Framework:	**Mapping & Modelling Framework**
Supplier:	**Jeremy Benn Associates Ltd**
Company Number:	**03246693**
Geographical Area:	
Project Name:	**Howden le Wear and Crook Modelling and Mapping**
Project Number:	[redacted]
Contract Type:	**Professional Service Contract**
Option:	**Option C**
Contract Number:	**project_34768**
Stage:	**All_Work_Types**

Revision	Status		Originator		Reviewer		Date
	[redacted]		[redacted]				[redacted]
	[redacted]		[redacted]				
	[redacted]		[redacted]				[redacted]

PROFESSIONAL SERVICE CONTRACT under the Mapping and Modelling Framework
CONTRACT DATA

Project Name Howden le Wear and Crook Modelling and Mapping

Project Number [redacted]

This contract is made on [redacted]
between the *Client* and the *Consultant*

- This Contract is made pursuant to the Framework Agreement (the "Agreement") dated 16th day of May 2019 between the *Client* and the *Consultant* in relation to the NGSA Mapping and Modelling Support Framework. The entire Agreement and the following schedules are incorporated into this Contract by reference

- Schedules 1 to 22 inclusive

- The following documents are incorporated into this contract by reference
  Howden le Wear and Crook Scope v04

Part One - Data provided by the *Client*

Statements given in all Contracts

1 General

The *conditions of contract* are the core clauses and the clauses for the following main Option, the Option for resolving and avoiding disputes and secondary Options of the NEC4 Professional Service Contract June 2017.

Main Option: Option C

Option for resolving and avoiding disputes: [redacted]

Secondary Options

X2: Changes in the law

X9: Transfer of rights

X10: Information modelling

X11: Termination by the *Client*

X18: Limitation of Liability

Y(UK)2: The Housing Grants, Construction and Regeneration Act 1996

Y(UK)3: The Contracts (Rights of Third Parties) Act 1999

Z: *Additional conditions of contract*

The *service* is *Modelling and Mapping Framework - requires model updates of Beechburn Beck, Crook Beck and Howden Beck from Crook to the confleunce with the River Wear.*

The *Client* is *Environment Agency*

Address for communications *Newcastle Upon Tyne*
NE4 7AR

Address for electronic communications [redacted]

The *Service Manager* is [redacted]

Address for communications *Environment Agency*
Catherine Holland
Newcastle Upon Tyne
NE4 7AR

Address for electronic communications [redacted]

The Scope is in
Howden le Wear and Crook Scope v04

The *language of the contract* is English

The *law of the contract* is

the law of England and Wales, subject to the jurisdiction of the courts of England and Wales

The period for reply is 2 weeks

The *period for retention* is
6 years following Completion or earlier termination

The following matters will be included in the Early Warning Register
1
2
3
4

Early warning meetings are to be held at intervals no longer than 2 weeks

2 The *Consultant's* main responsibilities

The *key dates* and *conditions* to be met are

conditions to be met	*key date*
'none set'	'none set'
'none set'	'none set'
'none set'	'none set'

The *Consultant* prepares forecasts of the total Defined Cost plus Fee and *expenses* at intervals no longer than 4 weeks

3 Time

The *starting date* is 07 February 2022

The *Client* provides access to the following persons, places and things

access	*access* date

The *Consultant* submits revised programmes at intervals no longer than 4 weeks

The *completion date* for the whole of the *service* is 07 December 2022

The period after the Contract Date within which the *Consultant* is to submit a first programme for acceptance is 4 weeks

4 Quality management

The period after the Contract Date within which the *Consultant* is to submit a quality policy statement and quality plan is 4 weeks

The period between Completion of the whole of the *service* and the *defects date* is 26 weeks

5 Payment

The *currency of the contract* is the £ sterling

The *assessment interval* is Monthly

The *expenses* stated by the *Client* are as stated in Schedule 9

The *interest rate* is 2.00% per annum (not less than 2) above the Base rate of the Bank of England

The locations for which the *Consultant* provides a charge for the cost of support people and office overhead are All UK Offices

The *Consultant's share percentages* and the *share ranges* are

share range					*Consultant's share percentage*
less than			80 %		0 %
from	80 %	to		120 %	50 %
greater than			120 %		100 %

6 Compensation events

These are additional compensation events

1. 'not used'

2. 'not used'
3. 'not used'
4. 'not used'
5. 'not used'

8 Liabilities and insurance

These are additional *Client's* liabilities

1. 'not used'
2. 'not used'
3. 'not used'

The minimum amount of cover and the periods for which the *Consultant* maintains insurance are

EVENT	MINIMUM AMOUNT OF	PERIOD FOLLOWING COMPLETION OF THE WHOLE OF THE *SERVICE* OR TERMINATION
The *Consultant's* failure to use the skill and care normally used by professionals providing services similar to the *service*	£[redacted] in respect of each claim, without limit to the number of claims	[redacted]
Loss of or damage to property and liability for bodily injury to or death of a person (not an employee of the *Consultant)* from or in connection with the *Consultant* Providing the Service	£[redacted] in respect of each claim, without limit to the number of claims	[redacted]
Death of or bodily injury to the employees of the *Consultant* arising out of and in the course of their employment in connection with the contract	Which ever is the greater of [redacted] or the amount required by law in respect of each claim, without limit to the number of claims	For the period required by law
The *Consultant's* total liability to the *Client* for all matters arising under or in connection with the contract, other than the excluded matters limited to		£[redacted]

