ANNEX B3.1.5

Environmental Assessment: Minworth and SLR Sedimentation

Minworth SRO
Severn Trent Water & Affinity Water

Environmental Assessment for the Trent Strategic Resource Options (SRO)

Minworth SRO and South Lincolnshire Reservoir (SLR) SRO

Appendix E: Sedimentation

Affinity Water, Anglian Water Services Ltd and Severn Trent Water Ltd

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Produced for Affinity Water in association with Anglian Water and Severn Trent Water

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1. Introduction

1.1 Background

1.1.1 AECOM previously completed the Hydrology, Environment and Ecological (HEE) gap analysis of the River Tame, River Trent and Humber (TTH) system for Gate 1, carried out jointly for Minworth and the South Lincolnshire Reservoir (SLR). Subsequent investigations completed for Gate 2 include baseline Aquatic Ecological Monitoring (July 2022), water quality monitoring in the River Tame (July 2022), and Hydrological, Aquator and Hydraulic Modelling of the rivers Tame and Trent (July 2022). The latter has been completed in parallel with these assessments and has provided modelling outputs to inform the assessment of potential environmental impacts.

1.1.2 The Hydrology, Ecology and Environmental baseline study for the Tame, Trent and Humber in support of the Minworth and SLR for Gate 1 encompassed 19 in-depth topic reports and an overall summary report to inform further environmental assessment for the Minworth and SLR Strategic Resource Options (SRO).

1.1.3 The Gate 1 work involved considering Water Framework Directive (WFD) related impacts and benefits, baseline ecological data, and in particular the potential impacts of changes in flow to ecological receptors such as designated sites and their qualifying features, protected and notable species, and particular constraints from the presence or future spread of Invasive Non-Native Species. Also assessed were Navigation, Sedimentation, Assets along the Trent, Abstraction and Discharge Licences, Saline Intrusion, Fish Habitats and Migration, Biodiversity Net Gain, Natural and Social Capital, and Soil and Humidity. Some of these topics have been carried forward for further detailed assessment at Gate 2, as presented here and in the overall Environmental Assessment report (60669746_REP_003_Env-Ass_Trent_SRO_V5[1], Annex B3.1), to which this report forms an appendix.

1.1.4 In Gate 1, baseline information was gathered via a desk study, with some initial assessments made on the sedimentation risks of two Strategic Resource Options (SRO), in support of the specific topic 5 *"Provide a summary of existing understanding of river flows and levels on geomorphology and sedimentation. Identification of relationships between habitats and geomorphology features present"*. As part of Gate 2, this study builds on that report to assess the likely effect of two SROs on sedimentation within the River Tame and River Trent. Both SROs may lead to reduced baseflows downstream of the discharge/extraction points and so have the potential to trigger sedimentation as a result of the channel's reduced entrainment capacity, hence this study.

1.1.5 This report presents the assessment of potential sedimentation impacts as a result of the SRO schemes.

1.2 Assessment Rationale

1.2.1 This report details the assessment of sedimentation risks and impacts, including any links and interdependencies with other topics, any gaps, or limitations to the assessment (e.g., the availability of supporting information, which would have been established and flagged at an early stage), and any recommendations for further work required to incorporate into further assessment for Gate 3. This will inform the next stage of environmental assessment of the Trent SROs in support of the two related SRO schemes:

- Minworth; and
- South Lincolnshire Reservoir (SLR).

1.2.2 The Services to be delivered are for Affinity Water, Anglian Water Services Limited and Severn Trent Water Limited.

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[1] AECOM (April, 2022). Environmental Assessment for the Trent Strategic Resource Options (SRO): Minworth SRO and South Lincolnshire Reservoir (SLR) SRO. Results and Recommendations.

1.2.3 The purpose of the Gate 2 assessment is to assess the impact of the reduction of discharge to the River Tame and Trent system, where Minworth currently discharges a Dry Weather Flow (DWF) of 417 Ml/d (as per Concept Design Report CDR, Jacobs 2022), separately and in-combination with the potential abstraction of up to 300 Ml/d (as an absolute maximum) for the SLR SRO. This assessment is critical to supporting concept design and scheme environmental assessment for key SROs at Gate 2.

1.2.4 A key element of the related SROs, Minworth and SLR, is to investigate the environmental risks and opportunities associated with delivery of the schemes.

