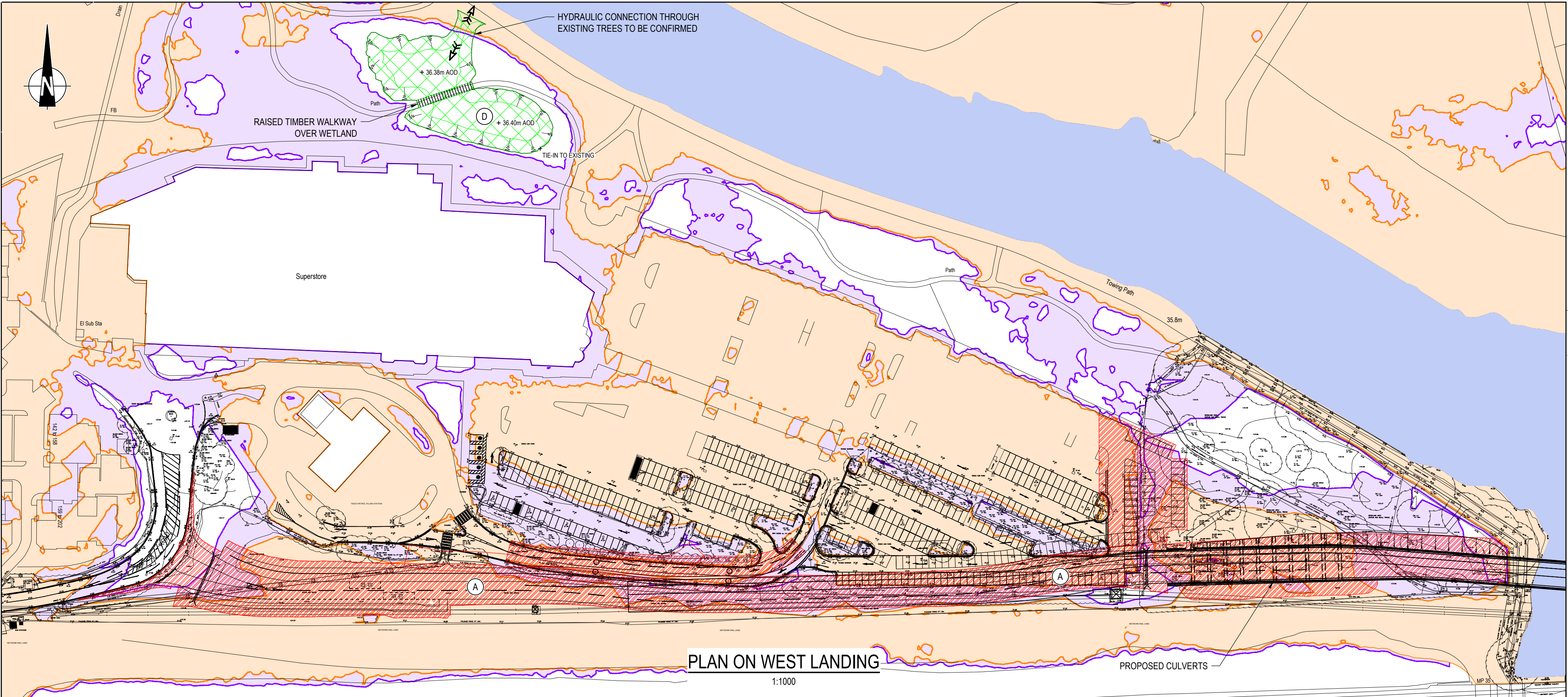




WEST LANDING FLOOD STORAGE ANALYSIS

ESSENTIAL INFRASTRUCTURE IN FLOOD ZONE 2 WITH +35% CLIMATE CHANGE ALLOWANCE

LEVEL BAND BELOW FLOOD LEVEL (mm)	FLOOD STORAGE IMPACT OF PROPOSED STRUCTURE(m³) (AREA A)	FLOOD STORAGE IMPACT OF PROPOSED GROUND REMODELLING (m³) (AREA D)	NET STORAGE (m³)	CUMULATIVE STORAGE (m³)
0 - 100	- 159.49	+ 118.40	-41.09	+497.49
100 - 200	- 59.03	+ 113.13	+54.10	+538.58
200 - 300	- 6.29	+ 107.98	+101.69	+484.48
300 - 400	+ 10.72	+ 102.87	+92.15	+382.79
400 - 500	+ 14.20	+ 97.84	+83.64	+290.64
500 - 600	- 1.68	+ 92.77	+91.09	+207.00
600 - 700	- 0.12	+ 86.99	+86.87	+115.91
700 - 800	0.00	+ 29.04	+29.04	+29.04
800 - 900	0.00	0.00	0.00	0.00
	- 201.69	+ 749.02	497.49	

KEY:

- PROPOSED CHANGES TO EXISTING GROUND LEVEL
- AREA OF PROPOSED GROUND REMODELING FOR COMPENSATION
- 1 in 100 (1%) ANNUAL PROBABILITY PLUS 35% ALLOWANCE FLOW DIRECTION
- 1 in 100 (1%) ANNUAL PROBABILITY PLUS 35% ALLOWANCE FOR CLIMATE CHANGE FLOOD EXTENT
- 1 in 100 (1%) ANNUAL PROBABILITY PLUS 70% ALLOWANCE FOR CLIMATE CHANGE FLOOD EXTENT
- WATER BODY

