Affinity Water

AFW18 - Bespoke Performance Commitments

Contents

Definitions

Average Time Properties Experience Low Pressure

Average Time Properties Experience Low Pressure

Purpose: This performance commitment is designed to incentivise the company to improve water pressure for properties in areas below 15m head (in the distribution network) and reduce the time that those properties experience low pressure.

Benefits: This performance commitment improves the water pressure for properties in areas below 15m head and, as a consequence, reduces the number of customer complaints. This measure targets persistent low pressure, improving service to customers.

Version control [not required for initial submission, for completion at draft determinations]

Version	Date of issue	Performance commitment changes
0.1		
1.0		
2.0		

Performance commitment definition and parameters

Detailed definition of performance measure

The average time per property that water pressure is below 15 metres head in the distribution network. The company will include one-off incidents due to operational activity (planned maintenance, mains bursts, failure of network equipment).

The measurement will only consider data recordable on loggers with a 15 minute interval between readings. A low pressure reading will be where a logger indicates below 15m pressure at the associated number of properties for a minimum of four consecutive 15 minute intervals (i.e. 1 hour). Reporting will then be to the nearest 15 minutes.

Additional detail on measurement units

The measurement of performance will reset to zero at the start of each reporting year on 1 April. The company's performance will be measured by the company's Critical Point pressure loggers. The number of properties that experience low pressure will be calculated using the company's Geographical Information System (GIS) and modelling tools based on ground level difference from the logger. The time that pressure was below the threshold at the logger will be multiplied by the number of properties identified. The sum of these values will be divided by the number of properties covered by critical point loggers at year end to calculate the average per property.

The measurement is by the average pressure recorded on the logger for the duration of the low pressure event. All pressure readings and all property heights will be rounded to the nearest whole number.

The pressure measurement will be in metres (m).

Specific exclusions

The measure will exclude reductions in water pressure pursuant to authorisation made by an ordinary drought order or emergency drought order under Section 74 of the Water Resources Act 1991(as amended). At times of drought, actions undertaken to maintain security of water supply to the wider population will be excluded. However, asset failure or incorrect PRV operation at times of drought would not qualify for this exclusion.

Reporting and assurance

The company shall ensure that its outcome delivery incentive payments only relate to real performance changes and not definitional, methodological or data changes in performance commitments.

To avoid loggers being removed from service to manipulate figures, a minimum level of logging is required with the expectation of this increasing over time. Coverage will be

reported from the Compliance Checklist. If coverage falls below the levels below, the associated uplift in the reported PC measure will be applied as per Table 1. The uplift will be applied for the total number of days the reported coverage meets the criteria in Table 1 and it will be applied to the total time accumulated on each of those days.

Table 1 Impact of loss of logger coverage from the removal of loggers

Percentage of properties covered by a Critical Point logger	R/A/G Status	% increase to Reported Average Time Properties Experience Low Pressure
> 85%	Green	0%
80% - 85%	Amber	5%
< 80%	Red	10%

The Percentage of properties covered by critical point loggers is the percentage of total properties in the company's area

Additionally, logger failure will impact on the accuracy of the measure. For loggers in fault, an uplift will be applied. The average time that properties experience low pressure for the area represented by the failed logger from the last correctly reported 24 hour period will be applied to all days where the logger is in fault plus a 5% uplift. On return of the logger to in service status, the uplift will cease. For clarity, the calculation is shown in Figure 1. Meter faults will be reported as part of the Compliance Checklist.

Figure 1 Calculation for uplift attributed to loggers in fault

Average Time Properties Experience Low Pressure on a logger in fault = Last accurately 24 hour period of Average Time Properties Experience Low Pressure associated with the logger in fault x 1.05 x Number of days the logger is in fault

Logger status will be recorded monthly to ensure up to date reporting of coverage.

Annex 1: Compliance checklist

Table 2 Compliance checklist for Average Time Properties Experience Low Pressure

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
1	Coverage				
1a	Percentage of properties covered by a Critical Point logger				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
1b	Percentage of critical point loggers in fault				

Table 3 Definition parameters

Parameters	
Measurement unit and decimal places	Hours per property per year (hours:minutes:seconds) The denominator is the number of properties covered by critical point loggers
Measurement timing	Reporting year
Incentive form	Revenue
Incentive type	Underperformance Only
Timing of underperformance and outperformance payments	In-period
Price control allocation	100% water network plus
Frequency of reporting	Annual
Any other relevant information	n/a
Links to relevant external documents	n/a

Annex 1 Compliance Checklist

This annex sets out the criteria on which to report checklists where specified in the performance commitment definition.

Compliance for elements is reported against:

R	Not compliant with the guidance and having a material impact on reporting
A	Not compliant with the guidance and having no material impact on reporting
G	Fully compliant with the guidance

An overall RAG to be assigned for each component based on the following rules:
Compliance for overall components is reported against:

R	There are one or more red elements in the component, or the combined effect of amber elements is considered to produce a material impact.

A	Half or more of the elements in the component are amber and the combined effect of the amber elements is considered not to produce a material impact
G	More than half of the elements in the component are green

For each component on the checklist, and for the overall performance measure, the company will report a confidence grade. Confidence grades provide a reasoned basis for companies to qualify the reliability and accuracy of the data.

The company shall employ a quality assured approach in the methodology used to assign confidence grades, particularly if sampling techniques are in place. The confidence grade combines elements of reliability and accuracy, for example:

A2 – Data based on sound records etc. (A, highly reliable) and estimated to be within +/- 5% (accuracy band 2) Reliability and accuracy bands are shown in the tables below.

Reliability Band	Description
A	Sound textual records, procedures, investigations or analysis properly documented and recognised as the best method of assessment.
B	As A, but with minor shortcomings. Examples include old assessment, some missing documentation, some reliance on unconfirmed reports, some use of extrapolation.
C	Extrapolation from limited sample for which Grade A or B data is available.
D	Unconfirmed verbal reports, cursory inspections or analysis.

Accuracy band	Accuracy to or within +/-	But outside +/-
1	1%	-
2	5%	1%
3	10%	5%
4	25%	10%
5	50%	25%
6	100%	50%
X	Accuracy outside +/- 100 %, small numbers or otherwise incompatible (see table below)	

Certain reliability and accuracy band combinations are considered to be incompatible, and these are blocked out in the table below.

Compatible confidence grades	
Accuracy band	Reliability band

	A	B	C	D
1	A1			
2	A2	B2	C2	
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5			C5	D5
6				D6
X	AX	BX	CX	DX

Abstraction Incentive Mechanism (AIM)

Purpose: The purpose of this performance commitment is to incentivise the company to reduce abstraction from environmentally sensitive sites when flows or levels are low.

Benefits: The benefit of this performance commitment is that environmentally sensitive sites are preserved by reducing abstraction from them during lower levels or flows.

Version control [not required for initial submission, for completion at draft determinations]

Version	Date of issue	Performance commitment changes
0.1		
1.0		
2.0		

Performance commitment definition and parameters

Detailed definition of performance measure

The abstraction incentive mechanism (AIM) encourages water companies to reduce the environmental impact of abstracting water at environmentally sensitive sites in low flow periods (when flow or levels are below an agreed point otherwise known as a trigger). The trigger point is based on a groundwater level or river flow, below which the AIM is considered to be "switched on". This trigger will usually be related to the point at which the environment is under stress due to low flows and is intended to ameliorate the negative impacts and help leave more water in the environment during these times.

In 2016, we put forward 23 groundwater sources to be included in AIM, based on the perceived environmental sensitivity of the sources identified in previous studies. From these 23 sources, seven sources would be subject to Sustainability Reductions (SR) in AMP6, followed by an additional six sources in AMP7 as per our PR14 submission. The remainder 10 sources, have either an operating agreement in place (i.e. augmentation scheme) or other Licence condition or were subject to a National Environment Programme (NEP) investigation at the time.

From 2016 to date, eight sources have been subject to SRs, with the deployable output (DO) at four of these sites being reduced to zero Ml/d. These four sources were omitted from the AIM assessment at the time of the SR, in addition to the CHAL source, which was removed following discussions with the Environment Agency (EA). The AIM baseline figures were reduced for AMER, WHIH and MARL/PICC to reflect the AMP6 SRs and these figures have been agreed with the EA. PERI and RUNL will be removed from the AIM assessment from 2025/26 to reflect cessation of the sources from December 2024. FULL, which is aggregated with DIGS, will also be removed from the AIM assessment from 2025/26. See Table 1 for a summary of the number of sources assessed from AMP6 onwards. Therefore, the company has included 16 sources to be assessed under AIM for AMP8 (2025-30):

1. BRIC: The trigger threshold for this site is a flow of 13.0 Megalitres per day (Ml/day) in the River Colne at Berrygrove gauging station (EA station reference 2830TH), this groundwater abstraction has a baseline of 18.65 Ml/day. This source is aggregated with NETH at a combined AIM baseline of 37.16 Ml/d. A summary of the individual and combined AIM triggers is provided in Table 2.
2. NETH: The trigger threshold for this site is a flow of 13.0 Ml/day at the River Colne at Berrygrove gauging station (EA station reference 2830TH), this groundwater abstraction has a baseline of 18.51 Ml/day. This source is aggregated with BRIC at a combined AIM baseline of 37.16 Ml/d.
3. WELL: The trigger threshold for this site is a flow of 0.26 Ml/day in the River Hiz at Hitchin gauging station (EA station reference E24817), this groundwater

abstraction has a baseline of 0.84 Ml/d. There is no aggregation with OFFS and OUGH. WELL is located in a separate sub-catchment to OFFS and OUGH.

4. OUGH: The trigger threshold for this site is a flow of 0.26 Ml/day in the River Hiz at Hitchin gauging station (EA station reference E24817), this groundwater abstraction has a baseline of 4.43 Ml/day. This source is aggregated with OFFS at a combined AIM baseline of 5.03 Ml/d.
5. OFFS: The trigger threshold for this site is a flow of 0.26 Ml/day in the River Hiz at Hitchin gauging station (EA station reference E24817), this groundwater abstraction has a baseline of 0.6 Ml/day. This source is aggregated with OUGH at a combined AIM baseline of 5.03 Ml/d.
6. DIGS: The trigger threshold for this site is a flow of 18.66 Ml/day in the River Mimram at Panshanger gauging station (EA station reference 4790TH), this groundwater abstraction has a baseline of 1.5 Ml/d. The AIM baseline has been updated to reflect the post AMP7 sustainability reduction at average licence (1.5 Ml/d at DIGS).
7. HOLY: The trigger threshold for this site is a flow of 7.44 Ml/day in the River Ver at Colney Street gauging station (EA station reference 2819TH), this groundwater abstraction has a baseline of 7.39 Ml/day. The AIM baseline has been updated to reflect the post AMP7 sustainability reduction at average licence (7.39 Ml/d). This source is aggregated with MUDL at a combined AIM baseline of 9.39 Ml/d (7.39 Ml/d at HOLY and 2 Ml/d at MUDL= 9.39 Ml/d HOLY + MUDL combined).
8. MUDL: The trigger threshold for this site is a flow of 7.44 Ml/day in the River Ver at Colney Street gauging station (EA station reference 2819TH), this groundwater abstraction has a baseline of 2 Ml/day. The AIM baseline has been updated to reflect the post AMP7 sustainability reduction at average licence (2 Ml/d). This source is aggregated with HOLY at a combined AIM baseline of 9.39 Ml/d (2 Ml/d at MUDL and 7.39 Ml/d at HOLY= 9.39 Ml/d MUDL + HOLY combined).
9. MARL: The trigger threshold for this site is a flow of 32 Ml/day in the River Gade at Croxley Green gauging station (EA station reference 2849TH), this groundwater abstraction has a baseline of 8.34 Ml/day. This source is aggregated with PICC at a combined AIM baseline of 14.06 Ml/d.
10. PICC: The trigger threshold for this site is a flow of 32 Ml/day in the River Gade at Croxley Green gauging station (EA station reference 2849TH), this groundwater abstraction has a baseline of 5.72 Ml/day. This source is aggregated with MARL at a combined AIM baseline of 14.06 Ml/d.
11. AMER: The trigger threshold for this site is a flow of 5.53 Ml/day in the River Misbourne at Denham Lodge gauging station (EA station reference 2879TH), this groundwater abstraction has a baseline of 2 Ml/d. The AIM baseline has been updated to reflect the post AMP7 sustainability reduction at average licence (2 Ml/d).

12. WHIH: The trigger threshold for this site is a flow of 15.47 Ml/day in the River Beane at Hartham Park gauging station (EA station reference 4890TH), this groundwater abstraction has a baseline of 2 Ml/d.

SLIP: The trigger threshold for this site is a flow of 2.55 Ml/day and in the River Rhee at Ashwell gauging station (EA station reference 033040), this groundwater abstraction has a moving AIM baseline (95% of licensed abstraction), see

13. Table 3.
14. SPRI: The trigger threshold for this site is a flow of 18.06 Ml/day in the River Dour at Crabble Mill gauging station (EA station reference E5080), this groundwater abstraction has a baseline of 2.5 Ml/day. This source is aggregated with SBUC at a combined AIM baseline of 6 Ml/d.
15. SBUC: The trigger threshold for this site is a flow of 18.06 Ml/day in the River Dour at Crabble Mill gauging station (EA station reference E5080), this groundwater abstraction has a baseline of 4.0 Ml/d. This source is aggregated with SPRI at a combined AIM baseline of 6 Ml/d.
16. SDNG: The trigger threshold for this site is 1.78 metres above Ordnance Datum and it has a baseline of 6.0 Ml/d.

Table 1. Sources operated under AIM from 1 April 2016 with AMP6 and AMP7 sustainability reductions

	Source	AIM site as of Apr 2025 (Yes/No)	AMP6 SR	AMP7 SR
NEP further sites	NETH	Yes	No	No
	BRIC	Yes	No	No
AMP5 sustainability operating agreements	OUGH	Yes	No	No
	SLIP	Yes	No	No
	WELL	Yes	No	No
	OFFS	Yes	No	No
	SPRI	Yes	No	No
	SBUC	Yes	No	No

	Source	AIM site as of Apr 2025 (Yes/No)	AMP6 SR	AMP7 SR
	SDNG	Yes	No	No
AMP6 Sustainability reduction sites	BOWB	No- removed in AMP6	Yes	N/A
	AMER	Yes	Yes	Yes
	WHIH	Yes	Yes	No
	FULL	No (aggregated with DIGS- to be removed as an AIM source from AMP8)	Yes	No
	MARL	Yes	Yes	No
	PICC	Yes	Yes	No
	HUGH	No- removed in AMP6	Yes	N/A
AMP7 planned Sustainability reduction sites	DIGS	Yes	No	Yes
	HOLY	Yes	No	Yes
	MUDL	Yes	No	Yes
	PERI	No- to be removed as an AIM source from AMP8	No	Yes
	RUNL	No- to be removed as an AIM source from AMP8	No	Yes
	CHES	No- removed at point of voluntary SR	No	Yes
Removed from AIM list in AMP6	CHAL	No	No	N/A

Table 2. AIM Baseline Abstraction

Source	Catchment	Combined AIM baseline (Ml/d)	AIM baseline (Ml/d)
BRIC	Colne	37.16	18.65
NETH			18.51
WELL	Hiz	0.84	0.84
OUGH		5.03	4.43
OFFS			0.60
DIGS (aggregated with FULL)	Mimram	3.5	3.5
HOLY	Ver	9.39	7.39
MUDL			2
MARL	Gade	14.06	8.34
PICC			5.72
AMER	Misbourne	2.00	2.00
WHIH	Beane	2.00	2.00
SLIP	Rhee	95% of licensed abstraction	95% of licensed abstraction
SPRI	Dour	6.50	2.50
SBUC			4.00
SDNG	Denge	6.00	6.00

Table 3. Moving Baseline at SLIP source

Flow at Ashwell Gauging Station at National Grid Reference TL 267 401 in litres per second	Flow (Ml/d)	Maximum Daily Abstraction rate in Ml/d	Proposed AIM trigger (95 % of Licensed volume)
Flows above 29.46	Above 2.55	Up to 6.82	
Between 28.95 and 29.46	Between 2.50 and 2.55	5.46	5.18
Between 28.41 and 28.94	Between 2.45 and 2.50	5	4.75

Flow at Ashwell Gauging Station at National Grid Reference TL 267 401 in litres per second	Flow (Ml/d)	Maximum Daily Abstraction rate in Ml/d	Proposed AIM trigger (95 % of Licensed volume)
Between 27.90 and 28.40	Between 2.41 and 2.45	4.55	4.32
Between 27.36 and 27.89	Between 2.36 and 2.41	4.09	3.89
Between 26.83 and 27.35	Between 2.32 and 2.36	3.64	3.46
Between 26.32 and 26.82	Between 2.27 and 2.32	3.18	3.02
Between 25.78 and 26.31	Between 2.23 and 2.27	2.73	2.59
Between 25.27 and 25.77	Between 2.18 and 2.23	2.27	2.16
Between 24.74 and 25.26	Between 2.14 and 2.18	1.82	1.73
Between 24.20 and 24.73	Between 2.09 and 2.14	1.36	1.3
Between 23.69 and 24.19	Between 2.05 and 2.09	0.91	0.86
Between 23.15 and 23.68	Between 2.00 and 2.05	0.46	0.43
Less than 23.15	Less than 2	0	0

Data sources

River flow data

The river flow data is monitored by the EA on a continuous basis through the gauging stations. It is calculated from 9am to 9am and the average daily value is applied for the AIM assessment. Verification of the data by the EA is completed within 3 days to 12 months dependent on the validation category of the gauging station. Therefore, most of the flow data will be verified by the time of the annual reporting, but there is potential that the last month of data may not be validated on time. To mitigate this risk, we undertake our own manual checks of the data, so we can infill missing data over a short period if required, query data with the EA and undertake basic QA checks. In addition, the AIM calculation is not always sensitive to absolute flow values. River flows are typically above the AIM flow trigger in March, apart from in a severe drought, so small inaccuracies in the flow data do not pose a risk to reporting.

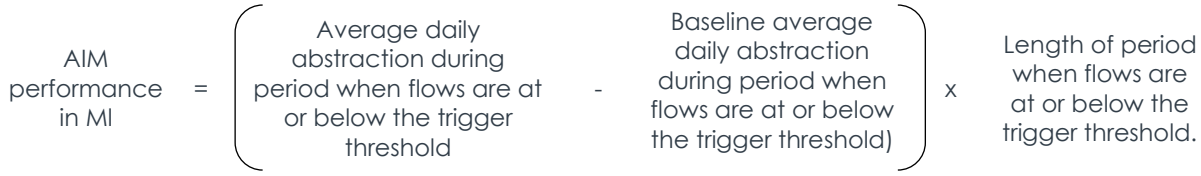
Abstraction data

The daily abstraction data is managed by the Control Operations team. The daily total is calculated from midnight to midnight on our Serck telemetry system. The data is then routinely reviewed and inputted into an internal spreadsheet. The data is then quality assured and signed off by the Operational controller before being submitted to the EA at the end of each financial year. This data is also used for the annual reporting for AIM. The abstraction flowmeters are calibrated at the point of purchase from the manufacturer and then verified in line with our flowmeter maintenance procedure. Their accuracy is also checked by the EA through compliance inspections.

Additional detail on measurement units

AIM performance is measured in megalitres (Ml) and is equal to the average daily abstraction during the period when flows are at or below the trigger threshold minus the baseline average daily abstraction during the period when flows are at or below the trigger threshold, multiplied by the length of the period when flows are at or below the trigger threshold.

Figure 1 AIM Calculation



For example, in the circumstance that the AIM baseline is 5 Ml/day and the company abstracts an average of 4 Ml/day from the abstraction source when river flows are below the trigger threshold, then if flows are below the threshold for 100 days, the company has an improved performance relative to the baseline of (4 Ml/day minus 5 Ml/day)*100 days = -100 Ml. A negative number signifies an improved performance as average abstraction is less than the baseline.

Specific exclusions

Drought permits are additional sources of water which water companies can draw upon during severe drought conditions. Use of these sources is permitted following application to the Environment Agency, to help maintain supplies for customers. Five of our sources assessed under the AIM are also drought permit sources (Amersham, Piccotts End, Fulling Mill, Whitehall and Buckland Mill).

The company will suspend assessment of the AIM in all supply regions if a drought order or permit has been granted by the Environment Agency. We consider it inappropriate for AIM to apply whilst a drought permit/order is active, as we would be experiencing an unprecedented supply risk. As the permit/order would be considered a last resort, any available sources of water would be being used to meet demand rather than for the AIM.

Reporting and assurance

The company shall ensure that its outcome delivery incentive payments only relate to real performance changes and not definitional, methodological or data changes in performance commitments.

Contextual information around AIM performance is provided in the annual reports. We plan to continue producing these annual reports in AMP8 which will be available on the Affinity Water website.

The AIM data (river flow, abstraction and groundwater level data) is assured through the Annual Performance Report (APR) process.

Compliance checklist

The company shall complete the checklist below and report to Ofwat if any element is not green. Where an element is not green, we may intervene to protect customers and ensure that the company does not benefit from insufficient data quality. See Annex 1 for assessment rules for each element.

Table 4 Compliance checklist for Abstraction Incentive Mechanism (AIM)

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
1	River flow data				
1a	Daily river flow data (average calculated by the EA from 9am to 9am) is required for the AIM assessment calculation.				
1b	Pre and post data is used to infill missing data if it occurs over a short period, and expert judgement applied when required.				
1c	Any suspect or missing data is recorded in a QA spreadsheet (one spreadsheet per AIM source),				
2	Daily abstraction data				
2a	Daily abstraction data (calculated as midnight to midnight for all sources under AIM) is required for the AIM assessment calculation.				

	Component / Element	Component R/A/G	Element R/A/G	Reason for any non-compliant component	Confidence grade
2b	All flow meters are required to be accurate within ±5% as per EA guidance (https://www.gov.uk/guidance/water-abstraction-how-to-make-sure-your-meter-is-accurate), and any flow meters that do not pass the calibration test will be replaced in a timely manner, as per our flow meter maintenance procedure.				
2c	Daily abstraction data is routinely checked and quality assured for the annual returns.				
2d	Instantaneous flow readings are available on our telemetry system for verification purposes.				

Table 5 Definition parameters

Parameters	
Measurement unit and decimal places	Megalitres to zero decimal places
Measurement timing	Reporting year
Incentive form	Revenue
Incentive type	Underperformance and outperformance
Timing of underperformance and outperformance payments	In-period
Price control allocation	100% water resources
Frequency of reporting	Annual
Any other relevant information	n/a
Links to relevant external documents	n/a

Annex 1 Compliance Checklist

This annex sets out the criteria on which to report checklists where specified in the performance commitment definition.

Compliance for elements is reported against:

A1 R	A2 Not compliant with the guidance and having a material impact on reporting
A3 A	A4 Not compliant with the guidance and having no material impact on reporting
A5 G	A6 Fully compliant with the guidance

An overall RAG to be assigned for each component based on the following rules:
Compliance for overall components is reported against:

A7 R	A8 There are one or more red elements in the component, or the combined effect of amber elements is considered to produce a material impact.
A9 A	A10 Half or more of the elements in the component are amber and the combined effect of the amber elements is considered not to produce a material impact
A11 G	A12 More than half of the elements in the component are green

For each component on the checklist, and for the overall performance measure, the company will report a confidence grade. Confidence grades provide a reasoned basis for companies to qualify the reliability and accuracy of the data.

The company shall employ a quality assured approach in the methodology used to assign confidence grades, particularly if sampling techniques are in place. The confidence grade combines elements of reliability and accuracy. The confidence grade for AIM is as follows:

A2 - The river flow and abstraction data are based on sound records etc. (A, highly reliable) and estimated to be within +/- 5% (accuracy band 2). The river flow data from the EA must be validated within a certain period as specified by the data validation category. A grading is provided for each flow value and any suspect data will be flagged. The daily abstraction is routinely checked and the instantaneous flow data is available on our telemetry system for additional checks if required. The abstraction flow meters should be accurate within +/- 5% as these are the parameters required to pass the flow meter calibration.

Reliability and accuracy bands are shown in the tables below.

Reliability Band	Description

A	Sound textual records, procedures, investigations or analysis properly documented and recognised as the best method of assessment.
B	As A, but with minor shortcomings. Examples include old assessment, some missing documentation, some reliance on unconfirmed reports, some use of extrapolation.
C	Extrapolation from limited sample for which Grade A or B data is available.
D	Unconfirmed verbal reports, cursory inspections or analysis.

Accuracy band	Accuracy to or within +/-	But outside +/-
1	1%	-
2	5%	1%
3	10%	5%
4	25%	10%
5	50%	25%
6	100%	50%
X	Accuracy outside +/- 100 %, small numbers or otherwise incompatible (see table below)	

Certain reliability and accuracy band combinations are considered to be incompatible, and these are blocked out in the table below.

Compatible confidence grades				
Accuracy band	Reliability band			
	A	B	C	D
1	A1			
2	A2	B2	C2	
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5			C5	D5
6				D6
X	AX	BX	CX	DX

Whole Life Carbon

Purpose: This performance commitment is designed to incentivise the company to reduce the whole life carbon impact of our capital works.

Benefits: This performance commitment supports the mitigation of the impact on the environment by reducing whole life carbon from the delivery of capital projects.

Version control [not required for initial submission, for completion at draft determinations]

Version	Date of issue	Performance commitment changes
0.1		
1.0		
2.0		

Performance commitment definition and parameters

Detailed definition of performance measure

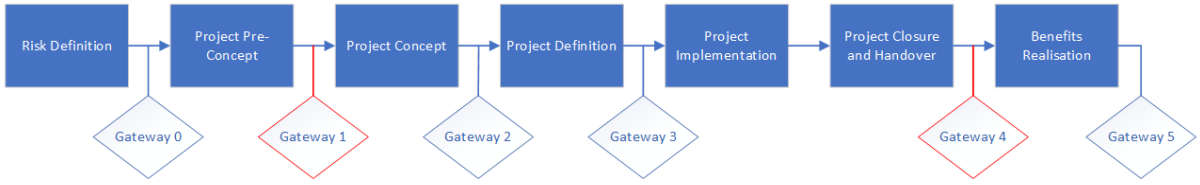
Percentage reduction in whole life carbon emissions arising from capital works from a baseline defined at the Gateway 1 project stage.
At the Pre-Concept stage of a project (Gateway 1), a scope will be defined which will deliver the defined needs for the project. An estimate of the whole life carbon of this scope will be calculated and recorded at this stage and form the baseline figure for the project.

The 'as built' design and construction activities at Project Closure and Handover (Gateway 4) and design estimates for operational emissions will be used to calculate the whole life carbon for the project.

Whole life carbon will consist of:

- Embedded emissions for construction and construction activities
- Operational emissions over a 20 year asset life span:
    - Energy
    - Chemicals

Figure 1: Affinity Water Project Lifecycle



If any changes to the defined need are made after Gateway 1 which requires a re-design a revised carbon estimate will be made, and the baseline will be updated accordingly. Changes of this nature will be recorded by formal change control processes.