1.3 Objectives

1.3.1 The key objectives of the Gate 2 Environmental Assessments are as follows:

- Build on the work completed in Gate 1 to provide a robust impact assessment of the discharge reduction from Minworth in to the TTH system and surrounding environment and assess the impact the proposed transfer could have on sedimentation.
- Build on the work completed in Gate 1 to provide a robust impact assessment of the abstraction of up to 300Ml/d for the SLR, to the Trent, Tame, Humber (TTH) system and surrounding environment and assess the impact the proposed transfers could have on sedimentation.
- Define what mitigation measures need to be implemented to satisfy regulators that the SROs are viable. Any mitigation measures that require engineering solutions such as modification to fish passes or weirs, should be fed back into the Engineering workstream.
- Support engagement with key stakeholders including the Environment Agency, Natural England, Canal and River Trust, Water Resources East, and the River Trent Working Group. This has taken the form of monthly workshops to present findings and/or discuss key themes, risks, or mitigations, and site visits to inform the assessment of specific features.
- Produce an environmental scoping checklist (Section 7) to ensure identification of the likely significant environmental effects of the proposed projects and ensure all assessments and data collection are completed to support environmental assessment during Gate 3.

1.3.2 This report sets out the preliminary findings of field surveys, monitoring, and desk-based environmental assessments; to drive engagement with relevant regulators and other decision-makers; to agree the survey specifications and locations for any data collection or studies.

1.3.3 This report covers the key theme of Sedimentation.

1.4 Environmental Assessment

1.4.1 The outcome of the environmental assessments supports an assessment of the potential impact and changes to the environment and ecology within the River Tame and Trent and associated water bodies and habitats as a result of activity associated with the SROs. This technical appendix and other supporting reports detail the assessment and demonstrate a clear line of sight to further assessment, identifying potential significant effects, and informing the scope for future detailed assessments as set out in the Strategic regional water resource solutions guidance for gate two (RAPID, April 2022[2]), including:

- Water Framework Directive (WFD) Compliance Assessment;
- Informal Habitats Regulations Assessment (HRA);
- Environmental Appraisal (including Strategic Environmental Assessment (SEA)); and
- Other Environmental Considerations including Biodiversity Net Gain (BNG) and Natural Capital Assessment (NCA).

1.4.2 The results of the environmental assessments are collated into the single overall report, supported by technical appendices, informed by regular liaison with the project teams and stakeholder engagement,

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[2] Regulators' Alliance for Progressing Infrastructure Development (RAPID) (April 2022). Strategic regional water resource solutions guidance for gate two.

for incorporation into the Gate 2 submission. This includes the results and recommendations from each topic within the environmental assessment.

1.4.3 The overall approach to the assessment and monitoring specification includes, but is not limited to, the extent of designated sites and Priority Habitats for ground truthing and walkover surveys, the extent of fluvial walkover surveys, and the range of data and supporting information required to support the assessment.

1.4.4 This technical appendix supports the overall environmental assessment report, the focus of which is as follows:

i. Results and recommendations of the topic assessment;

ii. A detailed assessment of the potential impacts and changes to the environment and ecology within the Rivers Tame and Trent, and associated water bodies, habitats, and species, as a result of activities associated with the SROs;

iii. The overall environmental assessment report and technical appendices will support subsequent assessment for RAPID Gate 2;

iv. Ensure a clear line of sight toward future environmental assessment and any additional planning requirements, e.g., HRA, SEA, WFD compliance assessment, etc. This will include identifying receptors to potential impacts, the likely extent, scale and significance of impacts according to industry standards, and preliminary recommendations for appropriate mitigation;

v. A key component of the final report will be an environmental scoping checklist to identify and grade likely significant environmental effects, to form the basis of and inform future environmental assessment at Gate 3;

vi. Clear identification of any gaps and limitations in the assessment, which would have been identified and discussed with the Clients and stakeholders at an early stage.