CONSTRUCTION (DESIGN & MANAGEMENT) REGULATIONS 2015 (CDM REGULATIONS 2015)

THE PROPOSED CONCEPTUAL FLOOD RISK MITIGATION MEASURES ARE BASED ON THE FOLLOWING INFORMATION AVAILABLE AT THE TIME:

- TOPOGRAPHIC SURVEY PROVIDED BY MK SURVEYS DRAWING No. 22109 DATED APRIL 2016.
- MODELLED FLOOD LEVELS EXTRACTED FROM ENVIRONMENT AGENCY RIVER THAMES (READING COMPLEX CHANGE) FLOOD ALLEVIATION STUDY (COMPLETED JUNE 2011) - 2D HYDRAULIC MODEL OBTAINED UNDER LICENCE BY READING BOROUGH COUNCIL.
- PROPOSALS TAKEN FROM PBA 3D CAD GROUND MODEL, AS PER DETAILS DISPLAYED IN PBA DRAWING 28791/2009/CIV/004 GENERAL ARRANGEMENT PHASE 1 - PHASE A AND PBA DRAWING 28791/2009/CIV/005 GENERAL ARRANGEMENT PHASE 1 - PHASE B.

AT THIS CONCEPT DESIGN STAGE IT HAS NOT BEEN POSSIBLE TO ELIMINATE ALL THE HEALTH AND SAFETY RISKS AND RESIDUAL RISKS TO THE PROPOSED GROUND WORKS, FOR EXAMPLE, IN RELATION TO THE LOCATION OF UNDERGROUND UTILITIES, GROUND CONDITIONS AND SLOPE STABILITY. SUCH RESIDUAL RISKS NEED TO BE MITIGATED AGAINST BY THE CLIENT AND COMMUNICATED TO FUTURE DESIGN TEAMS SO THAT AN ATTEMPT CAN BE MADE TO DESIGN THEM OUT AS THE DETAILED DESIGN IS PROGRESSED AND SITE CONSTRAINTS ARE FULLY UNDERSTOOD. ANY RISKS THAT ARE NOT DESIGNED OUT DURING THE DETAILED DESIGN STAGE MUST BE COMMUNICATED FURTHER TO THE CONSTRUCTION TEAM AND END USER SO THAT ADEQUATE MITIGATION MEASURES CAN BE PLANNED FOR AND MANAGED.

NOTES:

- EXISTING GROUND LEVEL INFORMATION BASED ON EA LIDAR DATA.
- TOPOGRAPHIC SURVEY PROVIDED BY MK SURVEYS DRAWING No. 22109 DATED APRIL 2016.
- MODELLED FLOOD LEVELS EXTRACTED FROM ENVIRONMENT AGENCY RIVER THAMES (READING COMPLEX CHANGE) FLOOD ALLEVIATION STUDY (COMPLETED JUNE 2011) - 2D HYDRAULIC MODEL OBTAINED UNDER LICENCE BY READING BOROUGH COUNCIL. ASSOCIATED MODELLED FLOOD EXTENTS REFINED USING LIDAR GROUND LEVEL DATA.
- LONG SECTION STATES MAXIMUM FLOOD DEPTH TO MODELLED 1in100 ANNUAL PROBABILITY PLUS ALLOWANCE FOR CLIMATE CHANGE FLOOD EVENTS.

Mark	Revision	Date	Drawn	Chkd	Appd
SCALING NOTE: Do not scale from this drawing. If in doubt, ask.					
UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.					
Drawing Issue Status					