Any projects which pass Gateway 1 but do not proceed to Gateway 4 will be removed from the Performance Commitment and no change will be recorded.

Additional detail on measurement units

All estimations of emissions will be calculated in Tonnes of CO2e (TCO2e).

Specific exclusions

Only new build capital delivery projects will be included in the calculation of this performance commitment. To allow sufficient scope to deliver tangible benefits, projects will only be considered above a Capex value of £250,000 based on the Latest Best Estimate at Gateway 1.

For clarity, the following activities will be excluded:

- Operational maintenance
- Minor works
- Reactive maintenance
- Estates and Facilities
- IT

For emissions calculations, decommissioning and disposal will be excluded. Operational emissions will be calculated over a 20 year life time of assets.

Reporting and assurance

The company shall ensure that its outcome delivery incentive payments only relate to real performance changes and not definitional, methodological or data changes in performance commitments.

To ensure incentives through action rather than reporting, emissions figures used will be estimated using the emissions factors from 2021-22. This aligns with the Performance Commitment for Operational GHG Emissions (Water). If new products become available which offer an improved embedded emissions value but have not been assigned a 2021-22 emissions factor then the PC will use the earliest available emissions factor.

All emissions estimations will be carried by an internal team independent from the Capital Delivery function and will follow the guidance set out in PAS2080. Estimations and reporting will be subject to third party assurance.

For reporting, the percentage change in whole life carbon emissions will be recorded in the reporting year which the Gateway 4 is passed for each specific project. As a result, projects will only contribute change to the metric in a single reporting year.

Baselining of projects will begin in 2025-26 for all relevant projects passing through Gateway 1 in the year, with the first changes to be reported in 2026-27.

For all projects passing Gateway 4 in a given reporting year, the baseline and actual figures will be respectively summed and a percentage change from baseline calculated. The calculation will be as below:

$$\text{Percentage reduction in Whole Life Carbon} = \frac{\sum \text{TCO2e at Gateway 1} - \sum \text{TCO2e at Gateway 4}}{\sum \text{TCO2e at Gateway 1}} \times 100$$

Where;

∑ TCO2e at Gateway	=	Embedded Emissions (TCO2e)	+	Emissions for energy for 20 year lifespan (TCO2e)	+	Emissions for chemicals for 20 year lifespan (TCO2e)

Table 1 Definition parameters

Parameters	
Measurement unit and decimal places	Percentage reduction in whole life carbon emissions to two decimal places
Measurement timing	Reporting year
Incentive form	Revenue
Incentive type	Underperformance and outperformance
Timing of underperformance and outperformance payments	In-period
Price control allocation	15% water resources, 85% water network plus
Frequency of reporting	Annual
Any other relevant information	N/A
Links to relevant external	N/A

Development of Outcome Delivery Incentive Rates

We have followed the guidance from Technical methodology for the ODI rates for Low Pressure and Abstraction Incentive Mechanism, using customer valuations :

ICS

Technical Note
Affinity Water:
Bespoke ODI Valuations
July 2023

1 Purpose of this note

This technical note provides details of the calculated valuations for Affinity's PR24 bespoke Performance Commitments (PCs).

The note covers two bespoke PCs:

- Low Pressure; and
- AIM/ Low Flow Rivers.

The valuations for the bespoke PCs are derived using the outputs of the triangulation exercise of customer willingness to pay (WTP) data undertaken by ICS for Affinity Water. This triangulated data is now updated with the outputs of the PR24 WTP research (WP5) undertaken by EFTEC for Affinity Water, where applicable.[1]

The triangulated values are combined with other data sources/assumptions to map the valuations to the PC units (as described below).

2 Low Pressure

2.1 Definition of the PC

This performance commitment is designed to incentivise the company to improve water pressure for properties in areas below 15m head (in the distribution network) and reduce the time that those properties experience low pressure. The units for the PC are defined as the average time (hh:mm:ss) per property that water pressure is below 15 metres head.

2.2 Primary valuation data

The primary valuation data used was for Persistent Low Pressure (£ per property impacted per year). The triangulated annual marginal benefit value for this primary measure (with lower and upper bounds) is provided in Table 1 below.

Table 1: Primary benefit valuation for Persistent Low Pressure

Measure	Unit	Lower Bound Value	Central Value	Upper Bound Value
Persistent Low Pressure	1 property affected	£2,899	£6,379	£9,859

This measure is defined as the "*Number of properties each year experiencing low pressure all the time*".

[1] The full outputs of the triangulations used for the purposes of this note are provided in the workbook <230330 Service Measure Framework v1.1.xlsx>, see tab <ICSValueSummary>.

2.3 Assumptions for valuation mapping

For the purposes of mapping to the PC units of minutes a simple conversion factor was applied. This conversion factor reflects the "all the time" definition of the primary valuation measure. A conversion factor of 525,600 is assumed which equals the number of minutes per year (= 60 minutes x 24 hours x 365 days).

2.4 Bespoke PC valuation

Dividing the benefit values in Table 1 by this conversion factor gives the benefit values (£ per minute per property) for this bespoke PC. The values are presented in Table 2 below.

Table 2: Marginal benefit valuation for Low Pressure PC

Performance Commitment	Unit	Lower Bound Value	Central Value	Upper Bound Value
Low Pressure	1 minute per property	£0.006	£0.012	£0.019

We recommend using the central values, with the lower and upper bounds available for sensitivity testing as required.

3 AIM / Low Flows

3.1 Definition of the PC

The purpose of this PC is to incentivise the company to reduce abstraction from environmentally sensitive sites *when* flows or levels are low. The unit of the PC is defined as the megalitres (Ml) of water abstracted below the baseline at times when low river flow triggers are active.

3.2 Primary valuation data

Our starting point for this bespoke PC valuation is the primary valuation data available for Low Flow Rivers (£ per mile of river length). This primary valuation represents the customer value associated with reducing low flows per mile of river length. In the Affinity Water WTP studies (included in the triangulations) this primary measure is described as:

> *"Rivers are impacted by Affinity Water as well as other sectors, including farming and industry.*
>
> *Removal of water for drinking water supply can cause low water levels and flow in rivers.*
>
> *This can cause an adverse impact on appearance, recreational use of the river and habitats for plants and wildlife.*
>
> *Affinity Water can invest to reduce this impact, which can contribute to an overall improvement in the quality of the rivers."*

The triangulated annual marginal benefit value for this primary measure (with lower and upper bounds) is provided in Table 3 below.

Table 3: Primary benefit valuation for AIM / Low Flow Rivers

Measure	Unit	Lower Bound Value	Central Value	Upper Bound Value
Low Flows	1 mile of river	£156,929	£443,755	£730,582

3.3 Assumptions for valuation mapping

The mapping of this primary valuation makes use of river flow data and river lengths (miles) for rivers located in the Affinity Water operating areas.

River flow data was sourced from https://environment.data.gov.uk/hydrology/explore for the years 2018 to 2022. This data was analysed to provide by river and by year a measure of average daily flows (in megalitres) covering:

- Baseline flows - measured as the annual average daily flow;
- Low flows – measured as the average daily flow during the months of May to September. This period was selected as the typical period when low river flows are most likely; and
- Deviation in average daily flows between baseline and low flow periods.

This flow data is presented in Table 4, Table 5 and Table 6. Table 6 is calculated as the difference between the values by river and year in Table 4 (baseline flows) and Table 5 (low flow period).

In these tables, the average flow in Ml is the average daily flow per river. It is averaged across a number of monitoring stations on each river length and the conversion assumes that the same average daily flow is supported across each unit of river length.

Total river capacity is represented as "River miles x River flows (unit = ML miles)" and total value of rivers is represented as "River miles x River Unit Value (£ per mile)". This total river value based on miles is converted to river value per Ml of flow capacity as follows:

Total river value / total river flow capacity

=

*(River miles * River unit value (per mile)) / (River miles * River flows)*

=

River unit value (per mile) / River flow capacity

The deviation between average flows in low flow periods compared to baseline period is used as the measure of the change in flow capacity during low flow periods.

The conversions used for the calculation of the bespoke PC valuation are based on the 5 year average daily flows (below baseline) supported across the Affinity river lengths in total (i.e. the value of 326.2 ML in Table 6).

Table 4: Annual average (daily) river flows by river and year - used as baseline flow

River	Season	2018 (Ml)	2019 (Ml)	2020 (Ml)	2021 (Ml)	2022 (Ml)	5 yr average	Max Daily Flow (Mld) - Summer Period	Min Daily Flow Mld - Summer Period	River Lengths (miles)
Brett	All Year	22.2	49.2	92.5	74.9	27.9	54.0	92.5	22.2	25.9
Dour	All Year	34.8	33.1	51.4	55.1	26.8	40.6	55.1	26.8	3.7
Rib	All Year	13.0	14.0	33.0	33.4	21.4	23.7	33.4	13.0	19.3
Ash	All Year	14.3	15.9	23.5	23.9	21.2	20.1	23.9	14.3	6.2
Beane	All Year	36.1	33.4	38.5	46.4	40.4	39.3	46.4	33.4	11.1
Chelmer	All Year	62.4	67.9	143.8	132.0	56.6	96.0	143.8	56.6	40.5
Chess	All Year	29.4	22.6	49.5	49.5	32.9	37.3	49.5	22.6	11.2
Colne	All Year	101.3	102.3	144.7	161.6	119.4	127.7	161.6	101.3	11.2
Gade	All Year	30.8	23.7	57.3	69.6	38.9	45.0	69.6	23.7	15
Ivel	All Year	161.4	179.4	295.0	328.7	203.6	238.7	328.7	161.4	15.6
Lea	All Year	215.0	159.7	280.3	312.0	130.7	225.0	312.0	130.7	42.4
Mimram	All Year	15.1	10.7	26.3	36.5	19.8	22.2	36.5	10.7	12.5
Misbourne	All Year	7.1	7.3	18.7	26.4	13.4	14.0	26.4	7.1	16.8
Ver	All Year	5.5	5.7	18.7	32.0	13.7	15.8	32.0	5.5	12.5
Totals		**748.2**	**725.0**	**1273.1**	**1382.0**	**767.0**	**999.4**	**1411.4**	**629.4**	**243.9**

Source: ICS Calculations from https://environment.data.gov.uk/hydrology/explore

Table 5: Average daily flows by river and year during "low flow" season (months of May to September)

River	Season	2018 (Ml)	2019 (Ml)	2020 (Ml)	2021 (Ml)	2022 (Ml)	5 yr average	Max Daily Flow (Mld) - Summer Period	Min Daily Flow Mld - Summer Period	River Lengths (miles)
Brett	Low Flow (May to Sept)	23.2	15.6	18.9	21.3	9.9	17.3	23.2	9.9	25.9
Dour	Low Flow (May to Sept)	43.0	25.1	40.1	44.3	20.1	34.5	44.3	20.1	3.7
Rib	Low Flow (May to Sept)	13.8	7.8	12.2	16.9	10.4	12.2	16.9	7.8	19.3
Ash	Low Flow (May to Sept)	14.6	13.6	15.3	18.6	16.0	15.6	18.6	13.6	6.2
Beane	Low Flow (May to Sept)	36.5	30.0	31.4	39.3	35.5	34.6	39.3	30.0	11.1
Chelmer	Low Flow (May to Sept)	31.2	28.3	31.7	55.8	18.3	33.8	55.8	18.3	40.5
Chess	Low Flow (May to Sept)	32.9	21.7	45.7	47.6	31.3	35.8	47.6	21.7	11.2
Colne	Low Flow (May to Sept)	103.3	89.4	120.7	145.3	107.3	113.5	145.3	89.4	11.2
Gade	Low Flow (May to Sept)	33.7	20.1	48.3	57.7	32.6	38.5	57.7	20.1	15
Ivel	Low Flow (May to Sept)	159.2	120.2	147.4	196.8	117.0	148.1	196.8	117.0	15.6
Lea	Low Flow (May to Sept)	157.7	108.4	146.9	232.2	70.1	147.5	232.2	70.1	42.4
Mimram	Low Flow (May to Sept)	16.7	8.5	20.9	29.8	16.0	18.4	29.8	8.5	12.5
Misbourne	Low Flow (May to Sept)	7.8	5.1	14.0	21.0	10.6	11.0	21.0	5.1	16.8
Ver	Low Flow (May to Sept)	5.1	4.7	14.5	26.5	10.2	12.3	26.5	4.7	12.5
Totals		**678.7**	**498.7**	**708.0**	**953.1**	**505.2**	**673.3**	**955.0**	**436.5**	**243.9**

Source: ICS Calculations from https://environment.data.gov.uk/hydrology/explore

Table 6: Average daily flows by river and year during "low flow" season (months of May to September)

River	Season	2018 (Ml)	2019 (Ml)	2020 (Ml)	2021 (Ml)	2022 (Ml)	5 yr average	Max Deviation	Min Deviation	River Lengths (miles)
Brett		-1.0	33.6	73.5	53.5	18.0	36.6	73.5	-1.0	25.9
Dour		-8.3	7.9	11.3	10.9	6.7	6.1	11.3	-8.3	3.7
Rib		-0.8	6.2	20.8	16.5	11.0	11.5	20.8	-0.8	19.3
Ash		-0.4	2.3	8.2	5.3	5.2	4.5	8.2	-0.4	6.2
Beane		-0.4	3.4	7.1	7.1	4.9	4.7	7.1	-0.4	11.1
Chelmer		31.2	39.5	112.1	76.2	38.3	62.2	112.1	31.2	40.5
Chess		-3.6	0.9	3.9	1.9	1.6	1.5	3.9	-3.6	11.2
Colne		-2.0	12.9	24.0	16.4	12.1	14.2	24.0	-2.0	11.2
Gade		-2.9	3.6	8.9	11.9	6.3	6.5	11.9	-2.9	15
Ivel		2.2	59.3	147.6	131.9	86.6	90.6	147.6	2.2	15.6
Lea		57.2	51.4	133.3	79.9	60.6	77.5	133.3	51.4	42.4
Mimram		-1.6	2.2	5.4	6.7	3.8	3.8	6.7	-1.6	12.5
Misbourne		-0.7	2.1	4.7	5.4	2.9	3.0	5.4	-0.7	16.8
Ver		0.5	1.0	4.2	5.4	3.6	3.5	5.4	0.5	12.5
Totals		**69.6**	**226.4**	**565.1**	**428.9**	**261.7**	**326.2**	**571.2**	**63.7**	**243.9**

Source: ICS Calculations

3.4 Bespoke PC valuation

Dividing the benefit values in Table 3 by the 5 year average conversion factor of 326.2 Ml (see Table 6) gives the benefit values (£ per Ml) for this bespoke PC. The values are presented in Table 7 below.

Table 7: Marginal benefit valuation for AIM/Low FLow PC

Performance Commitment	Unit	Lower Bound Value	Central Value	Upper Bound Value
AIM/Low Flows	£ per Ml	£481	£1,361	£2,240

We recommend using the central values, with the lower and upper bounds available for sensitivity testing as required.

Using the guidance laid out in PR24: Assessment of bespoke performance commitment proposals (July 2023), for the development of the marginal benefit rate for Whole Life Carbon. We have used an approach that is broadly consistent with the top-down approach used to set the indicative ODI rates.

We have used 0.3% RoRE as the amount at risk for this performance commitment to give an appropriate weighting when compared with the common performance commitments. Using this value, we have reviewed our targets and our expected P90/P10 positions to give a £ per % ODI rate for Whole Life Carbon.

Outcome	RoRE at Risk %	RoRE at Risk	PC Unit at risk	P90 (25/26)	P50 (25/26)	P10 (25/26)	Incentive Rate £m
Whole Life Carbon	0.3%	£2.24m	±8%	17.5%	9.5%	1.5%	0.28

In the longer term, once we have more maturity in measuring and improving our whole life carbon, we would look to move to a valuation of a Tonne of CO2e consistent with embedded or operational carbon. Therefore, the ODI rate for Whole Life Carbon will match the ODI rate for the Operational GHG Emissions – Water PC once published by Ofwat.

Response to Ofwat Feedback

We have reviewed all feedback received from Ofwat in the development of our Bespoke Performance Commitment Definitions. Our response is summarised in the tables below.

Average Time Properties Experience Low Pressure

Ofwat Feedback		Affinity Water Response
Structure	**Feedback/Observation**	
Purpose	*The statement provided is sufficiently clear.*	n/a
Benefits	*The statement currently states the benefit to the company e.g. 'reduces the number of complaints'. You should amend the statement to be more focused on the benefits to the customer.*	Definition updated
Detailed definition of performance measure	*In general, this section is sufficiently clear, although it may add further clarity to include a formula.*	n/a
Additional detail on measurement units	*The units for pressure readings and property heights should be specified.*	Definition updated
Specific exclusions	*You have added an exclusion for customer complaints about low pressure, to avoid double counting with the C-Mex measure. C-Mex is a qualitative measure whereas this PC and other common PCs that include customer contacts are quantitative measures. Also, C-Mex is based on sample data, whereas this PC would capture all contacts. We do not consider that there is an overlap and recommend that you remove this exclusion from the definition.*	C-Mex references removed from definition

	We consider that the exclusion for drought orders, including clarity about asset or operational failures, appears reasonable. If drought orders are in place, it may be appropriate to reduce pressure for some, in order to ensure all customers receive supply, even if it is at a lower pressure.	N/a
Reporting and assurance	*You include a reporting adjustment to increase the reported value if the logger numbers fall below 85% coverage of all properties. We do not understand how you have derived the adjustment. Please explain:* - *how 85% compares to the actual logger coverage and why 85% has been chosen as the trigger value for the adjustment;* - *why the % increase values have been chosen as 5 and 10%; and* - *explain why the % increase adjustment remains the same if logger % coverage falls to any level below 80%.*	We have looked to create a definition that gives sufficient protection to customers. 85% represents our actual level of logger coverage, so this mechanism is to protect against falling logger coverage and to ensure comparative logger coverage if this definition were to be used wider. If logger coverage is below 80%, this would be reported as red through our formal reporting processes. 10% is deemed sufficiently penalising and would motivate action to resolve without further performance or financial penalty. This approach was assured by third party auditors at the time of definition submission.
	We recommend that it is clarified in the definition whether the 'percentage of properties covered by critical point loggers' is the percentage of total properties in the company's area or not.	A statement has been added for clarity.
	The definition should be clear that significant changes in this value will be highlighted in its annual returns and the impact on reporting quantified.	This would be captured through the above mechanism and is covered in the Compliance Checklist

Overall observations	*Based on the information that has been submitted to date, in our initial feedback we said that this measure was potentially suitable as a bespoke PC because:* - *it could lead to significant additional benefit for customers;* - *it is outcome focused; and* - *there are no overlaps with other PCs.* *It also represents a continuation of a PR19 measure, which means reporting methodologies are established.*	n/a

Abstraction Incentive Mechanism

Ofwat Feedback		Affinity Water Response
Structure	**Feedback/Observation**	
Purpose	*The statement provided is unchanged from PR19 and is considered sufficient for PR24.*	n/a
Benefits	*The statement provided is unchanged from PR19 and is considered sufficient for PR24.*	n/a
Detailed definition of performance measure	*The measure broadly aligns with that in place for PR19. The second and third paragraphs provide reasoning for a change in the number of sites included and we consider that this information could be condensed to that which is relevant for the measure at PR24.* *A number of sites have been aggregated and there are several discrepancies in terms of the site they have been aggregated with and the baselines provided between the narrative description and the table in figure two. For example, the narrative lists the OUGH site as being aggregated with the OUGH site, whilst the table in figure two lists the OUGH site as being aggregated with the WELLS and OFFS sites. These discrepancies need to be clarified. We note that there is a potential that the last month of river flow data may not be validated in time for annual reporting. You should clarify within the definition how you intend to handle this risk.*	Sites have been reviewed and corrected

	The triggers and baselines for sites have been updated from PR19. It is unclear how the updated triggers and baselines have been calculated. These ultimately define the circumstances in which underperformance or outperformance can occur. We expect you to provide in your business plan clear evidence that the level of each of the triggers and baselines represent stretching performance.	In order to calculate the trigger and abstraction baseline, the AIM Taskforce guidelines have been followed. Based on these, the AIM trigger is set based on a specific environmental trigger identified through the Environment Agency's (EA) RSA assessments, NEP investigations or other EIA work. Q95 flows have been adopted as the best indicator of low flow conditions below which AIM should operate. Alternatively for five of the sources, the triggers adopted were either specified as a licence condition or based on an operating agreement. In the majority of cases, the potentially impacted surface water body is the river, so the trigger was set at the downstream gauging station that is considered to be representative of the groundwater catchment. There are exceptions to this, where a groundwater level trigger has been used instead, due to better representation of the aquifer baseline conditions and the absence of a gauging station. Where the Q95 or Q70 values have been used, these were adopted from the UK Centre of Ecology and Hydrology as published on their website in July 2016. None of the AIM flow triggers have been changed from PR19 definition and all changes to the AIM baseline figures have been described in the definition document.

Additional detail on measurement units	*In line with the practice adopted for the common performance commitments, you should avoid referencing further guidance and instead include any guidance in one definition. You should remove the reference to our 2016 'Guidelines on the Abstraction Incentive Mechanism'.*	This reference did not appear in the submitted definition, so unsure where this is comment referring to. No changes made
Specific exclusions	*No specific exclusions have been provided, which is in line with our PR24 methodology.*	n/a
Reporting and assurance	*Although present in the compliance checklist, an explanation should be included within the definition as to how any missing data will be handled. A reporting and assurance process has been included within the definition and we consider that this would benefit from being conducted or at least assured by a third party, with the resulting report(s) being provided on an annual basis alongside the Annual Performance Report submission.* *You should also provide contextual information around your AIM performance as part of your reporting. The definition should be updated to reflect these provisions. The reporting processes represent a continuation of a PR19 performance commitment.*	The definition has been updated to explain the process for missing data. Our performance for AIM, alongside all other performance commitments, is subject to third party assurance this will continue for 2025-30. We will provide the assurance for AIM alongside the APR. Our annual AIM report includes contextual performance information, we will continue to publish this report on our website.

Overall observations	*As outlined in our initial feedback letter, we consider that the measure is potentially suitable as a bespoke PC, but we expect the company to:* – *consider how it can provide Ofwat and the Environment Agency with confidence and assurance with regard to the setting and reporting of this performance commitment;* *and* – *undertake a study to show how the environmental impact could be measured using credible data, the likely timescale of the impacts and how any changes could be attributed to AIM.* *We consider that there is a need to have a definitive study which identifies whether there are clear benefits to the introduction of the AIM measure, or whether the benefit to the environment is only realised by stopping water abstraction and identifying an alternative source. We expect the company to consider how such a study can be carried out and provide an update on progress and realistic timeline for the study in its business plan. We have provided a similar requirement for Southern Water and the two companies may want to collaborate on this requirement.* *Stakeholders have previously commented that AIM can be difficult to engage with. We expect you to consider how to best communicate with stakeholders to increase transparency. We recommend that the definition is stated in clearer terms.*	This measure has been in place for a number of years, and has been subject to third party assurance as part of the APR process, we will continue this level of scrutiny for future years. We have also used third party assurance of our definition to give further confidence. Our reporting of this measure is mature and we will continue publishing our annual AIM report on our website. We commissioned a third party study into the benefits of AIM, following this feedback. The results are attached included in this appendix We noted the suggestion to collaborate with Southern Water and held discussions with them around evidencing the benefits of AIM. Due to the nature of groundwater modelling, it is done based on geographical areas and with the majority of our AIM sites in our Central region, the modelling for ourselves and Southern Water would not fit into the same study. For that reason, we agreed to progress studies independently. We have made some amendments to language in the definition but consider a full description is needed for the PC definition to provide confidence to regulatory stakeholders. We have included our AIM plans in our overall business plan document, this is intended to give a less technical and more accessible description of our performance, plans and ambition

		in this area. We will commit to working with stakeholders to improve the transparency of reporting.

Other changes made:

We have added an exclusion in the definition for when Drought Permits are active. In these circumstances AIM will cease to active, until the Drought Permit is revoked. This exclusion will save incentivising to reduce abstraction at the same time as us being required to maximise abstraction to comply with the Drought Order.

Justification for AIM as a Bespoke PC

We recognise that we operate in a water-stressed area where chalk stream catchments are of significant ecological importance. In order to reduce our impact on the local environment, we have implemented a number of permanent sustainability reductions aiming to leave more water in the environment. Through our Water Industry National Environment Programme, we quantify the response of the environment to the abstraction reductions post-implementation. Whilst we consider this to be a permanent measure, we believe there is benefit in going above and beyond for the chalk stream environment and adapt the way we operate during low flow conditions. AIM allows us to reduce our environmental impact during times when the environment would be under stress. AIM contributes to leaving more water in the environment at the onset of a low flow period and reduces groundwater level recovery time in the aquifer. When AIM is active in the summer months, it is more likely to discourage peak use of sources which would otherwise have been maximised based on peak demand.

Our customers and stakeholders are supportive of our sustainability reduction programme and challenge us to go above and beyond. For this reason, we believe that AIM can play an important role in terms of safeguarding the environment during times of environmental stress, as set out in our Drought Management Plan.

We have reduced average abstraction by 42.09 Ml/d in AMP6, followed by a further 6.38 Ml/d in AMP7 to date in a number of chalk groundwater sources. The monitoring data we have collected to date, has helped us to refine our conceptualisation of the chalk aquifer and the groundwater-surface water interactions. We have evidence that the chalk is a layered aquifer and the impact of groundwater abstraction on river flows is dynamic. This means that as a general rule, the river flow response will be greater in average/high flow conditions and lower during low flow conditions. Local geological and morphological characteristics can also affect the degree of groundwater-surface water interactions at a local scale. In light of this, AIM serves as an additional measure aiming to leave more water in the aquifer during low flows, which can (under certain conditions) provide additional baseflow to the nearby rivers and allow local groundwater level recovery.

Whole Life Carbon

Ofwat Feedback		Affinity Water Response
Reference	**Feedback/Observation**	
Reflections on initial assessment of bespoke performance commitments (letter from Ofwat dated 31 May 2023)	*"We recognise the uncertainties that exist in relation to the measurement and reporting of greenhouse gas emissions. However, for the UK and Welsh governments' net zero emissions targets to be achieved, all companies need to reduce their embedded greenhouse gas emissions.* *While we welcome the bespoke performance commitment proposals in this area, we want to see the sector make greater and more rapid progress. Therefore, we strongly encourage more companies to come forward with bespoke PCs focused on incentivising reductions in embedded GHG emissions. In doing so, we encourage companies to develop targeted approaches that are linked to external verification and accreditation standards."*	As indicated, we have included a bespoke performance commitment which would incentivise focus on reducing embedded GHG emissions. The bespoke PC definition for Whole Life Carbon is included in the Definition section above. Whilst embedded greenhouse gas emissions PC's have been requested, we would suggest whole life carbon would be a more suitable measure. A pure embedded emissions PC could lead to short sighted decisions to reduce emissions through construction, only to create a higher operational carbon footprint over the lifetime of an asset.
PR24: Assessment of bespoke performance commitment proposals (July 2023)	*Affinity Water set out that it would include an additional proposal for an embedded greenhouse gas emissions measure with its business plan submission. We welcome Affinity Water's effort to do this but ask that it reflects the advice detailed in section 2.5, ensuring that the bespoke performance commitment will help wider sector learning to reduce embedded emissions.*	We have considered the request for how to share learning cross sector and will commit to publishing an extensive case study of our largest whole life carbon saving project annually. Additionally, are an active member of the WaterUk Net Zero Technical Group, we will commit to sharing learning with this group of including successes and lessons learnt through our delivery of this PC.

