainage area property flood risk, it is imperative that an appropriate input dataset is prepared. This involves the preparation of a 'cleaned' building polygon dataset, removing buildings that are not inhabited (e.g. garages, outhouses).

Strategic Planning Area	Planning Objective	Required Outputs from Hydraulic Model	Method of Assessment	Key Modelling Considerations
ENVIRONMENTAL	**PO4 Bathing Water Quality**	Storm overflow spill frequency and volume predictions across the design horizons to assist with option development. Storm overflows linked to bathing waters in line with the SODRP guidance.	Three years of TSR model simulations.	A selection list of all assets (incoming/outgoing link(s), as well as spill link(s)) to be assessed should be prepared and used in the hydraulic model simulations. Reference to previously completed bathing water quality investigations is imperative to ensure all relevant assets are identified.
ENVIRONMENTAL	**PO5 River Water Quality**	Storm overflow spill frequency and volume predictions across the design horizons to assist with option development. Storm overflows linked to inland watercourses in line with the SODRP guidance.	Three years of TSR model simulations.	A selection list of all assets (incoming/outgoing link(s), as well as spill link(s)) to be assessed should be prepared and used in the hydraulic model simulations.
ENVIRONMENTAL	**PO6 Pollution**	Predicted flood volumes at manholes within 100m of a waterbody receptor from the 1 in 5 year 2D hydraulic model simulations.	An assessment of whether future catchment changes pose a risk to the likelihood and frequency of pollution events within a catchment will be undertaken using a combination of RBCS data, stakeholder input and hydraulic model results. An assessment of the potential risk caused by flooding manholes located within close proximity to a waterbody receptor will be completed.	No other considerations.
COMPLIANCE	**PO7 Sewage Pumping Station (SPS) Performance**	No longer a DWMP Planning Objective.		
COMPLIANCE	**PO8 WWTW DWF Compliance**	Calculation of 80th percentile inflow at WwTW using the 1D hydraulic model annual TSR results.	An indication of future compliance issues as a result of future catchment pressures.	A selection list of all assets (incoming/outgoing link(s), as well as spill link(s)) to be assessed should be prepared and used in the hydraulic model simulations.