Resolving and avoiding disputes

The *tribunal* is	Litigation in the courts
The *Adjudicator* is	'to be confirmed'
Address for communications	'to be confirmed'
Address for electronic communications	*'to be confirmed'*
The *Adjudicator nominating body* is	The Institution of Civil Engineers

Z Clauses

Z1 Disputes

Delete existing clause [redacted]

Z2 Prevention

The text of clause 18 Prevention is deleted.
Delete the text of clause 60.1(12) and replaced by:
The *service* is are affected by any of the following events

- War, civil war, rebellion, revolution, insurrection, military or usurped power;
- Strikes, riots and civil commotion not confined to the employees of the *Consultant* and sub consultants,
- Ionising radiation or radioactive contamination from nuclear fuel or nuclear waste resulting from the combustion of nuclear fuel,
- Radioactive, toxic, explosive or other hazardous properties of an explosive nuclear device,
- Natural disaster,
- Fire and explosion,
- Impact by aircraft or other aerial device or thing dropped from them.

Z3 Disallowed Costs

Add the following in second bullet of 11.2 (18) add:
(including compensation events with the sub contractor, i.e. payment for work that should not have been undertaken).
Add the following additional bullets after 'and the cost of ' :
• Mistakes or delays caused by the *Consultant's* failure to follow standards in Scopes/quality plans.
• Reorganisation of the *Consultant's* project team.
• Additional costs or delays incurred due to *Consultant's* failure to comply with published and known guidance or document formats.
• Exceeding the Scope without prior instruction that leads to abortive cost
• Re-working of documents due to inadequate QA prior to submission, i.e. grammatical, factual arithmetical or design errors.
• Production or preparation of self-promotional material.
• Excessive charges for project management time on a commission for secondments or full time appointments (greater than 5% of commission value)
• Any hours exceeding 8 per day unless with prior written agreement of the *Service Manager*
• Any hours for travel beyond the location of the nearest consultant office to the project unless previously agreed with the *Service Manager*
• Attendance of additional individuals to meetings/ workshops etc who have not been previously invited by the *Service Manager*
• Costs associated with the attendance at additional meetings after programmed completion, if delay is due to *Consultant* performance.
• Costs associated with rectifications that are due to *Consultant* error or omission.
• Costs associated with the identification of opportunities to improve our processes and procedures for project delivery through the *Consultant's* involvement
• Was incurred due to a breach of safety requirements, or due additional work to comply with safety requirements
• Was incurred as a result of the *Client* issuing a Yellow or Red Card to prepare a Performance Improvement Plan
• Was incurred as a resulting of rectifying a non-compliance with the Framework Agreement and/or any call off contracts following an audit

Z4 Share on termination
Delete existing clause 93.3 and 93.4 and replace with:
92.3 In the event of termination in respect of a contract relating to services there is no *Consultant's* share'

Z6 The Schedule of Cost Components
The Schedule of Cost Components are as detailed in the Framework Schedule 9.

Z24 Requirement for Invoice
Add the following sentence to the end of clause 51.1:
The Party to which payment is due submits an invoice to the other Party for the amount to be paid within one week of the *Service Manager's* approval of a fee note.
Delete existing clause 51.2 and replace with:
51.2 Each certified payment is made within one week after the paying Party receives an invoice from the other Party and
If a certified payment is late, interest is paid on the late payment. Interest is assessed from the date by which the late payment should have been made until the date when the late payment is made, and is included in the first assessment after the late payment is made

Secondary Options

OPTION X2: Changes in the law

The *law of the project* is the law of England and Wales, subject to the jurisdiction of the courts of England and Wales

OPTION X10: Information modelling

The period after the Contract Date within which the *Consultant* is to submit a first Information Execution Plan for acceptance is 2 weeks

OPTION X18: Limitation of Liability

The *Consultant's* liability to the *Client* for indirect or consequential loss is limited to

£[redacted]

The *Consultant's* liability to the *Client* for Defects that are not found until after the *defects date* is limited to

[redacted]

The *end of liability date is* 6 years after the Completion of the whole of the *service*

Y(UK2): The Housing Grants, Construction and Regeneration Act 1996

The period for payment is 14 days after the date on which payment becomes due

Y(UK3): The Contracts (Rights of Third Parties Act) 1999

term	*beneficiary*
any	none

Part Two - Data provided by the *Consultant*

Completion of the data in full, according to the Options chosen, is essential to create a complete contract.

1 General

The *Consultant* is

Name: Jeremy Benn Associates Ltd

Address for communications:
Springfield House
76 Wellington Street
Leeds
West Yorkshire
LS1 2AY

Email address: [redacted]

The subcontract *fee percentage* is: Option C [redacted]

The *key persons* are

Name (1) [redacted]
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (2) [redacted]
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (3)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (4)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (5)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (6)
Job
Responsibilities
Qualifications
Experience

The *key persons* are

Name (7)
Job
Responsibilities
Qualifications
Experience

The following matters will be included in the Early Warning Register

3 Time

If a programme is to be identified in the Contract Data.