	While we welcome the bespoke performance commitments already submitted for this measure, we want to see the sector make greater and more rapid progress in this area. Therefore, we strongly encourage more companies to come forward with bespoke performance commitments focused on incentivising reductions in embedded GHG emissions	n/a
	Proposals should be clear on how they align with our net zero principles and our PR24 final methodology. 7 They should also demonstrate how they support more sustainable and resource efficient water services, providing intergenerational value that ensures the achievement of company and wider government net zero targets. *We expect companies to clearly explain how a proposed performance commitment will incentivise emissions reductions to enable government and company net zero targets to be met. Therefore, we encourage companies to develop targeted approaches that are linked to external verification and accreditation standards*	The reduction of whole life carbon will support wider Net Zero targets by incentivising investment in lower carbon solutions and construction techniques. Additionally, by looking at whole life, we will ensure we are minimising the ongoing carbon impact of our investments. Our PC will support our journey our Net Zero targets. We have been clear in our definition that we will align our work with PAS2080 and that our baseline and actual calculations will be subject to third party assurance. We have heard the challenge that our performance commitment and targets need to support the government achieve its Net Zero commitments. Therefore, we have used the governments Balance Net Zero Pathway to set our level of ambition. We have reviewed this profile and determined which elements are applicable to our Whole Life Carbon performance commitment, namely, hydrogen, and other low-carbon technology, reduce demand and improve efficiency. We have stripped these element from the pathway to give our profile which will support the government achievement of their target.

	The performance commitment definition should also be clear on exactly what direct company actions will count as facilitating decarbonisation - this information is crucial to understanding the benefit of company actions. We also expect the definition to make clear all sources of GHG emissions, measured as tCO2e, against which any reduction in emissions will be counted. We encourage companies to include an example calculation, which will help with ensuring that the definition is clear and that all the necessary details have been included.	The direct action incentivised through this definition will be the promotion of lower carbon solutions to capital projects. Critical project decisions will now be informed by their carbon footprint. Calculations have been included in the definition.

Abstraction incentive mechanism (AIM) modelling

Executive Summary

An assessment of nine catchments flows has been carried out, using the HCM2020 model, to evaluate the effect of AIM reductions at selected groundwater sources. Some catchments show positive impacts on low flows, and benefits can be more significant in terms of percentage of the abstraction reductions. However, the assessment highlights that the cumulative impacts of the reductions have a low average benefit when AIM is active, due to the small volumes associated to the 5% and 10% reductions during triggered periods.

The catchments with the greatest benefit to flows are the Ver and the Gade, according to the Flow Duration Curves. Peak benefits to the River Ver and River Gade are 1.15Ml/d at the River Ver at Colney Street GS and 1.37Ml/d at the River Gade at Croxley Green GS. Under the AIM Scenario 2 reductions, this also has a positive impact of up to 6Ml/d on the cumulative flows of the River Colne (downstream of the tributaries). The greatest changes to flows are generally observed under low-flow conditions. Average impacts on the Misbourne, Beane and Mimram catchments are smaller, with peak benefits of 0.17Ml/d, 0.11Ml/d and 0.36Ml/d respectively.

The resulting additional water which is left in the environment during low flow periods may provide greater environmental resilience and also help to focus the attention of both the industry and AFW customers on environmental sensitivities and low flows. Outperformance of the scenarios modelled in this report could produce a greater environmental benefit, however these scenarios have not been investigated.

1 Introduction

At the request of Affinity Water, we have carried out a groundwater modelling assessment of abstraction reduction scenarios at selected sources, and their potential impacts on the surface water catchments associated with the chalk aquifer. These reductions have been proposed in response to the AIM (Abstraction Incentive Mechanism) performance commitment, which Affinity Water have adopted since 2016. AIM encourages water companies to take no more water than historically abstracted during low flow conditions in catchments considered sensitive. The recently updated Hertfordshire Chalk Regional Groundwater model (HCM2020) has been used to evaluate the impact and efficacy of AIM reductions in abstraction rates, applied when bespoke river low flow triggers are met, as part of AFW AMP8 plan.

Specific tasks of this work include:

- Setup and run three model scenarios using the HCM2020 model, including: Baseline, AIM setup 1, and AIM Setup 2. AIM values for these scenarios have been agreed with Affinity Water.
- Carry out an abstraction impact assessment on the required catchments, using the following indicators at agreed monitoring points and reaches:
    - Stream flow time series
    - Stream flow duration curves
    - Accretion profiles
    - Changes in flow at specific percentile values (Q95, Q70, Q50, Q10)

The abstraction sources under assessment in this study are outlined in Table 0.1. Each source is linked to a corresponding trigger location for which a flow trigger has been defined. For the sources presented in the table, the trigger was set at the downstream Gauging Station (GS), considered to be representative of the surface water catchment. An abstraction reduction would be implemented at the source when the flow at the gauging station falls below the trigger value. Flow triggers were provided by Affinity Water and, in most cases, are based on the Q95 adopted from the Centre of Ecology and Hydrology (CEH). However, for a few cases, bespoke triggers have been adopted, as detailed in

Table 0.2.

Table 0.1: Location of AIM sources

ID	Short Name	Full Name	Easting	Northing
1	Amersham	Amersham Pumping Station	496237.5	197099.5
2	Bricket Wood	Bricket Wood Pumping Station	514174	201489.5
3	Netherwild	Netherwild Pumping Station	515338	201627.3333
4	Holywell	Holywell Pumping Station	514639	206627.25
5	Mud Lane	Mud Lane Pumping Station	514258	206648
6	Digswell	Digswell Pumping Station - POINT 'C'	523977	215345.5
7	Fulling Mill	Fulling Mill	522880	216630
		Fulling Mill	522650	216900
8	Whitehall	Whitehall Pumping Station Point A	528731	221380
		Whitehall Pumping Station Point B	528636	221612
		Whitehall Pumping Station Point C	528460	222041
9	Offley Bottom	Bore At Offley Bottom	516046	228894
10	Wellhead	Well Head Charlton	517786	227751
11	Oughton Head	Well Oughton Head, Hitchin	515904	229832
12	Slip End	Two bore, Slip End	528288	237016.5
13	Piccotts End	Piccotts End Pumping Station	504800	209300
14	Marlowes	Marlowes Pumping Station	505300	207400

Table 0.2: River flow triggers at the AIM catchments.

Source	Trigger Location	ID	Monitoring Record	Q95 or bespoke trigger (Ml/d)	Comments
Bricketwood Netherwild	River Colne at Watford, Berrygrove	2	April 1995 to March 2015	13.00	Bespoke trigger based on minimum flows derived from AMP5 Options Appraisal Work
Well Head Oughton Head Offley Bottom	River Hiz at Hitchin	6	August 1980 to date	0.26	Trigger based on Q95 adopted from CEH
Digswell Fulling Mill	River Mimram at Panshanger	9	December 1952 to date	18.66	Trigger based on Q95 adopted from CEH
Holywell Mud Lane	River Ver at Colney Street, Hansteads	13	April 1995 to March 2015	7.44	Trigger based on Q95 adopted from CEH
Marlowes Piccotts End	River Gade at Croxley Green	5	October 1970 to date	32.00	Trigger based on Hunton Bridge Licence condition for flows at Croxley Green
Amersham	River Misbourne at Denham Lodge	11	July 1984 to date	5.53	Trigger based on Q95 adopted from CEH
Whitehall	River Beane at Hertford, Hartham Park	1	August 1979 to date	15.47	Trigger based on Q95 adopted from CEH
Slip End	River Rhee at Ashwell	12	November 1965 to date	Dependent on licensed flow condition	Trigger based on Operating Agreement for Ashwell BH Augmentation from Slip End

The location of AIM sources and trigger locations assessed in this report can be found in

Figure 0.1.

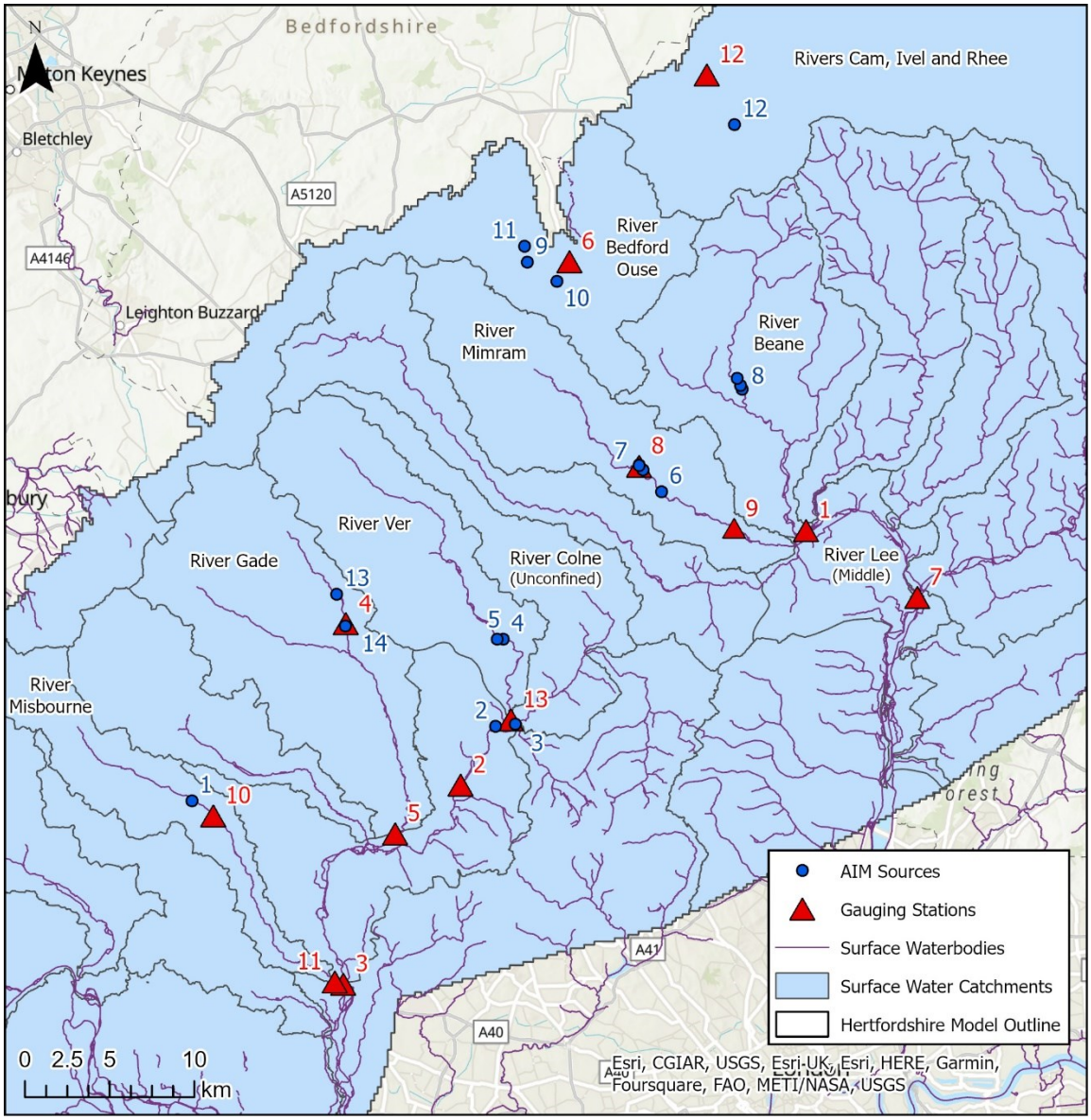
To understand potential changes resulting from abstraction reductions, stream flows at gauging stations downstream of AIM sources were investigated. To investigate the potential cumulative downstream impact, the River Colne at Denham Colne GS and the River Lee (Middle) at Fieldes Weir GS were also assessed. The full list of gauging stations and their locations within the model area can be found in Table 0.3 and

Figure 0.1.

Table 0.3: Locations of surface water gauging station.

ID	Gauging Station	Catchment	Easting	Northing
1	River Beane at Hertford, Hartham Pk	River Beane	532503	213143
2	River Colne at Watford, Berrygrove	River Colne - Unconfined	512108	198118
3	River Colne at Denham Colne	River Colne - Unconfined	505180	186360
4	River Gade at Hemel Hempstead, Bury Mill	River Gade	505326	207648
5	River Gade at Croxley Green	River Gade	508243	195241
6	River Hiz at Hitchin	River Bedford Ouse	518534	229020
7	River Lee (Middle) at Fieldes Weir	River Lee (Middle)	539074	209193
8	River Mimram at Welwyn, Fulling Mill	River Mimram	522646	216944
9	River Mimram at Panshanger	River Mimram	528256	213276
10	River Misbourne at Quarrendon Mill	River Misbourne	497500	196300
11	River Misbourne at Denham Lodge	River Misbourne	504677	186493
12	River Rhee at Ashwell	Rivers Cam, Ivel and Rhee	526646	240047
13	River Ver at Colney Street, Hansteads	River Ver	515077	201969

Figure 0.1: AIM sources and surface water gauging station locations.



Note: Numbers are referenced in Table 0.1,

Table **0.2** and Table 1.3

To understand potential changes resulting from abstraction reductions, stream flows at gauging stations downstream of AIM sources were investigated. To investigate the potential cumulative downstream impact, the River Colne at Denham Colne GS and the River Lee (Middle) at Fieldes Weir GS were also assessed. The full list of gauging stations and their locations within the model area can be found in Table 0.3 and

Figure 0.1.

2 Methodology and model setup

Simulated scenarios and abstraction rates

The Hertfordshire groundwater model (HCM2020) Recent Actual (RA) run is used as the basis for the scenarios generated for this assessment. The following scenarios are simulated:

- **Baseline**: The HCM202 RA is modified such that abstraction rates for AIM sources are set to AIM baseline rates. The AIM baseline rates were provided by Affinity Water and for most sources are defined by the average abstraction during the historic period when river flows were at or below the trigger. Where a sustainability reduction has been implemented, the AIM baseline is equal to the post reduction average licensed rate.
- **Scenario 1**: The baseline is modified such that abstraction rates for AIM sources are reduced by 5% for AIM sources during low flow periods.
- **Scenario 2**: The baseline is modified such that abstraction rates for AIM sources are reduced by 10% for AIM sources during low flow periods.

The abstraction rates under the Baseline, Scenario 1 and Scenario 2 for each of the AIM sources (except for Slip End) are shown in Table 0.1. Catchment names are as defined in the HCM2020 model. The abstraction rates for Slip End are shown in Table 0.2.

The AIM trigger for the Slip End source varies depending on flow at the Ashwell gauging station on the Rhee and the permitted abstraction rate specified in the licence. Since AFW typically abstracts slightly less than the specified licensed volume, the AIM baseline for Slip End is set at the 95th percentile of the licensed abstraction at the site at any time, assuming that flow is below 2.55 Ml/d.

Table 0.1: Abstraction rates for AIM sources under AIM Baseline, Scenario 1 and Scenario 2.

Catchment	Source	AIM Baseline (Ml/d)	Scenario 1	Scenario 2
Misbourne	Amersham	2.00	1.90	1.80
Gade	Marlowes	8.34	7.92	7.51
	Piccotts End	5.72	5.43	5.15
Ver	Holywell	7.39	7.02	6.65
	Mud Lane	2.00	1.90	1.80
Colne (Unconfined)	Bricket Wood	18.65	17.72	16.79
	Netherwild	18.51	17.59	16.66
Beane	Whitehall	2.00	1.90	1.80
Mimram	Fulling Mill	2.00	1.90	1.80
	Digswell	1.50	1.43	1.35
Bedford Ouse	Wellhead	0.84	0.80	0.76
	Oughton Head	4.43	4.21	3.99
	Offley Bottom	0.60	0.57	0.54
Cam, Ivel and Rhee	Slip End	95% of licensed abstraction (see **Table 0.2**)	5% less than the moving AIM baseline (see **Table 0.2**)	10% less than moving AIM baseline (see **Table 0.2**)

Table 0.2: Abstraction rates for Slip End under AIM Baseline, Scenario 1 and Scenario 2.

Flow at Ashwell Gauging Station (Ml/d)	Maximum Daily Abstraction rate in Ml/d	AIM Baseline (95 % of Licensed volume) in Ml/d	Scenario 1 5% reduction below baseline	Scenario 2 10% reduction below baseline
Above 2.55	Up to 6.82	-	-	-
Between 2.50 and 2.55	5.46	5.18	4.92	4.66
Between 2.45 and 2.50	5.00	4.75	4.51	4.28
Between 2.41 and 2.45	4.55	4.32	4.10	3.89
Between 2.36 and 2.41	4.09	3.89	3.70	3.50
Between 2.32 and 2.36	3.64	3.46	3.29	3.11
Between 2.27 and 2.32	3.18	3.02	2.87	2.72
Between 2.23 and 2.27	2.73	2.59	2.46	2.33
Between 2.18 and 2.23	2.27	2.16	2.05	1.94
Between 2.14 and 2.18	1.82	1.73	1.64	1.56
Between 2.09 and 2.14	1.36	1.30	1.24	1.17
Between 2.05 and 2.09	0.91	0.86	0.82	0.77
Between 2.00 and 2.05	0.46	0.43	0.41	0.39
Less than 2	0.00	0.00	0.00	0.00

Calculation of abstraction reduction periods

The periods during which abstraction reductions are implemented at each source are calculated as the periods when the flow at the corresponding trigger location falls below the trigger. The following approach has been taken:

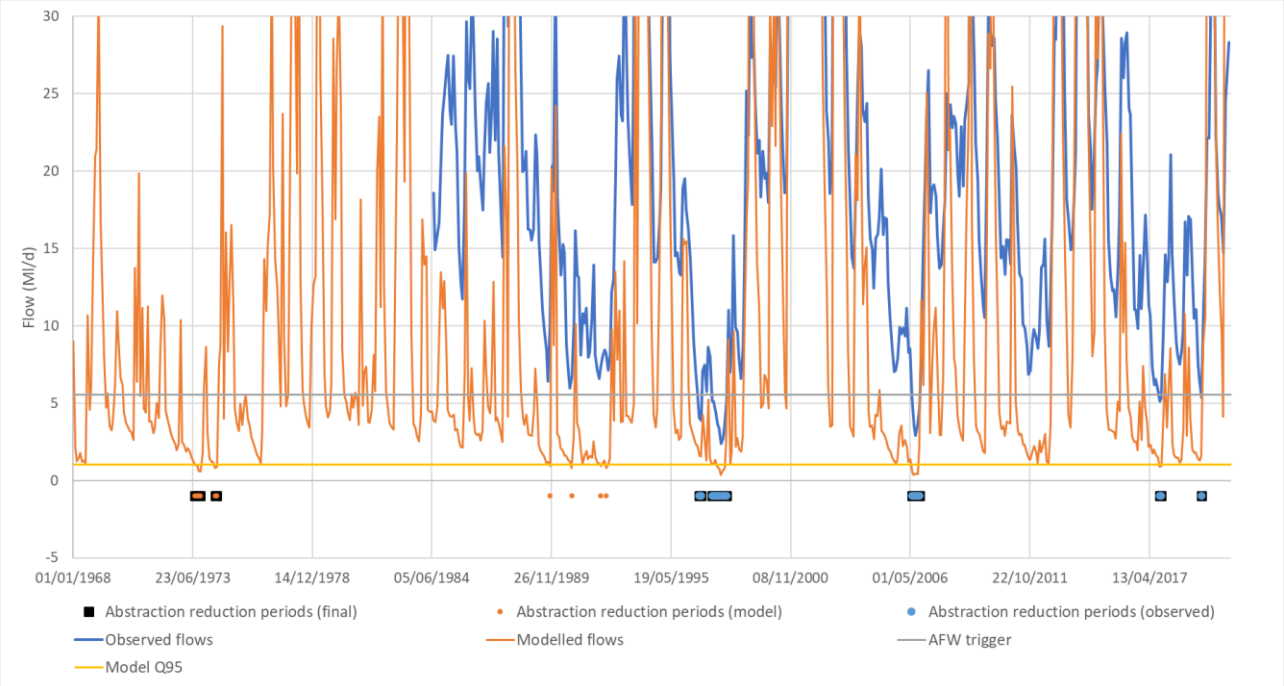
- If observed flow data is available for the full simulation period (1968-2020): An abstraction reduction is applied whenever the monthly average observed flow at the

trigger location falls below the trigger value (as provided by AFW). This approach was taken for the River Mimram at Panshanger and the River Ver at Colney Street, Hansteads.

- For periods (partial or whole simulation) where observed flow data is not available:
    - If the AFW trigger was defined based on the Q95 adopted from CEH: An abstraction reduction is applied whenever the monthly average simulated flow at the trigger location falls below the model Q95. This approach was taken for the River Misbourne at Denham Lodge and the River Beane at Hertford, Hartham Pk.
    - If the AFW trigger was bespoke: An abstraction reduction is applied whenever the monthly average simulated flow at the trigger location falls below the AFW trigger. This approach was taken for the River Colne at Berrygrove and the River Gade at Croxley Green.

Figure 0.1 shows the approach taken for the River Misbourne at Denham Lodge, as an example. Where observed flows are available (from July 1984 onwards), the abstraction reduction periods are defined as those where the observed flow falls below the defined flow trigger (5.53Ml/d). For the early period (pre-1984), the abstraction reduction periods are defined as those where the model flow falls below the model Q95.

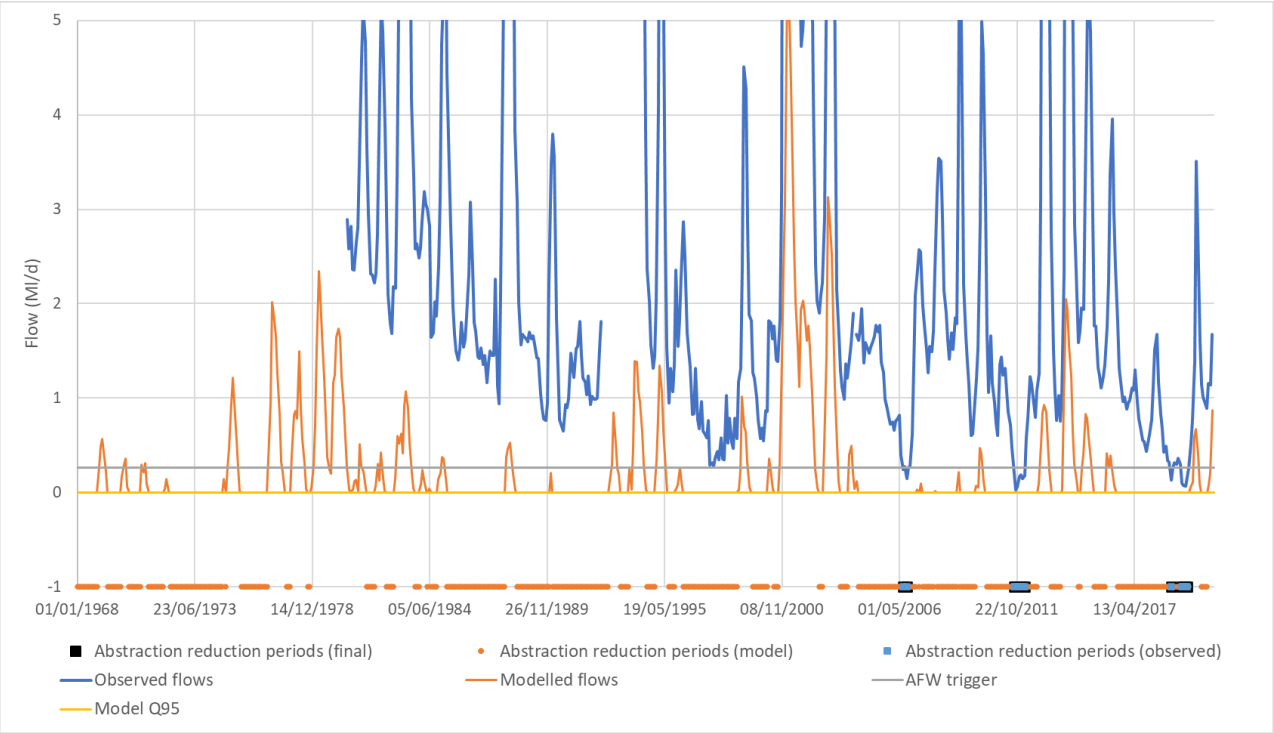
Figure 0.1: Abstraction reduction periods selected for the River Misbourne at Denham Lodge.



A different approach has been applied for the River Hiz at Hitchin, which was considered a more complex case. Figure 0.2 presents the data for the River Hiz at Hitchin. In this case, where observed flows are available (from August 1980 onwards), the abstraction reduction periods are defined as those where the observed flow falls below the defined flow trigger (0.26Ml/d). For the early period (pre-1980), the model flows were found to often reach zero (due to under-simulation by the model). In this case, the comparison of the model Q95 against the simulated data was not considered appropriate. However, the trend in the observed data shows that the flows are generally higher during the early period, and well

above the defined flow trigger. Therefore, it was agreed that an abstraction reduction would not be applied to this period of the record.

Figure 0.2: Abstraction reduction periods selected for the River Hiz at Hitchin.



Post processing setup

Stream flows were extracted from the model at all gauging stations for the full model simulation period. The simulated flows between 1970 to 2020 were used to generate Flow Duration Curves (FDCs) at the gauging stations within the study area. Stream flows were also extracted from the model for selected stress periods for the purpose of generating accretion profiles. The stress periods were chosen to represent those dates with highest impact from the abstraction reductions implemented at each gauging station. This was determined by calculating the end date of the longest triggered periods (i.e., where flows were below the trigger for the longest period of time) for each gauging station. As shown in Table 0.3, these dates coincide with well know drought periods (the 1970s, 1997, 2006 and 2011/2). Specific stress periods matching the highest impact (to account for lag in some cases) were used to calculate the final accretion profiles.

Table 0.3: End dates of the longest triggered period for each gauging station.