FOR INFORMATION

EAST READING, MASS RAPID TRANSIT

FLOOD STORAGE ANALYSIS
WEST LANDING

Client

Reading Borough Council
Working better with you

Date of 1st Issue
29.06.2017

Designed
☐

Drawn
GD

A2 Scale
AS SHOWN

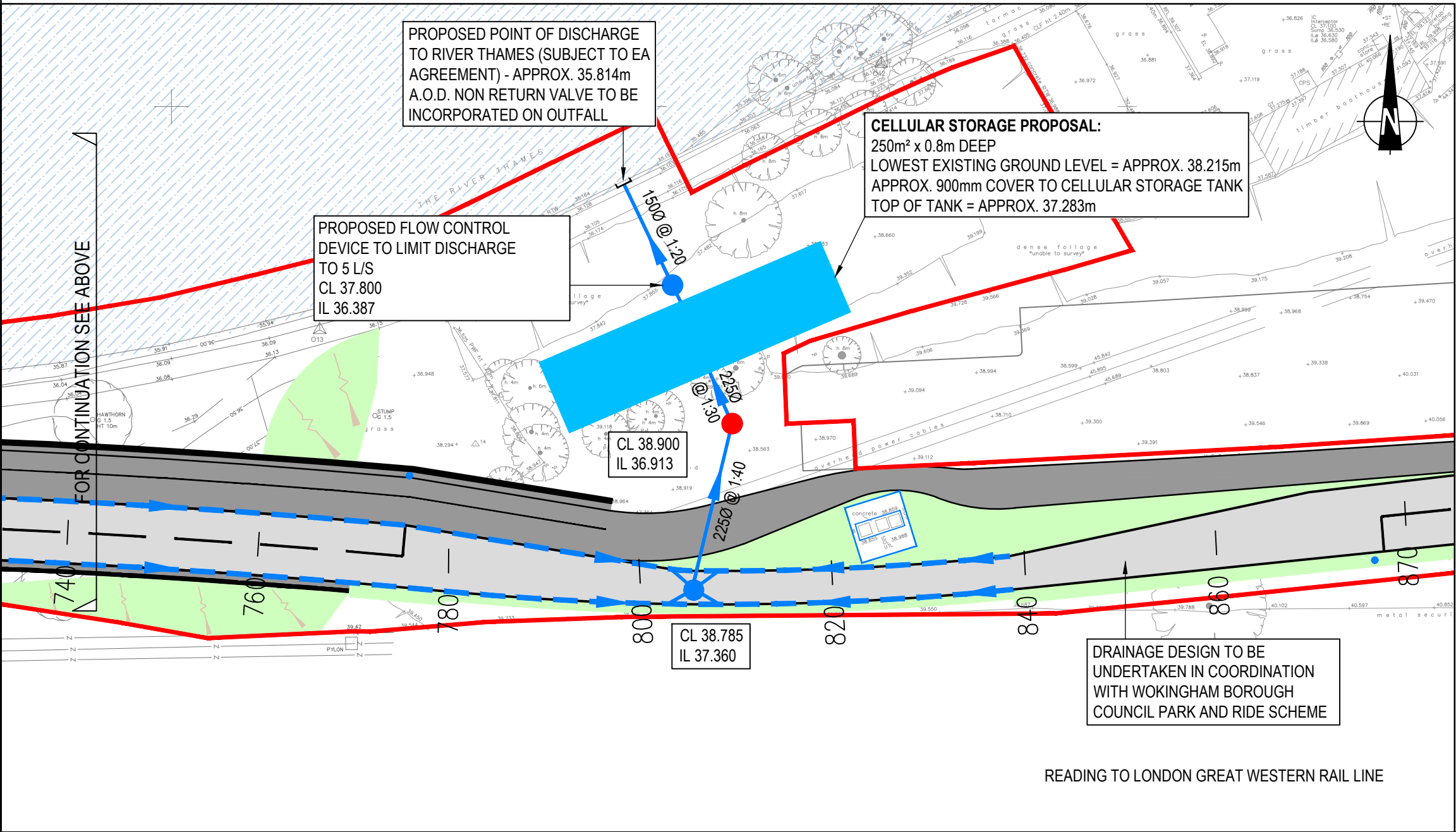
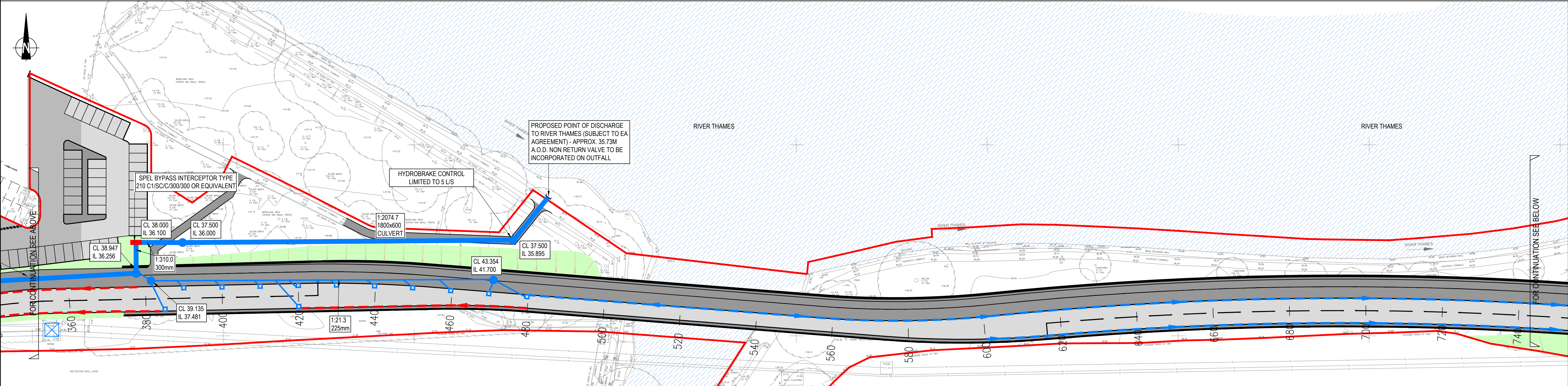
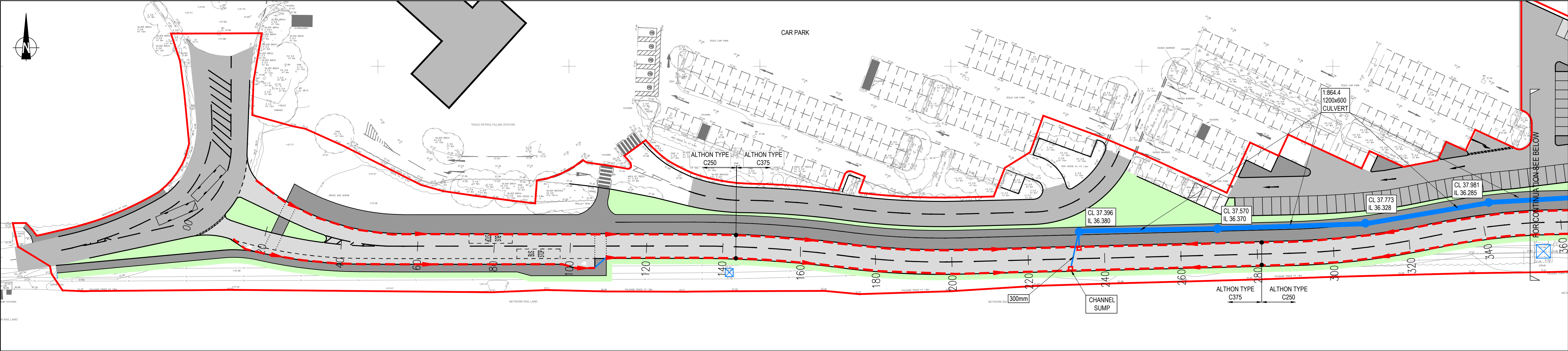
Checked
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Drawing Number
28791/4001/012