The programme identified in the Contract Data is

W21-3238 Howdon-le-Wear and Crook Programme v1.0

5 Payment

The *activity schedule* is
W21-3238 Howdon-le-Wear and Crook Activity Schedule v1.0

The tendered total of the Prices is
£35,035.25

Resolving and avoiding disputes

The *Senior Representatives* of the *Consultant* are

Name (1) [redacted]
Address for communications
JBA Consulting
[redacted]
Address for electronic communications
[redacted]

Name (2) [redacted]
Address for communications
JBA Consulting
[redacted]
Address for electronic communications
[redacted]

X10: Information Modelling

The information execution plan identified in the Contract Data is

Contract Execution

Client **execution**

Signed Underhand by [**PRINT NAME**] for and on behalf of the Environment Agency

Consultant **execution**

Signed Underhand by [**PRINT NAME**] for and on behalf of Jeremy Benn Associates Ltd

Signature Date Role

Environment Agency
NEC4 professional service contract (PSC)
Scope

Project / contract Information

Project name	Howden-le-Wear and Crook Modelling and Mapping Study
Project 1B1S reference	[redacted]
Contract reference	[redacted]
Date	03/12/2021
Version number	4.0
Author	[redacted]

Revision history

Revision date	Summary of changes	Version number
22/07/2021	First issue	1.0
04/08/2021	PSC Scope version amended	2.0
06/08/2021	Clarifications added	2.1
22/11/2021	DgC Review	3.0
03/12/2021	Clarifications added	4.0

This scope should be read in conjunction with the version of the Minimum Technical Requirements current at the Contract Date. In the event of conflict, this scope shall prevail. The service is to be compliant with the version of the Minimum Technical Requirements.

Document	Document Title	Version No	Issue Date
LIT 18686	NEC4 Minimum Technical Requirements for Modelling	3.1	12/07/2021
LIT 17616	2021-9_16_PSC_Howden le Wear and Crook_V5	5	19/11/2021

Details of the *service*

Details of the *service* are:

1. Objective

This project will aim to improve our understanding of flood risk along Howden Beck, Beechburn Beck and Crook Beck. The service will focus on the communities at risk of flooding from these watercourses from Crook, through Howden-le-Wear, down to the confluence with the River Wear. This Scope is supplemented with further technical details specified in the document 2021-9_16_PSC_Howden le Wear and Crook_V5.

Existing understanding of flood risk in Howden-le-Wear and Crook is based on HEC-RAS modelling carried out in 2008 and 2011. An updated hydraulic model is required to provide more detailed understanding of flood risk from Howden Beck, Beechburn Beck and Crook Beck at Howden-le-Wear and Crook. Updated culvert survey should be used to inform the model updates.
Tasks include: data review, site visit, modelling method statements, survey specification and commissioning, comprehensive hydrological review, provision of a updated calibrated and verified hydraulic model, provision of hydrology and model reports and provision of GIS outputs.

[redacted]

financial year.
The, results from this modelling study will inform future defence and maintenance works at Howden-le-Wear and Crook. Additionally, it will help to improve our understanding of flood risk, flood mapping, and warning for key communities of Howden-le-Wear and Crook. The results from this study may also be used within Northumbria Iintegrated Ddrainage Partnership Study with Northumbria Water at Howden-le-Wear. Durham County Council have also expressed an interest in the modelling work going on in the area, as they are looking to improve flood risk at Crook. The *Consultant* should seek clarity with the *Service Manage*r should there be any uncertainty around elements that are to be completed.

2. Outcome Specification

The *Consultant* shall undertake and complete the tasks as set out below further supporting information is included in the Appendix 1 in the document titled 2021-9_16_PSC_Howden le Wear and Crook_V5:

1. The *Consultant* shall undertake one site visit (maximum 2 people, 1 day). The *Client* will facilitate this visit and arrange for appropriate *Client* staff to accompany the *Consultant* to provide local knowledge. If the *Consultant* needs to visit areas that do not have public access they must discuss this in advance with the *Service Manager*. A warranted officer may need to accompany the *Consultant* on private land.
2. The site visit shall be used to understand the local flood flow pathways and flood history. The *Consultant* will also use the site visit to review existing topographic data and make recommendations in terms of suitability and define additional survey requirements.
3. Once survey requirements and any other new data requirements have been agreed with the *Service Manager*, the *Consultant* will be responsible for procuring and managing the acquisition of this data. Survey quotes will be reviewed by the *Service Manager*.
4. The *Consultant* will undertake a desktop review of the data which has been collected and provided by the *Client* as defined in the "Project Data Register". Commentary and recommendations from this review shall be documented in Hydrology and Modelling Method Statements produced as part of this commission.

