Appendix D. SLR (November, 2017) FRA extract

FORT AUGUSTUS SUBSTATION AUCHTERAW

Proposed Substation Extension
Platforms LT92 and LT94

APPENDIX FRA-A: Hydrological Modelling Report

FLOOD RISK ASSESSMENT

Prepared for: Scottish and Southern Energy

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Drawing No. APP-A-1: Baseline Model Hydrological Overview
Drawing No. APP-A-2: Development Model Hydrological Overview

APPENDICES

Appendix 01: Baseline Model Inflow Hydrographs
Appendix 02: Development Model Inflow Hydrographs

1.0 Introduction

1.1 Context

SLR Consulting Ltd (SLR) has been appointed by Scottish and Southern Energy (SSE) to undertake a Flood Risk Assessment (FRA) to support a planning application for the proposed extension of the existing electrical substation facility at Auchteraw, Fort Augustus (the Site) in the Scottish Highlands.

The proposed substation expansion comprises the construction of 2no. new platforms referred to as LT92 and LT94 which will adjoin to the existing platform boundary.

SEPAs Flood Maps for the Study Site, are produced at an indicative and strategic level scale and only modelled for watercourses with catchment areas >3km^2 and thus fails to capture the potential flood risk posed by the 'minor' watercourses flowing through and adjacent to the development site area.

This report therefore presents the detailed Hydrological Analysis for the flood flows to inform the 1-Dimensional (1D)/2-Dimensional (2D) linked TUFLOW model developed for the FRA. Appendix FRA-B should be referred to for detail of the hydraulic model developed and associated mapped outputs.

1.2 Model Scenarios

Two separate model scenarios have been considered for the Hydraulic Model:

- **Baseline** – assesses the flood risk to the existing platform during a 0.5% and 0.1% Annual Exceedance Probability (AEP) events. The flood risk to the existing platform when allowing for the impact of climate change (+20%) on the 0.5% AEP event has also been assessed.
- **Proposed Development** – assesses the impact of the proposed LT92 and LT94 substation platforms on the flood risk at the development site and elsewhere. Under this scenario, flood mitigation measures, including new / diverted watercourses and culverts have been assessed (without flood compensatory analysis to determine the likely initial compensation requirements to be detailed at the post-planning stage). As for the baseline scenario, the impact of the proposed platforms on flood risk has been assessed during a 0.5% (with and without a +20% allowance for climate change) and 0.1% AEP events.

1.3 Model Inflow locations

There are 4no. watercourses relevant to the assessment and these are depicted on Drawing No. APP-A-1 and APP-A-2 - these have been explicitly represented within the Hydraulic Flood Models for the Baseline and Development scenarios.

Modelled inflow location are also presented on the aforementioned drawings and summary hydrological details are provided in Table 1-1 and Table 1-2 below for the Baseline and Development models.

Table 1-1
Baseline Model – Hydrological Overview

Inflow ID	Inflow Type	Watercourse	Catchment Delineation NGR	Catchment Area (km^2)	SAAR[1] (mm)	SPRHOST[2]	BFIHOST[3]	Upstream Boundary Condition
B_I1(a)	Point Hydrograph	Auchteraw Burn (Watercourse 1)	NH 35205 08257	3.13	1481	0.52	0.32	Site access road bridge at NGR: NH 35724 08641

Inflow ID	Inflow Type	Watercourse	Catchment Delineation NGR	Catchment Area (km^2)	SAAR[1] (mm)	SPRHOST[2]	BFIHOST[3]	Upstream Boundary Condition
B_I1(b)	Point Hydrograph	Auchteraw Burn (Watercourse 1)	NH 35459 07898	0.54	1455	0.49	0.38	Governed by water level in the Auchteraw Burn
B_I2	Point Hydrograph	Allt na Fearna (Watercourse 2)	NH 35721 08644	2.79	1492	0.54	0.311	Minor road bridge at NGR: NH 35207 08254
B_I3(a)	Hyetograph (overland flow)	Tributary to the Auchteraw Burn (Watercourse 3)	NH35370 08491	0.06	1455	0.49	0.38	Governed by capacity of the NW Boundary ditch
B_I3(b)	Point Hydrograph	Tributary to the Auchteraw Burn (Watercourse 3	NH 35195 08518	0.59	1455	0.49	0.38	Forestry Track Drainage Ditch at NH 35195 08518
B_I4	Point Hydrograph	Tributary to the Auchteraw Burn (Watercourse 4)	NH 35481 08373	0.0025	1455	0.49	0.38	Governed by the capacity of Culvert H

Table 1-2
Development Model – Hydrological Overview

Inflow ID	Inflow Type	Watercourse	Catchment Delineation NGR	Catchment Area (km^2)	SAAR (mm)	SPR HOST	BFI HOST	Upstream Boundary Condition
D_I1(a)	Point Hydrograph	Auchteraw Burn (Watercourse 1)	NH 35205 08257	3.13	1481	0.52	0.32	Site access road bridge at NGR: NH 35724 08641
D_I1(b)	Point Hydrograph	Auchteraw Burn (Watercourse 1)	NH 35459 07898	0.54	1455	0.49	0.38	Governed by water level in the Auchteraw Burn
D_I2	Point Hydrograph	Allt na Fearna (Watercourse 2)	NH 35721 08644	2.79	1492	0.54	0.311	Minor road bridge at NGR: NH 35207 08254
D_I3	Point Hydrograph	Tributary to the Auchteraw Burn (Watercourse 3	NH 35195 08518	0.59	1455	0.49	0.38	Forestry Track Drainage Ditch at NH 35195 08518
D_I4	Point Hydrograph	Tributary to Watercourse 3 (Watercourse 4)	NH35386 08422	0.0554	1455	0.49	0.38	Beginning of Watercourse 4

2.0 Hydrological Analysis

2.1 Overview

All watecourses relevant to the assessment are ungauaged and thus flow estimation using the methods outlined in the Flood Estimation Handbook (FEH)[1] for ungauged catchments in the UK has been adopted.

The FEH offers two principal methods of flood flow estimation; the Rainfall-Runoff Method and the Statistical Method. The Statistical Method estimates peak flow for a catchment for a given AEP event using a combination of historic gauging station data and catchment descriptors. The Rainfall Runoff Method estimates the response of a catchment to a rainfall event of a given AEP and generates a peak flow based entirely on catchment descriptors.

The FEH is supported by WINFAP-FEH and the Revitalised Flood Hydrograph V.2 (ReFH2) software applications which are used in combination with the FEH Web Service[2].

The FEH Web Service provides digital catchment descriptors for any catchment in the UK with an area greater than 0.5km^2. Physical catchment descriptors are estimated from the Institute of Hydrology Digital Terrain Model (IHDTM). Other catchment descriptors are estimated from various publically available sources including soils and climatic datasets.

The WINFAP-FEH software supports the statistical procedures for flood frequency estimation, using historic annual maxima data alongside catchment descriptors. The latest version of WINFAP, version 4.0, has been used in this study.

2.2 Rainfall-Runoff Method

The ReFH2 design package utilises the Rainfall Runoff Method to generate a hydrograph for any catchment generated by a rainfall event of a given AEP. The ReFH2 software is the first version to incorporate SEPA data and thus be calibrated to Scottish catchments/environmental conditions. This method is therefore considered appropriate for this study. It should be noted that during the calibration of ReFH2 the estimated time to peak is considerably reduced and the peak flow increased to reflect the more responsive nature of a Scottish upland catchment[3].

The Institute of Hydrology carried out a number of studies on revising the runoff equations produced in the original Flood Studies Report (1975). IH124 was specifically produced to address the runoff from small catchments (Institute of Hydrology, 1994) and is thus regarded as a valid method for the Site, with the largest inlfow catchment having an area of only 3.13ha.

However, the IH124 method relies on an equation / relationship which does not take into account key catchment descriptors such as the SPRHOST and BFIHOST. It therefore considered to be less accurate than the more recent FEH based methods[4].

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[1]Centre for Ecology and Hydrology (CEH), 1999. Flood Estimation Handbook
[2]Centre for Ecology and Hydrology (CEH), 2017. Flood Estimation Handbook Web Service accessed on 05.09.2017 at: https://fehweb.ceh.ac.uk/GB/map
[3]WHS, 2016. Revitalised Flood Hydrograph Model ReFH2: Technical Guidance, pp 67
[4] CIRIA C753, 2015. The SuDS Manual, 24.3.2

2.3 Statistical Method

2.3.1 Overview

The Statistical Method is broadly a two part process; the estimation of the mean annual flood (QMED) and the derivation of a growth curve. The growth curve relates the increase in peak flow as a multiple of QMED against the rarity of the AEP event.

QMED can be generated from either annual maxima flow data or catchment descriptors, whereas the growth curve is generated solely from annual maxima data.

The annual maxima data required to generate the growth curve can either be from a single gauged site, or from a pooled group of hydrologically similar gauged sites.

The use of the single site analysis technique is only recommended when the flow record length, R, for a gauging station is longer than the required return period, T.

If the record length is between T and 2T, then it is suggested that both a pooling group and single site analysis are competed. Only if the flood data record is longer than 2T is it suggested to use only single site analysis. The record lengths for the selected gauging stations are 34 and 35 years. As the flood risk at the Site is being assessed for a 0.1% AEP both the single site and pooled analyses have been completed for this study.