Revision
☐

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READING
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- NOTES:**
- DO NOT SCALE THIS DRAWING. IF IN DOUBT PLEASE REQUEST FURTHER INFORMATION.
 - ALL DIMENSIONS ARE IN METRES UNLESS STATED OTHERWISE.
 - STRATEGIC DRAINAGE LAYOUT SHOWN IS SUBJECT TO DETAILED DESIGN.
 - FOR FURTHER INFORMATION ON THE SURFACE WATER DRAINAGE STRATEGY, REFER TO EAST READING MASS RAPID TRANSIT SCHEME FLOOD RISK ASSESSMENT.

- KEY:**
- PLANNING APPLICATION RED LINE BOUNDARY
 - PROPOSED COMBINED KERB DRAINAGE SYSTEM / FLOW DIRECTION
 - PROPOSED HIGH CAPACITY DRAINAGE CHANNEL (ALTHON OR SIMILAR APPROVED SYSTEM) / FLOW DIRECTION
 - PROPOSED TANKED CELLULAR STORAGE (WRAPPED IN GEOMEMBRANE) EXACT LOCATION TO BE CONFIRMED DURING DETAILED DESIGN
 - PROPOSED SURFACE WATER DRAINAGE CARRIER PIPE / FLOW DIRECTION
 - PROPOSED SURFACE WATER DRAINAGE MANHOLE
 - PROPOSED OIL INTERCEPTOR
 - WATERBODY
 - PROPOSED GULLY

Mark	Revision	Date	Drawn	Chkd	Appd

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UTILITIES NOTE: The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.

Drawing Issue Status

FOR PLANNING

EAST READING MASS RAPID TRANSIT

PROPOSED SURFACE WATER DRAINAGE STRATEGY

Client

Reading Borough Council
Working better with you

Date of 1st Issue: 08.06.2017
Designed: AM / IJF
Checked: SE / IJF
Drawing Number: 28791/2009/CIV/008

Drawn: RMLM
Approved: SM
Revision

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Appendix F - PBA Modelling Technical Notes

'Reading Complex Change Hydraulic Model 25%, 35% and 70% Climate Change Model Runs'

'Lower Kennet Flood Study (TH641) Hydraulic Model 25%, 35% and 70% Climate Change Model Runs'

TECHNICAL NOTE

Job Name: Reading Complex Change Hydraulic model
Job No: -
Note No: 1 Rev A
Date: 30th January 2017
Prepared by: Shumol Bari
Subject: **Reading Complex Change Hydraulic Model 25%, 35% and 70% Climate Change Model Runs**

1 - Introduction

This technical note summarises the hydraulic modelling carried out by Peter Brett Associates LLP (PBA) to apply the most recent updates climate change allowances (Flood Risk Assessments: Climate Change Allowances (February 2016)) for the River Thames, from Mapledurham to Sonning. This model used the current EA River Thames hydraulic model for this reach (Reading Complex Change model (2011)) and updated the 1 in 100 (1%) Annual Probability (AP) event to consider the plus 25%, 35% and 70% climate change allowances for fluvial flow.

The EA model along this reach was originally developed for the Reading Complex Change Project (2011) which investigated a range of return period events including the (previously relevant) 1 in 100 AP plus 20% climate change scenario.

2 – Climate Change Planning Policy

In February 2016 the Environment Agency (EA) released new guidance on the application of climate change allowances in flood risk assessments:

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

The peak river flow allowances table within the new guidance replaces the single 20% allowance previously used for England and Wales. Instead a range of allowances for fluvial flooding are provided, which take account of the findings from a series of different climate change models. Through a statistical analysis of the climate change impacts from these different models, estimates for a range of fluvial climate change impacts were provided, in a series of climate change 'bands'.

The new climate change estimates are based on location and timescale, with three principal climate change bands; 'central', 'higher central' and 'upper end'.

- The 'central' band represents the 50th percentile of the range of climate change impacts (i.e. 50% of the range of climate change impacts were below this level).
- The 'higher central' represents the 75th percentile of the range of climate change impacts and;
- The 'upper end' represents the 90th percentile of climate change impacts.

Additionally, a H++ scenario was considered as representing the extreme worst case climate change scenario.

As well as varying geographically (the river basin district of the site) and for the lifetime of the development (2015-2039, 2040-2069 and 2070-2115), the EA guidance for selecting the appropriate climate change allowance is also subject to the Flood Zone of the site and the flood risk vulnerability classification of the proposed use.

TECHNICAL NOTE

Table 1 below indicates the climate change impacts for the three bands for the River Thames Basin for the different future timescales.