Gauging station	End date of longest triggered period	10-day model stress period	Number of consecutive months triggered
River Colne at Watford, Berrygrove	01/12/1973	216	7
River Hiz at Hitchin	01/03/2012	1591	7
River Mimram at Panshanger	01/12/1973	216	5
River Ver at Colney Street, Hansteads	01/11/1976	319	7
River Gade at Croxley Green	01/01/1974	217	11
River Misbourne at Denham Lodge	01/12/1997	1078	9
River Beane at Hertford, Hartham Pk	01/09/2006	1393	4

3 AIM Assessment

The AIM assessment has been organised by watercourse resulting in the following major catchments:

- River Colne and tributaries (Misbourne, Gade and Ver)
- River Lee and tributaries (Beane and Mimram)
- River Bedford Ouse (Hiz)
- Rivers Cam, Ivel, and Rhee (Rhee)

The surface water catchments are assessed in the following sections considering:

- Difference in flow percentiles observed under Scenario 1 and Scenario 2
- Flow benefits resulting from AIM abstraction reductions
- Impacts on FDC on selected gauging stations
- Impact on accretion profiles (provided in Appendix 0)

Flow duration curves and flow percentiles (Q) values have been calculated for the whole simulation period. Due to the small impact of the AIM abstraction reductions, **which are only applied when low flows are triggered**, this section will present flow benefits and FDC differences (impacts) for each catchment. In the case of flow benefit profiles, these are calculated from model results at the location of the gauging stations. As such, there will be a lag between implementation of the AIM reduction and the increased flow response. This is due to the distance between abstraction sources and the gauging stations and travel time, affected by groundwater flow velocity and river routing.

The accretion profiles have been generated for each of the dates specified in Section 0 for the River Colne (and all its tributaries under investigation) and the River Lee (and all its tributaries under investigation). Accretion profiles have not been generated for the Bedford Ouse or the River Rhee as these are located close to the northern boundary of the model, meaning watercourses are not completely captured by the model and present calibration issues.

River Colne and tributaries

River Misbourne

The AIM abstraction source within the River Misbourne catchment is Amersham Pumping Station (PS). The abstraction reduction is 0.1Ml/d under Scenario 1 and 0.2Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed for the River Misbourne at Quarrendon Mill (no longer operational) and River Misbourne at Denham Lodge gauging stations. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.1.

Table 0.1: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Misbourne catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (% increase)	Baseline vs Scenario 2 Ml/d (% increase)
	Q10	40.380	0.000 (0.00%)	0.000 (0.00%)

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (% increase)	Baseline vs Scenario 2 Ml/d (% increase)
River Misbourne at Quarrendon Mill	Q50	15.243	0.000 (0.00%)	0.000 (0.00%)
	Q70	7.288	0.001 (0.01%)	0.002 (0.03%)
	Q95	0.005	0.000 (0.00%)	0.000 (0.00%)
River Misbourne at Denham Lodge	Q10	54.122	0.000 (0.00%)	0.006 (0.01%)
	Q50	9.095	0.001 (0.01%)	0.001 (0.01%)
	Q70	3.281	0.001 (0.03%)	0.001 (0.03%)
	Q95	1.133	0.001 (0.09%)	0.002 (0.18%)

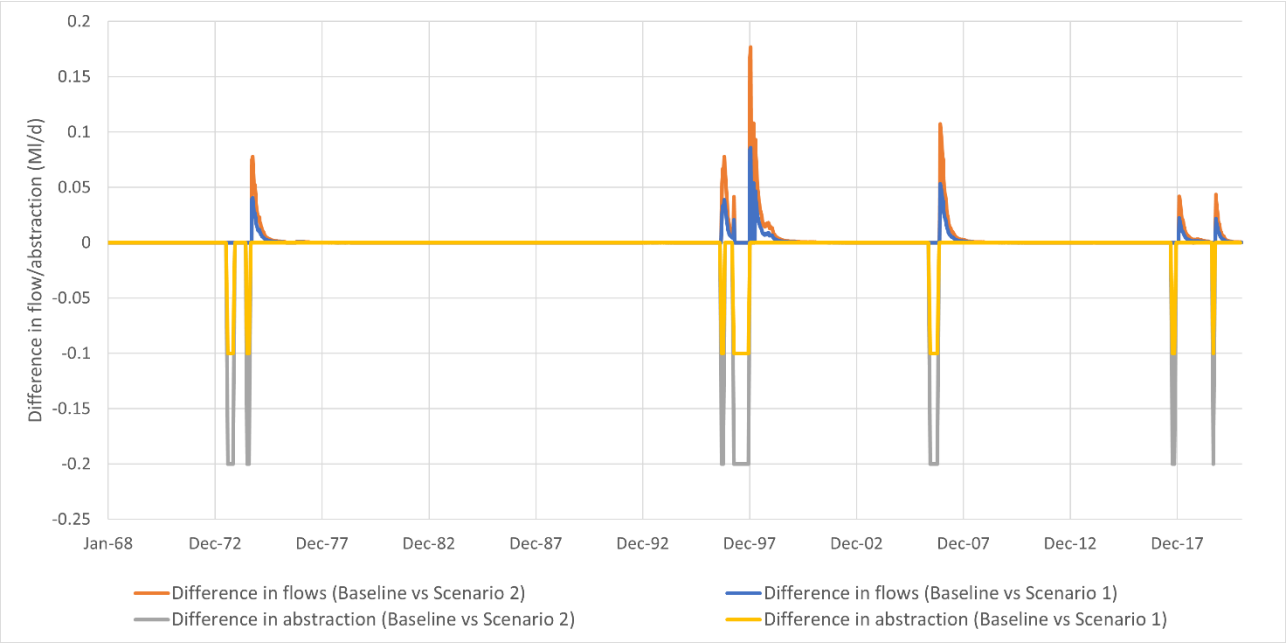
Comparison of modelled flows show that the difference between baseline conditions and abstraction reductions, in both Scenario 1 and Scenario 2, are very minimal. This is unsurprising given the small reduction in abstraction volumes of 0.1Ml/d and 0.2Ml/d under Scenario 1 and Scenario 2.

Figure 0.1 and Figure 0.2 demonstrate the flow benefits to the River Misbourne at Quarrendon Mill and the impacts on the FDC for this gauging station. There is a noticeable lag from the period of abstraction reductions to the flow benefits at the gauging stations, particularly at the River Misbourne at Denham Lodge GS located further downstream. This could be an effect of aquifer storage, or the change in extent of the losing or gaining streams within the stream profile, however, this would require further analysis of groundwater levels within the catchment. During a drought, aquifer levels can go down and disconnect from surface water bodies (no recharge); and the lag is potentially due to the time it takes for the aquifer to recharge to a level where it can recharge the surface water course again. Lag time would be a function of aquifer drawdown depth and hydrogeology.

The largest difference in flows (0.18%) in Table 0.1 are observed further downstream at the River Misbourne at Denham Lodge GS during low flows under a 10% abstraction reduction (Scenario 2). Although Figure 0.4 shows a few occurrences where flow differences, as ML/d, are more significant at moderate-high flows, they are smaller as a percentage of baseline flow at those percentiles.

Figure 0.1 and Figure 0.3 show that the greatest increase in flow is 0.18 Ml/d at the River Misbourne at Quarrendon Mill GS and 0.11 Ml/d at the River Misbourne at Denham Lodge under Scenario 2, which are 90% and 55% of the upstream abstraction reduction, respectively.

Figure 0.1: Flow benefits to the River Misbourne at Quarrendon Mill.



Source: The difference in abstraction is given by the abstraction reduction at Amersham PS.

Figure 0.2: Impacts on the FDC at River Misbourne at Quarrendon Mill

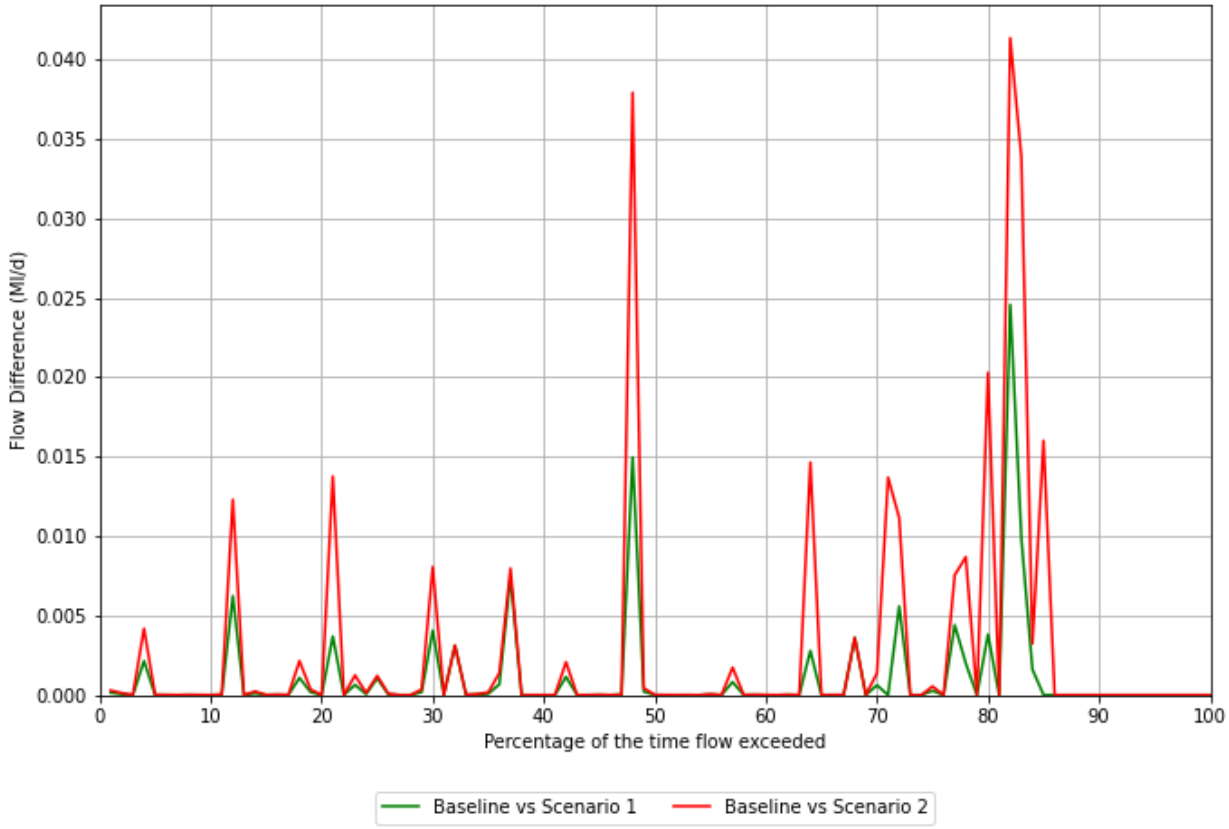
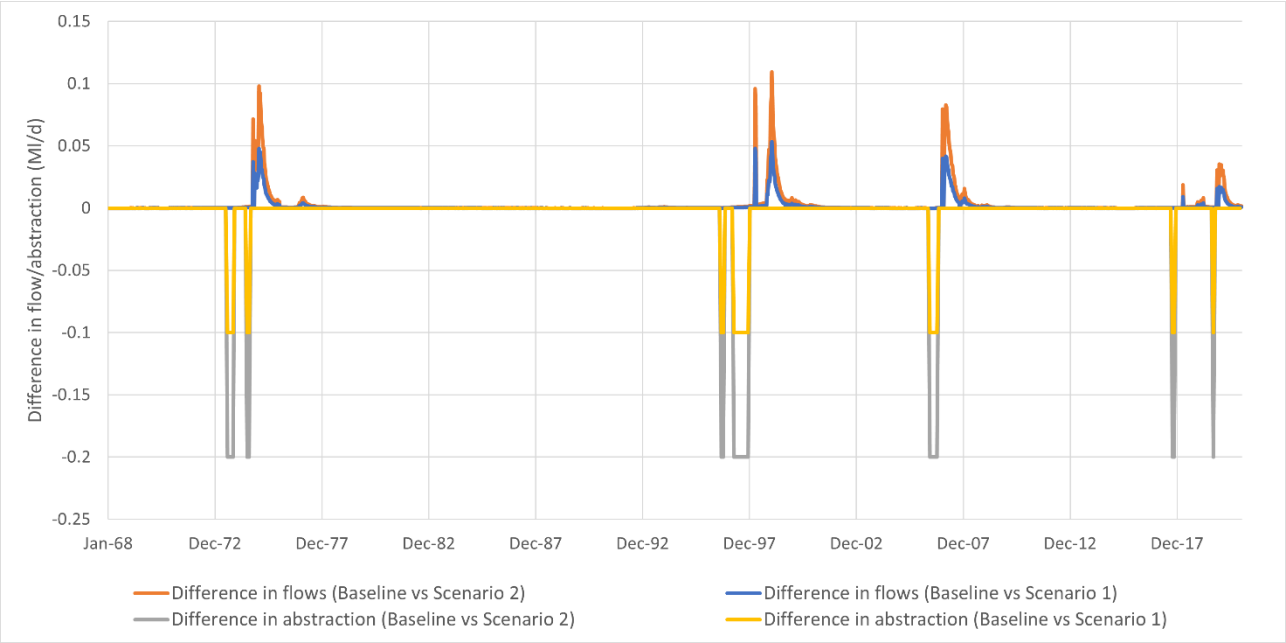
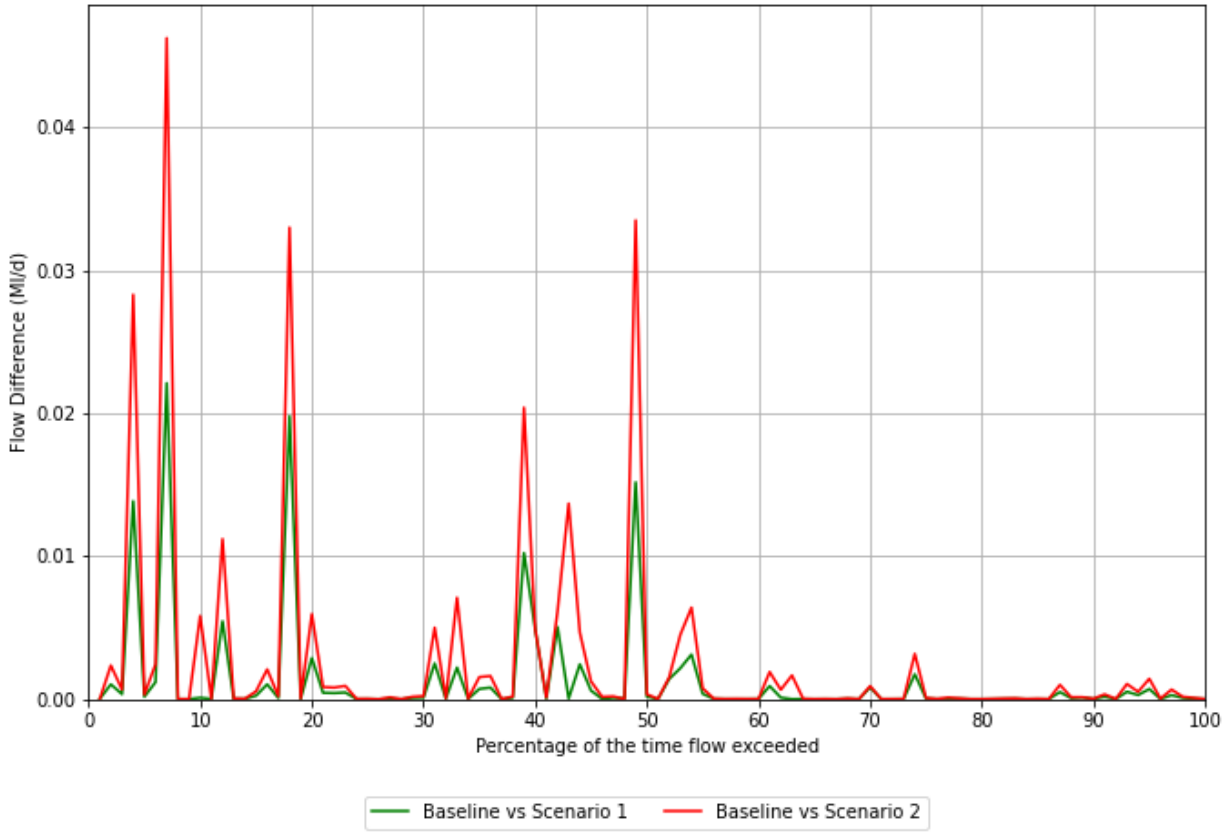


Figure 0.3: Flow benefits to the River Misbourne at Denham Lodge.



Source: The difference in abstraction is given by the abstraction reduction implemented at Amersham PS.

Figure 0.4: Impacts on the FDC for the River Misbourne at Denham Lodge



River Gade

The AIM abstraction sources within the River Gade catchment are Marlowes and Piccotts End. The combined abstraction reduction (from both sources) is 0.7Ml/d under Scenario 1 and 1.4Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed at the River Gade at Hemel Hempstead (Bury Mill) and the River Gade at Croxley Green. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.2.

Table 0.2: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Gade catchment

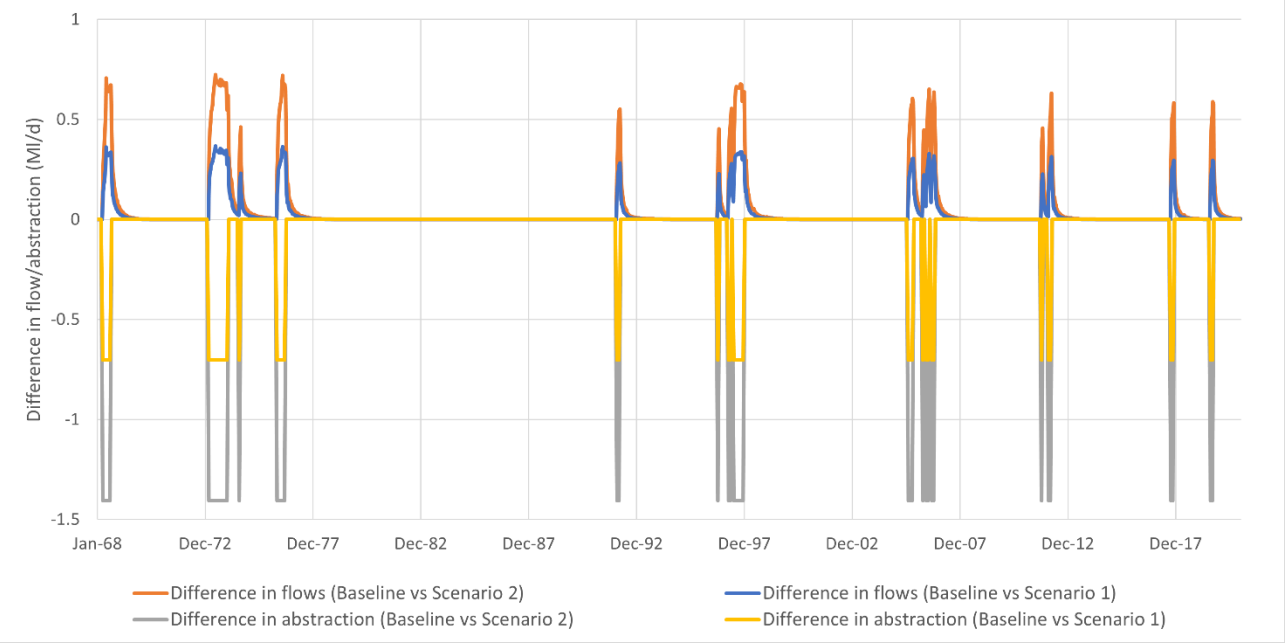
Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Gade at Hemel Hempstead, Bury Mill	Q10	36.130	0.000 (0.00%)	0.010 (0.03%)
	Q50	21.340	0.004 (0.02%)	0.023 (0.11%)
	Q70	15.521	0.006 (0.04%)	0.031 (0.20%)
	Q95	6.238	0.143 (2.29%)	0.233 (3.74%)
River Gade at Croxley Green	Q10	154.018	0.193 (0.13%)	0.346 (0.22%)
	Q50	87.974	0.061 (0.07%)	0.092 (0.10%)
	Q70	68.275	0.050 (0.07%)	0.056 (0.08%)
	Q95	34.867	0.359 (1.03%)	0.730 (2.09%)

Abstraction reductions at Marlowes and Piccotts End are more significant under low flow conditions where the river benefits from greater baseflow contributions. The River Gade at Hemel Hempstead, Bury Mill GS, located ~1.7km downstream from Piccotts End and ~400m upstream of Marlowes, has a 0.23Ml/d (3.74%) increase in flow at Q95 under Scenario 2. The flow benefits observed at this gauging station can be seen below in Figure 0.5 and the impacts to the FDC in Figure 0.6.

The River Gade at Croxley Green gauging station is located much further downstream of the Marlowes AIM source. The impacts of abstraction reductions to the FDC can be found in Figure 0.8. Here, the average flow increase is reported at 0.73Ml/d (2.09%) following abstraction reductions are observed at low flow conditions. This is a greater increase in flow in comparison to the River Gade at Hemel Hempstead GS but a smaller percentage increase when comparing to baseline conditions.

Figure 0.5 and Figure 0.7 show that the greatest increase in flow is 0.72Ml/d at the River Gade at Hemel Hempstead GS and 1.37Ml/d at the River Gade at Croxley Green under Scenario 2, which are 51% and 98% of the upstream abstraction reduction, respectively.

Figure 0.5: Flow benefits to the River Gade at Hemel Hempstead, Bury Mill.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Marlowes and Piccotts End.

Figure 0.6: Impacts on the FDC for the Gade at Hemel Hempstead, Bury Mill.

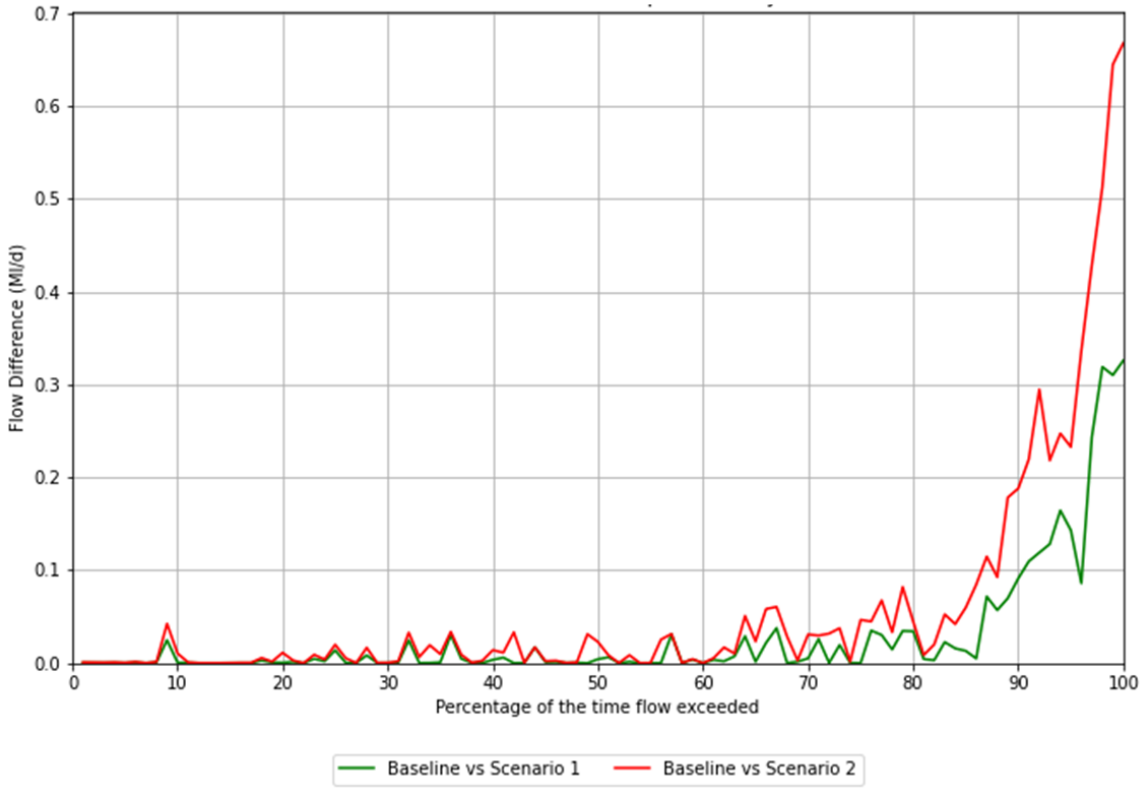
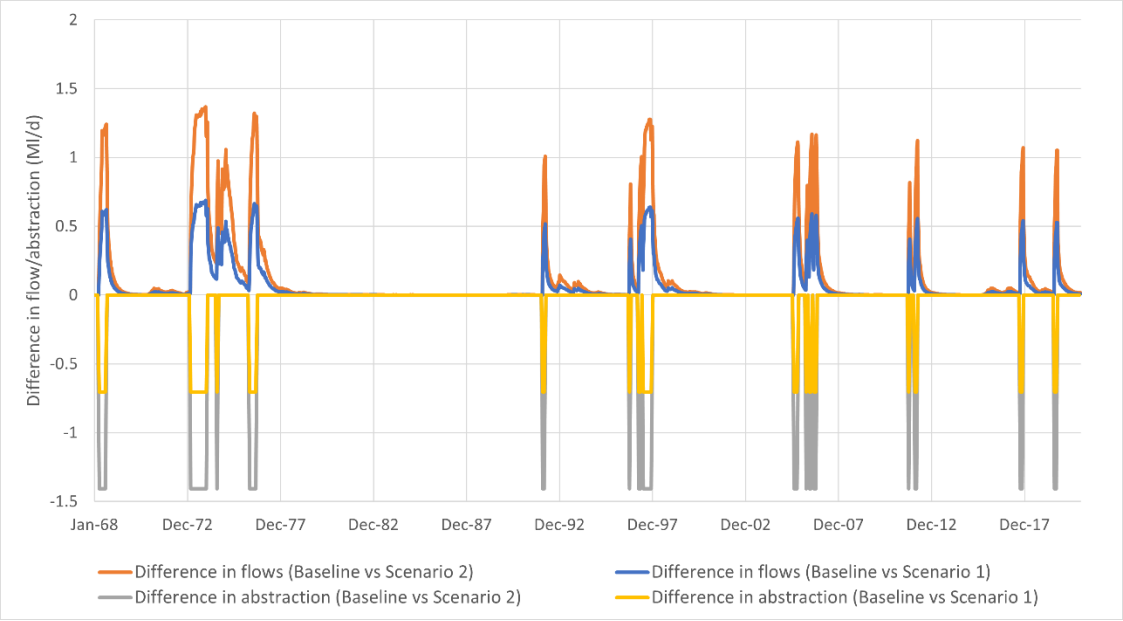
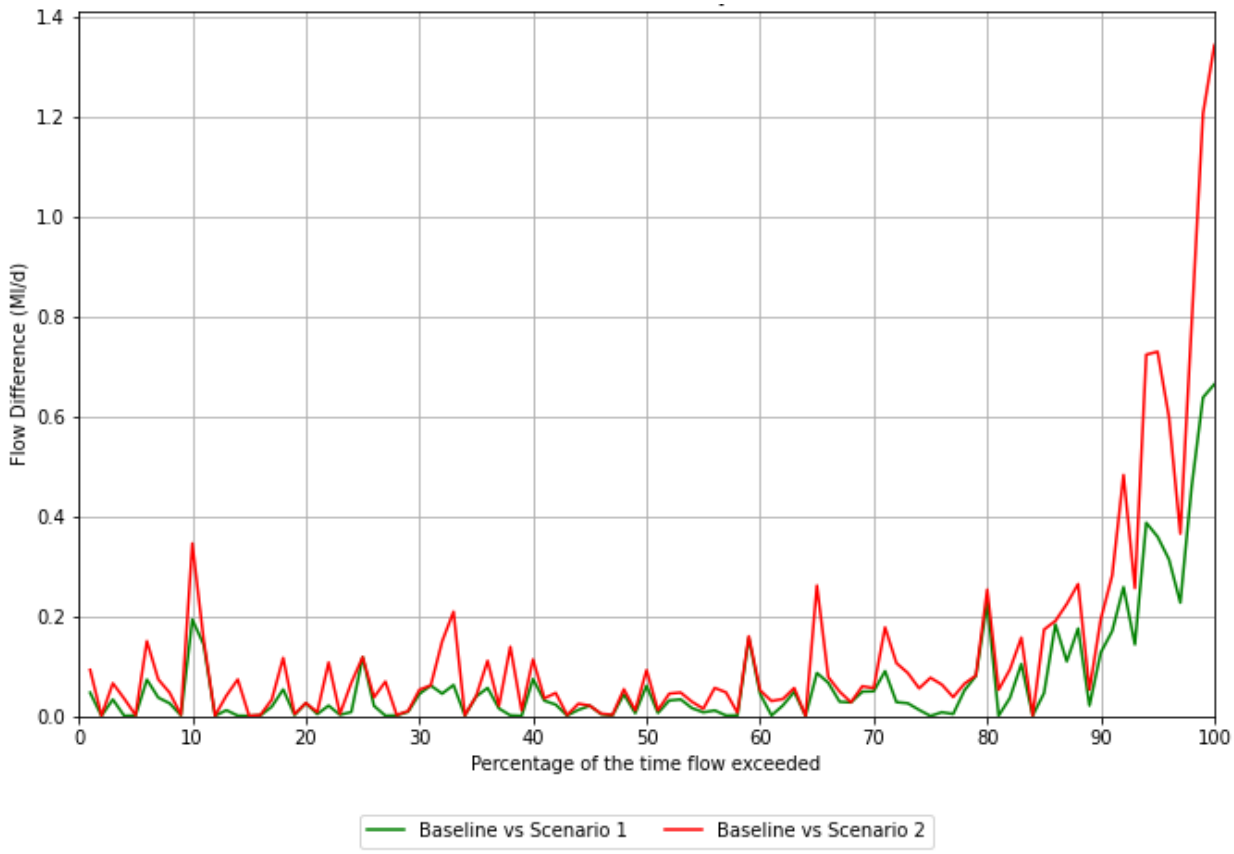


Figure 0.7: Flow benefits to the River Gade at Croxley Green.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Marlowes and Piccotts End.