The statistical method is only applied on the downstream end of the Site at the 1D model outflow location (i.e. on Watercourse 1 – the Auchteraw Burn) as the individual upstream catchment sizes are considered too small for the statistical method to be appropriately applied. Instead the downstream peak flow values are scaled using the relevant catchment areas to upstream inflow locations – this is considered to be a pragmatic approach as all other individual watercourses form tributaries to Watercourse 1 and thus are hydrologically of the same catchment system.

2.3.2 Gauging Stations

Two hydrologically similar gauging stations were selected as donor sites. These were the National River Flow Archive (NRFA) gauging station 28033 – River Dove at Hollinsclough; and 91802 on the Allt Leachdach. Both these sites have small catchment areas with similar key FEH catchment characteristics such as Flood Attenuation by Reservoirs and Lakes (FARL) index, BFIHOST, SAAR and SPRHOST.

2.3.3 QMED

The QMED for the Site is applied to the growth curve to estimate the flood flow of a given AEP event.

There are three methods for deriving a value of QMED for an ungauged site, these are:

1. Directly from the FEH catchment descriptors downloaded for the Site. The QMED estimation from catchment descriptors performed by WINFAP-FEH is in line with the updated 2008 statistical guidelines published by Kjeldsen (2008)[5].
2. FEH donor transfer scheme which provides an estimate of QMED at the target location. This adjusts the value of QMED at the selected donor sites based of the differences in the catchment areas and geographical centroids of the target and donor sites. The donor transfer scheme is applied to both donor locations.

[5]Kjeldsen et al, 2008. Improving the FEH statistical procedures for flood frequency estimation

3. WINFAP multiple donor QMED adjustment function. This method is new for WINFAP V.4 and based upon Kjeldsen et al. (2014)[6]. It uses six donor catchments selected by WINFAP to adjust the catchment descriptor derived value of QMED for the target location.

Estimates of QMED using each method are summarised in Table 2-1 below.

Table 2-1
QMED Estimates – Statistical Method (results in m^3s^{-1})

Inflow ID	Physical Catchment Descriptors	Donor Transfer (91802)	Donor Transfer 28033	WINFAP Multiple Donor Adjustment
Downstream Boundary	8.08	6.95	8.08	8.71

The analysis indicates how the estimate of QMED from the WINFAP Multiple Donor Adjustment method is slightly higher than QMED derived from catchment descriptors or donor transfer. Taking a precautionary (conservative) approach which is entirely appropriate for flood risk assessments, the value of QMED derived from the WINFAP Multiple Donor Adjustment has been selected to develop the Hydraulic Model flood flows.

2.3.4 Growth Curve

Single Site Analysis

Single site analysis requires annual maxima flow data to estimate the peak flow for a given AEP event. As the target location is ungauged, the single site analysis will be performed on the two selected donor sites.

The gauging station annual maxima flow data is used to generate growth curves. L-moments are the preferred Statistical Method[7] for estimating parameters of a probability distribution from a data sample as they are robust in the presence of outliers in the data set, which are often present in flood data sets.

A flood growth curve for NFRA Gauges 91802 and 28033 has been generated in WINFAP-FEH by fitting a set of extreme value distributions to the observed annual maxima data. The General Logistic (GL), 3 Parameter Lognormal (LN3) and Generalised Extreme Value (GEV) distributions provided the best fit to the annual maxima data. However, the GL distribution was selected to estimate peak flows for a range of AEPs for the Site in line with the FEH guidance (Section 17.3.2). The guidance concludes that the GL distribution is the most appropriate selection for UK catchments.

No adjustment for urbanisation is required as the catchment is essentially rural as discussed at Section 2.2.

Pooling Group Analysis

As discussed previously, due to a record length of 25 years at NFRA 4006, a pooling group analysis alongside a single site analysis is advised for flood frequency estimation of peak flow for lower AEP events. A pooling group comprises gauging stations with similar catchment characteristics to the target site. Gauging stations within a pooling group need not to be close to one another in geographical space, but rather have similar area

[6]Kjeldsen, T. R., D. A. Jones, and D. G. Morris (2014), Using multiple donor sites for enhanced flood estimation in ungauged catchments, Water Resour. Res., 50, 6646–6657, doi:10.1002/ 2013WR015203.
[7] Centre for Ecology and Hydrology (CEH), 1999. Flood Estimation Handbook

(AREA), SAAR and BFIHOST. By utilising a pooling group, more flood data becomes available to obtain more reliable estimates for lower probability AEP events.

A pooling group for both the target site and the both donor sites were automatically generated using WINFAP-FEH. Discordancy of a pooling station is a measure of how different annual maxima data is from the pooled values L-moment ratios, with a higher value indicating a higher degree of variation. The discordancy values indicate the annual maxima data for one gauging station in the 28033 pooling group was deemed unsuitable (NFRA Gauge 49006) and so was removed from the pooling group. NFRA Gauge 26802 was added as a replacement. The remaining gauging stations were suitably similar to the pooled values L-moment ratios. Values of discordancy and heterogeneity statistic (H_2) are measures to evaluate pooling station suitability to predict a flood curve for the target or donor site. H_2 compares the variability of L-CV and L-skewness across the pooling group, with a high H_2 value indicating that group members have different growth curves. The low H_2 values for the donor site pooling groups indicate that both pooling groups are acceptably homogenous and that there is no hydrological reason for adjusting the pooling group further.

A set of flood growth curves has been generated for each of the pooling groups in WINFAP-FEH. The 'goodness of fit' test, which evaluates the fit of extreme value distributions to the pooled data, indicates that GL, GEV and LN3 are statistically acceptable fits. Of the three, the GL distribution has been selected for both pooling groups as it is widely used in UK flood frequency analyses with a strong theoretical justification[10]. It also provides the highest peak flow estimates for all AEP events and is therefore deemed a precautionary approach.

2.4 Revitalised Flood Hydrograph

Unlike the Statistical Method discussed previously, which provide only an estimate of peak flow, the Rainfall Runoff Method provides a full flood hydrograph for a given AEP flood event.

The catchment descriptors extracted from the FEH Web Service for each catchment detailed in Table 2-1 and 2-2 were used in the ReFH2 Scottish catchments analysis to generate a 0.1% and 05% AEP event hydrographs for each model input locations. The R&D Technical Report FD1913/TR report, published jointly by the Department for Environment, Food and Rural Affairs (Defra) and the Environment Agency in 2005, recommends a winter design profile be used for rural catchments (URBEXT < 0.125).

The rainfall depth is distributed across the design storm duration using the appropriate design storm profile as described by Houghton-Carr (1999)[8].

2.5 Institute of Hydrology Report No. 124 (IH124)

Due to the small input catchment areas, the IH124 is a suitable method to estimate the model input peak flows. The FEH catchment descriptors as summarsied in Table 1-1 and Table 1-2 have been used to provide the values of SAAR and SPRHOST for each catchment. The IH124 calculation has been completed within the 'Rural-Runoff' calculator built-into the MicroDrainage software package. The minimum area for a IH124 catchemnt in microdrainage is 50ha, so 50ha has been used for each area and then the value has been scaled linearly for each catchment, as stated in CIRIA SuDS Manual EQ 24.3[9].

[8] Centre for Ecology and Hydrology (CEH), 1999. Flood Estimation Handbook (Vol 4)
[9] CIRIA C753 2015. The SuDS Manual, page 513

2.6 Summary of Hydrograph Method Selection

A summary of the peak flows derived for the downstream boundary catchment for the baseline are included in Table 2-2 below.

Table 2-2
QMED Estimates (results in m^3s^{-1})

Annual Exceedance Probability (%)	ReFH2	IH 124	Statistical Methods				
			Donor (28033)		Donor (91802)		Target
			Single	Pooled	Single	Pooled	Pooled
0.5	22.1	266.54	43.44	35.90	23.56	23.35	30.54
0.5+20% CC	26.52	319.85	52.13	43.08	28.28	28.01	***36.65***
0.1	28.08	344.31	80.82	56.46	33.73	32.27	45.13

It is clear that the peak flow values generated from the IH124 method are an order of magnitude higher than the alternative methods and are therefore discounted. However, as discussed at Section 2.0, IH124 method is relatively simple approach derived in 1994[10]. As such, the more advanced and up to date techniques of the Statistical analysis and ReFH2 are seen as providing more reliable peak flow results for the input catchments.

The Statistical Method is preferred to the Rainfall Runoff Method due to the inclusion of observed flood data from a pooling group. The Statistical Method also provides higher estimates of peak flow and has therefore been adopted as a precautionary approach.

As discussed at Section 2.1.1, the Statistical Method has been applied to the two donor sites, pooling groups for each of these donor sites and the target site. The single site analysis for the two donor sites have been discounted as the record length is insufficient for the long return period required for the hydraulic analysis (0.1% AEP). When comparing the relative merits of the donor and target pooling groups, it must be noted that the target pooling group generated is directly applicable to the Site, as the pooling group was generated using the Site catchment descriptors rather than those for the donor station.

The Statistical Method applied to the pooled group target site has therefore been adopted as the preferred method for the estimation of flood flows for input to the hydraulic model. The downstream value of flow for the 0.1% and 0.5% AEP events have been scaled directly to each catchment via their relative areas.

The preferred method of estimating input catchment flows provides only a peak flow and a flood hydrograph is required as an input to the model. The ReFH2 hydrographs for each catchment have then been scaled so that the peak matches the target pooling group peak flow for each catchment. This provides a hydrograph which has the form/shape relative to each catchment (smaller catchments having shorter hydrographs) but with the peak flow from the chosen hydrological method.