Table 1: Climate Change – Peak River Flow Allowances

River Basin District	Timescale in the future	Range of Climate Change Allowances requiring consideration (2070–2115)		
		Central	Higher Central	Upper end
Thames	2015-2039	+10%	+15%	+25%
	2040-2069	+15%	+25%	+35%
	2070-2115	+25%	+35%	+70%

The climate change allowances for future timescales, Flood Zones and vulnerability ‘uses’ for the River Thames Basin are set out in Table 2. For certain development scenarios the EA recommend that several bands are considered to assess climate change impacts across a range of allowances.

Table 2: Climate Change – Peak River Flow Allowances for River Thames Basin

River Basin District	Flood Risk Vulnerability Classification	Future Timescale	Range of Climate Change Allowances requiring consideration		
			Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Thames	Essential infrastructure	2015-2039	+15% and +25%	+25%	+25%
		2040-2069	+25% and +35%	+35%	+35%
		2070-2115	+35% and +70%	+70%	+70%
	Highly Vulnerable	2015-2039	+15% and +25%	Development Not permitted	Development Not permitted
		2040-2069	+25% and +35%		
		2070-2115	35% and +70%		
	More Vulnerable	2015-2039	+10% and +15%	+15% and +25%	Development Not permitted
		2040-2069	+15% and +25%	+25% and +35%	
		2070-2115	+25% and +35%	+35% and +70%	
	Less Vulnerable	2015-2039	+10%	+10% and +15%	Development Not permitted
		2040-2069	+15%	+15% and +25%	

TECHNICAL NOTE

		2070-2115	+25%	+25% and 35%	
	Water Compatible	2015-2039	No allowance to be made	+10%	+10%
		2040-2069		+15%	+15%
		2070-2115		+25%	+25%

3 - Existing Hydraulic Model

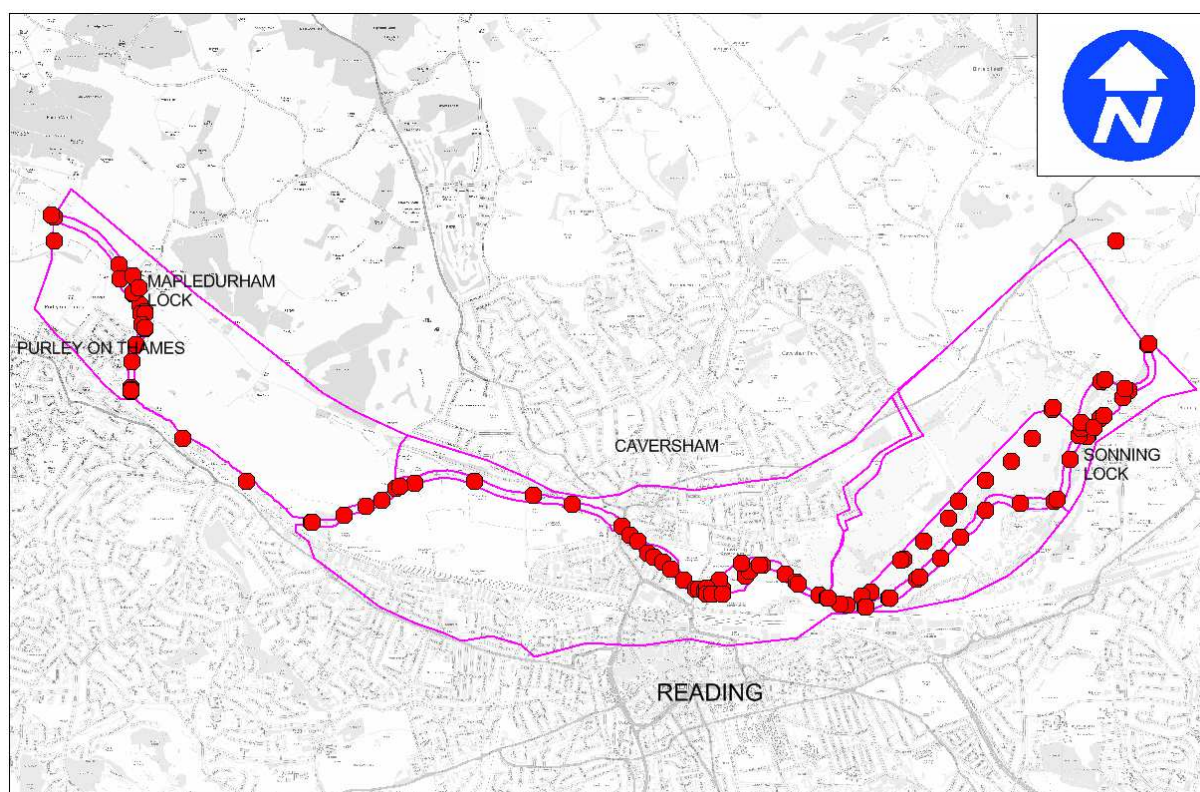
The EA's Reading Complex Change hydraulic model was completed in 2011. The model is a linked 1d-2d model built using ISIS-TUFLOW and was run using TUFLOW version 2009-07-AD-iSP and ISIS version 3.3

The 1d ISIS model extends from upstream of Whitchurch Lock to downstream of Marsh Lock, (the EA Reading Complex Change hydraulic modelling report indicates the model extends from Whitchurch Lock to Shiplake Lock approximately 4.4km upstream of actual downstream end of the ISIS model).

The 2d TUFLOW model was a multiple domain model which is attached to the 1d ISIS model from upstream of Mapledurham Lock to downstream of Sonning Lock, past Sonning Bridge (Figure 1).

The model 2d domains varied between 10 m grid and 30 m grid sizes connected with 2d-2d links.