Figure 0.8: Impacts on the FDC for the Gade at Croxley Green.



River Ver

The AIM abstraction sources within the River Ver catchment are Holywell and Mud Lane. The combined abstraction reduction (from both sources) is 0.47Ml/d under Scenario 1 and 0.94Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed at the River Ver at Colney Steet, Hansteads. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.3.

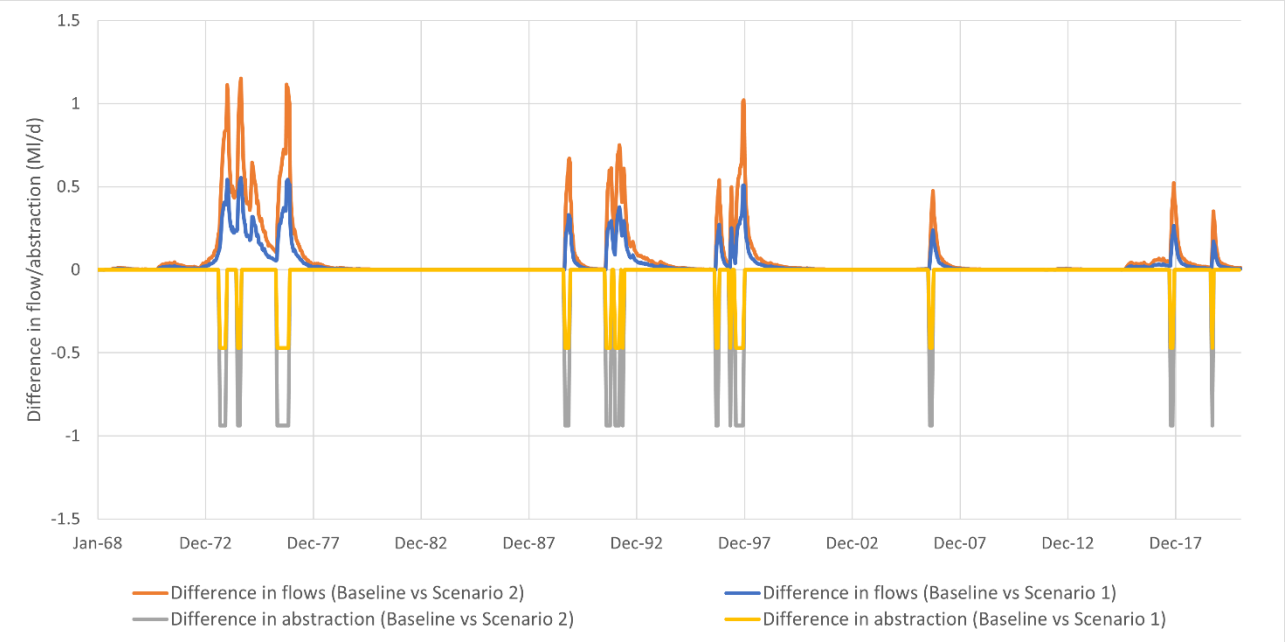
Table 0.3: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Ver catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Ver at Colney Street, Hansteads	Q10	96.609	0.001 (0.00%)	0.002 (0.00%)
	Q50	44.765	0.008 (0.02%)	0.026 (0.06%)
	Q70	32.395	0.007 (0.02%)	0.053 (0.16%)
	Q95	11.565	0.103 (0.89%)	0.125 (1.08%)

At the River Ver at Colney Street, Hansteads gauging station, there are minor improvements at low-moderate flows. The impact of abstraction reductions at Holywell and Mud Lane are more noticeable at low flows (0.13Ml/d or 1.08% at Q95 under Scenario 2) due to the greater

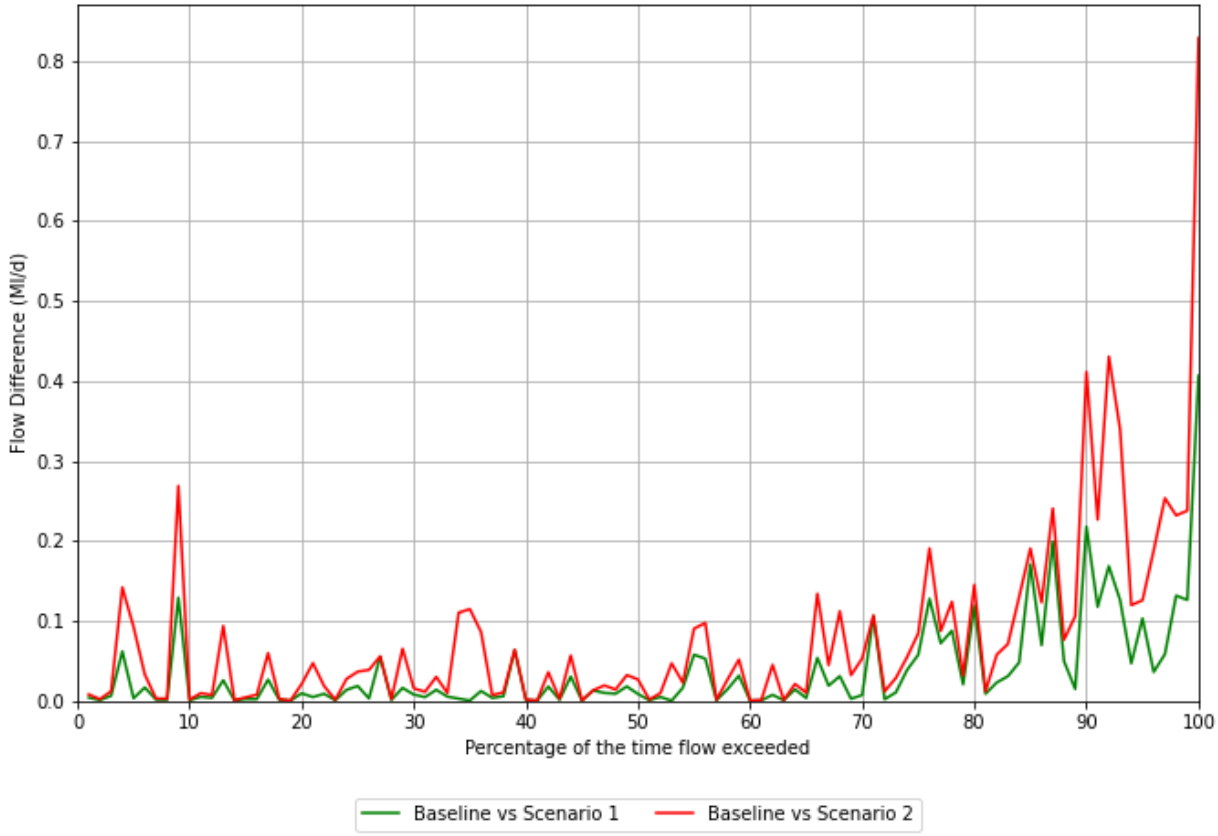
baseflow contributions. Figure 0.9 and Figure 0.10 demonstrate the flow benefits to the River Ver at Colney Street, Hansteads GS and the impacts on the FDC for this gauging station. Over the entire time series, the greatest increase in flow recorded at this gauging station is 1.15Ml/d, which is 122% of the upstream abstraction reduction. This can potentially be due to impacts of the area of influence of abstractions located in nearby catchments, or model calibration issues.

Figure 0.9: Flow benefits to the River Ver at Colney Street, Hansteads.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Holywell and Mud Lane.

Figure 0.10: Impact on the FDC for the River Ver at Colney Street, Hansteads



River Colne

The AIM abstraction sources within the River Colne catchment are Bricket Wood and Netherwild. The combined abstraction reduction (from both sources) is 1.85Ml/d under Scenario 1 and 3.71Ml/d under Scenario 2. Considering the upstream tributaries, the total combined abstraction reductions are 3.12Ml/d under scenario 1 and 6.25 Ml/d under scenario 2. The impacts of the abstraction reductions are analysed at the River Colne at Watford, Berrygrove and River Colne at Denham gauging stations. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.4. It should be noted that the flow is impacted by AIM reduction effects on its upstream tributaries: the Misbourne, Gade, and Ver.

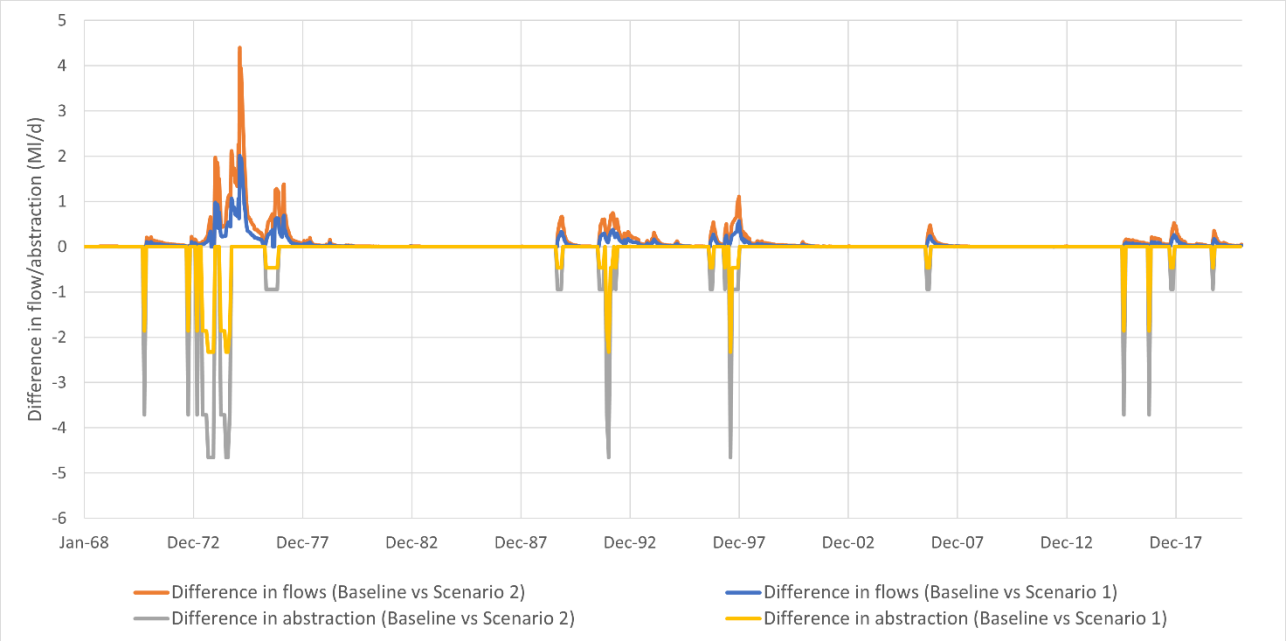
Table 0.4: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Colne catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Colne at Watford, Berrygrove	Q10	138.756	0.050 (0.04%)	0.098 (0.07%)
	Q50	58.266	0.037 (0.06%)	0.099 (0.17%)
	Q70	41.826	0.067 (0.16%)	0.068 (0.16%)
	Q95	19.119	0.180 (0.94%)	0.288 (1.51%)
River Colne at Denham Colne	Q10	500.730	0.136 (0.03%)	0.176 (0.04%)
	Q50	289.177	0.093 (0.03%)	0.181 (0.06%)
	Q70	229.239	0.001 (0.00%)	0.154 (0.07%)
	Q95	132.952	0.519 (0.39%)	1.023 (0.77%)

The increase in flows at the River Colne at Watford, Berrygrove and the River Colne at Denham Colne gauging stations are less significant as a % than other catchments, likely due to the higher flows encountered in the River Colne. It is important to note however that these modelled flow increases constitute an additional response on top of the AMP6 and AMP7 sustainability reduction programme. The minor increases to flows at the River Colne at Denham Colne GS suggests that the cumulative impact from all upstream AIM sources abstraction reductions is not substantial for average flows. However, Figure 0.13 shows that abstraction reductions under Scenario 2 could lead to increased flows of up to 6Ml/d at the River Colne at Denham Colne gauging station during the 1973/4 drought period; or 96% of the total upstream abstraction reduction. During the same drought period, flow benefits of up to 3.9Ml/d occurred at the River Colne at Watford, Berrygrove (see Figure 0.11 below).

Although flows at selected specific percentiles in Table 0.4 imply a correlation between greater difference in flow with lower flows, the trend in the full FDC (as shown in Figure 0.12 and Figure 0.14 for River Colne at Watford, Berrygrove and River Colne at Denham Colne respectively) is less notable, particularly at the River Colne at Watford, Berrygrove.

Figure 0.11: Flow benefits to the River Colne at Watford, Berrygrove.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at all upstream sources. This includes Bricket Wood, Netherwild (Colne - Unconfined catchment), Holywell and Mud Lane (Ver catchment).

Figure 0.12: Impact of the FDC for the River Colne at Watford, Berrygrove

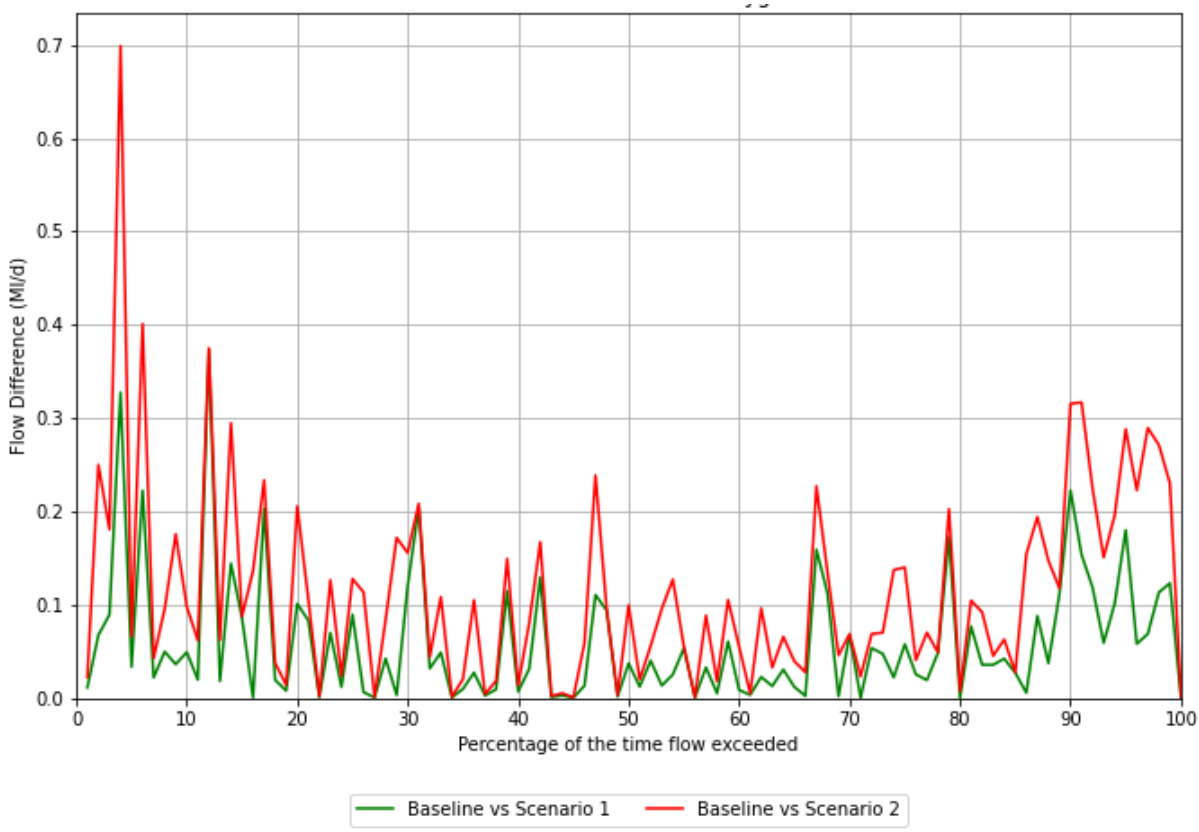
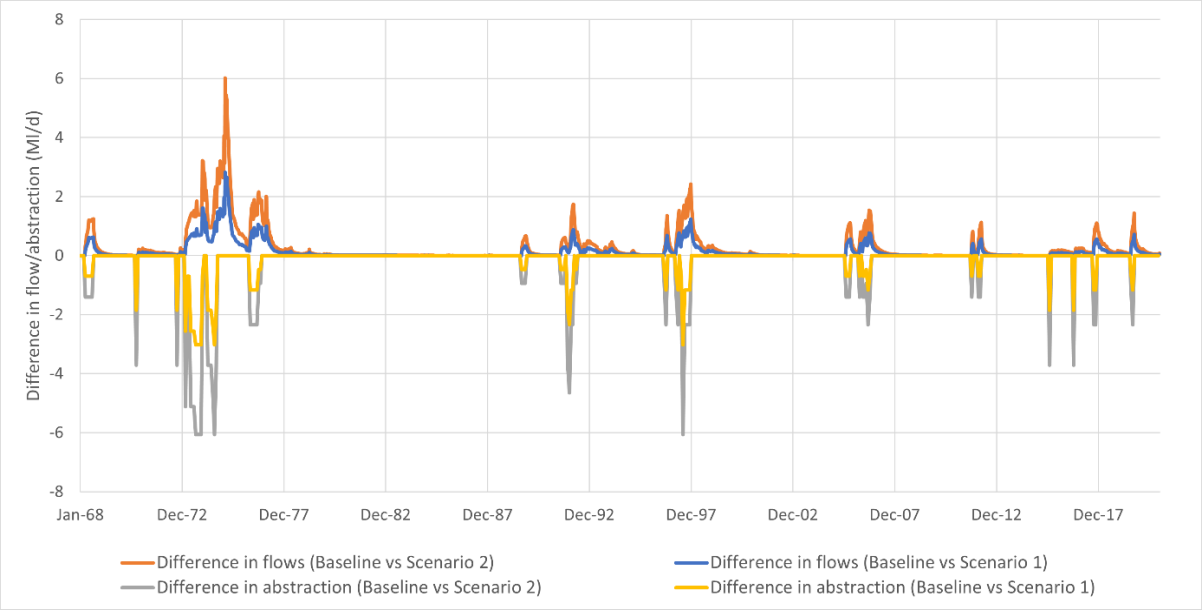
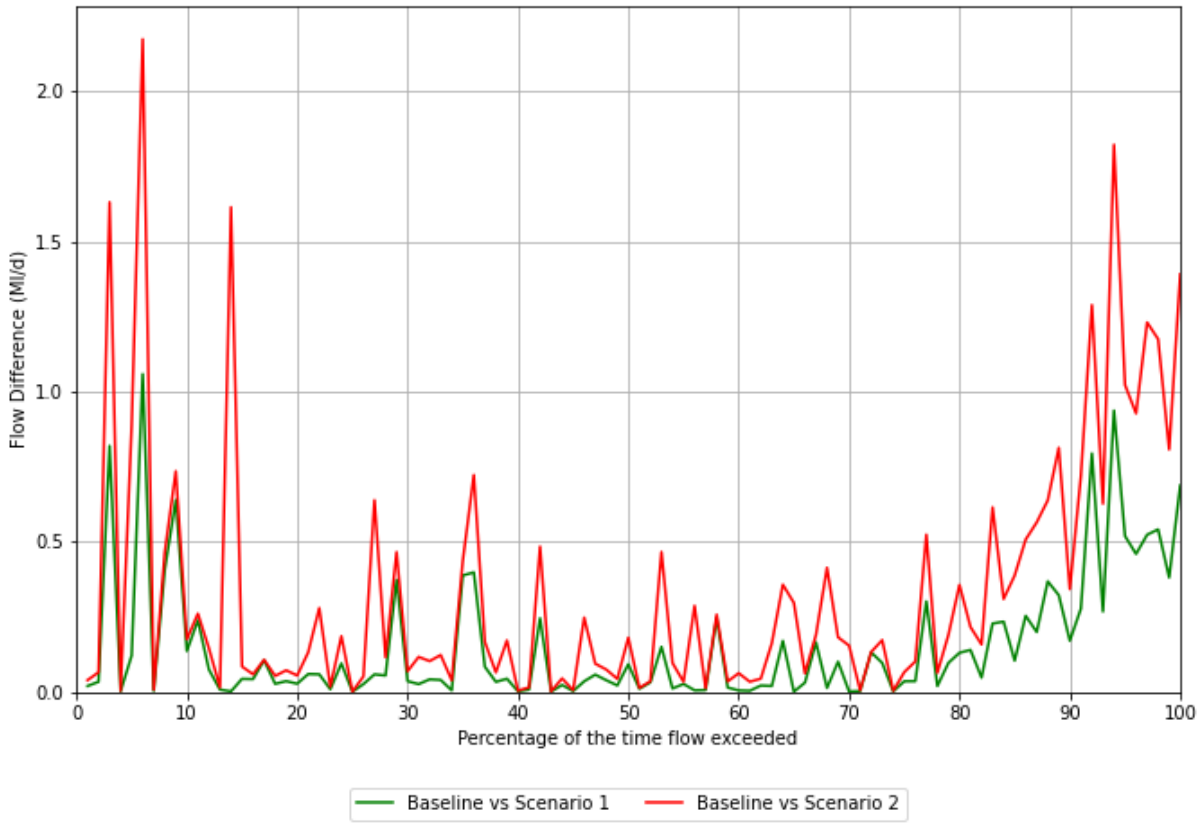


Figure 0.13: Flow benefits to the River Colne at Denham Colne.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at all upstream sources. This includes Bricket Wood, Netherwild (Colne - Unconfined catchment), Holywell, Mud Lane (Ver catchment), Marlowes and Piccotts End (Gade catchment).

Figure 0.14: Impact on the FDC for the River Colne at Denham Colne



River Lee and tributaries

River Beane

The AIM abstraction source within the River Beane catchment is Whitehall. The abstraction reduction is 0.1Ml/d under Scenario 1 and 0.2Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed for the River Beane at Hertford, Hartham Pk gauging station. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.5.

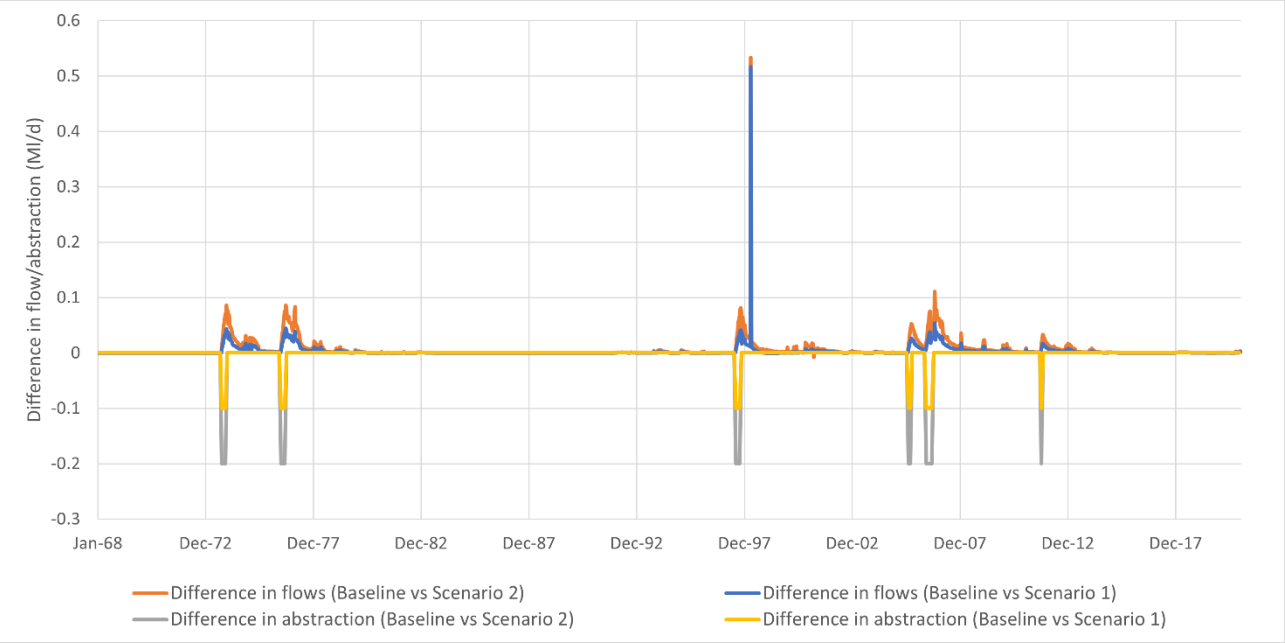
Table 0.5: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Beane catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Beane at Hertford, Hartham Pk	Q10	87.729	0.001 (0.00%)	0.002 (0.00%)
	Q50	42.752	0.000 (0.00%)	0.000 (0.00%)
	Q70	33.977	0.001 (0.00%)	0.002 (0.01%)
	Q95	17.615	0.004 (0.02%)	0.007 (0.04%)

Comparison of modelled flows show that the difference between baseline conditions and abstraction reductions, in both Scenario 1 and Scenario 2, are very minimal; resulting from the small reduction in abstraction volumes of 0.1Ml/d and 0.2Ml/d under Scenario 1 and Scenario 2. Figure 0.15 and Figure 0.16 demonstrate the flow benefits to the River Beane at Hertford, Hartham Pk and the impacts on the FDC for this gauging station. Figure 0.15 demonstrates the largest increase in flows recorded at this gauging station are minimal at 0.11Ml/d under Scenario 2 (55% of upstream abstraction reduction). The single spike in 1997/98 is believed to be a model outlier and has been removed from accretion profile assessments.