The **Development** model hydrographs have been scaled using their relative areas from the **Baseline** hydrographs.

[10] HR Wallingford, 2017, UKSUDS. Accessed on 13.09.2017 at http://www.uksuds.com/FAQRetrieve.aspx?ID=55033

The design hydrographs developed and used for the **Baseline** and **Development** Hydraulic Models are enclosed as Appendix 01 and Appendix 02.

2.7 Hyetograph

The above discussed methodology has been applied to all catchments except Catchment I3(a) – in the Baseline Model only - as demonstrated in Drawing No.APP-A-1.

The receiving watercourse (part of Watercourse 3) is essentially flat with no positive (unilateral) flow direction and is aligned perpendicular to the runoff flow direction from the upstream catchment. The watercourse will therefore intercept runoff along its reach rather than at a discrete location. A hyetograph has been selected for use for this catchment rather than a point inflow. The hyetograph has been applied across the upstream catchment area.

The Rainfall Runoff Method is the only hydrological method discussed above which can generate a hyetograph, which uses the FEH catchment descriptors to generate a hyetograph. The hyetograph has been generated for a 0.5% and 0.1% AEP events and a copy of the graphical input also included in Appendix 01.

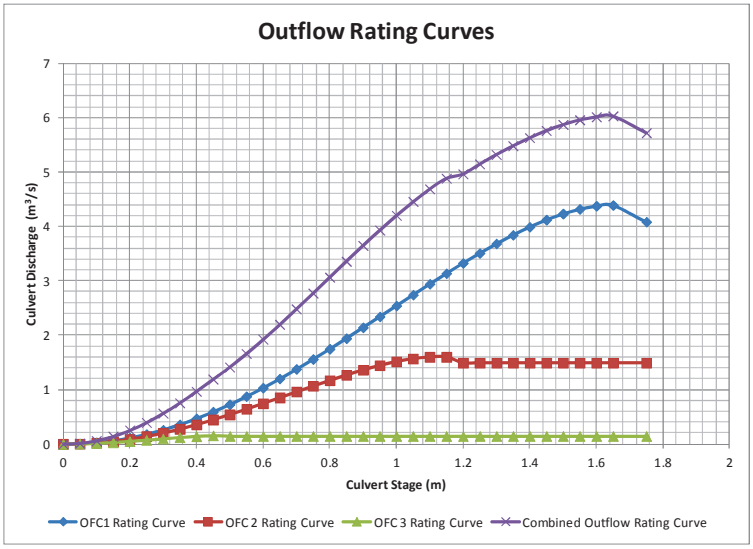
The hyetograph was removed in favour of a point inflow for Watercourse 4 in the Development model which replaced the flat section of Watercourse 3 from the Baseline model – refer to Inflow I4 on Drawing No.APP-B-2

3.0 1D Downstream Model (Outflow) Boundary

The 1D model outflow boundary condition is governed by the outflow capacity of 3 x circular corrugated steel culverts on the Auchteraw Burn (Watercourse 1), which are located approximately 550m southeast of the proposed development area as shown on Drawing No's. APP-B-1 and APP-B-2. Thus a total combined rating curve has been derived by applying Manning's principles of pipe flow.

The combined outflow rating curve combines the individual rating curves for each of the three culverts (OFC 1, OFC 2 and OFC 3) as presented in Figure 1 below.

Figure 1
Downstream Boundary Developed Rating Curves



The same combined rating curve is used in both the baseline and proposed development and models.

4.0 Climate change

Scottish Planning Policy (SPP)[11] recommends that:

> *'a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts)' be adopted by the planning system, 'taking account of the predicted effects of climate change.'*

Although the 2009 climate change predictions (UKCP09) provides information on spatial variations in the potential effects climate change, a 20% increase in peak flow has been adopted in line with SEPA recommendations.

A 20% increase has therefore been applied to the 0.5% AEP flood hydrographs to represent the impact of climate change on fluvial flood flows.

5.0 Conclusions

This summary Hydrological Modelling report forms Appendix FRA-A to the Flood Risk Assessment report and informs the development of Flood flows for the 1D/2D linked Hydraulic TUFLOW Models for the Baseline and Development scenarios - Appendix FRA-B should be consulted for full details of the hydraulic modelling.

The hydrological analysis undertaken is considered to be suitable for the purposes of this assessment and takes due cognisance of SEPAs requirements and adopts current industry best practice for the development of flood flows using the most current industry standard hydrological modelling methods / packages.

[11] The Scottish Government, 2014. Scottish Planning Policy

DRAWINGS

235000 235500 236000 236500

809000 808500 808000

INFLOW I3a DETAILS:
CATCHMENT AREA = 0.06km^2
(MODELLED AS HYETOGRAPH INPUT)
PEAK 1:200yr FLOW = 0.24m^3/s
PEAK 1:200yr + 20% CC FLOW = 0.29m^3/s
PEAK 1:1000yr FLOW = 0.35m^3/s

INFLOW I2 DETAILS:
CATCHMENT AREA = 2.79km^2
PEAK 1:200yr FLOW = 11.17m^3/s
PEAK 1:200yr + 20% CC FLOW = 13.4m^3/s
PEAK 1:1000yr FLOW = 16.5m^3/s

INFLOW I4 DETAILS:
CATCHMENT AREA = 0.0025km^2
PEAK 1:200yr FLOW = 0.01m^3/s
PEAK 1:200yr + 20% CC FLOW = 0.012m^3/s
PEAK 1:1000yr FLOW = 0.015m^3/s

INFLOW I3b DETAILS:
CATCHMENT AREA = 0.59km^2
PEAK 1:200yr FLOW = 2.36m^3/s
PEAK 1:200yr + 20% CC FLOW = 2.83m^3/s
PEAK 1:1000yr FLOW = 3.49m^3/s

INFLOW I1a DETAILS:
CATCHMENT AREA = 3.13km^2
PEAK 1:200yr FLOW = 12.53m^3/s
PEAK 1:200yr + 20% CC FLOW = 15.03m^3/s
PEAK 1:1000yr FLOW = 18.51m^3/s

INFLOW I1b DETAILS:
CATCHMENT AREA = 0.54km^2
PEAK 1:200yr FLOW = 2.16m^3/s
PEAK 1:200yr + 20% CC FLOW = 2.59m^3/s
PEAK 1:1000yr FLOW = 3.19m^3/s

I1a I1b I2 I3a I3b I4

A B C D E F G H J K L M

EXISTING SUBSTATION
PROPOSED LT94
PROPOSED LT92
EXISTING SGT4
El Sub Sta
FILTER DRAIN AND SOAKAWAY TO DISCHARGE FLOW FROM I4
AUCHTERAW BURN DISCHARGES TO RIVER OICH
DOWNSTREAM MODEL BOUNDARY AT CULVERTS BENEATH FORESTRY TRACK

Waterfall Weir Waterfalls Drain Sheepfold Forestry Nurs Path FB Lundie Cottage Talamh Carraig Auchteraw Hostel Torr Sionnaich Whinhill Auchteraw House Auchteraw Burn River Track

48m 43m 39m 54m 51m 44m 41m

N

0 50 100 150 200
Metres

NOTES

1. CONTOURS GENERATED FROM GETMAPPING 5m AP DERIVED DTM INTEGRATED WITH SLR TOPO SURVEY.

LEGEND

- SSE LAND OWNERSHIP BOUNDARY
- EXISTING PLATFORM BOUNDARY
- SGT4 PLATFORM EXTENT
- PROPOSED LT92 PLATFORM EXTENT
- PROPOSED LT94 PLATFORM EXTENT
- CULVERT + ID
- WATERCOURSE 1 - AUCHTERAW BURN
- WATERCOURSE 2 - ALLT NA FEARNA
- WATERCOURSE 3 - MINOR WATERCOURSE (ENGINEERED)
- WATERCOURSE 4 - MINOR WATERCOURSE (ENGINEERED)
- MODEL INFLOW LOCATION + ID
- UPSTREAM MODEL BOUNDARY LOCATION
- DOWNSTREAM MODEL BOUNDARY LOCATION
- WATERCOURSES RELEVANT TO STUDY (NOT MODELLED)
- SITE BUILDING
- 1m CONTOUR

SSE

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EH12 9DH
T: +44 (0)131 335 6830
www.slrconsulting.com

FORT AUGUSTUS FRA
HYDROLOGICAL MODELLING REPORT
BASELINE MODEL
APP-A-1

Scale 1:5,000 @ A3
Date NOVEMBER 2017

00660.00047.18.AppA-1.0 Hydrological Overview

Contains Ordnance Survey data © Crown copyright and database rights (2017) 0100031673 Expires 14/11/2018

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235000 235500 236000 236500

809000 808500 808000

INFLOW I2 DETAILS:
CATCHMENT AREA = 2.79km^2
PEAK 1:200yr FLOW = 11.17m^3/s
PEAK 1:200yr + 20% CC FLOW = 13.4m^3/s
PEAK 1:1000yr FLOW = 16.5m^3/s

INFLOW I4 DETAILS:
CATCHMENT AREA = 0.06km^2
PEAK 1:200yr FLOW = 0.22m^3/s
PEAK 1:200yr + 20% CC FLOW = 0.27m^3/s
PEAK 1:1000yr FLOW = 0.33m^3/s