Figure 1: 2d model domains



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The model was previously run by the EA for the following events:

- 1 in 5 year (1 in 5 or 20% AP)
- 1 in 20 year (1 in 20 or 5% AP)
- 1 in 100 year (1 in 100 or 1% AP)
- 1 in 100 year (1 in 100 or 1% AP) plus 20% allowance for climate change.
- 1 in 1000 year (1 in 1000 or 0.1% AP)

The model used IED files to provide the appropriate inflow boundaries for each modelled event. Each model run used a single IED file.

Each event also has a specific ISIS model DAT file, however the models have been compared in ISIS and there are no changes between the ISIS models (including the boundary conditions) for each event.

The model boundary conditions in the ISIS model are listed below; they have been separated into inflow boundaries in the IED file; the inflow boundaries in the model DAT file and the downstream boundaries in the model DAT file:

Inflow boundaries in the IED files are:

- 38.002a – Main Thames Inflow
- KEN – River Kennet inflow
- 34b.053q – River Loddon catchment (minus Berry and Folley) inflow

Other Inflow boundaries in the ISIS model DAT file (unchanged by the IED file):

- PANGM1 – dummy inflow into Pangbourne meadow
- 37.PANG

TECHNICAL NOTE

- B40a
- FLOOD1

Downstream boundaries:

- SC14 – fixed Stage time boundary
- SB02 – fixed Stage time boundary
- H_Dummy – fixed Stage time boundary
- BER3 – fixed Stage time Boundary
- 32.096 – Flow Stage boundary at downstream of Thames model.

The Other Inflow boundaries in the ISIS model DAT files do not vary between the different ISIS model .DAT files used for each event. It is assumed that these constant inflows were used in the EA models as sweetening flows.

The main downstream boundary condition 32.096 is a flow stage curve located at the downstream end of the Thames model. The EA hydraulic modelling report indicates that this boundary condition is located away from the main area of interest of the EA study (Reading) such that *'...the assumed (downstream) boundary condition does not affect water levels in the study area'*.

There are no 2d inflow boundary conditions in the model.

4 – New Climate Change Runs

The ISIS run (IEF) files for the EA models indicated that a single IED file was used for each modelled return period. The boundary conditions in the DAT files did not change between the different return periods modelled. Consequently, only the inflows in the IED file are understood to have changed for the EA model runs.

To carry out the new climate change runs, the 1 in 100 AP IED file ('run_100yr.ied') was used as the base boundary condition file. The IED file only altered three of the inflow boundaries. It was assumed that the remaining fixed inflows in the model would not be affected as they did not vary between the EA 100 AP and 100 AP + CC (20%) ISIS model (DAT) files.

The model report for the Reading Complex Change Project Hydraulic Modelling Report v 2 (June 2011) did not indicate what the individual constant inflows (PANGM1, 37.PANG, B40a and FLOOD1) in the DAT files were.

The 'run_100yr.ied' IED file, used for the 1 in 100 AP run, was compared against the EA 100 AP plus 20% 'run_100yr+CC.ied' IED file. It was found that the raw inflow data (hydrographs) was (in general) scaled by 1.2 (as opposed to using a flow multiplier to scale the 100 AP hydrograph) to provide the 20%.

Inflow 34b.053q was scaled to be marginally less than 1.2 (1.2 scaling should be 92.28 m³/s as opposed to the 92.18 m³/s in the IED file), but it was considered that this discrepancy was negligible (~0.1% difference) and there was no information to explain this discrepancy in 34b.053q in the Complex Change hydraulic modelling report.

Rather than scaling the raw inflow data for the new 25%, 35% and 70% climate change a flow multiplier was used to scale the 'run_100yr.ied' inflows. This was considered acceptable as the only difference between the 'run_100yr.ied' and the 'run_100yr+CC.ied' was the scaling by 1.2 of the raw data – the minor discrepancy in 34b.053q apart.