1.5 Assessment Scenarios

1.5.1 Assessment of different scenarios for operation of the SRO schemes will be undertaken. This is based on the likely seasonal operation and operational regime requirements for the Minworth transfers and SLR abstraction, as described in detail in the overall assessment report (60669746_REP_003_Env-Ass_Trent_SRO_V5[3]. Annex B3.1), and briefly summarised as follows:

Minworth SRO

1.5.2 The Minworth SRO supports two options for transfer of final effluent, resulting in corresponding reductions in the discharge of effluent to the River Tame. These are transfer to the Grand Union Canal (GUC) SRO, and transfer to the River Avon for the Severn to Thames Transfer (STT) SRO. This is currently divided into the following volume options:

- 57 Ml/d (Megalitres per day) discharge to GUC SRO;
- 115 Ml/d discharge to GUC SRO;
- 57 Ml/d discharge to River Avon for STT SRO;
- 115 Ml/d discharge to River Avon for STT SRO; or
- Combined 230 Ml/d transfer to both River Avon and GUC (115 Ml/d to each).

1.5.3 Therefore, the current approximately 417 Ml/d (DWF) discharge of final treated effluent from Minworth will reduce by a maximum of 230 Ml/d.

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[3] AECOM (April 2022). Environmental Assessment for the Trent Strategic Resource Options (SRO): Minworth SRO and South Lincolnshire Reservoir (SLR) SRO. Results and Recommendations.

SLR SRO

1.5.4 The SLR SRO includes an option for abstraction from the River Trent to the River Witham, supported by further abstraction from the River Witham downstream. The Trent transfer has a maximum capacity of 300 Ml/d, with abstraction subjected to the Hands-off Flow (HoF) on the River Trent – when the HoF level is reached, abstraction will cease. The Trent transfer will support the SLR when there is insufficient flow in the River Witham.

2. Scope and Approach

2.1 Introduction

2.1.1 This section sets out the approach to Environmental Assessment of the Minworth and SLR SRO schemes, informed by RAPID guidance for Gate 2 and on-going stakeholder engagement.

2.2 Projects and Work Completed to Date

2.2.1 Key findings and recommendations from the Tame, Trent and Humber baseline assessment for Gate 1 included:

- Identification of ecologically sensitive designated sites, Priority Habitats, protected/notable species, hydro-geomorphological features, WFD statuses.
- Recommendations to complete and maintain the baseline assessment, inform subsequent impact assessment, and data refresh.
- AECOM is now undertaking follow-on work to inform Gate 2, including macroinvertebrate, macrophyte, River Habitat Surveys (RHS), Invasive Non-Native Species (INNS) surveys, Water Quality monitoring, and Hydrological, Aquator and Hydraulic Modelling of the rivers Tame and Trent.

2.2.2 The literature search involved contacting statutory and local bodies, scientific literature databases, with data sources listed.

2.2.3 Reports set out the literature review and baseline information for each topic, including data gaps/recommendations, links to the consistent methodology (including SEA framework) currently being developed for the environmental assessment of SROs. This helped to demonstrate to regulators and stakeholders that the evidence effectively informed the strategic assessments.

2.2.4 These reports critically evaluated the information gathered and identified gaps in knowledge, reviewed areas of uncertainty or conflicting opinion, and formed the basis for further environmental investigation and impact assessment, including recommendations for the next stages (Gate 2) of the assessment process.

2.3 Scope of Field Surveys, Monitoring and Desk-Based Environmental Assessments

2.3.1 Critical to the assessment is the requirement to liaise with stakeholders and decision makers to agree the monitoring specification and purpose for discussion with the Regulators. This will be an on-going and iterative process through on-going engagement, and consideration of each stage of the assessment as it progresses.

2.3.2 Through the assessments for the Tame, Trent and Humber baseline study, it was noted that constraints and limitations may be encountered, for example due to the availability and completeness of available data, and therefore it has been critical to engage stakeholders at each stage to resolve potential issues, and tailor the assessment methodology to maximise the benefits of available data and information. This is critical to ensure the success of the assessment through Gate 2.

2.3.3 The outcomes of the Gate 1 baseline assessment and outputs of parallel monitoring and modelling work also underway have been used to support the large-scale environmental assessment.

2.4 Sedimentation

Objectives

2.4.1 The objectives for the sedimentation assessment, as set out by the Client, are as follows:

- *Assess where to expect impacts to geomorphology based on understanding of the SRO. Clearly low flows occur already, where Minworth discharges are still available to the system. Modelling of impacts of* *low flows on levels including the HoF at North Muskham is underway. We will incorporate the outputs of this modelling to inform an understanding of how geomorphology would be impacted.*

- *Carry out fluvial audits targeted to the SRO locations to define geomorphological baselines and allow assessments of the effects of the SRO.*

Assessment Methodology

2.4.2 The Gate 1 assessments for the whole of the Tame and Trent to the Humber identified that geomorphology and sedimentation baseline data for the study area were largely unavailable. Instead, indicative data were synthesised by AECOM, to map areas along the River Tame and River Trent channels that are likely to have relatively high risks of sedimentation and are likely to be sensitive to changes around Minworth and the SLR abstraction.