INFLOW I3 DETAILS:
CATCHMENT AREA = 0.59km^2
PEAK 1:200yr FLOW = 2.36m^3/s
PEAK 1:200yr + 20% CC FLOW = 2.83m^3/s
PEAK 1:1000yr FLOW = 3.49m^3/s

INFLOW I1a DETAILS:
CATCHMENT AREA = 3.13km^2
PEAK 1:200yr FLOW = 12.53m^3/s
PEAK 1:200yr + 20% CC FLOW = 15.03m^3/s
PEAK 1:1000yr FLOW = 18.51m^3/s

INFLOW I1b DETAILS:
CATCHMENT AREA = 0.54km^2
PEAK 1:200yr FLOW = 2.16m^3/s
PEAK 1:200yr + 20% CC FLOW = 2.59m^3/s
PEAK 1:1000yr FLOW = 3.19m^3/s

10m STANDOFF FROM L94 PLATFORM TO DIVERTED WATERCOURSE 3. STANDOFF DISTANCE LIKELY TO BE INCREASED TO 15-20m

STEPPED PLATFORM ELEVATIONS

STEPPED PLATFORM ELEVATIONS

EXISTING SUBSTATION

PROPOSED LT94

PROPOSED LT92

EXISTING SGT4

AUCHTERAW BURN DISCHARGES TO RIVER OICH

DOWNSTREAM WATERCOURSE NETWORK BOUNDARY AT TRACK CULVERTS

I1a I1b I2 I3 I4 L M (NEW) D (NEW) J

Waterfall Weir Waterfalls Waterfalls Drain Drain Drain Drain Sheepfold Forestry Nurs Path FB Lundie Cottage Talamh Carraig Auchteraw Hoste Torr Sionnaich Whinhill Auchteraw House Auchteraw Burn River Track Track

0 50 100 150 200 Metres

NOTES

1. CONTOURS GENERATED FROM GETMAPPING 5m AP DERIVED DTM INTEGRATED WITH SLR TOPO SURVEY.

2. LAYOUT AND DETAILS OF PROPOSED WATERCOURSE DIVERSIONS AND NEW WATERCOURSE ARE CONSIDERED INITIAL DESIGN AND SUBJECT TO REFINEMENT AT THE POST PLANNING STAGE.

LEGEND

- SSE LAND OWNERSHIP BOUNDARY
- EXISTING PLATFORM BOUNDARY
- SGT4 PLATFORM EXTENT
- PROPOSED LT92 PLATFORM EXTENT
- PROPOSED LT94 PLATFORM EXTENT
- CULVERT + ID
- WATERWAYS RELEVANT TO STUDY (NOT MODELLED)
- WATERCOURSE 1 - AUCHTERAW BURN (UNCHANGED)
- WATERCOURSE 2 - ALLT NA FEARNA (UNCHANGED)
- WATERCOURSE 3 - REVISED DESIGN
- WATERCOURSE 4 - NEW INTERCEPTION DRAIN
- SITE BUILDING
- MODEL INFLOW LOCATION + ID
- UPSTREAM MODEL BOUNDARY LOCATION
- DOWNSTREAM MODEL BOUNDARY LOCATION
- 1m CONTOUR

SSE

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HYDROLOGICAL MODELLING REPORT