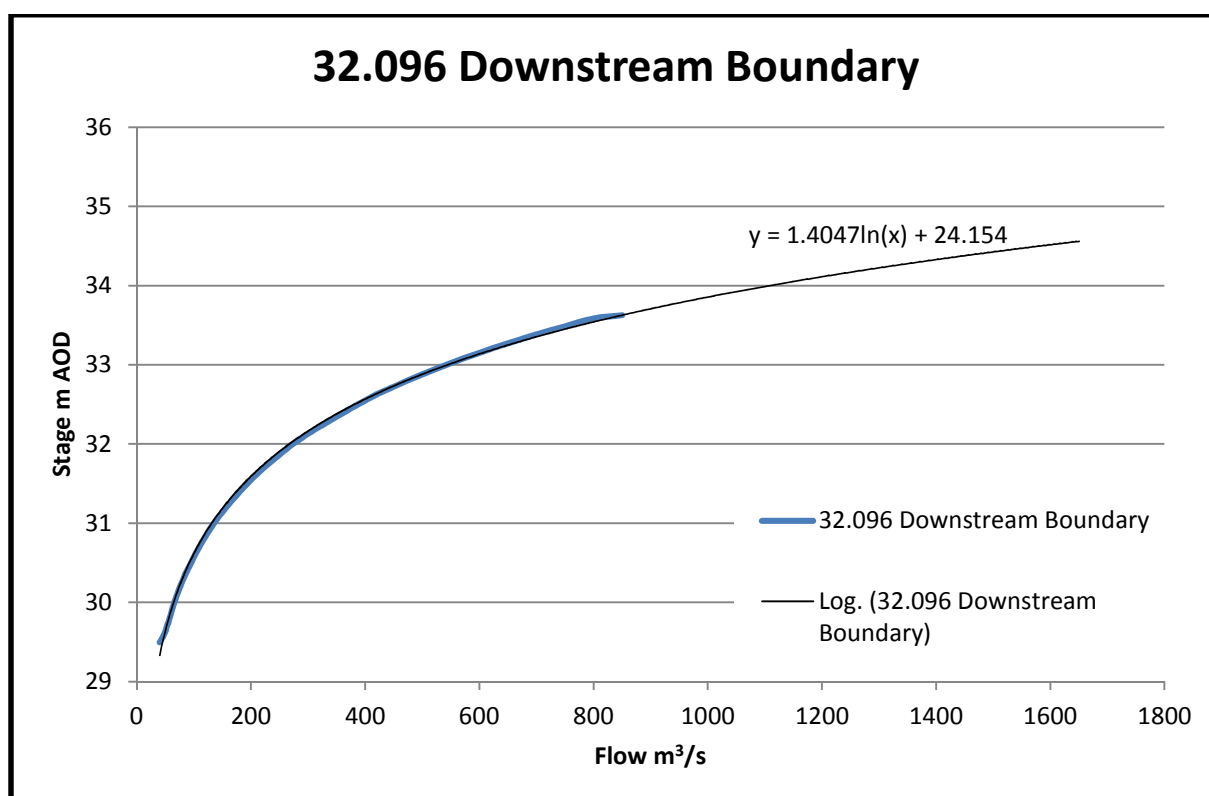
Table 2 – Updates to EA's 1 in 100 AP IED

Inflow	EA's 1 in 100 AP + 20% IED	PBA 1 in 100 AP + 25% IED	PBA 1 in 100 AP + 35% IED	PBA 1 in 100 AP + 70% IED
38.002a	Scaled from 375 to 450	1.25 flow multiplier	1.35 flow multiplier	1.70 flow multiplier
KEN	Scaled from 62.7 to 75.3	1.25 flow multiplier	1.35 flow multiplier	1.70 flow multiplier
34b.053q	Scaled from 76.9 to 92.18	1.25 flow multiplier	1.35 flow multiplier	1.70 flow multiplier

The 70% climate change scenario caused the downstream water level to exceed the downstream Flow Stage boundary (32.096) and triggered the initial model runs to crash – data exceeded limit of rating curve. This downstream boundary curve was extrapolated to provide the additional flow data for greater flood levels to allow the 70% climate change runs to be completed.

The curve was extrapolated using Excel (Figure 2), with the existing Flow vs. Stage data points being fitted to a log curve. The Flow vs. Stage curve in the existing model extended to flow values of 850 m³/s which allowed for water levels of 33.63 m AOD. The Flow vs. Stage curve was extended to provide flow data to 1900 m³/s which allowed for the downstream boundary to reach water levels of approximately 34.75 m AOD.

Figure 2: extrapolation of 1d downstream boundary (32.096)



The correlation between the Flow vs. Stage data from the existing model and the equation for the extrapolated Flow vs. Stage curve is good, and consequently the extrapolated downstream boundary curve is considered an appropriate extension to the existing downstream boundary, assuming that the Flow vs. Stage relationship at the downstream boundary continues to follow the same trend.

The model was run using the same parameters as the existing Complex Change model.

No other changes were made to the EA's existing model.

TECHNICAL NOTE

5 – Model Results

The model runs were both stable with the 2d mass balance within the +/- 1% tolerance throughout both model runs (Figure 3).

The ISIS convergence plots for all the model runs were also good, with the only period of poor convergence occurring as the model initialised (Figure 4).