2.4.3 Gate 2 sedimentation assessment for the Minworth and SLR SROs builds on Gate 1 scoping, to review targeted impact zones using fluvial audit desk-based surveys and field surveys where the river banks are safely accessible. Geomorphological data has been requested from the Environment Agency, and substantial relevant information has been provided for parts of the River Tame, but baseline geomorphological and sediment data are largely unavailable for the study area.

2.4.4 From Minworth, impacts on the River Tame would be mitigated by the confluence with the River Blythe approximately 5km downstream, but effects could still persist further downstream. Fluvial audit has therefore been extended from the River Rea confluence at Nechells upstream of Minworth to Lea Marston downstream. It is important to assess river reaches upstream of the SROs to interpret flow and sediment delivery into the impacted reach, thereby providing understanding of the potential impacts of the SRO. Nechells to Lea Marston is a distance along the River Tame channel of approximately 17 km, but access is limited, and survey has been confined to safe visibility from intermittent highway crossings for most of this area.

2.4.5 For the SLR, impacts would mainly be downstream of the proposed abstraction location at East Stoke, including Newark-on-Trent and the Cromwell Weir some 8km downstream of Newark-on-Trent. The Cromwell weir is the tidal limit, so habitats and sedimentation further downstream will have increasing tidal influence and will naturally be dominated by sedimentation and sediment recirculation. Fluvial audit has therefore been extended from Newark-on-Trent to Gainsborough, which is a distance of 58 km along the River Trent, but only intermittent observations were required. The Trent is a large, low-lying river with generally consistent character through this area, meaning that large areas can be assessed rapidly.

2.4.6 The geomorphological assessment has also focused on weirs as impoundments to sediment transport, morphological continuity, and fish passage, and has taken a holistic approach to interactions between sediment, physical habitats, water quality, and ecology.

2.4.7 Sediment sampling, or sediment transport or sedimentation modelling, has not been undertaken. Rather, assessments are qualitative and based on expert judgement of geomorphological risks in the context of WFD objectives. Fluvial audits have been completed at an appropriate spatial scale to the potential impacts.

2.4.8 The sedimentation assessment benchmarks the existing sediment conditions in the rivers and assesses the potential effects of the SROs. Audits are presented as concise, map-based reports to summarise geomorphology/sediment baselines in the context of physical habitats underpinning river ecology and SSSIs.

2.4.9 Sediment sources are reviewed to demonstrate historic river and catchment uses (urbanisation and agriculture, and construction of weirs and flood embankments), as being the primary controls on river sediment loads, with water resource abstraction likely to be a relatively minor effect. Potential impacts of the SROs have been assessed through interpretation of baseline sedimentation patterns throughout the study reaches, and the potential for increased sedimentation associated with changing low flow patterns as indicated by hydrological and hydraulic modelling. Sediment zones have been updated in relation to key channel assets and habitats maps produced for the Gate 1 sedimentation assessments using the fluvial audits and model outputs.

Priority Areas

2.4.10 Fluvial audits cover two areas: at the River Tame from Minworth to at least the confluence with the River Blythe; and for the proposed locations of the SLR intake to at least the next confluence downstream. These assessments advise if geomorphological and sedimentological impacts would be ‘absorbed’ by the river locally, or if further assessments are needed at larger scale.

Data and Information Requirements

2.4.11 Information has been obtained by direct correspondence with the EA, including site walkovers guided by local EA catchment officers. Direct liaison with the EA through Gate 2 has also uncovered considerable historic river information that was not available at Gate 1, including records of historic river restoration schemes, especially through the River Trent, which have been implemented inclusive of sedimentation considerations as a key component of holistic ecological processes.

2.4.12 Sedimentation assessments have been undertaken based on data and information produced in collaboration with other Gate 2 Topics, including hydraulic modelling. Otherwise, data collection for sedimentation focussed on targeted site visits as scoped from the Gate 1 analysis.