DEVELOPMENT MODEL HYDROLOGICAL OVERVIEW

APP-A-2

Scale 1:5,000 @ A3

Date NOVEMBER 2017

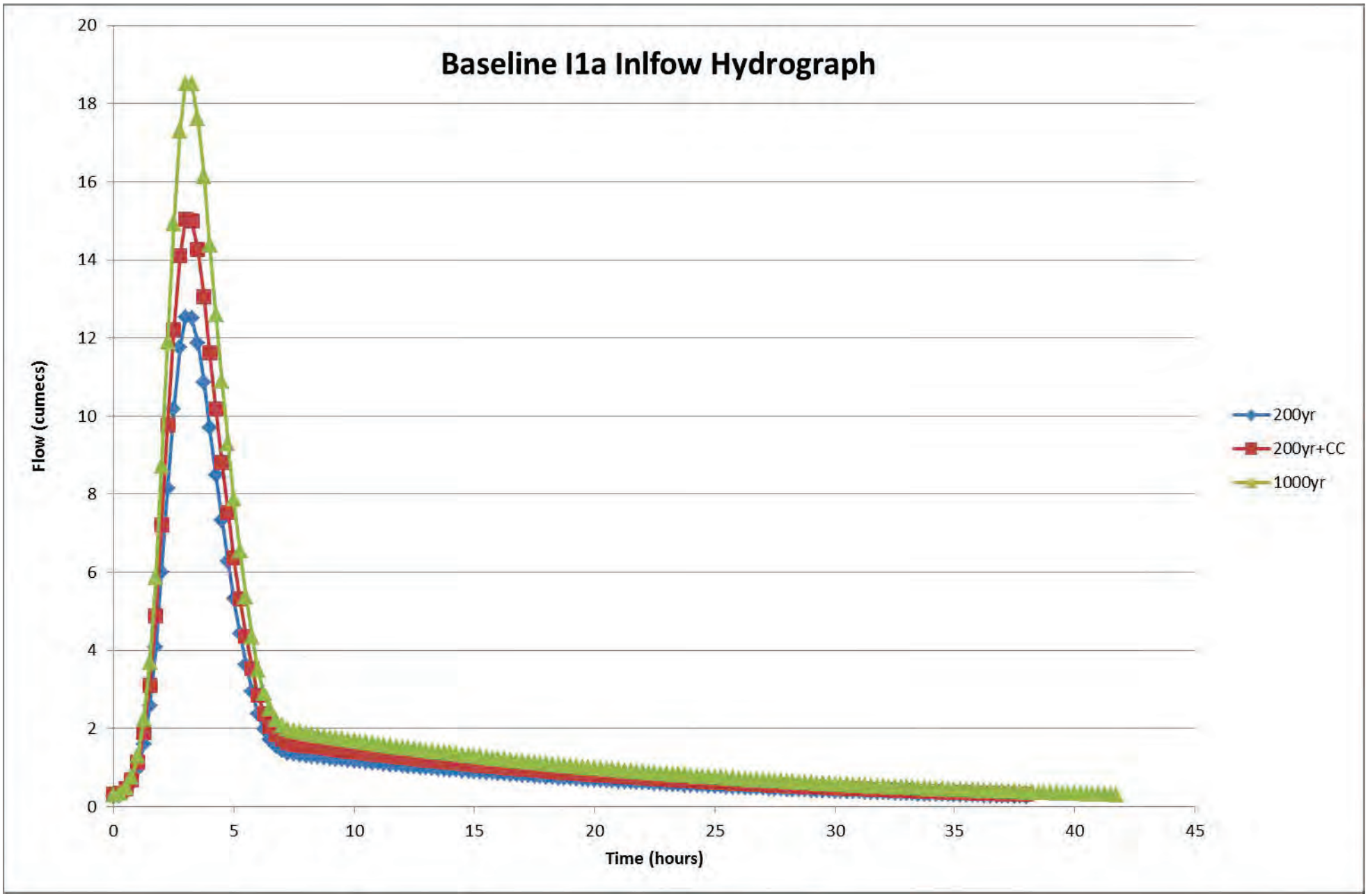
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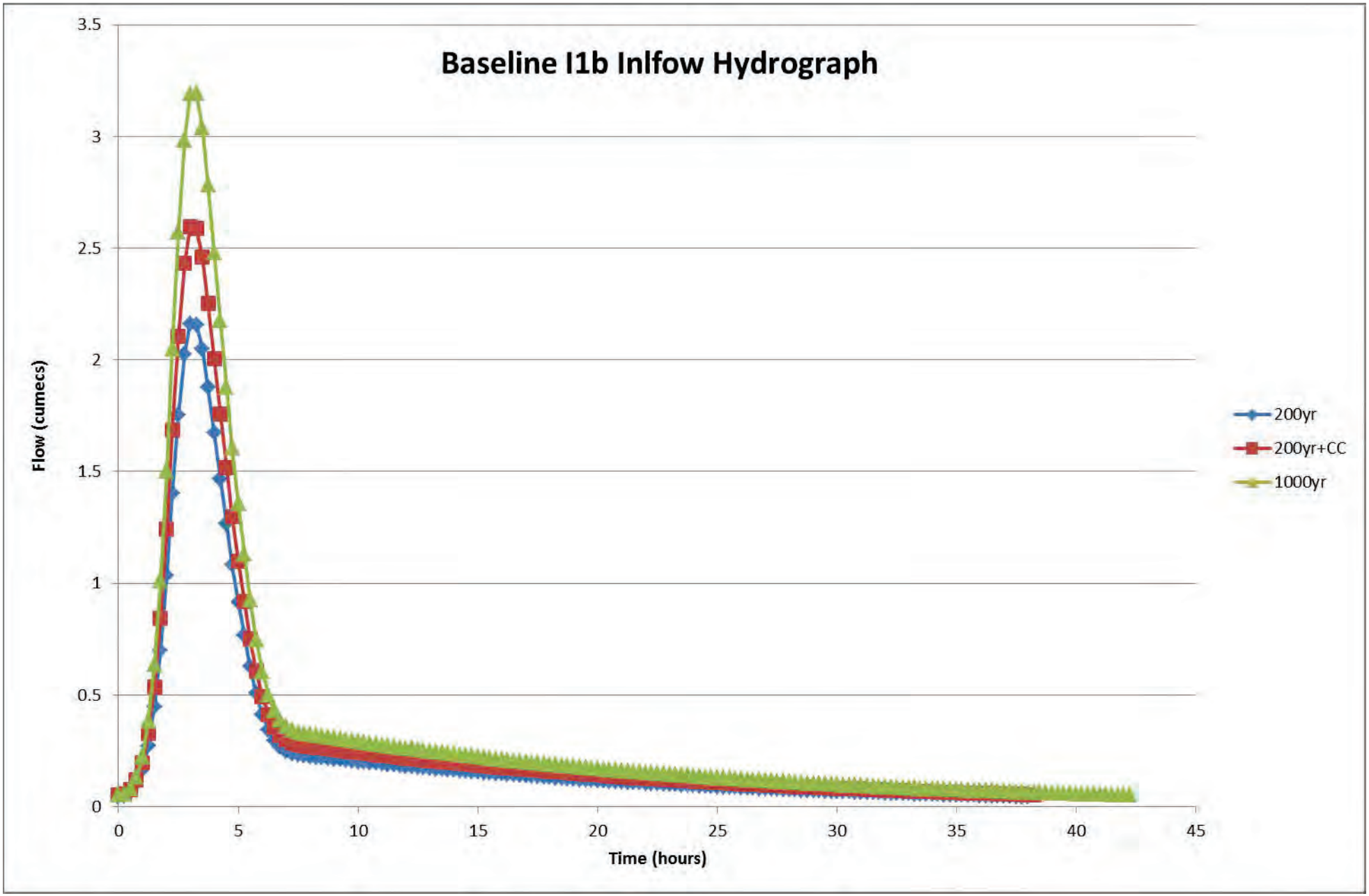
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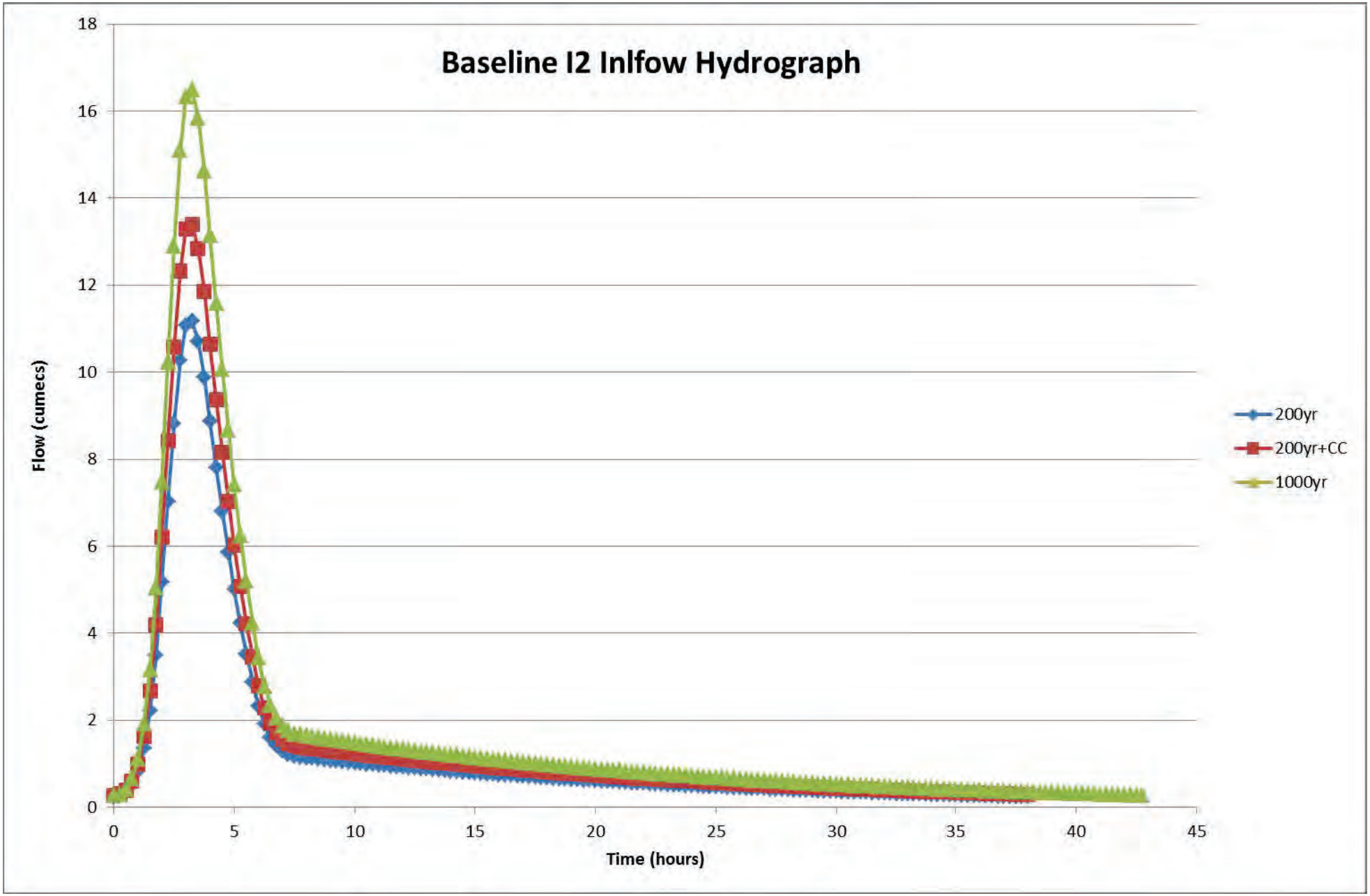
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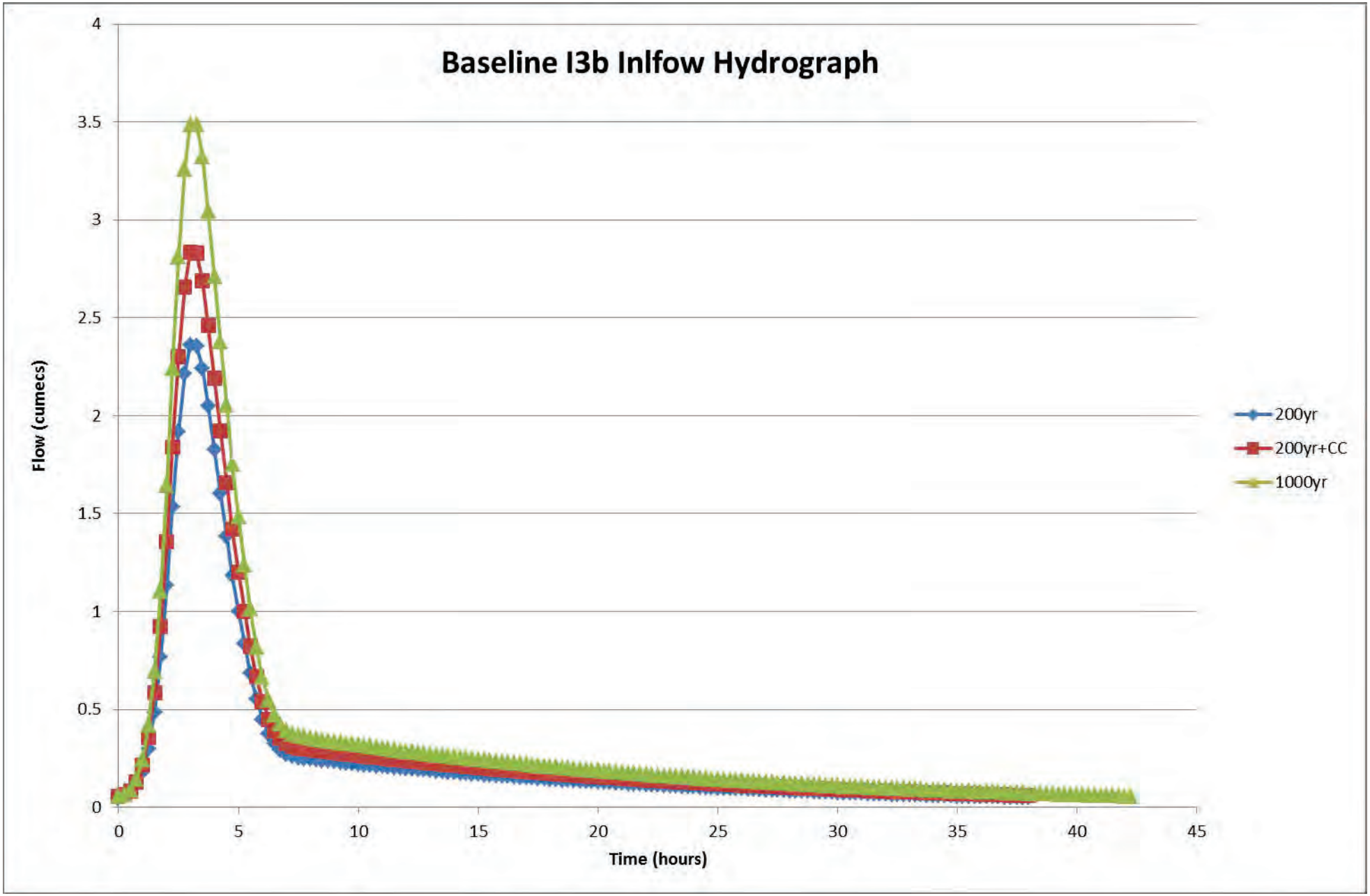
APPENDIX 01