5. The *Consultant* shall provide and submit for approvaal clear recommendations on required activities to build the hydraulic model and derive inflows in line with Environment Agency hydrology and modelling guidance.
   Please refer to the LIT 18686 Minimum Technical Requirements for details.
6. The *Consultant* shall produce and submit for approaval a new hydraulic model.
7. The *Consultant* shall produce and submit for approval flood warning improvement deliverables in accordance with Operational Instruction 137_05 Flood Warning Levels of Services and OI 55_07 Threshold Stetting in Flood Incident Management.

3. Constraints on how the *Consultant* provides the *service*

1. The *Consultant* shall only carry out work directly associated to Provide the Service as set out in the outcome specification above.

2. The *Consultant* is to report monthly on task they plan to do and tasks they have undertaken and time to be charged for that month as detailed in the *Client's* NEC4 Professional Services Contract.

3. The *Consultant* shall maintain close contact with the *Client* in order that their actions reflect the *Service Manager's* objectives.

4. The *Consultant* shall notify the *Service Manager* of any proposed changes from the Scope, and also if there is any detrimental change to any of the following aspects of the Contract; time, cost and quality. The *Consultant* shall:

    I. cease all work, howsoever arising, associated with the task

    II. await the *Service Manager's* written instruction on how to proceed

5. Data held by the *Client* that is relevant to the project will be collected by the *Service Manager* and provided directly to the *Consultant*.

4. Standards to be achieved

4.1 Health and Safety

Health and Safety is the number one priority of the *Client*. The *Consultant* will promote and adopt safe working methods and shall strive to work in a safe manner.

5. Requirements of the programme

1. The *Consultant* shall provide a detailed programme in a format (pdf). The programme must show critical path activities, gateway, risk buffers and activities requiring *Client* input, for example review periods. The programme shall comply with the requirement of Clause 31.

2. A baseline programme shall be provided for the project start up meeting and this will be updated monthly, with actual and forecast progress against the baseline. The programme shall cover all the activities to be undertaken by the *Consultant* to deliver the study. Include all major project and modelling milestones. Milestones include, but are not limited to:

    a. Start up meeting

    b. Site visit

    c. Data review

    d. Survey specification

    e. Survey procurement

    f. Hydraulic Modelling Methodology

g. Hydrology Method Statement and Interim Hydrology Report

h. Model Build

i. Calibration

j. Design Runs

k. Flood Warning

l. Reporting

3. It is acknowledged that the *period for reply* outlined in the contract is two weeks, however please allow for 15 working days for the *Service Manager* to review items F – L outlined above. Provision of 2 weeks' notice of submission for review is required.

6. Services and other things provided by the *Client*

1. All of the data listed as being supplied to the *Consultant* as part of this study remains the Intellectual Property of the *Client*.

2. The *Client* is responsible for the accuracy & sufficiency of existing data owned by the *Client*. The *Client* will only cover the costs of sourcing new data, if existing data is proven to be incomplete or to contain mistakes or errors.

3. The *Consultant* is responsible for any new data requirements. The *Consultant* is to scope, procure and manage the acquisition of any new surveys.

4. The data custodian for project deliverables from this commission will be the *Client*'s area Partnerships and Strategic Overview (PSO) team.

5. Licenses for LiDAR Data, Ordnance Survey mapping, model survey, hydrometric and historical data will be provided to the *Consultant* upon award of this commission.

6. All model and survey information will be provided to the *Consultant* according to *Client* data security policy. Once the commission is completed, the original data sent to the *Consultant* which is classed as commercially sensitive, is returned following the *Client* data security policy.

7. Timesheets as normally utilised by the *Consultant* shall be submitted with applications for payment unless otherwise agreed with the *Service Manager*. Electronic submissions would be acceptable

8. Payment is subject to the procedure agreed in or under the framework.

9. The quality management system complies with the requirements of ISO9001 and ISO14001.

10. The *Consultant* shall use the specifications and guidance included in LIT 13528 Minimum Technical Requirements.

7. Appendix 1

2021-9_16_PSC_Howden le Wear and Crook_V5

Appendix 1

Project Details

Environment Agency

NEC4 Professional Service Contract (PSC)

Modelling Technical Scope

Project / contract Information

Project name	Howden le Wear and Crook
Expected completion date	07/12/2022
Version number	5
Environment Agency Area	[redacted]
Area lead	[redacted]
Modelling technical	[redacted]
Contact for additional information	[redacted]

This scope should be read in conjunction with LIT 56326 Fluvial Modelling Standards current at the Contract Date. In the event of conflict, this Scope shall prevail. The service is compliant with the minimum technical requirements set out in LIT 56326 Fluvial Modelling Standards and LIT 18686 NEC4 Minimum Technical Requirements for Modelling current at the Contract Date.

Project Overview

a) The Howden le Wear and Crook flood mapping project is looking to improve understanding of risk by producing an updated model. Currently only a Flood Alert Area exists in the catchment, with no Flood Warning Service. There is no telemetry within the catchment.

There are three models which should be used as a baseline for this project 2008 model of Howden Beck, 2011 model of Beechburn Beck and JFLOW work which produced a high level assessment of the culverts through Howden le Wear. The Howden le Wear and Crook modelling project should include these to create a more detailed assessment of the flood risk resulting from the presence of culverts through the centre of Howden le Wear. The 2008 and 2011 HECRAS models should be reviewed to ensure the are suitable for use together. This commentary should be included and inform the model method statement produced as part of the Phase 1 deliverables.Extension to the model should not be required, unless at phase 1 it is suggested by the *Consultant* that there is hydraulic influence we were previously unaware of that will lead to the need for extension (e.g a large/new structure not currently included or glass walling at boundaries).