Figure 3: TUFLOW Mass Balance plots

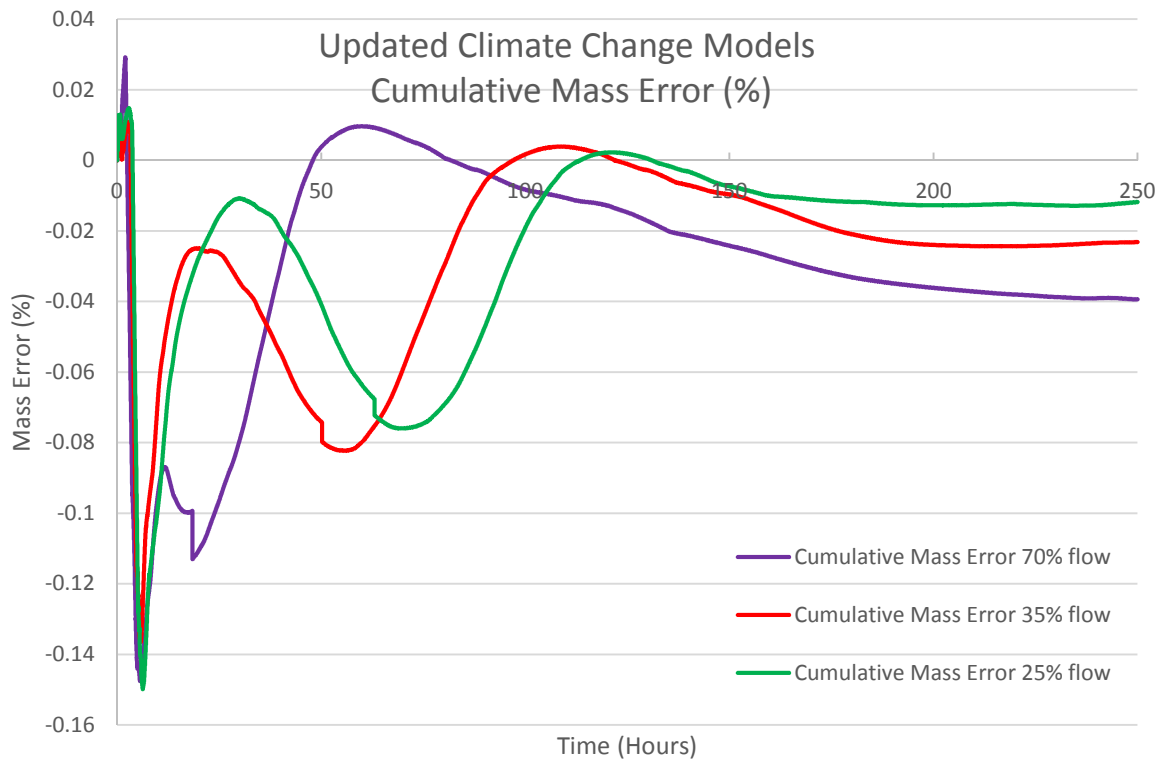
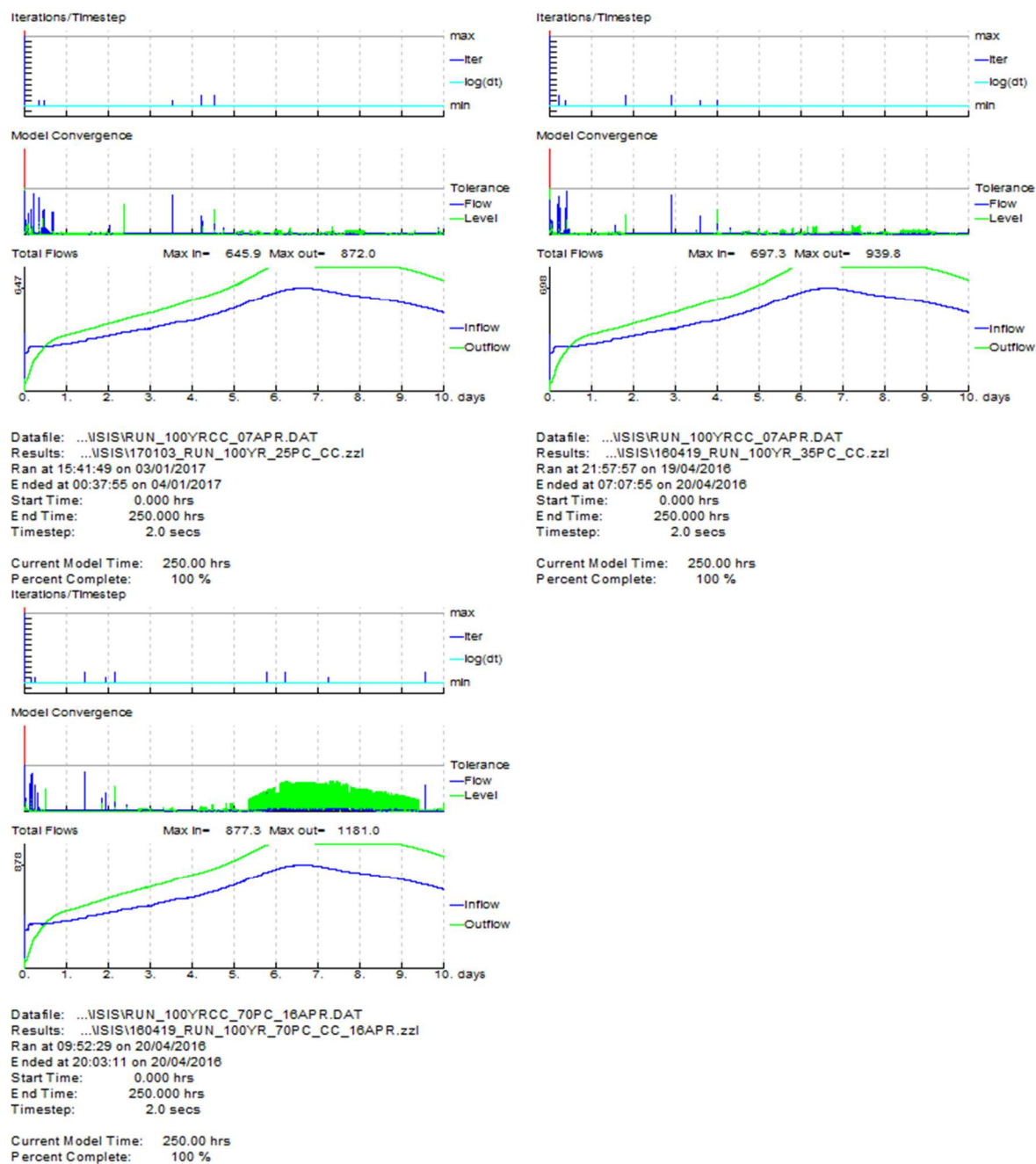


Figure 4: ISIS Convergence plots



TECHNICAL NOTE

Figure 6: 1 in 100 event (blue) with 25% (red), 35% (green) and 70% (brown) ISIS maximum water levels

Long Section: 38.002a - 32.096 - Maximum Stage; 0 - 250 h.