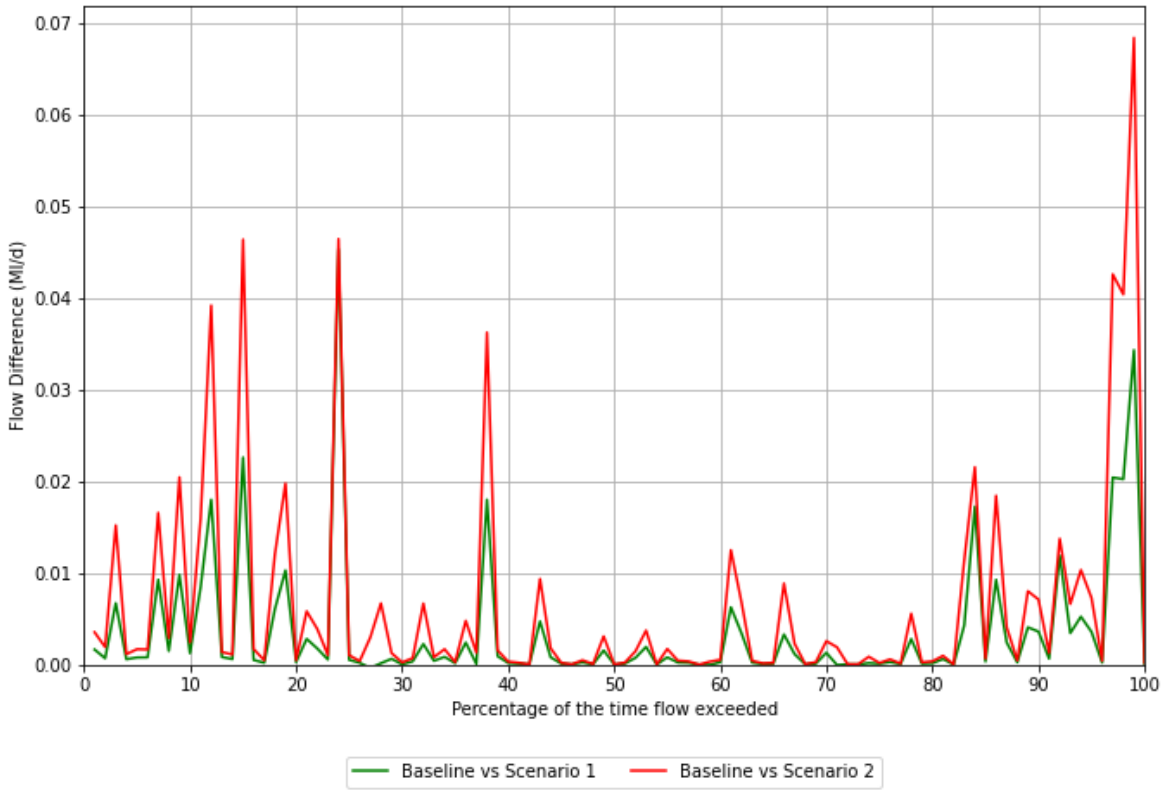
The largest difference in average flows (0.007Ml/d or 0.04%) in Table 0.5 are observed during low flows under a 10% abstraction reduction (Scenario 2). However, slightly greater increases to average flows can be found at >Q95 in Figure 0.16.

Figure 0.15: Flow benefits to the River Beane at Hertford, Hartham Pk.



Source: The difference in abstraction is given by the abstraction reduction implemented at Whitehall.

Figure 0.16: Impact on the FDC for the River Beane at Hertford, Hartham Pk



River Mimram

The AIM abstraction sources within the River Mimram catchment are Fulling Mill and Digswell. The combined abstraction reduction (from both sources) is 0.17Ml/d under Scenario 1 and 0.35Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed at the River Mimram at Welwyn, Fulling Mill and River Mimram at Panshanger gauging stations. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.6.

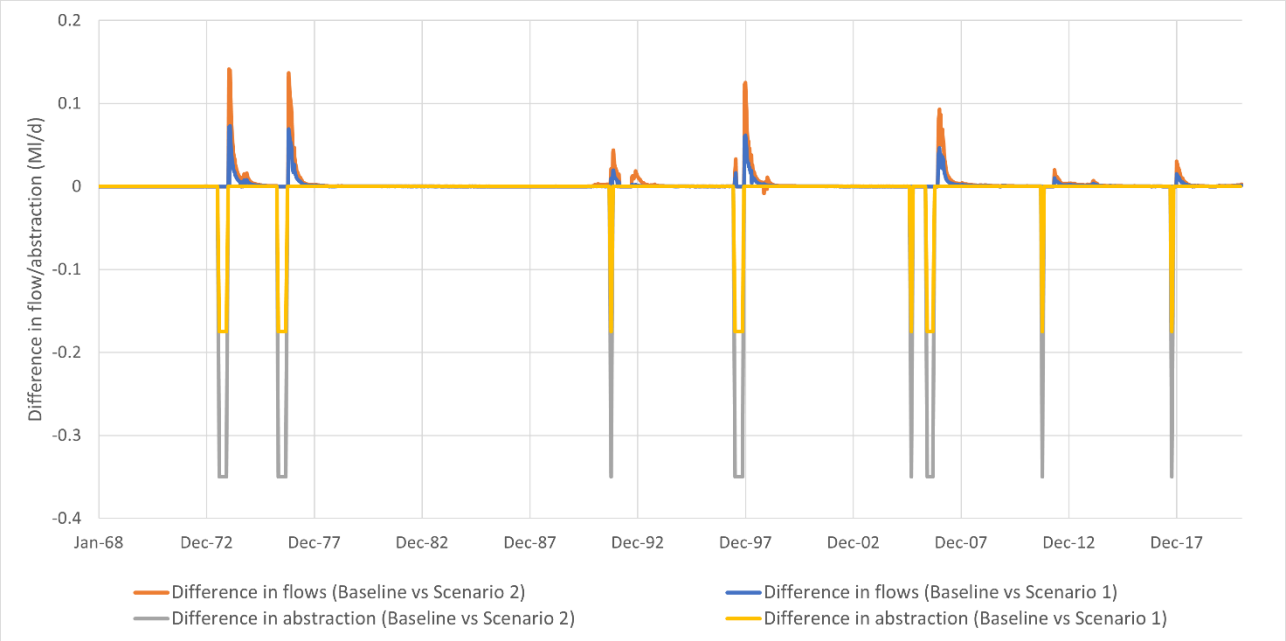
Table 0.6: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Mimram catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Mimram at Welwyn, Fulling Mill	Q10	44.192	0.005 (0.01%)	0.013 (0.03%)
	Q50	14.551	0.000 (0.00%)	0.001 (0.01%)
	Q70	7.733	0.037 (0.48%)	0.037 (0.48%)
	Q95	0.000	0.000 (0.00%)	0.000 (0.00%)
River Mimram at Panshanger	Q10	88.893	0.001 (0.00%)	0.002 (0.00%)
	Q50	42.139	0.000 (0.00%)	0.001 (0.00%)
	Q70	31.733	0.021 (0.07%)	0.021 (0.07%)
	Q95	18.481	0.023 (0.12%)	0.041 (0.22%)

Following abstraction reductions at Fulling Mill AIM source, there is a minor improvement (0.037Ml/d or 0.48% at Q70 under Scenario 1 and 2) to average stream flows at the River Mimram at Welwyn, Fulling Mill gauging station. These minor improvements result from the small changes to flow at Fulling Mill at 0.1Ml/d under Scenario 1 and 0.2Ml/d under Scenario 2. At this location, the AIM source is located <30m from the gauging station. The flow benefits to the River Mimram at Welwyn, Fuling Mill GS and impact on the FDC can be found in Figure 0.17 and Figure 0.18 respectively. Here, the greatest increase in flow recorded during the entire model stimulation period is 0.14Ml/d under Scenario 2 following the 1973/4 drought period.

Due to the higher flows at the River Mimram at Panshanger gauging station located further downstream and the impact of abstraction reductions at both Fulling Mill and Digswell, the flow benefits (see Figure 0.19) are more notable. Flow differences greater than 0.36Ml/d are observed following the 1973/4 drought period (102% of upstream abstraction reduction). Figure 0.20 shows the impacts on the FDC at River Mimram at Panshanger GS.

Figure 0.17: Flow benefits to the River Mimram at Welwyn, Fulling Mill



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Digswell and Fulling Mill.

Figure 0.18: Impact of the FDC for the River Mimram at Welwyn, Fulling Mill

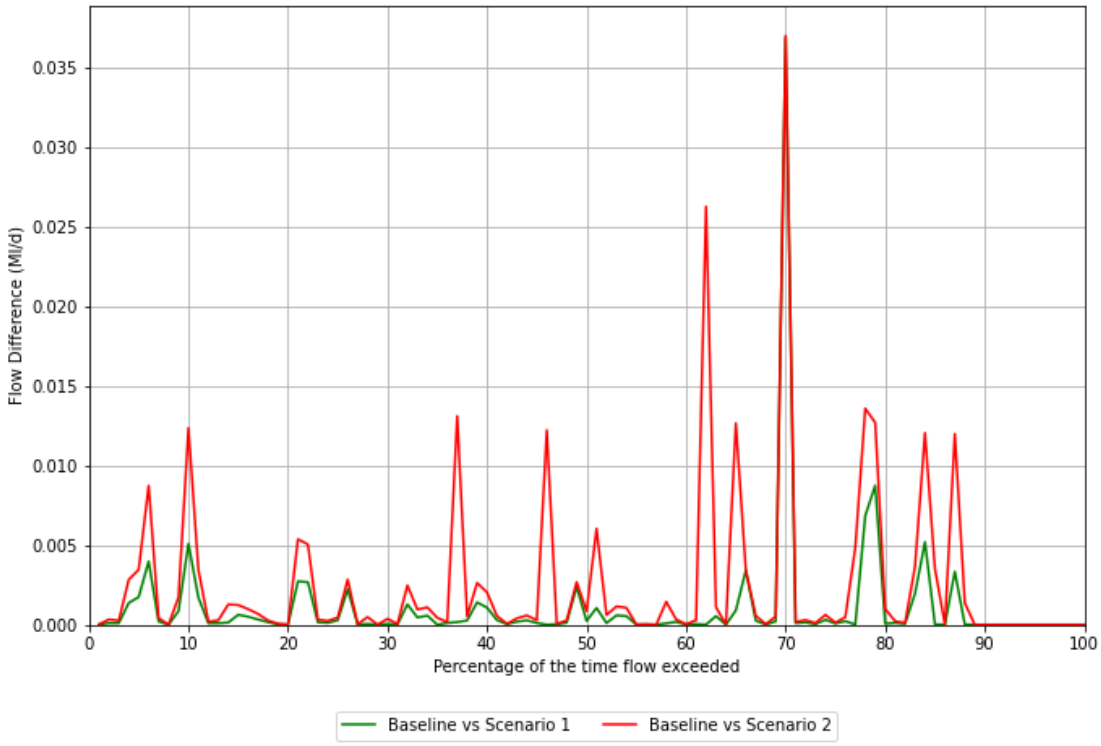
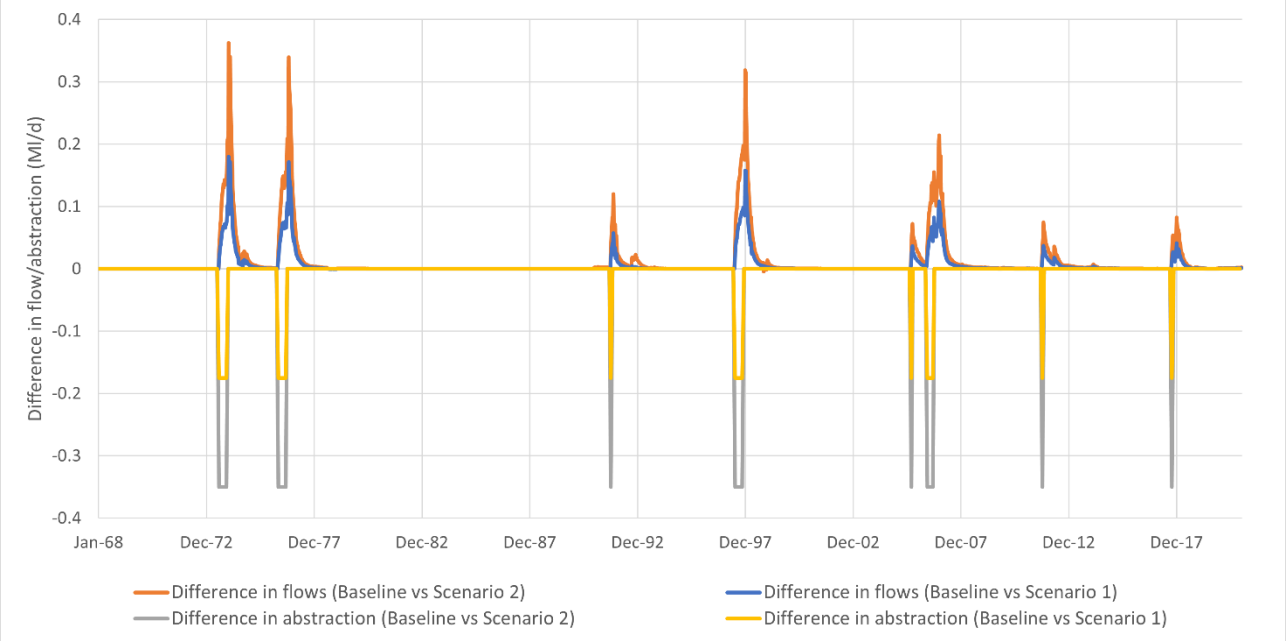
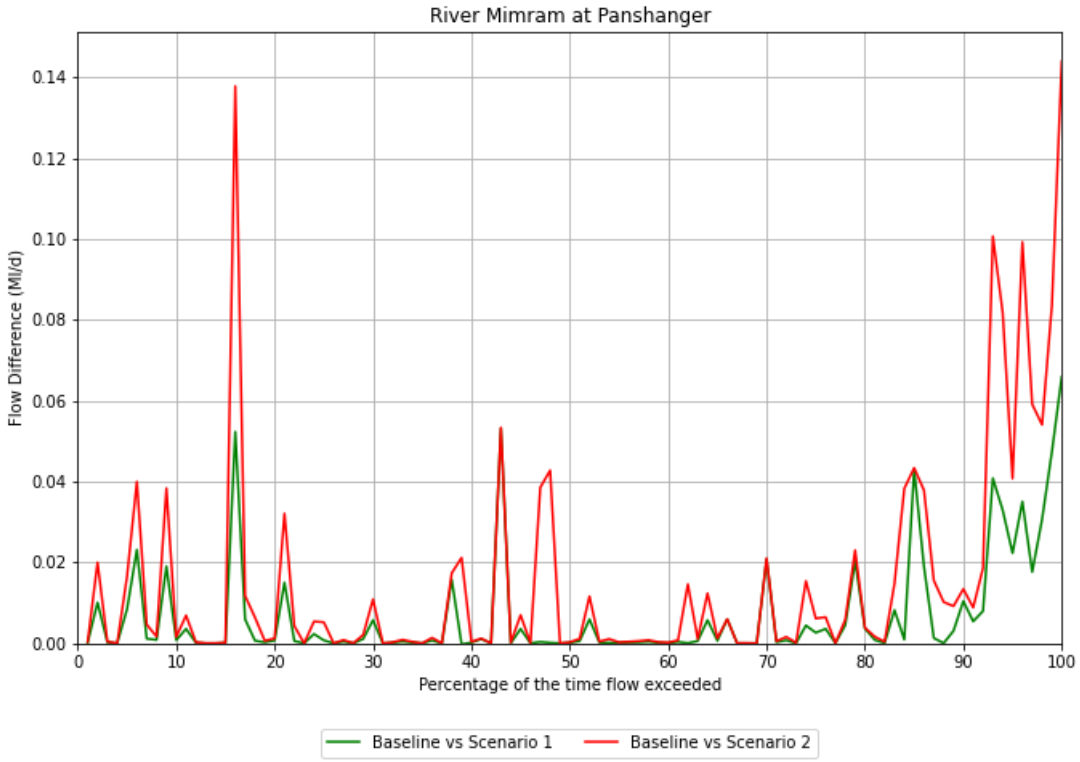


Figure 0.19: Flow benefits to the River Mimram at Panshanger.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Digswell and Fulling Mill.

Figure 0.20: Impact of the FDC for the River Mimram at Panshanger



River Lee (Middle)

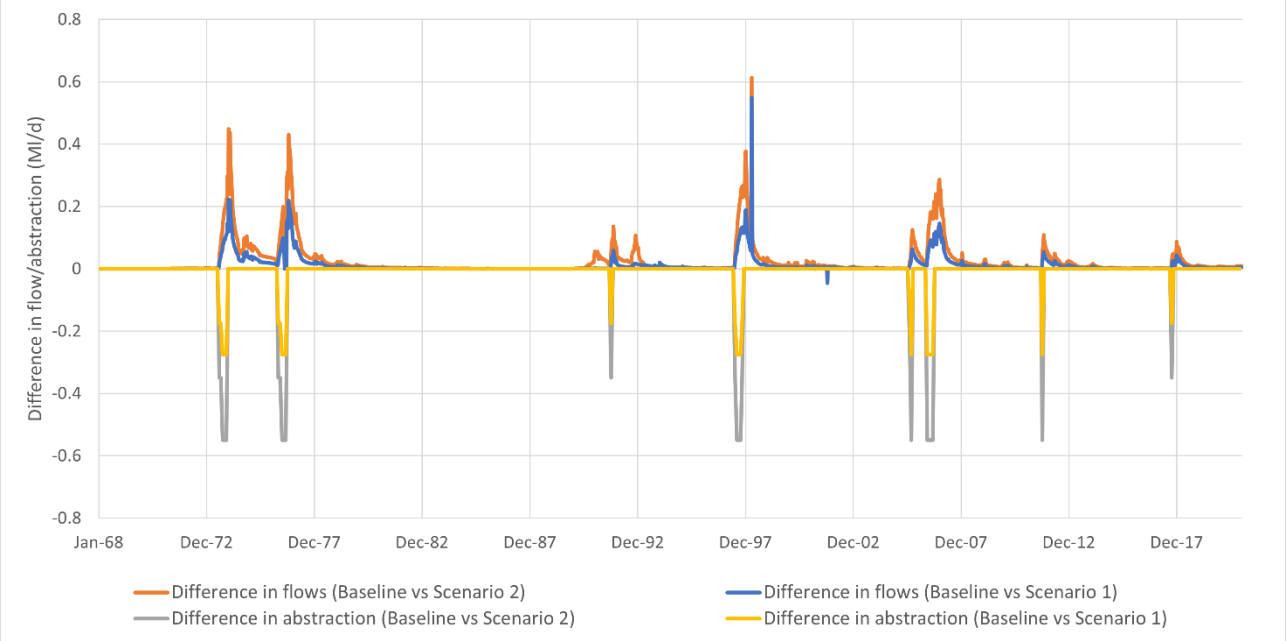
There are no proposed AMP8 AIM sources within the River Lee (Middle) catchment. The impact of abstractions at the River Lee (Middle) at Fieldes Weir GS were analysed in order to assess the cumulative impact of abstraction reductions upstream. The total upstream abstraction reductions under Scenario 1 is 0.27 Ml/d and Scenario 2 is 0.55 Ml/d. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.7.

Table 0.7: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Lee (Middle) catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Lee (Middle) at Fieldes Weir	Q10	839.553	0.013 (0.00%)	0.030 (0.00%)
	Q50	286.665	0.001 (0.00%)	0.003 (0.00%)
	Q70	200.439	0.003 (0.00%)	0.006 (0.00%)
	Q95	94.614	0.009 (0.01%)	0.018 (0.02%)

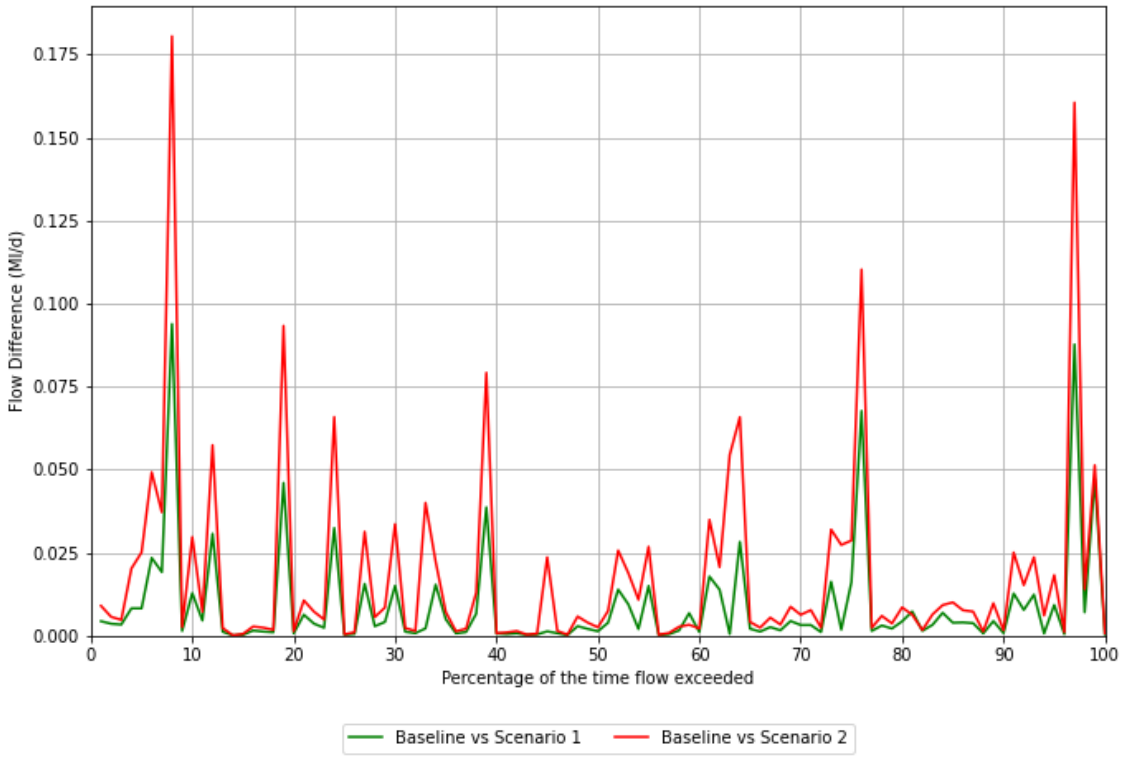
Due the location of the River Lee (Middle) at Fieldes Weir and the high flow in the river along this section, downstream of multiple catchment areas, the average flow differences under Scenario 1 and Scenario 2 are small (0.018Ml/d or 0.02% maximum at Q95 under scenario 2). This implies that the effect of AIM abstraction reductions upstream has minor cumulative impacts downstream. The flow benefits to the River Lee (Middle) at Fieldes Weir GS and the impact on the FDC can be found in Figure 0.21 and Figure 0.22 respectively. The largest increase in flow recorded is 0.45Ml/d following the 1973/4 drought period. **This is 82% of the total upstream abstraction reductions**. The single spike in 1997/98 is believed to be a model outlier and has been removed from accretion profile assessments.

Figure 0.21: Flow benefits to the River Lee (Middle) at Fieldes Weir GS.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at all upstream sources. This includes Whitehall (Beane catchment), Fulling Mill and Digswell (Mimram catchment).

Figure 0.22: Impact of the FDC for the River Lee (Middle) at Fieldes Weir GS



River Bedford Ouse

The AIM abstraction sources within the River Bedford Ouse catchment are Wellhead, Oughton Head and Offley Bottom. The combined abstraction reduction (from all sources) is 0.29Ml/d under Scenario 1 and 0.58Ml/d under Scenario 2. The impacts of the abstraction reductions are analysed at the River Hiz and Hitchin gauging station. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.8.

Table 0.8: Difference in flow percentiles between baseline and scenarios 1 and 2 in the River Bedford Ouse catchment

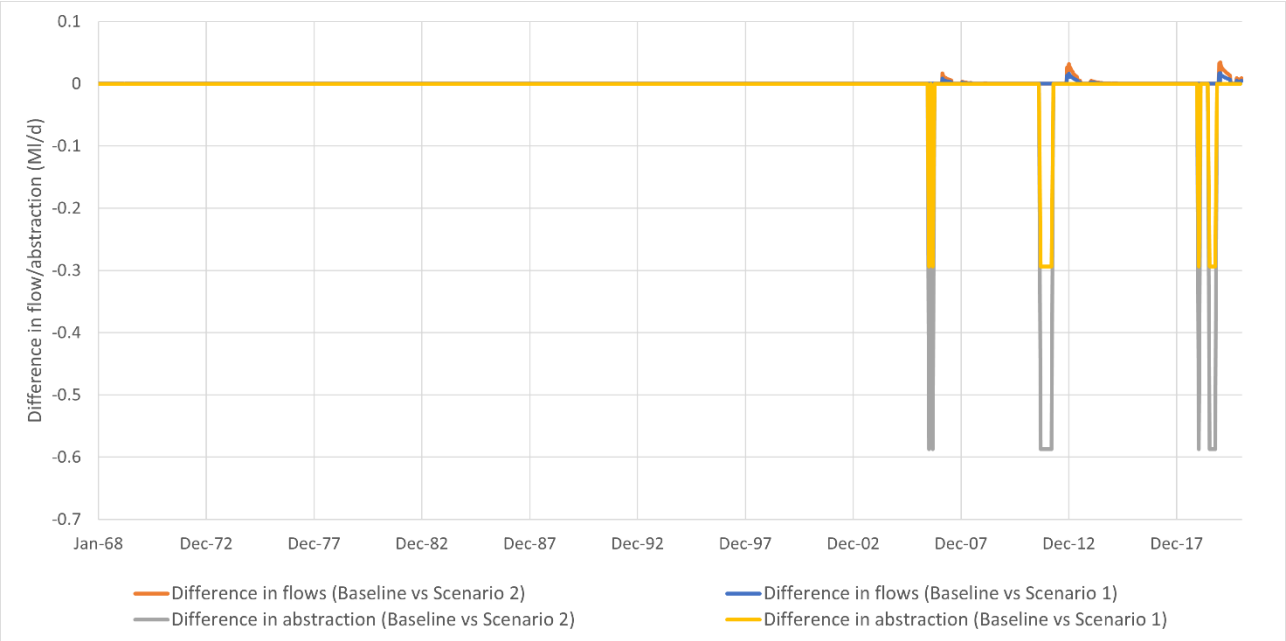
Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Hiz at Hitchin	Q10	1.068	0.000 (0.00%)	0.003 (0.28%)
	Q50	0.000	0.000 (0.00%)	0.000 (0.00%)
	Q70	0.000	0.000 (0.00%)	0.000 (0.00%)
	Q95	0.000	0.000 (0.00%)	0.000 (0.00%)

The differences in flows under Scenario 1 and Scenario 2 abstraction reduction volumes have insignificant impacts on flows at the River Hiz at Hitchin GS. This is also reflected in

Figure 0.23, where maximum flow benefits are no greater than 0.03 Ml/d (5% of upstream abstraction reduction). Figure 0.24 presents the impact of abstraction reductions on the FDC at this gauging station.