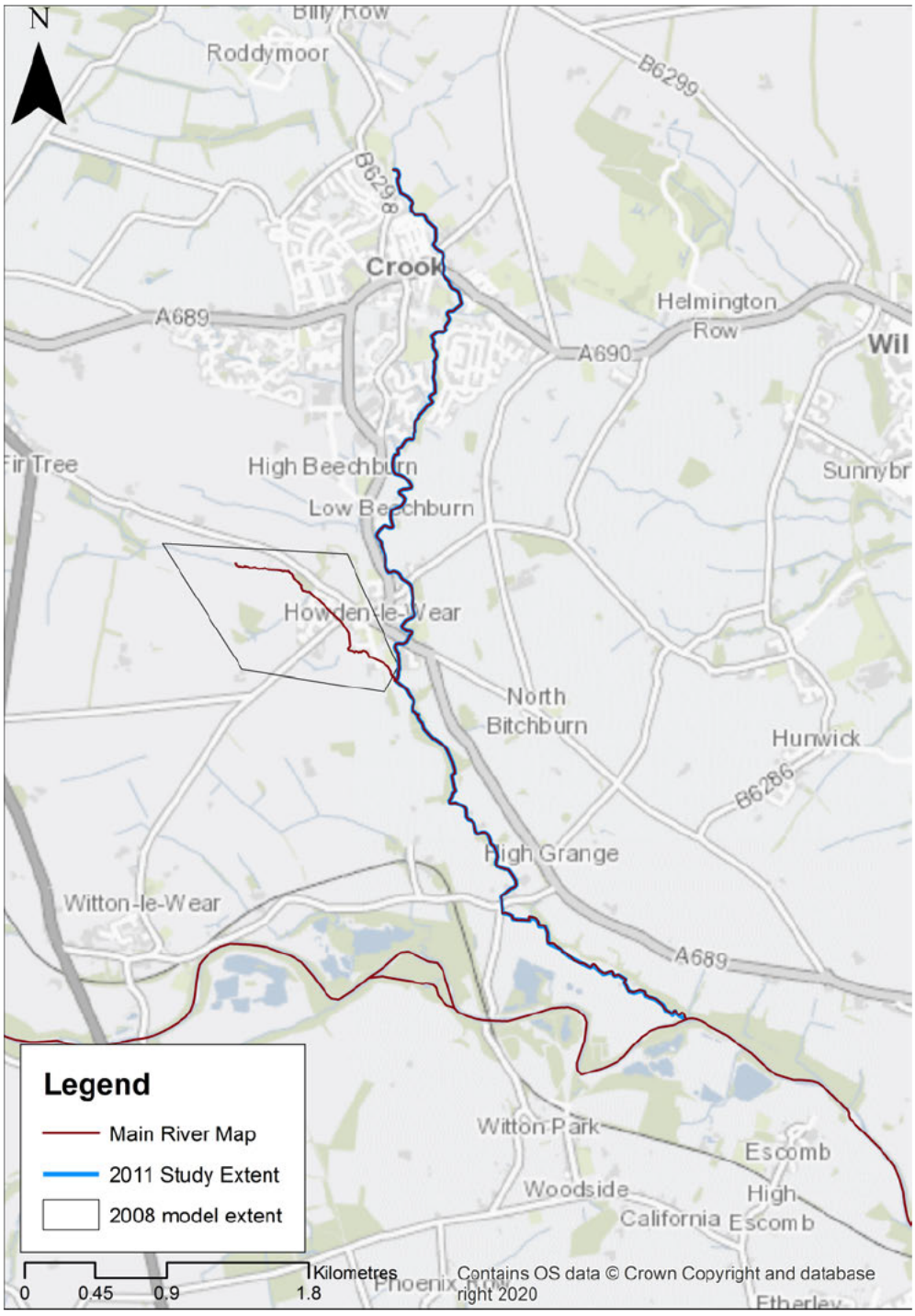
b) Beechburn Beck is a left bank tributary of the River Wear. IIt joins with the River Wear at NZ182 308. Channel maintenance is generally good. The bed load material in the river is largely gravel and cobbles, indicative of an active sediment transport regime. Bank erosion at channel bends is common.

Crook is situated to north of the catchment where Crook Beck becomes Beechburn Beck and flows through the town in open channel. The terrain in the vicinity of Crook is a fairly steep valley, flattening out downstream as it passes through Howden-le-Wear. Howden-le-Wear is located on Howden Beck which flows into Beechburn Beck approximately 2km downstream of Crook. Beechburn Beck flows predominantly north to south and enters the River Wear, just before the Wear flows through Bishop Auckland.