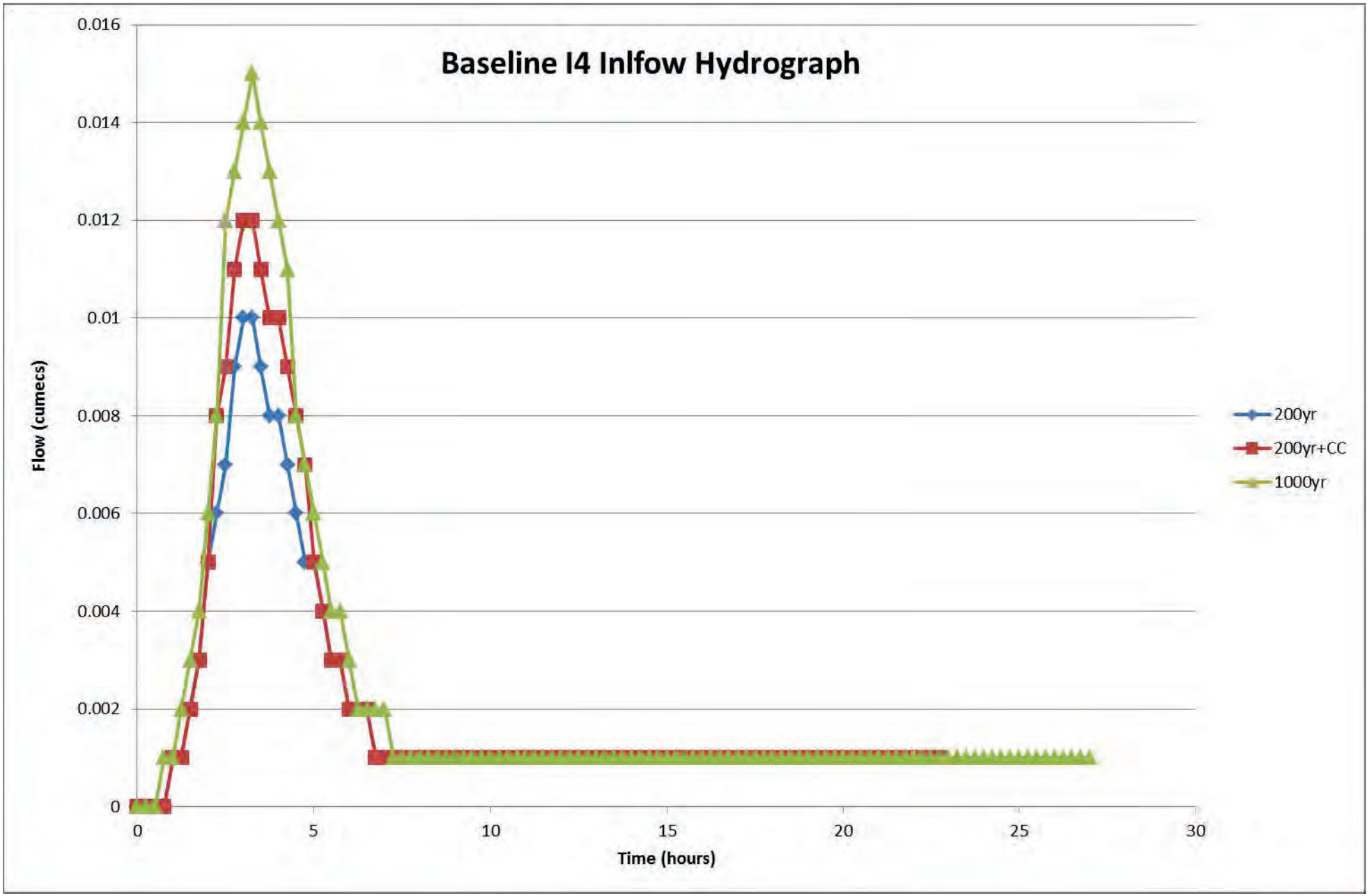
Baseline Model Inflow Hydrographs

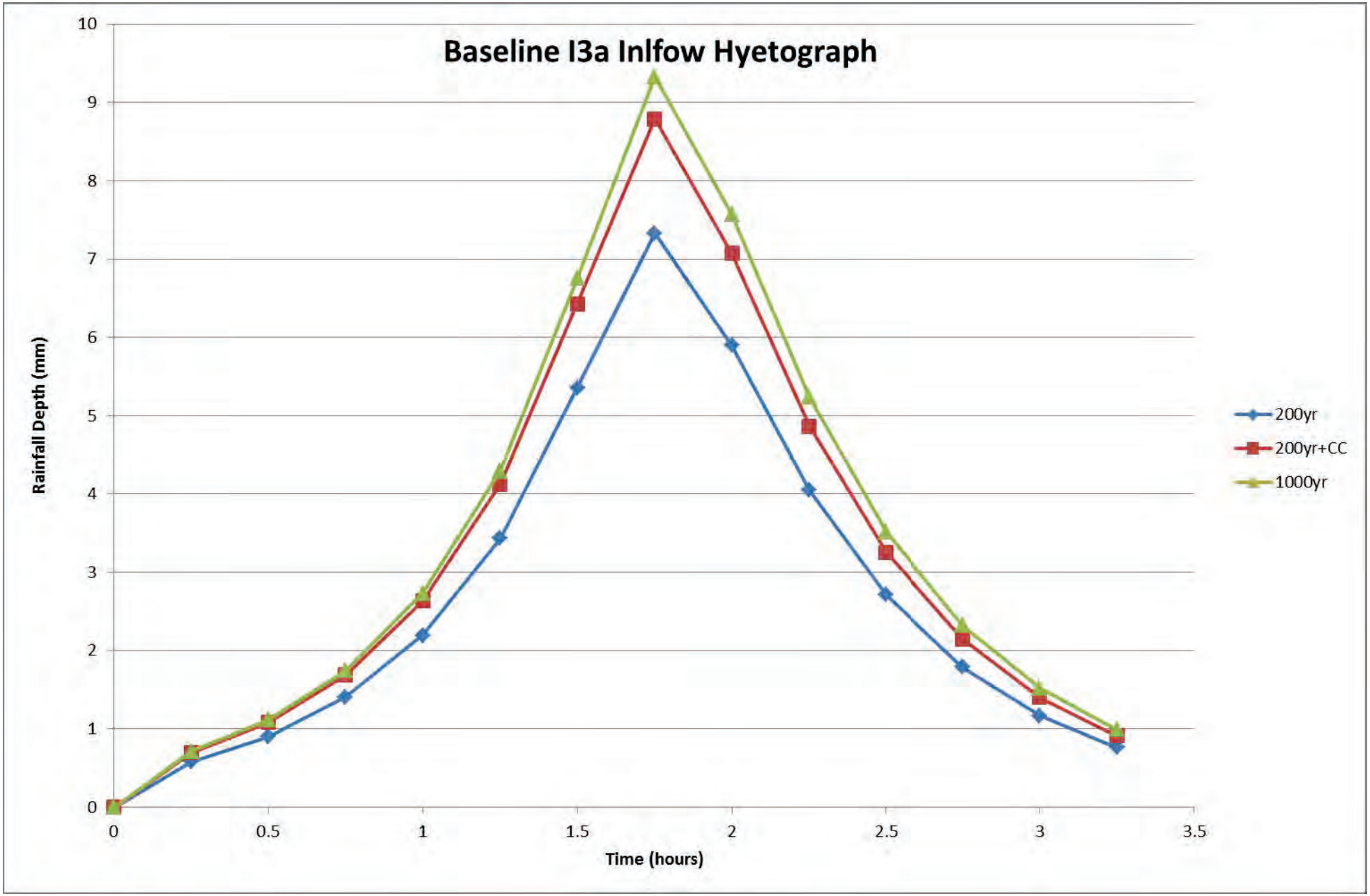

Baseline I1a Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Baseline I1b Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
0.5
1
1.5
2
2.5
3
3.5
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Baseline I2 Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr

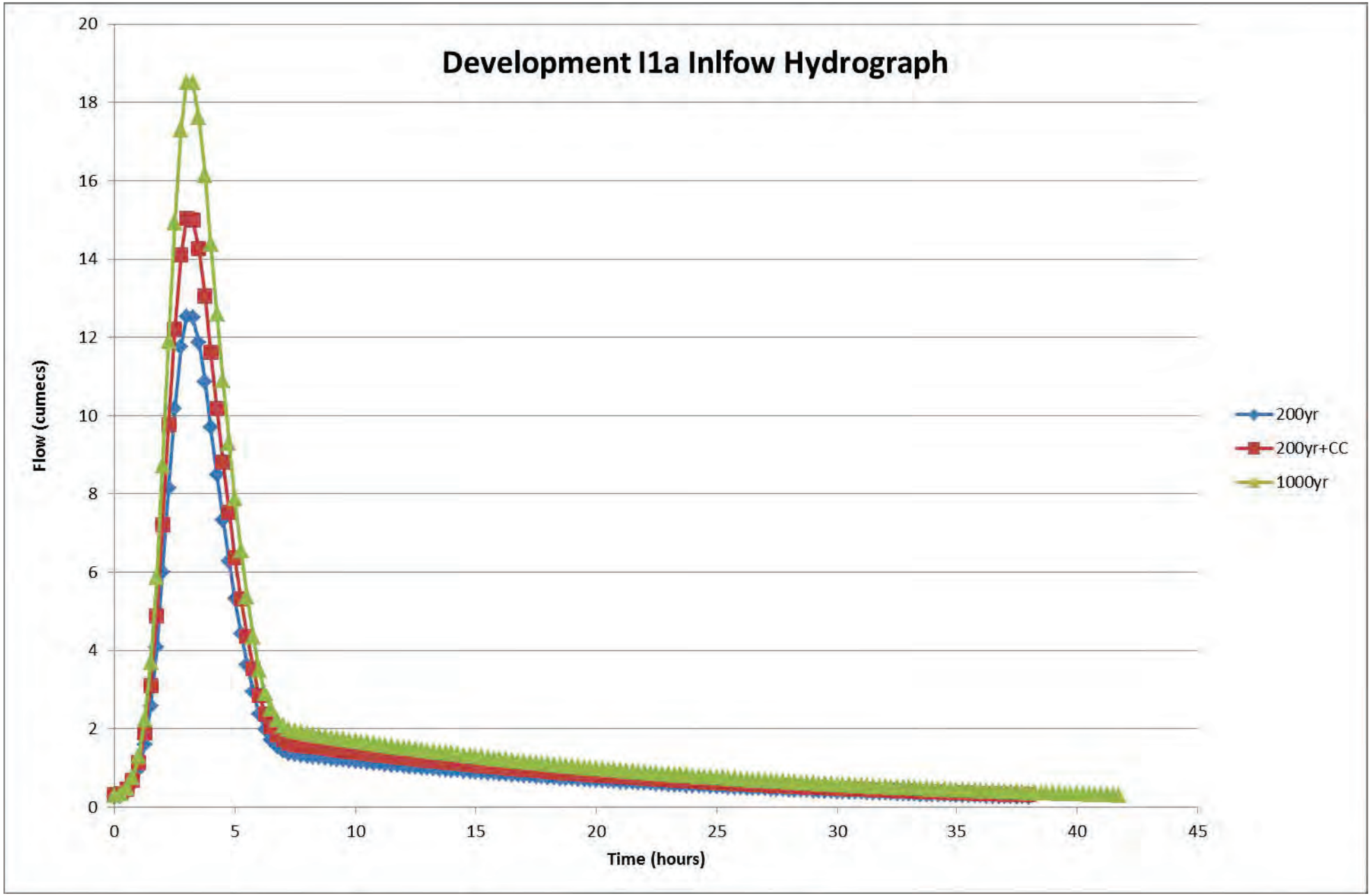

Baseline I3b Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr

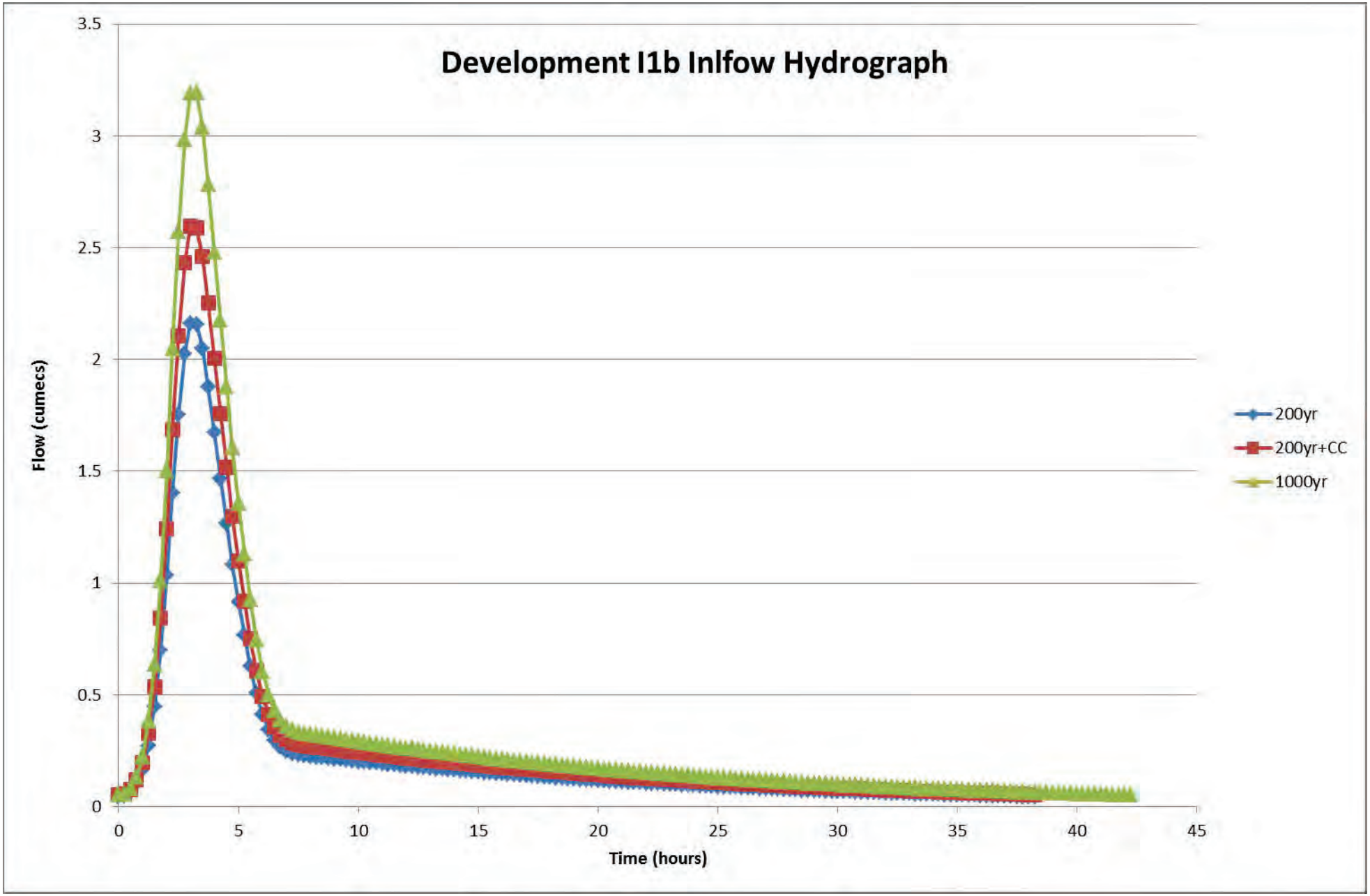

Baseline I4 Inlfow Hydrograph
Flow (cumecs)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
5
10
15
20
25
30
Time (hours)
200yr
200yr+CC
1000yr

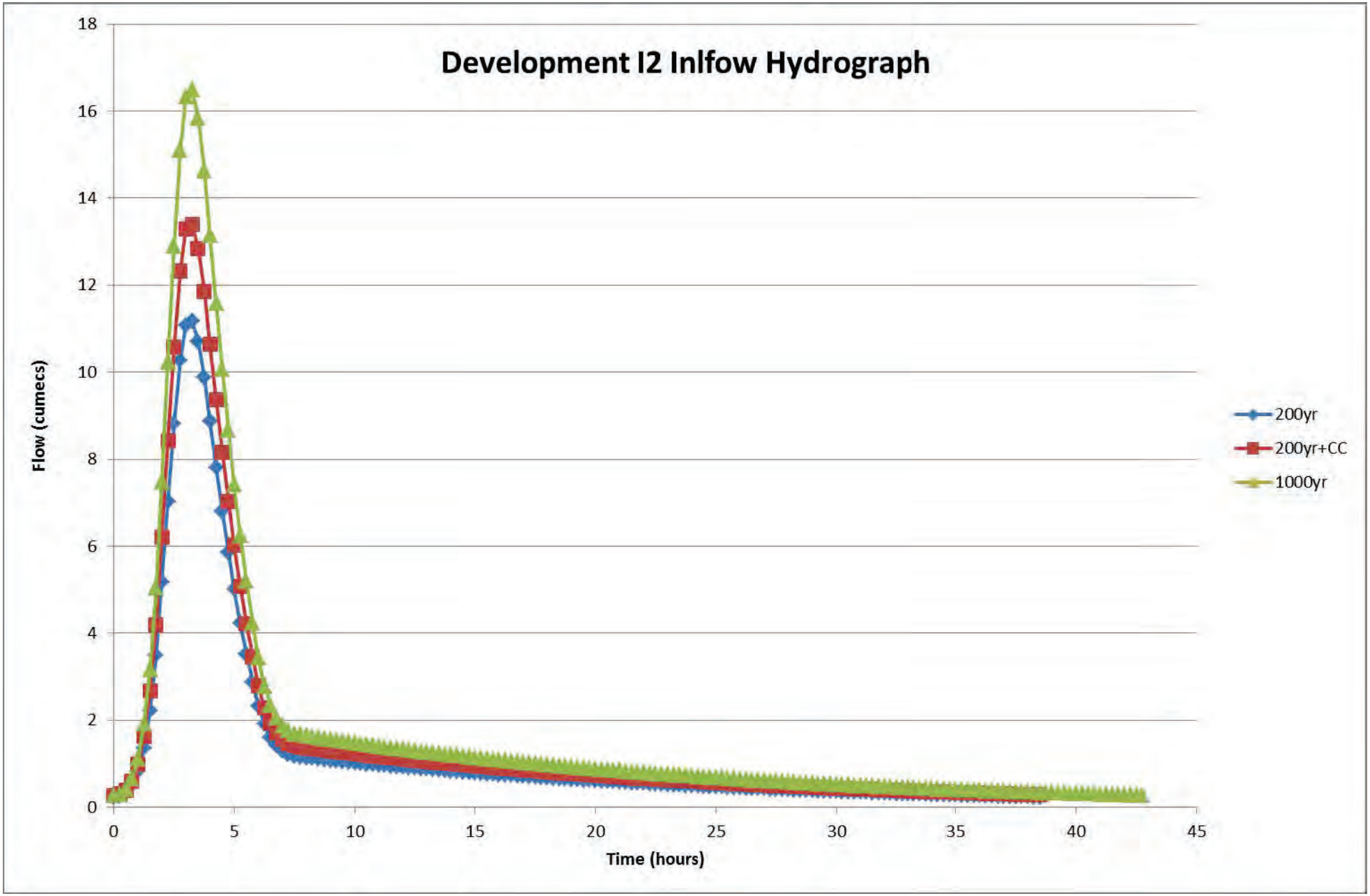

Baseline I3a Inlfow Hyetograph
Rainfall Depth (mm)
Time (hours)
0
1
2
3
4
5
6
7
8
9
10
0
0.5
1
1.5
2
2.5
3
3.5
200yr
200yr+CC
1000yr