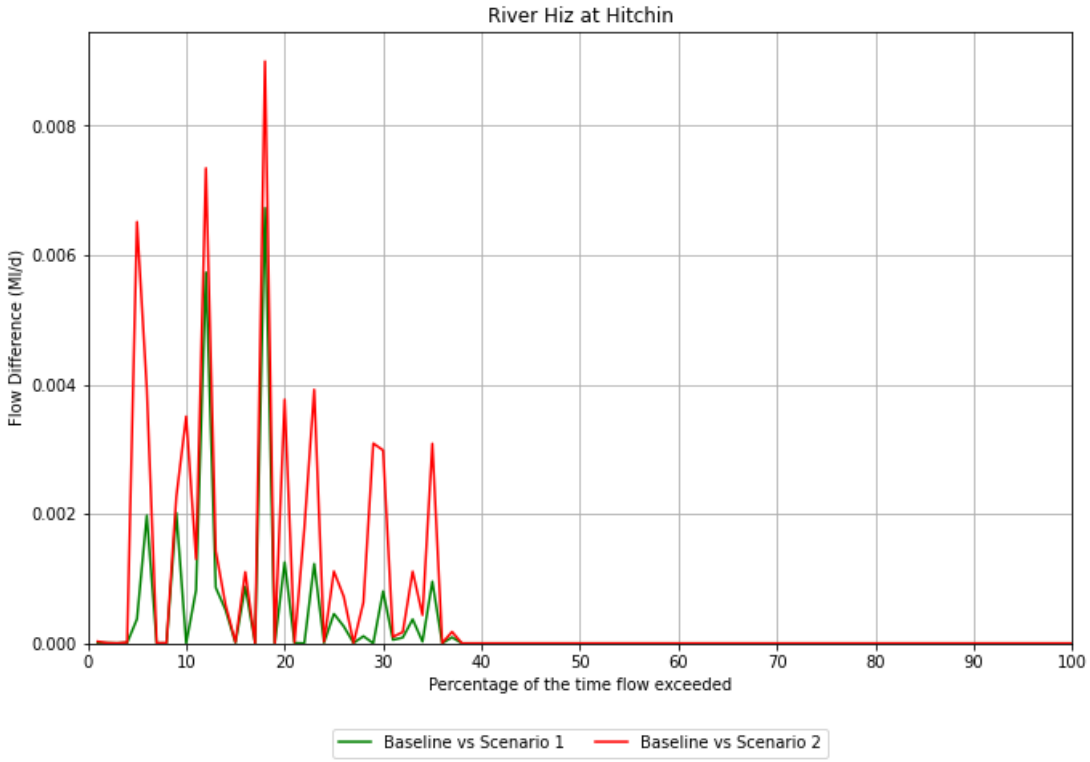
However, this surface water catchment is located along the northern boundary of the HCM2020 model, which probably results in poor calibration at this area; in addition to the stream flow going outwards of the model area. As a result, the flow at this location is considerably under simulated, and is dry for flows below Q30. This GS assessment point is considered not representative of a realistic scenario for this assessment and is provided for reference only.

Figure 0.23: Flow benefits to the River Hiz at Hitchin.



Source: The difference in abstraction is given by the combined abstraction reduction implemented at Oughton Head, Offley Bottom and Well Head.

Figure 0.24: Impact of the FDC for the River Hiz at Hitchin



Rivers Cam, Ivel and Rhee

The AIM abstraction source within the Rivers Cam, Ivel and Rhee catchment is the Slip End source. The AIM trigger for the Slip End source varies depending on flow at Ashwell gauging station on the Rhee and the permitted abstraction rate specified in the licence. The abstraction rates under Scenario 1 and Scenario 2 are outlined in

Table 0.2. When flow at the Ashwell gauging station is between 2.50 and 2.55Ml/d, abstraction reductions are 0.26Ml/d under Scenario 1 and 0.52Ml/d under Scenario 2. At lower flows (between 2.00 and 2.05Ml/d), abstraction reductions are 0.02Ml/d under Scenario 1 and 0.04 Ml/d under Scenario 2. When the flow at the River Ashwell gauging station is greater than 2.55Ml/d or less than 2Ml/d, no abstraction reductions are implemented.

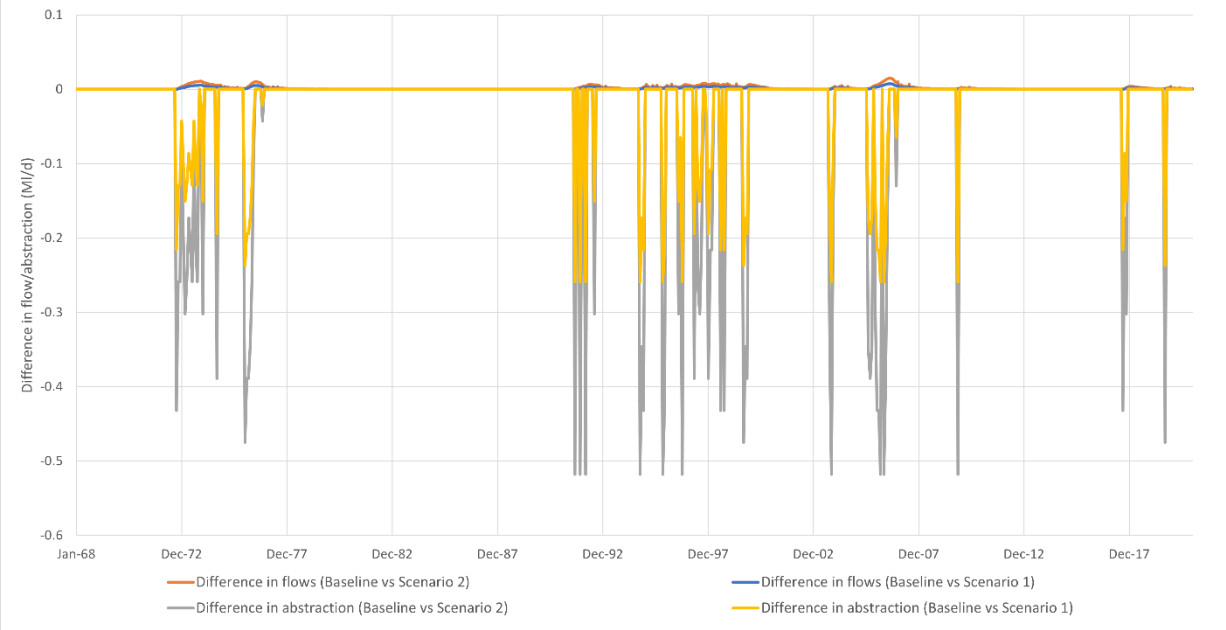
The impacts of the abstraction reductions are analysed at the River Rhee at Ashwell gauging station. The difference in flow percentiles observed under Scenario 1 and Scenario 2 are outlined in Table 0.9.

Table 0.9: Difference in flow percentiles between baseline and scenarios 1 and 2 in the Rivers Cam, Ivel and Rhee catchment

Gauging station	FDC%	Baseline (Ml/d)	Baseline vs Scenario 1 Ml/d (%)	Baseline vs Scenario 2 Ml/d (%)
River Rhee at Ashwell	Q10	1.511	0.001 (0.07%)	0.002 (0.13%)
	Q50	1.005	0.001 (0.10%)	0.001 (0.10%)
	Q70	0.804	0.000 (0.00%)	0.001 (0.12%)
	Q95	0.412	0.001 (0.24%)	0.003 (0.73%)

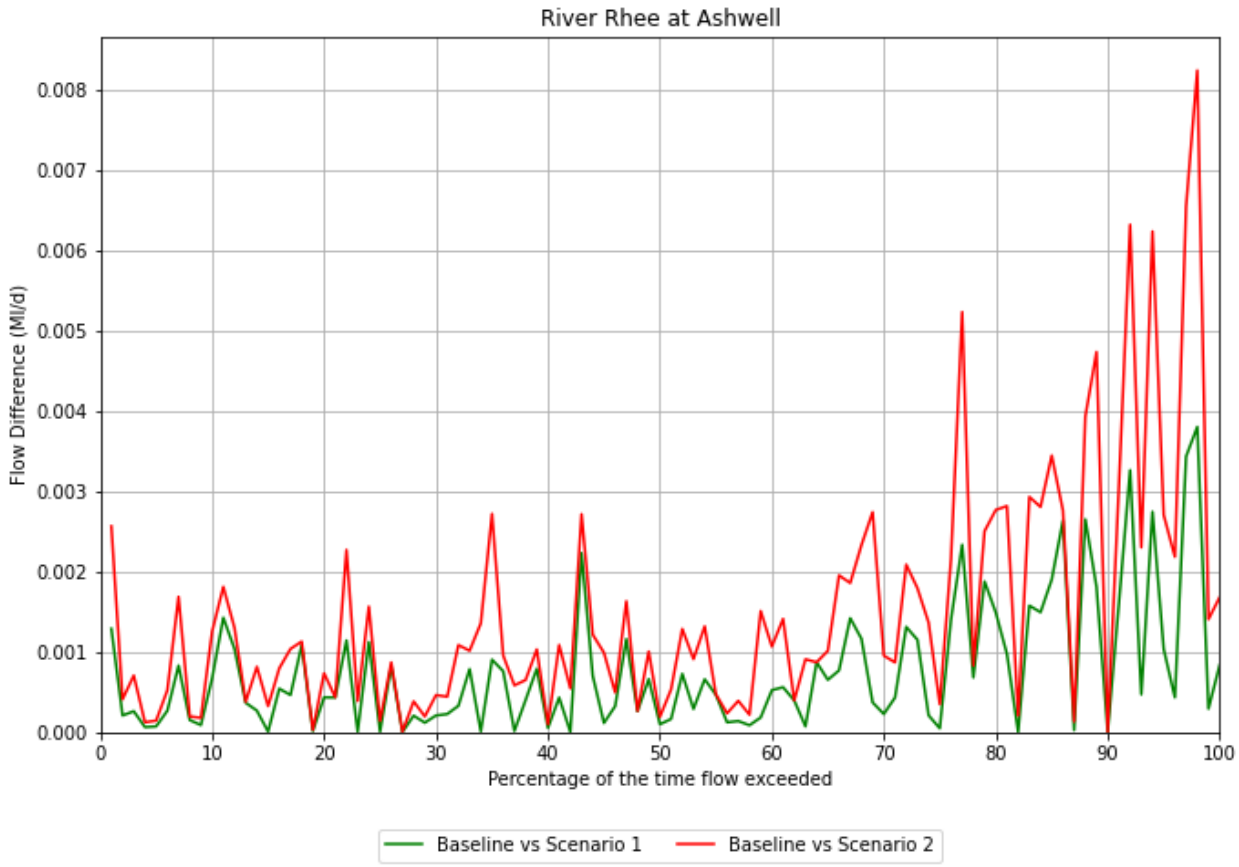
Despite generally low flows encountered at the River Rhee at Ashwell under baseline conditions, minor improvements can be observed under low flow conditions (0.73% at Q95 under Scenario 2). Since changes in flows are so small, flow benefits to the River Rhee at Ashwell gauging station are almost imperceptible with a maximum increase of 0.015Ml/d (Figure 0.25). The impact of abstraction reduction at Slip End on the River Rhee at Ashwell FDC can be found in Figure 0.26 and demonstrates that baseflow contributions appear to slightly increase flow during low flow conditions.

Figure 0.25: Flow benefits to the River Rhee at Ashwell.



Source: The difference in abstraction is given by the abstraction reduction implemented at Slip End.

Figure 0.26: Impact of the FDC for the River Rhee at Ashwell



4 Conclusions and limitations

Conclusions

An assessment of nine catchments flows has been carried out, using the HCM2020 model, to evaluate the effect of AIM reductions at selected groundwater sources. Some catchments show positive impacts on low flows, and benefits can be more significant in terms of percentage of the abstraction reductions. However, the assessment highlights that the cumulative impacts of the reductions have a low average benefit when AIM is active, due to the small volumes associated to the 5% and 10% reductions during triggered periods.

The catchments with the greatest benefit to flows are the Ver and the Gade, according to the FDCs. Peak benefits to the River Ver and River Gade are 1.15Ml/d at the River Ver at Colney Street GS and 1.37Ml/d at the River Gade at Croxley Green GS. Under the AIM Scenario 2 reductions, this also has a positive impact of up to 6Ml/d on the cumulative flows of the River Colne (downstream of the tributaries). It is important to note however that this modelled flow increases constitutes an additional response on top of the AMP6 and AMP7 sustainability reduction programme. The greatest changes to flows are generally observed under low-flow conditions. Average impacts on the Misbourne, Beane and Mimram catchments are negligible with peak benefits of 0.17Ml/d, 0.11Ml/d and 0.36Ml/d respectively.

Based on the accretion profiles from Appendix 0, the largest benefit to flows is observed under the AIM Scenario 2 reductions, and match the flow benefits presented in section 3. The maximum benefits observed in the catchments show that abstraction reductions have the largest impact on the River Colne and its tributaries. A cumulative benefit of 6 Ml/d is modelled for the River Colne at Denham, which is significant and in addition to any responses which occur following upstream sustainability reductions, but only happens during a short period of time when AIM reductions are triggered. The Lee and its tributaries show a modest benefit at 0.45 Ml/d, whilst the Hiz and the Rhee show minimal improvements.

The resulting additional water which is left in the environment during low flow periods may provide greater environmental resilience and also help to focus the attention of both the industry and AFW customers on environmental sensitivities and low flows. Outperformance of the scenarios modelled in this report could produce a greater environmental benefit, however these scenarios have not been investigated.

Caveats and Limitations

- Results from the HCM202 model are presented as-is; we have not carried out any modifications or re-calibrations to the groundwater model or its parameters.
- Baseline and AIM reduction abstraction rates have been discussed and agreed with AFW.
- Any modelled results presented here are subject to calibration accuracy of the model, and variance on model parameters. As such, they should not be considered predictive, but an estimate on potential behaviour.

Appendices

A Accretion profiles

Each plot shows the accretion profiles generated under the three scenarios (top) and the difference between the baseline against scenario 1 and 2 (bottom).

River Misbourne

Figure A.1: River Misbourne accretion profile – January 1998

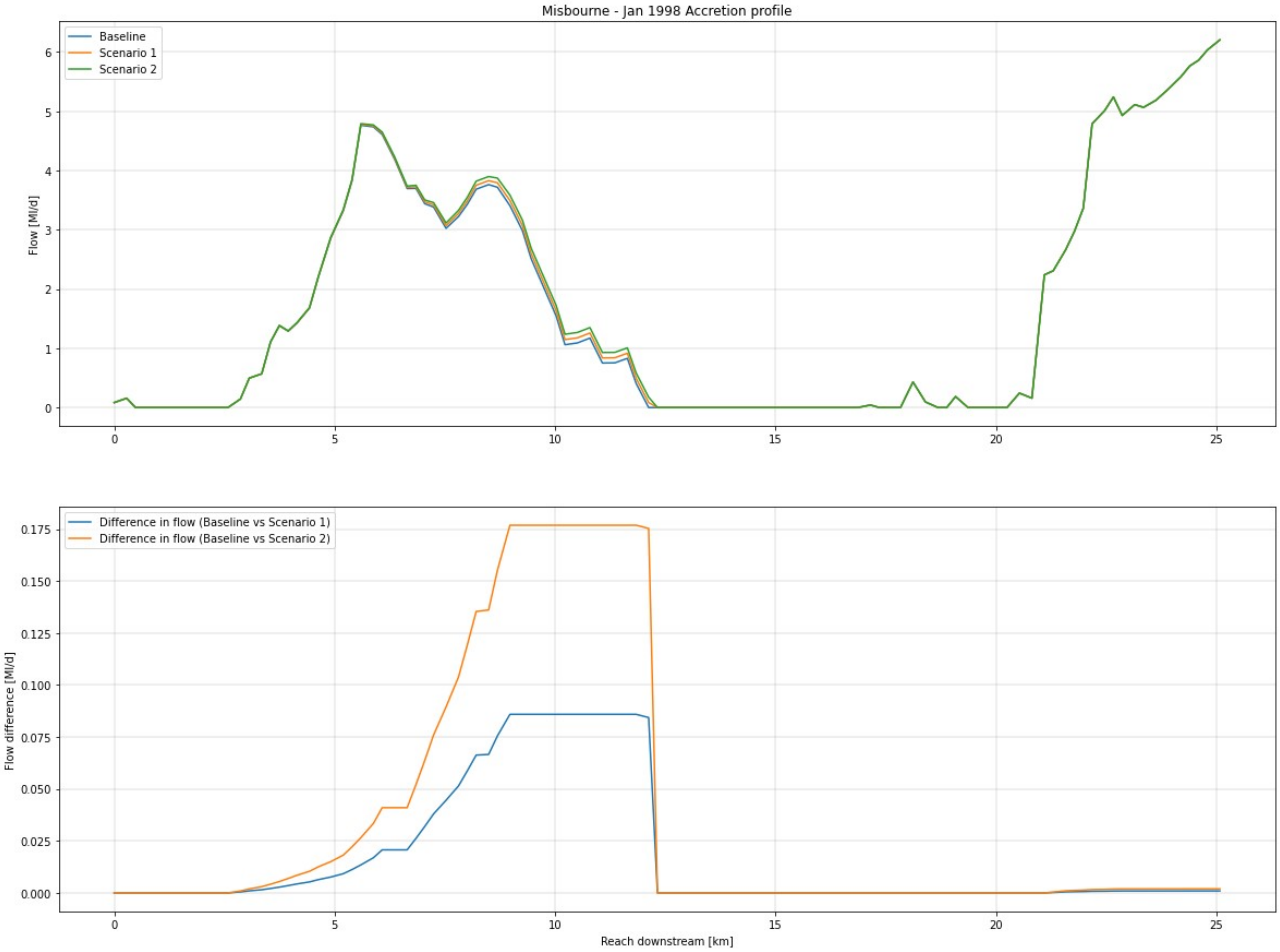
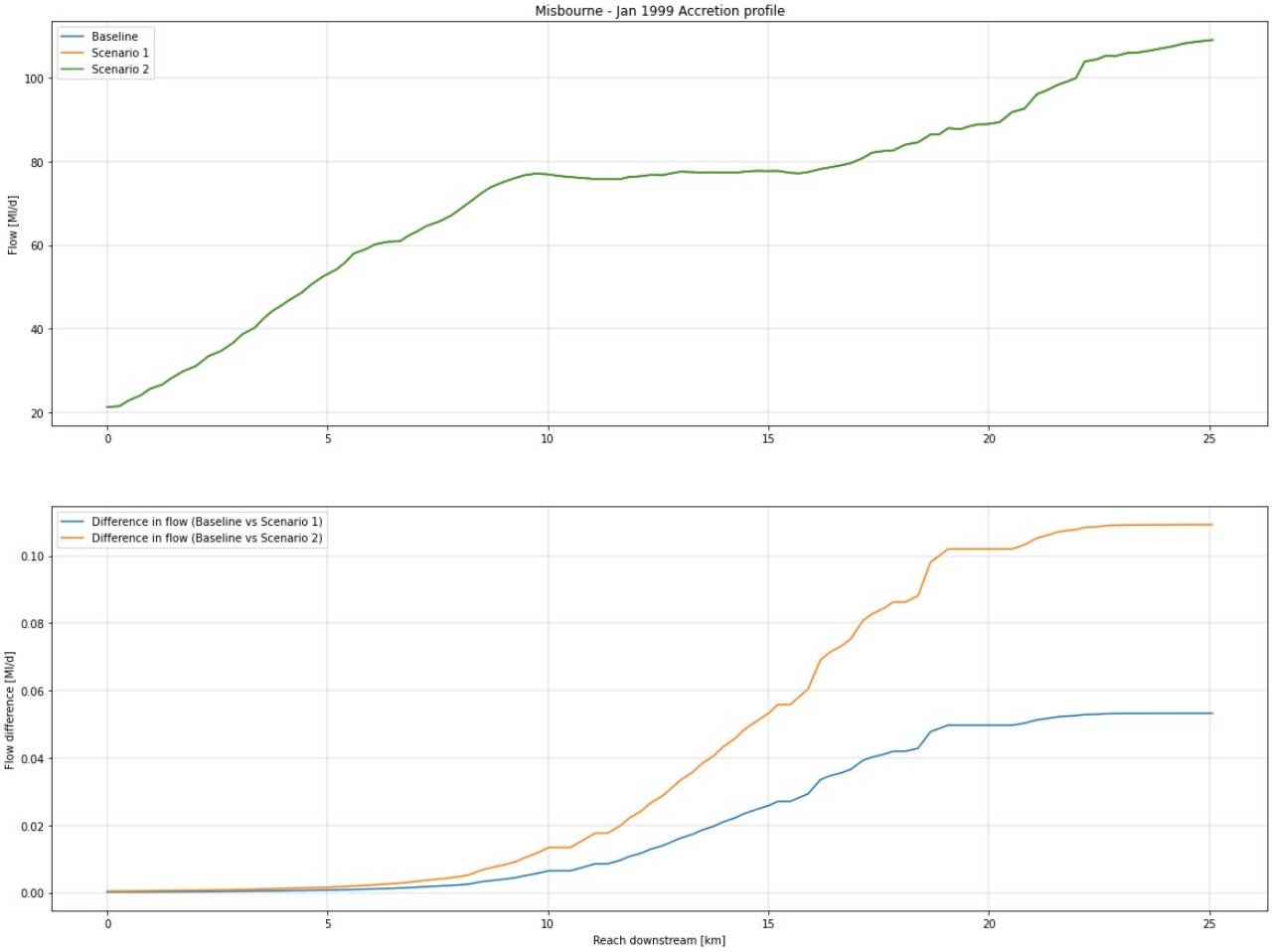


Figure A.2: River Misbourne accretion profile – January 1999.



River Gade

Figure A.3: River Gade accretion profile – December 1973.