Through the Crook, the Crook Beck/Beechburn Beck are contained in a well maintained concrete channel with concrete dished invert and slightly off-vertical side walls. Two single arch bridges span the channel: the Old Crook Bridge and the newer Mill Street Bridge. Upstream of Mill Street, the river runs between house gardens. At the end of the concrete invert, the watercourse continues in a slightly incised channel besides open ground and allotments. Upstream the river meanders alongside the football ground in a wide gravel bed channel.

The Howden Beck is a right bank tributary of Beechburn Beck, which drains into the River Wear downstream of High Grange. The Howden Beck catchment is around 7km north-west of Bishop Auckland in County Durham, with a small area of 7km2. The catchment is fairly steep with agricultural land at the upstream (formerly soil heaps) and urban areas at the downstream. Annual rainfall over the catchment was 706mm when measured for the 2003 study.

Map of Study Area



1: Hydraulic Model Review

The *Consultant* shall review the 2008 and 2011 models and provide written commentary using the standard Environment Agency Non-Real Time Hydraulic Model Review template.

The *Consultant* shall submit a method statement for acceptance prior to model update activity, providing clear recommendations on required activities to update and combine the models in line with the Environment Agency hydrology and modelling guidance.

2: Hydrological Model & Tidal / Coastal Boundary Review

2.1 The *Consultant* shall review the model using the Environment Agency hydrological review sheet. Clear recommendations on required activities to update the hydrology to the *Client's* stated needs.

3: Local Flood History

3.1 The *Consultant* shall produce a written commentary in the Interim Hydrology Report or Hydrology Review Report to document local flood history analysis. The commentary shall consider the following:

3.2 Likely causal mechanism of flooding (including combined sources).

3.3 The *Client* shall collect and evaluate data from the *Client*, Durham County Council, Northumbrian Water

3.4 The *Consultant* shall collect and evaluate data from social media / other potential sources of information.

4: Site Visit and Topographic Survey

The *Consultant* shall:

4.1 Visit the site to understand the local flood flow pathways and flood history. The *Client* will facilitate this visit / these visits and arrange for appropriate staff to accompany the *Consultant* to provide local knowledge. The *Consultant* shall give the *Service Manager* 10 working days' notice prior to any required visits.

4.2 The *Consultant* shall specify the survey scope in accordance with the *Client's* standard survey specification. The *Service Manager* will approve the scope before confirming a contractor. The *Client* will review quotes for all survey and provide approval before the commencement of the survey.The following locations and survey types shall be considered:

Upstream Location: culverts at Howden Beck: ; Survey Type: CCTV survey, Structure survey. Howden Beck: in channel and bank top survey. Cross sections or spot survey along Howden Beck, Crook Beck and Beechburn Beck and embankments.

5: Hydrological Assessment & Hydrometric Review

The *Consultant* shall undertake the following activities to provide a hydrological assessment and / or hydrometric review in accordance with the Environment Agency's Flood Estimation Guidelines.

Reporting

5.1.1 Submit a Hydrology Method statement for acceptance before commencing the hydrological assessment and/or hydrometric review. This shall set out the proposed approach, review of hydrometric data, catchment schematisation, and set out the methods and outputs.

5.1.3 Submit for acceptance a Draft Hydrology Review Report prior to the commencement of design simulations.

5.1.5 Submit for acceptance a Final Hydrology Review Report.

Review data availability

5.2.1 Undertake a review of the hydrometric data (rainfall, levels, flow, flood extent) that are available for use in the study (including donor catchments, model calibration and verification of models). Assess data availability, and the uncertainties in the accuracy of the data and what effect this could have on the reliability and accuracy of model outputs.

5.2.2 Review the performance of all rating relationships that will be used in this study during high flow conditions. The rating throughout the full range of flows shall also be assessed, albeit in a less rigorous manner. The review shall include commentary on the extrapolation above validated range, modular limits, likely hydraulic control in drowned mode and inter-site comparison.
Clear conclusions on the suitability of ratings for rainfall-runoff model development and calibration of hydraulic models must be provided. Conclusions must include an estimate of likely gauge accuracy (% error in flow) for flows up to and including AMAX1. An indication of gauge accuracy at high and extreme flows (0.1% AEP or similar) shall be provided where possible.

5.2.3 Review the available survey data and any existing hydraulic models to determine whether a detailed model can be updated / constructed to improve the rating relationship at required gauging stations. State the extent of model required, any new survey requirements, and the most appropriate modelling approach. Consider whether simpler methods (e.g. velocity/area) can produce the required results.

5.2.4 Recommend any improvements to hydrometric networks and data collection in floods

Catchment understanding

5.4.1 Schematise the catchment. Subcatchment schematisation shall represent key hydrological features (e.g. changes in catchment response, key tributaries/confluences, flood storage reservoirs). Catchment delineation must be verified including use of surface water sewer data in urbanised catchments. A GIS shape file of subcatchment boundaries must be provided for acceptance by the *Client* as part of the Draft Hydrology Report. Boundary unit type (ReFH, FEH, pumped catchment, etc) and inflow locations (point, distributed lateral) shall be described and justified.

5.4.2 Update subcatchment schematisation to improve delineation of urbanised areas, improve resolution of inflows, changes on the ground.