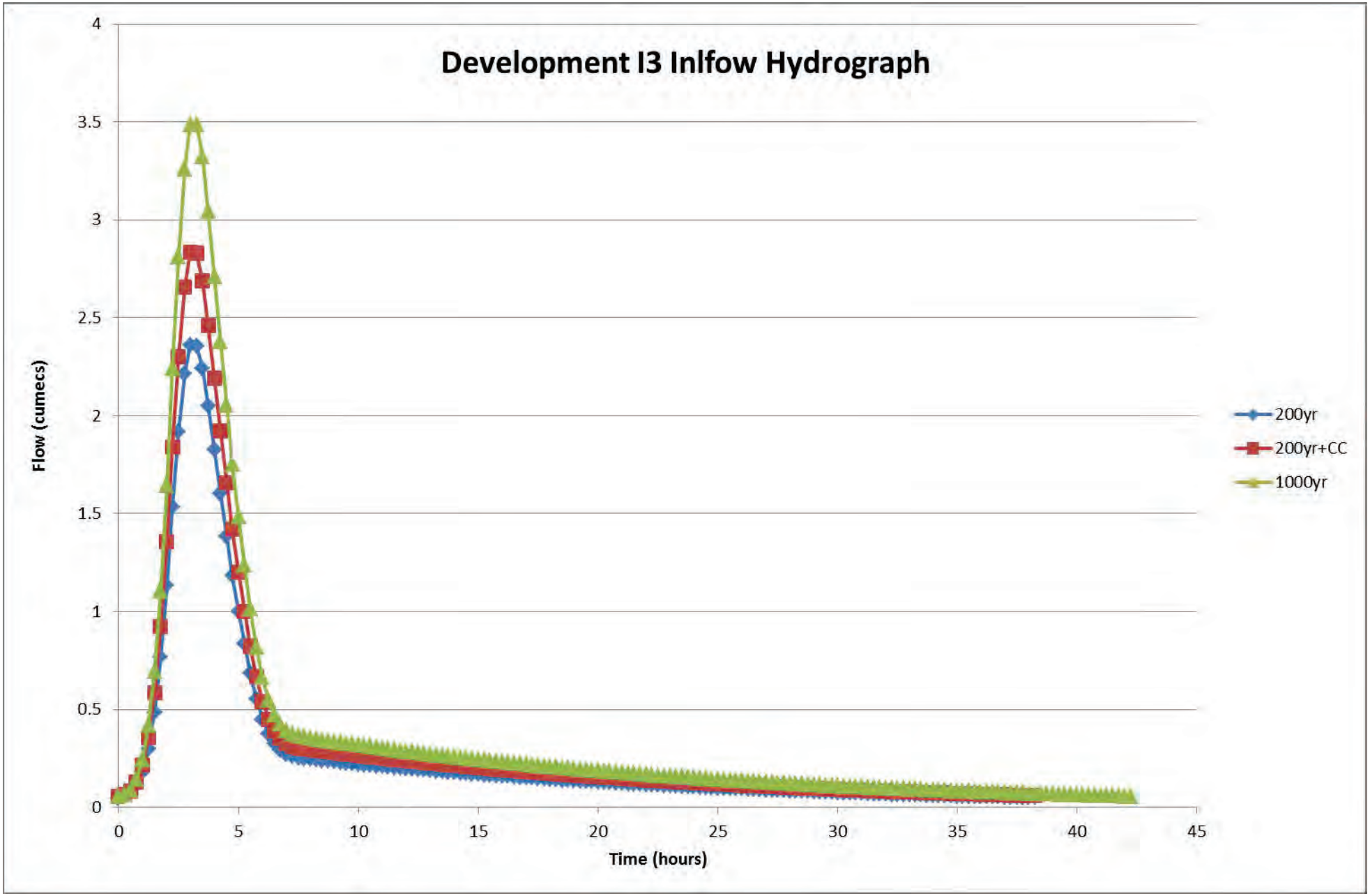
APPENDIX 02

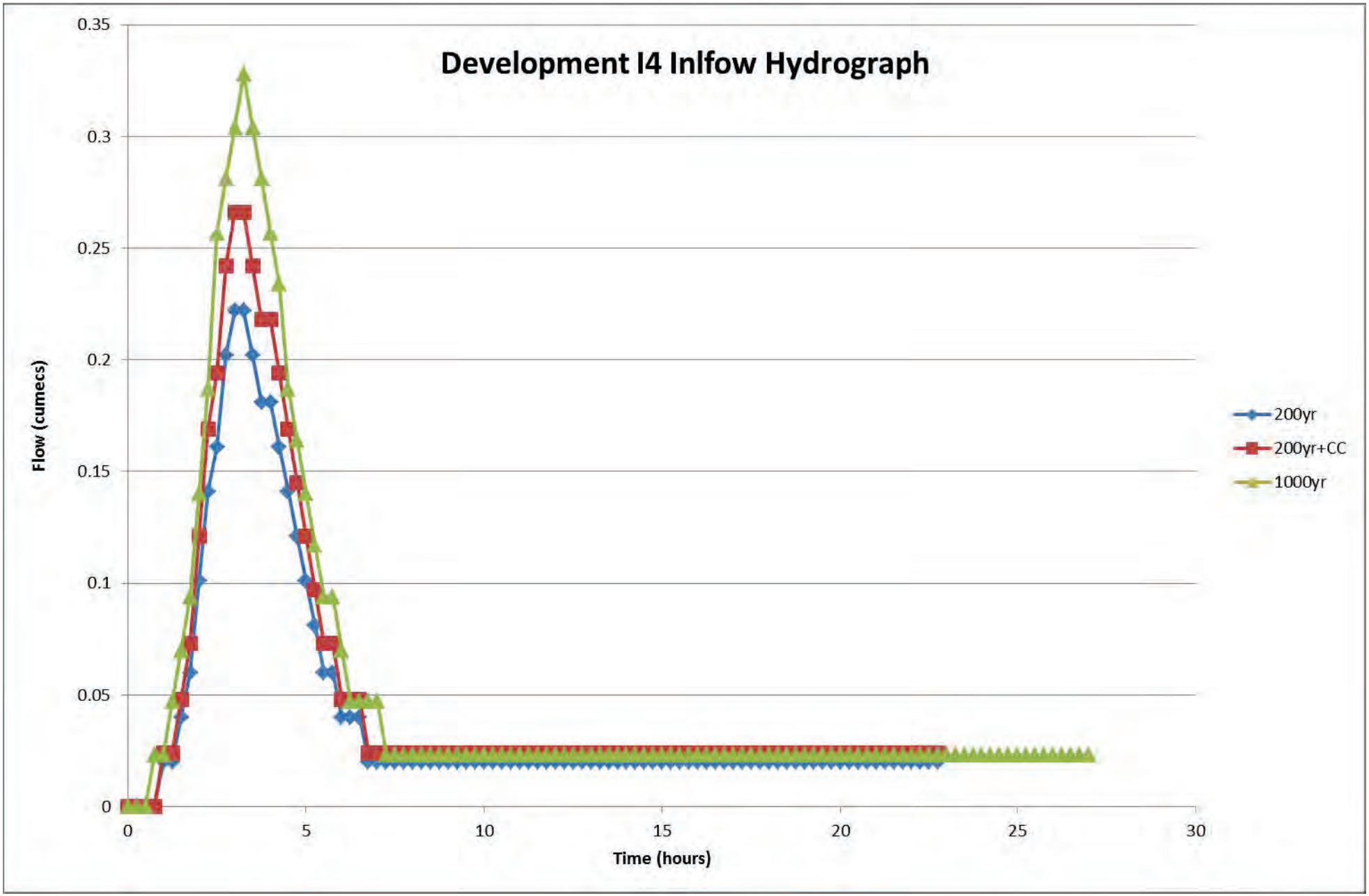
Development Model Inflow Hydrographs


Development I1a Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Development I1b Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
0.5
1
1.5
2
2.5
3
3.5
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Development I2 Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Development I3 Inlfow Hydrograph
Flow (cumecs)
Time (hours)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
30
35
40
45
200yr
200yr+CC
1000yr


Development I4 Inlfow Hydrograph
Flow (cumecs)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
Time (hours)
200yr
200yr+CC
1000yr