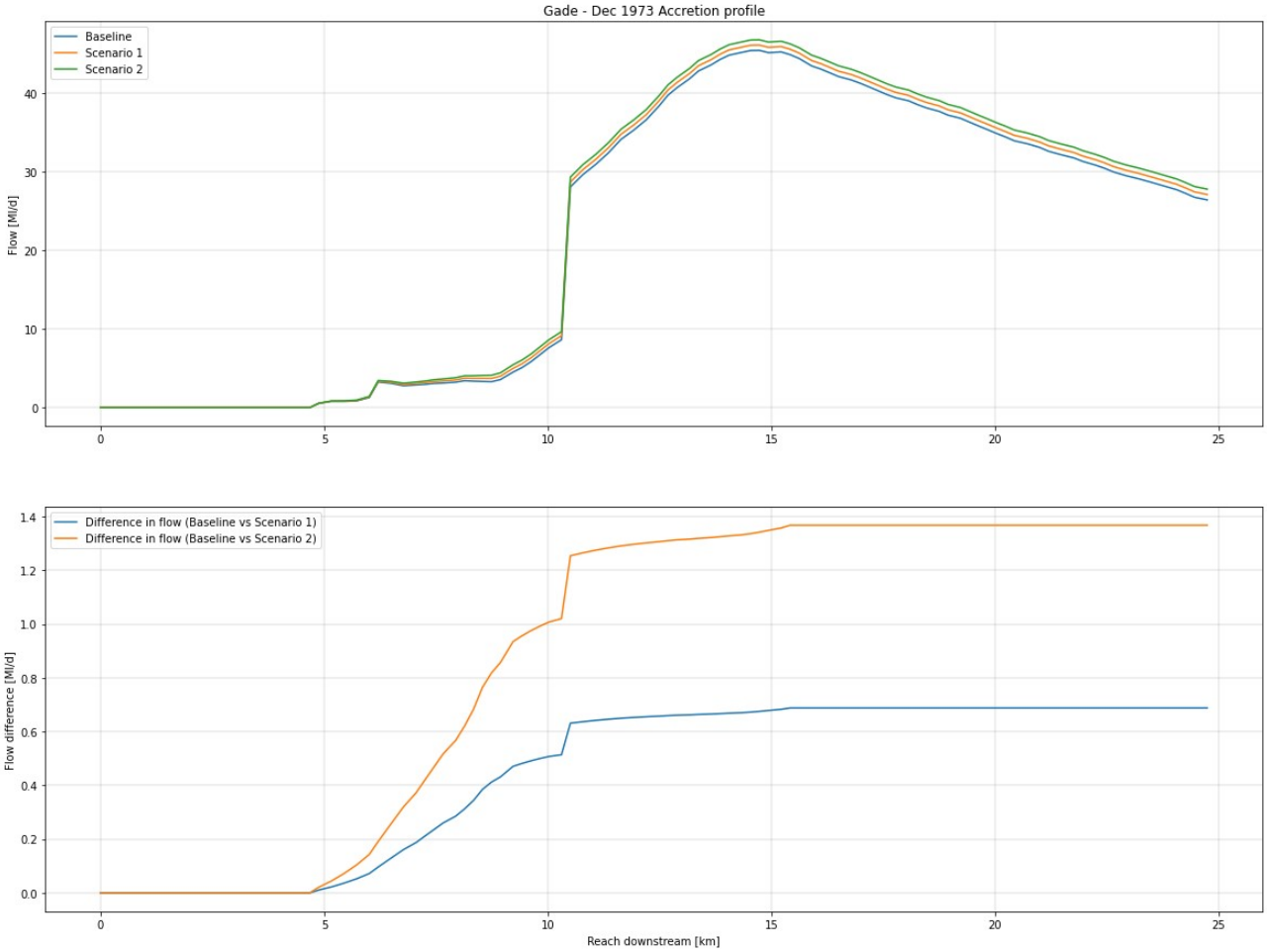
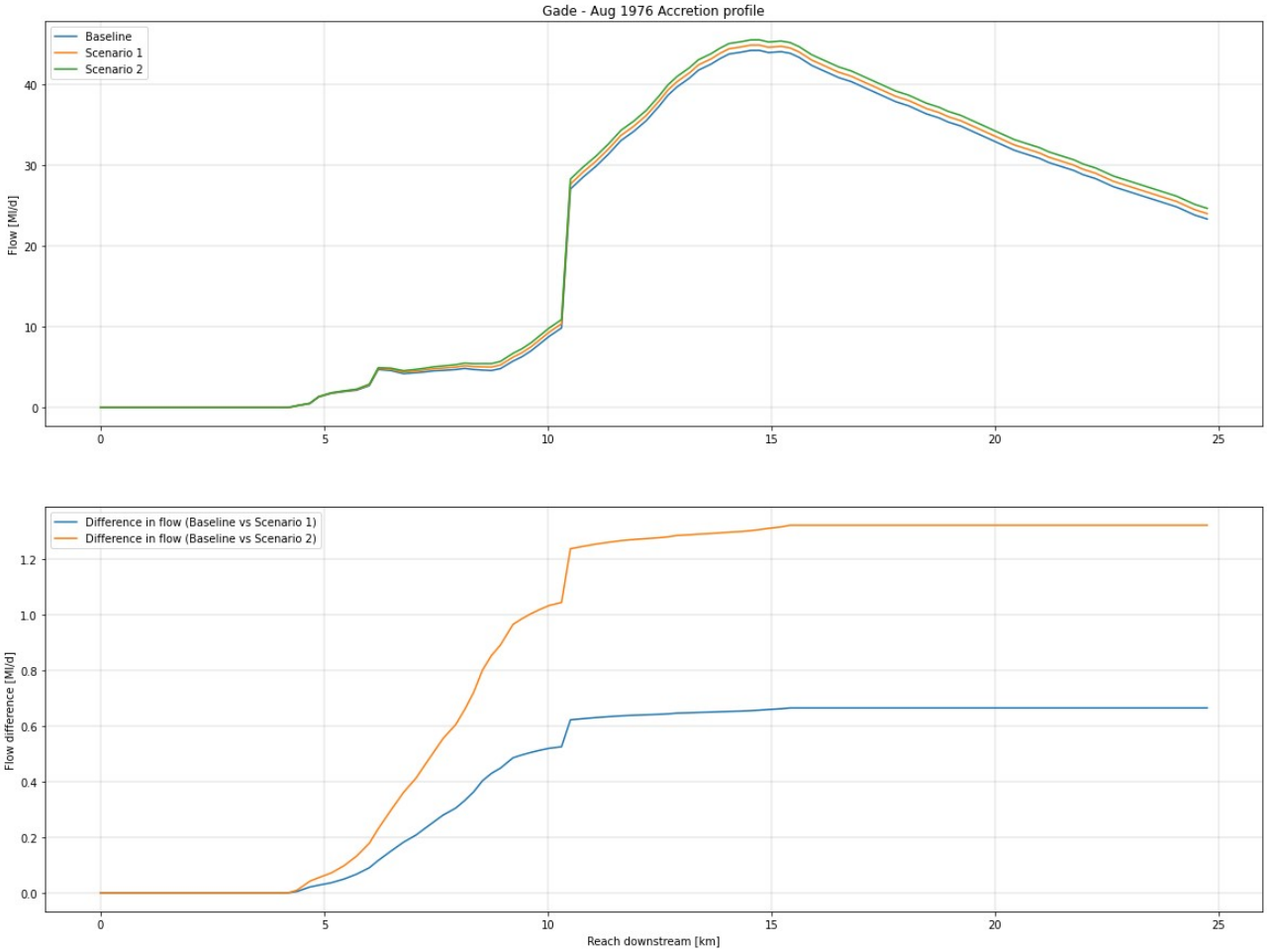
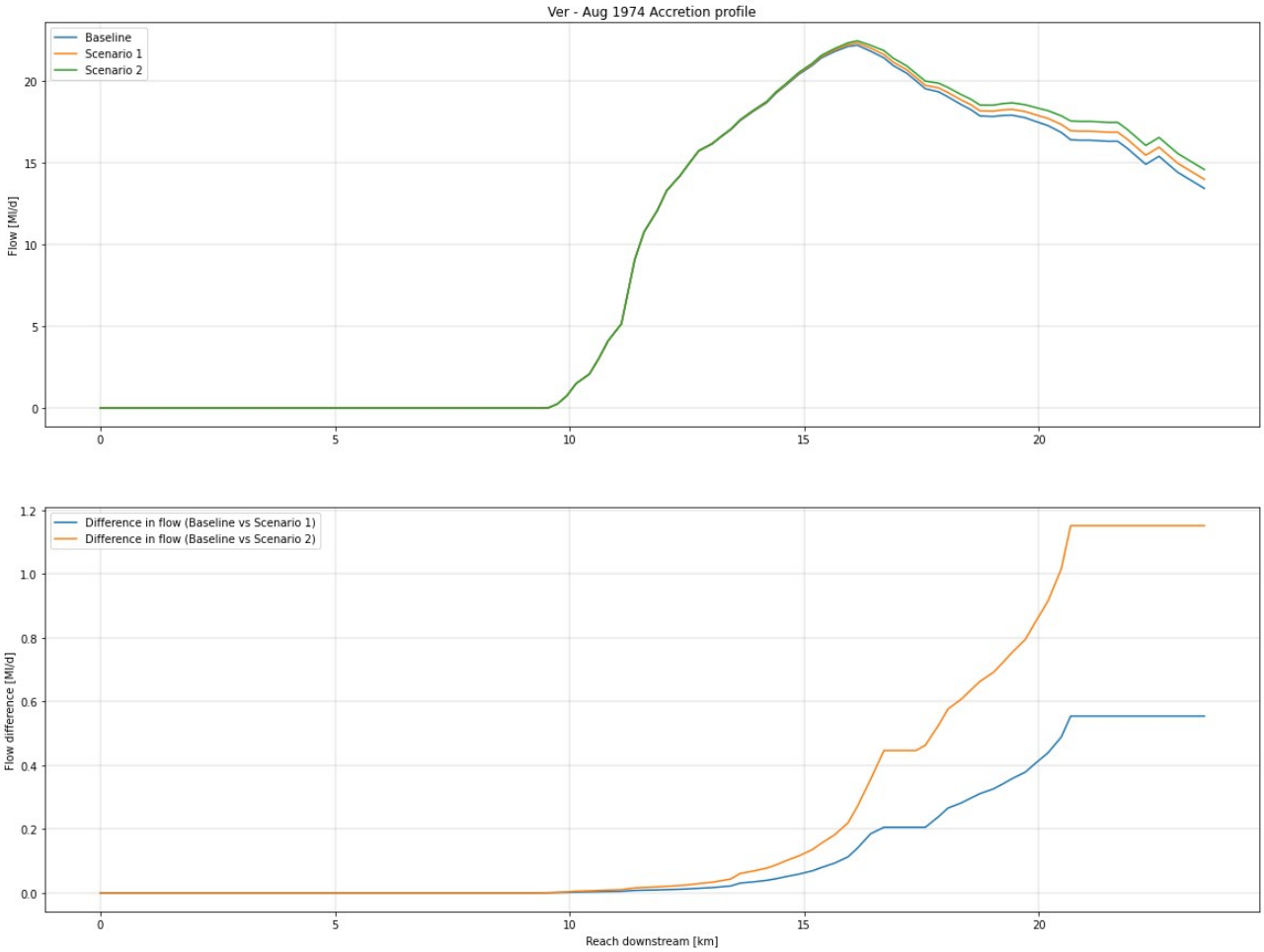


Figure A Error! No text of specified style in document..**4: River Gade accretion profile – August 1976**



River Ver

Figure Error! No text of specified style in document..**5: River Ver accretion profile – August 1974.**



River Colne

Figure A.6: River Colne accretion profile – February 1975

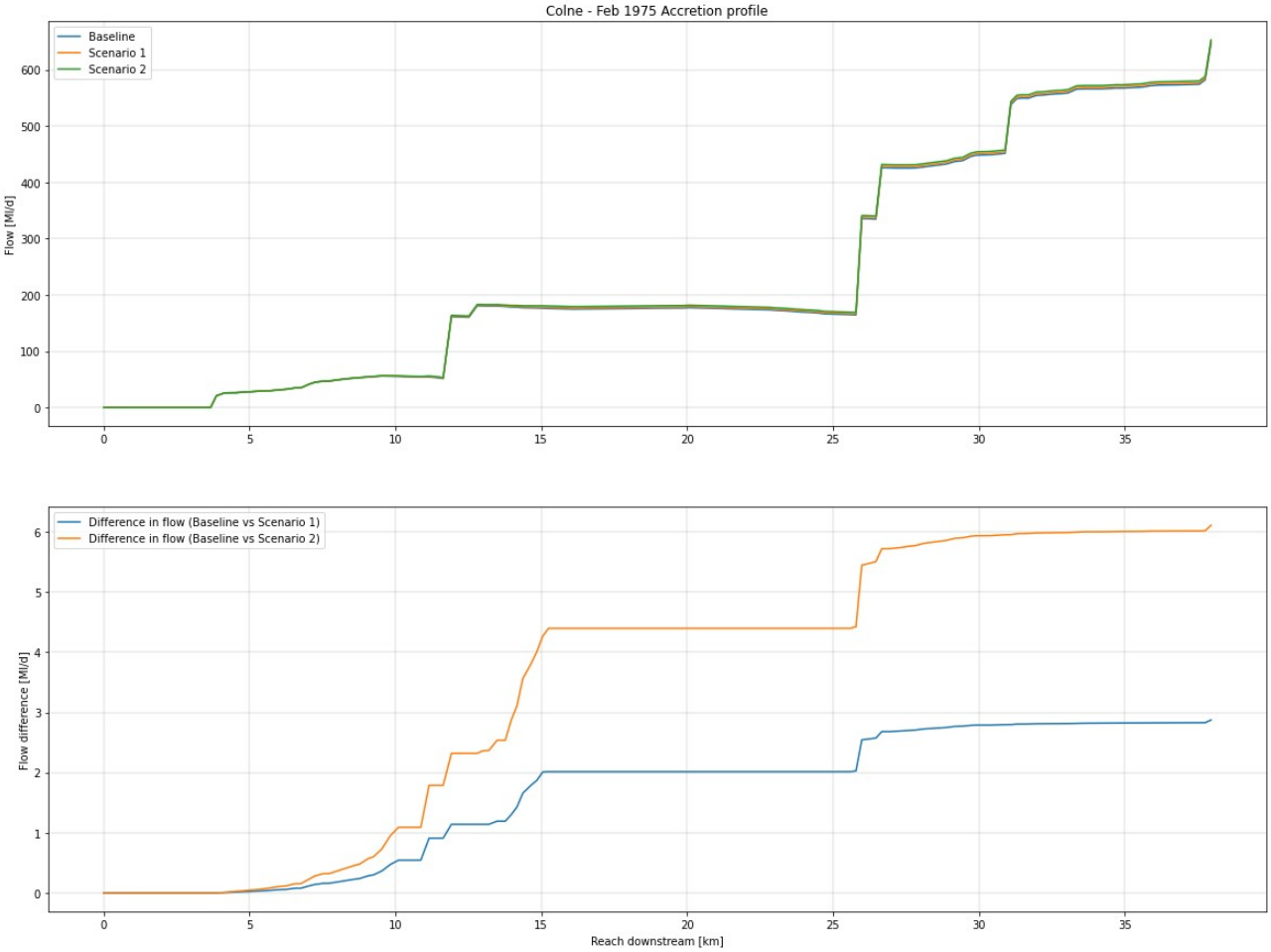
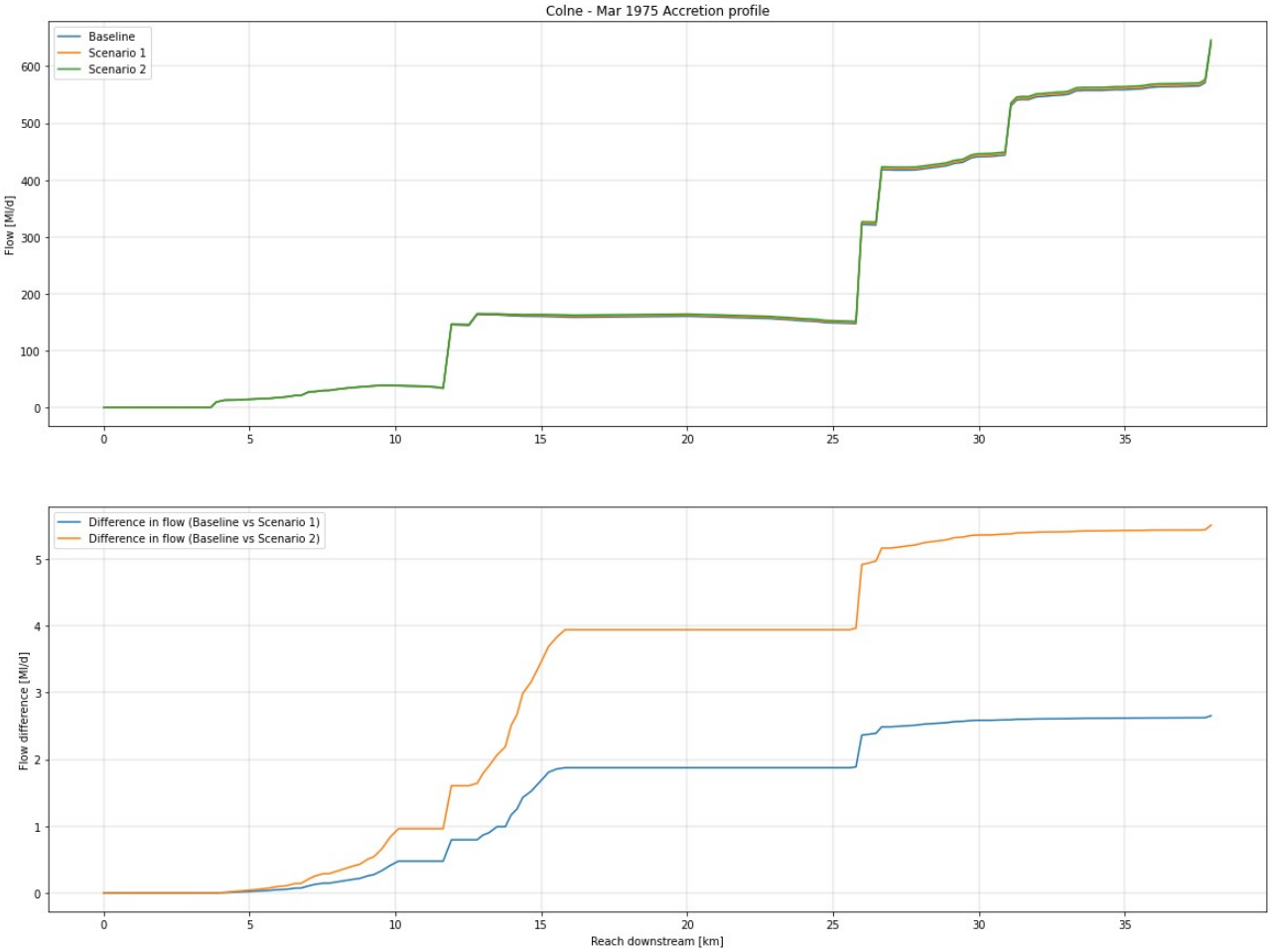
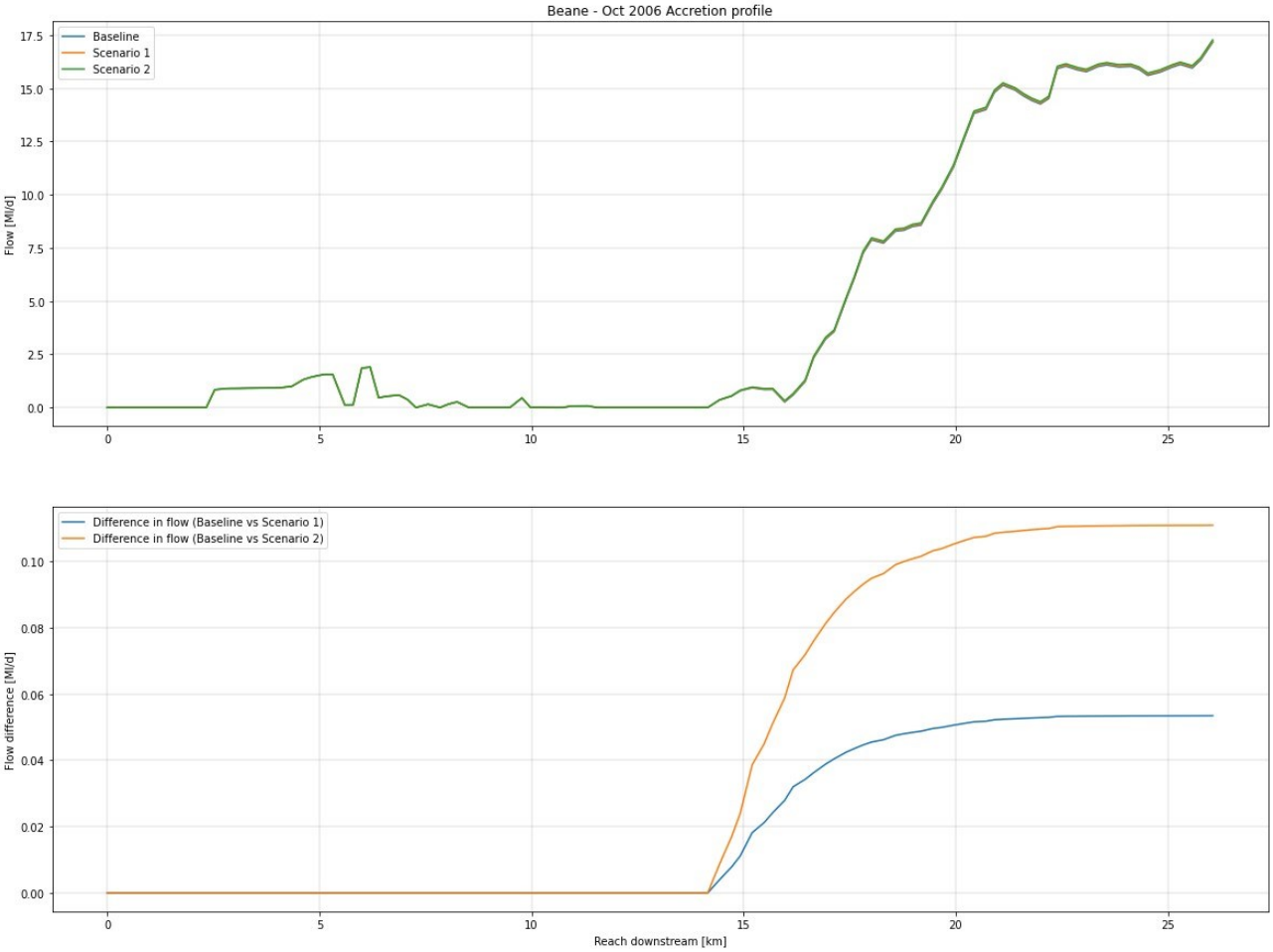


Figure A.7: River Colne accretion profile – March 1975



River Beane

Figure A.8: River Beane accretion profile – October 2006



River Mimram

Figure Error! No text of specified style in document..**9: River Mimram accretion profile – January 1974.**

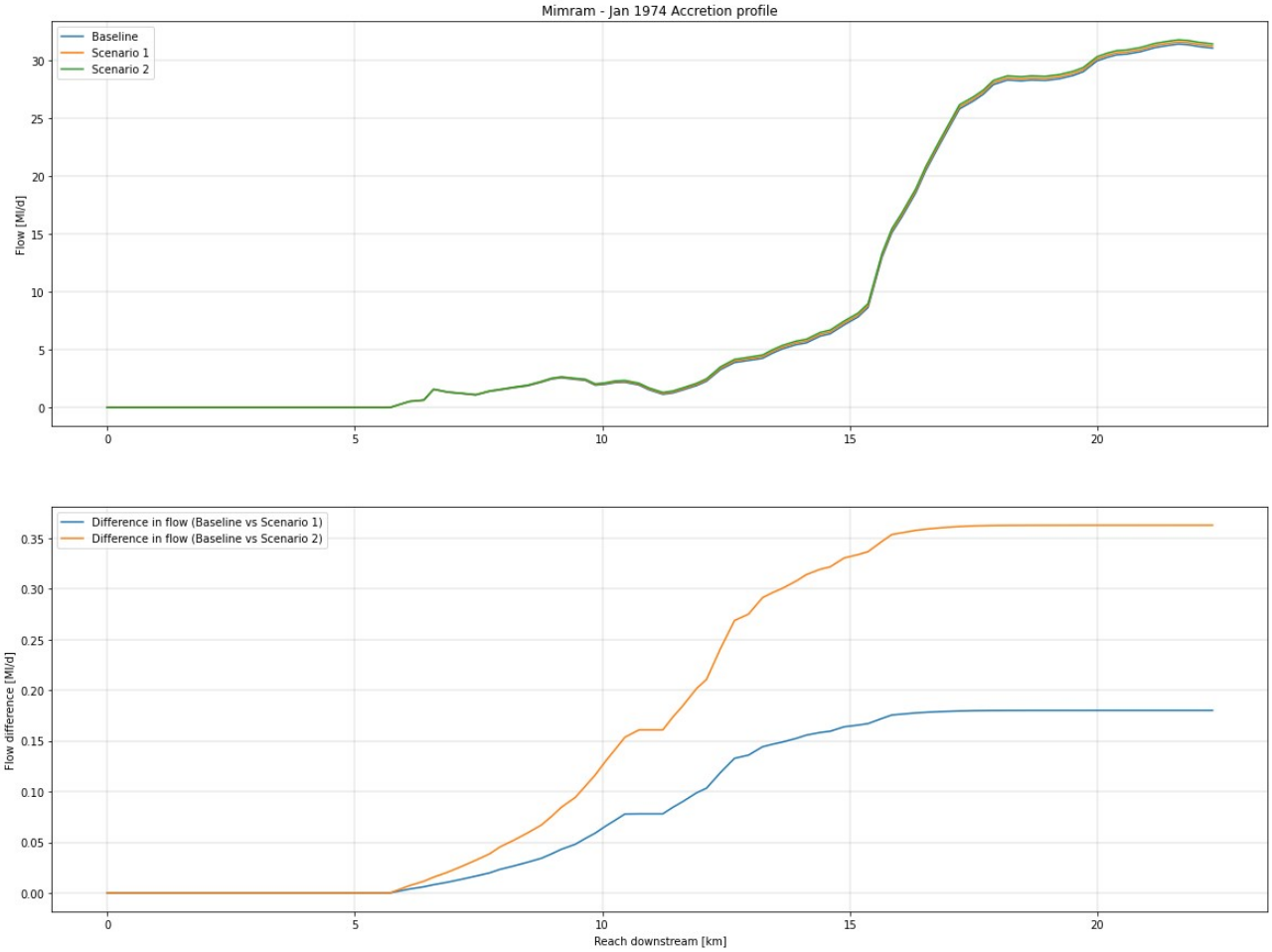
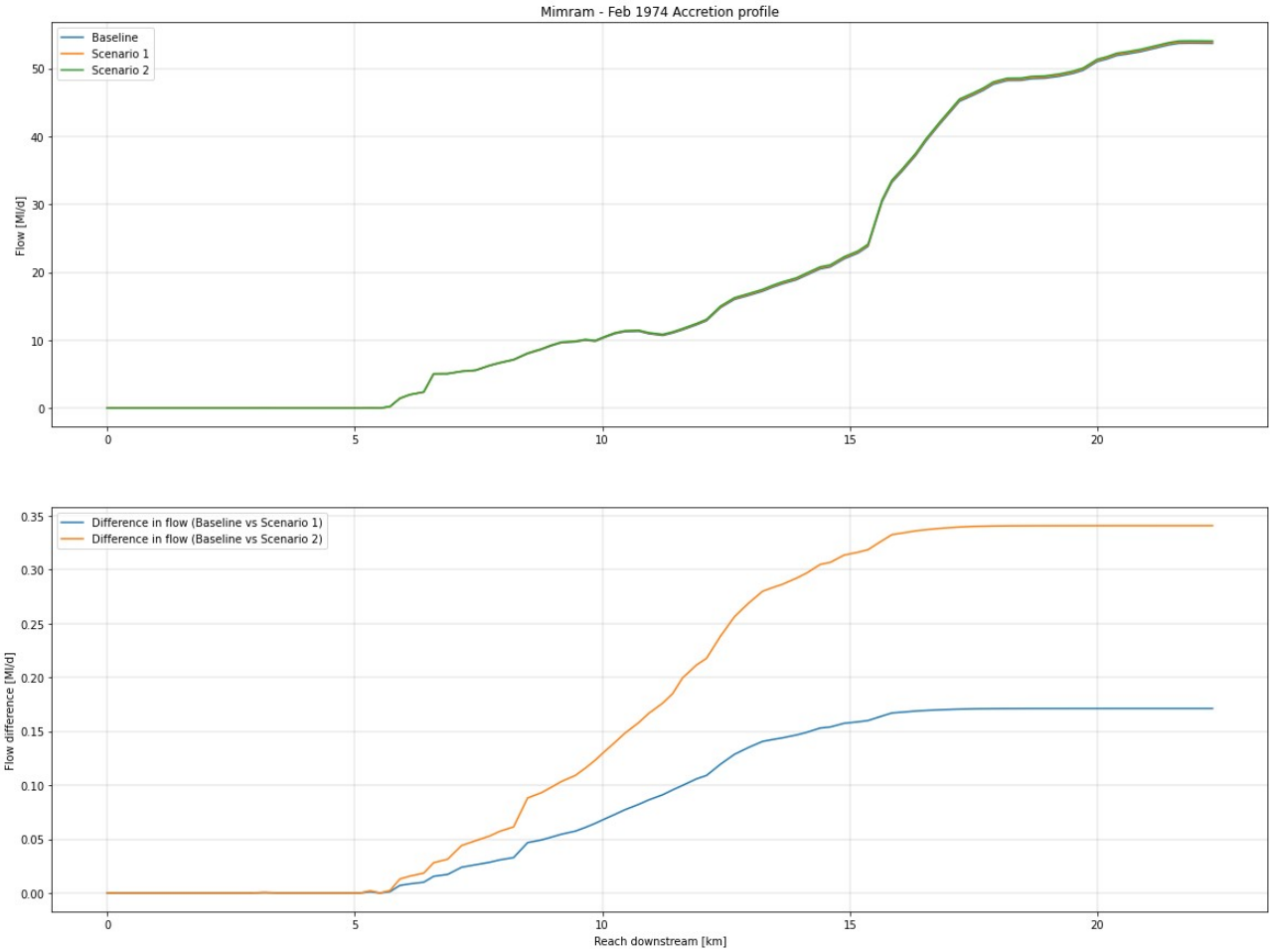


Figure A.10: River Mimram accretion profile – February 1974.



River Lee

Figure Error! No text of specified style in document..**11: River Lee accretion profile – January 1974**