5.4.3 Agree representation of reservoirs within the catchment with the *Service Manager*.

Design flow estimation - general

5.5 Tabulate the hydraulic model node labels corresponding to the locations of all level and flow recorders and other points of interest within the modelled area.

Design flow estimation - statistical method

5.6.1 Agree peak flow data to be used for the analyses with the *Service Manager*. The data will be based on available data as modified during the study (e.g. by the modelled rating curves).

5.6.2 Undertake flood frequency analysis at all gauging stations using the agreed peak flow data. By default, FEH statistical methods (using the latest updates) will be applied - changes to these methods shall be agreed with the *Service Manager.* Compare with any relevant previous estimates. The degree of uncertainty in the estimates shall be assessed. The effect of these uncertainties on the modelled levels and flood extents shall be assessed and documented.

5.6.3 Estimates of peak flows of different annual exceedance probabilities shall also be made at the following locations:
Howden Beck D/S of study reach – confluence with Beechburn Beck 416250 533050
Howden Beck U/S of study reach – culvert inlet at Fox Covert Grove 415800 533550

5.6.4 Where available use historical information to inform flood frequency analyses and choice of design values.

Design flow estimation - rainfall-runoff methods

5.7.1 Assess the applicability of rainfall-runoff methods such as ReFH1 and ReFH2.

5.7.2 Determine the critical design storm(s), including storm duration, DDF and ARF parameters. If the modelled area has a large variation in catchment size and response at different points of interest, the selection of design storms shall take this into account.

5.7.3 Derive design flood hydrographs (e.g. ReFH, factor ReFH to fit statistical \ accepted design peaks, Archer method).

5.7.4 Improve estimated rainfall-runoff parameters in accordance with the FEH Guidelines.

Reconcile results and produce final design values

5.9.1 Reconcile the results from different approaches (e.g. rainfall-runoff and statistical). If peak flows are significantly changed, the effect on runoff volumes shall be investigated and hydrograph shapes amended if necessary.

5.9.2 Compare flood estimates with previous studies at all gauging stations and other points of interest. Justify the final selection of methodology to be taken forward to design runs.

6: Tidal / Coastal Boundary Analysis

This section is not relevant to this study

7: Fluvial - New Hydraulic Model Build

This section is not relevant to this study

8: Fluvial - Update Existing Hydraulic Model(s)

The *Consultant* shall review and update the defended and defences removed or no defences exist hydraulic models). If an update is not suitable, an alternative approach should be agreed with the *Client*. The scope for updating will be confirmed following acceptance by the *Service Manager* of the Model Review Report. The following activities are required.:

The model must be able to simulate flood events for:
Fluvial defences removed: 50%, 0.1%, 0.5%, 1%, 1.33%, 2%, 3.3%, 5%, 10%, 20%; Fluvial defended: 50%, 20%, 10%, 5%, 3.3%, 2%, 1.33%, 1%, 0.5%, 0.1% AEPs. Climate change scenarios are required as part of this project. Please refer to Minimum Technical Requirements for Modelling for details of climate change requirements.
Please include climate change for the 1% (3 CC's) and 0.1% (1 CC).

8.1 Potential extension of the existing model upstream/downstream to be recommended by the *Consultant* and agreed with the *Client. Client.*

8.2 Incorporation of:
Beechburn Beck (August 2011) Model
Howden Beck at Howden le Wear Pre- feasibility Study (August 2008)

8.4 Updating of the floodplain representation using latest LiDAR. The area requiring update is shown on the study area plan in project details.

8.5 The model will be updated with the most up to date topographic survey and remote sensing data available at the time of baseline model development.

9: Model Proving, Calibration and Verification & Sensitivity

9.1 The *Consultant* shall provide written interpretation of results, including impact on model calibration / proving, design configuration, onset of flooding, standard of protection and recommendations for prioritisation of maintenance.

9.2 Calibrate the model through simulation of 2 events (to be agreed with the *Client* and verify performance through simulation of a further 1 event.

9.3 Inflows shall be generated using observed rainfall and flow data and the *Consultant* is expected to select events to maximise available information. Variation in antecedent conditions between events must be explicitly computed.

9.4 Fluvial Models:
The *Consultant* shall undertake sensitivity analysis on the model. Sensitivity analysis shall be undertaken for the 1% AEP or AEP closest to bank top level (where the 1% AEP event is in bank), shall be submitted to the *Client* for acceptance and at a minimum shall comprise:

- ±20% roughness
- ±20% slope change in downstream boundary
- ±20% flows
- Greater and smaller grid cell size than the proposed grid cell size

The *Consultant* shall also undertake the following project specific tests:

9.6 Structure coefficients: +/-20% x 1AEP

10: Design Simulations & Results

10.1 All scenarios listed below must be delivered for defended scenarios:

10.2 Fluvial, tidal, coastal and surface water hazard scenarios are modelled with the flood defence system scenario of defended, no failure by breaching.

10.3 Scenarios:
Fluvial defences removed: 50%, 0.1%, 0.5%, 1%, 1.33%, 2%, 3.3%, 5%, 10%, 20%; Fluvial defended: 50%, 20%, 10%, 5%, 3.3%, 2%, 1.33%, 1%, 0.5%, 0.1% AEPs. Climate change scenarios are required as part of this project. Please refer to Minimum Technical Requirements for Modelling for details of climate change requirements.

10.4 The *Consultant* shall provide written commentary on the %AEP of onset of flooding, standard of protection and suitability of fit with the anecdotal historic evidence of flooding. Limitations with historical evidence results shall be clearly identified in the conclusions and further recommendations shall be given if appropriate (e.g. state where new telemetry gauges shall be installed, where new survey / LiDAR would improve model accuracy etc). This commentary is to be included within the draft and final Model Report.

10.5 In addition the *Consultant* shall:

Identify the design event probabilities for which the defence provides benefit – this shall include all events where retained water level is above local ground levels. The assessment shall include identification of receptors protected. The analysis must be sufficiently detailed to distinguish between individual communities and include strategic infrastructure (trunk road, railways, power sub-stations). Provide this commentary as part of the Model Report.

10.6 Produce animations of flow and velocity vectors for the 2D model domain for 2 animations x 4 locations x 2%AEPs.

10.7 Simulate structure blockage scenarios for 3 locations x 5 scenarios x 3 %AEPs.

10.8 Produce a table of the number of residential, critical infrastructure and other non-residential properties within all defended and defences removed or no defences exist and blockage %AEP outlines referring to the flood level at the nearest relevant river gauge(s) - if applicable.

11: Flood Warning Improvements

The *Consultant* shall deliver the following services in accordance with the guidance as referred to within the latest version of the Minimum Technical Requirements for Modelling document. The following services are anticipated following receipt of the improved flood outlines but allowance shall be made by the *Consultant* for liaising with the Flood Resilience team for specific guidance on the process and at key points:

11.1 Review the existing Flood Alert Area in comparison with the updated modelled outputs and advise whether modifications are required to the extent(s). Review the first impacts (out of bank), first property to flood and trigger thresholds using the updated and accepted flood maps / levels. There is 1 existing Flood Alert Area and 0 existing Flood Warning Area.

11.1.1 Update the existing Flood Alert Areas extents based on the updated modelled outputs (defences removed / no defences exist 0.1% AEP plus historic flood extents, where appropriate) following the *Client's* acceptance of recommended modifications from 11.1 and provide revised extents.

12: Blank section

This section is not relevant to this study

13: Flood Forecasting - Inception Stage

This section is not relevant to this study

14: Flood Forecasting - Model Development and Calibration

This section is not relevant to this study

15: Coastal - New Hydraulic Model

This section is not relevant to this study

16: Coastal - Hydraulic Model Review

This section is not relevant to this study

17: Coastal - Update Existing Hydraulic Model(s)

This section is not relevant to this study

18: Broadscale Modelling

This section is not relevant to this study

19: Options Appraisal

This section is not relevant to this study

20: Surface Water - Hydraulic Model Review

This section is not relevant to this study

21: Surface Water- Update Existing Hydraulic Model(s)

This section is not relevant to this study

22: Surface Water - New Hydraulic Model Build

This section is not relevant to this study

Further supporting information is provided in Appendix 1.

Appendix 1. Additional Information

Flood history::

A minor flood event occurring at Howden-le-Wear in February 2021. Anecdotal emails suggest flooding at the Foxgrove/Hetton le Wear screen caused by overtopping to right of the screen and the access track.

There are planned works to upgrade to a lateral screen, this will improve the situation slightly. Unfortunately, in this case when the flows that overtopped the screen and got through the gardens, it jjoined the flows on the road to the front of the houses and ran down the hill, resulting in 1 property downstream being flooded.

IIt is known the culvert is undersized and was flowing full bore for a long period as a result of snow melt combined with rainfall.

Survey::

Asset performance have informed us that there is a plan to upgrade the screen and inlet at Foxgrove this financial year. This is currently due to complete February/March 2022. Please bare this in mind when planning for survey.

Hydrology::

The catchment is considered lacking in hydrometric data. The nearest flow data is Witton Park on the Wear.

Existing Model Summary descriptions:

Beechburn Beck- August 2011:

The extent of the study reach focus on Beechburn Beck as it passes through Crook and Howden-le-Wear. However, the model consists of a single reach that extends from the confluence of Beechburn Beck with the River Wear (NZ182 308)) to upstream at (NZ163 362).

100 year flood events, 1000 year flood events, 100 year + Climate Change

A GPS derived topographic survey of the river channel and floodplain was undertaken in December 2008.

Howden-le-Wear Pre Feasibility Study - August 2008::

The study reach is on the Howden Beck from upstream of the residential area to the downstream of the confluence with Beechburn Beck. (OS NGR/D/S 416400, 532989 U/S 414309, 534165). The study carried out channel cross sectional, topographic and threshold survey.

Events: 2 yr, 5 yr, 10 yr, 25 yr, 50 yr, 75 yr, 100 yr, 200 yr, 1000 yr flood event return period for the Do Nothing, Do Minimum and Culvert improvements scenarios.

JFLOW blockage assessment::
Some culvert blockage modelling.
The culvert assetIID is needed as that corresponds to the report - not all culverts were done, but some at Howden le Wear definitely were completed.