2.5 Limitations

Sedimentation Assessment

2.5.1 The following limitations have been identified in terms of the sedimentation assessment:

- Detailed geomorphological baseline assessments are generally absent for the River Tame and River Trent. Geomorphological information is available from various sources but is far from comprehensive. Information can be interpreted from other studies, but direct assessments of geomorphology and sedimentation are generally not available.
- Sediment and sedimentation monitoring data are generally non-existent.
- Hydraulic modelling to date is preliminary and does not cover the whole study area.
- Modelling focusses on baseflow hydraulic properties, and does not include sediment transport, spate or flood events, or floodplain inundation events. Floodplain connectivity is a critical component of sediment systems, since floodplain inundation frequencies, extents, and durations control rates of out-of-channel floodplain sedimentation.
- Sediment transport modelling, based on hydraulic model outputs, is not feasible until hydraulic model results are finalised. Sediment transport modelling is highly complex, but high-level assessments would be information and could be used to quantify the sedimentation effects of the SROs.

2.5.2 The effects of any limitations will be considered through the assessment to inform the requirement for further assessment in terms of next steps and recommendations.

3. Results

3.1 Catchment Baseline

3.1.1 The catchment sedimentation baseline assessments developed through desk studies in Gate 1 have been refined and verified based on field surveys in Gate 2. This section summarises the results of the sedimentation assessment through Gate 2, and provides an updated, more illustrative baseline.

3.2 Tame

General characteristics

3.2.1 The Tame study area has been reviewed in two parts, broadly seen by the rural-urban boundary shown in Figure 3-1:

- Upstream of Minworth STW (SP 1741 9146), to assess channel evolution in accordance with existing flow processes towards the discharge, and to set context for how flow processes might change. In this area the Tame flows west out of the city of Birmingham through a heavily modified and straightened channel and developed and urbanised floodplain (Ref. 1).
- Downstream of the Minworth STW, i.e., where flow reductions would commence. In this area the channel is able to follow a more natural and sinuous course, with greater floodplain connectivity. The decrease in urban modifications will help to mitigate the impact of flow reductions. The Tame continues westwards for some 4.8 km downstream of the STW before turning north (SP 2181 9195) towards Lea Marston lakes (Ref. 1).

3.2.2 The upper Tame is an urban river, heavily realigned, deepened and within flood embankments. Built infrastructure encroaches extensively into its floodplains, frequently up to bank tops. The channel is crossed in numerous locations by roads and railways, including a 1.08 km section (SP 1216 8984 to SP 1312 9013) where the channel runs underneath the M6 motorway, and a 1.3 km section (SP1479 9064 to SP 1602 9099) where the channel runs parallel to the railway line (Ref. 2, Ref. 1).

3.2.3 There are nine weirs within the study area. Four of these (SP 1128 8983, SP 1143 8969, SP 1695 9144, and SP 1741 9142) upstream of Lea Marston lakes, the first two found around the M6 crossing of the River Tame, and the latter two the Minworth WwTW. The other five are all within Lea Marston lakes (SP 2073 9364, SP 2123 9431, SP 2134 9423, SP 2136 9504, and SP 2183 9524). These weirs are shown within Figure 2-1 (Ref. 1).

3.2.4 There are also two SSSIs within the Tame study area, as well as a third (Sutton Park) within the city of Birmingham, but no SACs, Ramsar sites, or SPAs. These are summarised in Table 3-1 and in Figure 3-1 (Ref. 3).

Table 3-1 Designated areas within the Tame study area

Statutory Site Name	Area	Location relevant to study area	Reason(s) for Designation
Whitacre Heath SSSI (SP 208928)	44.1 ha	Located on the western floodplain of the Tame, just downstream of Lea Marston lakes.	The area is an important breeding ground for a range of water birds. The SSSI displays a collection of vegetation types as a result of the differing habitats within the area across the ecotone from open water to seasonally wet meadows (Ref. 4).
River Blythe (SSSI) (SP 2121 9159)	102.2 ha	The Blythe flows into the Tame within the study area at SP 2121 9159, downstream of Minworth STW and upstream of Lea Marston lakes.	The entire 39km stretch of the Blythe, which culminates with its confluence with the Tame, is an example of a lowland clay river, exhibiting natural features such as riffle-pool sequences and meander bends. This diversity in turn supports a range of plant species (Ref. 5).

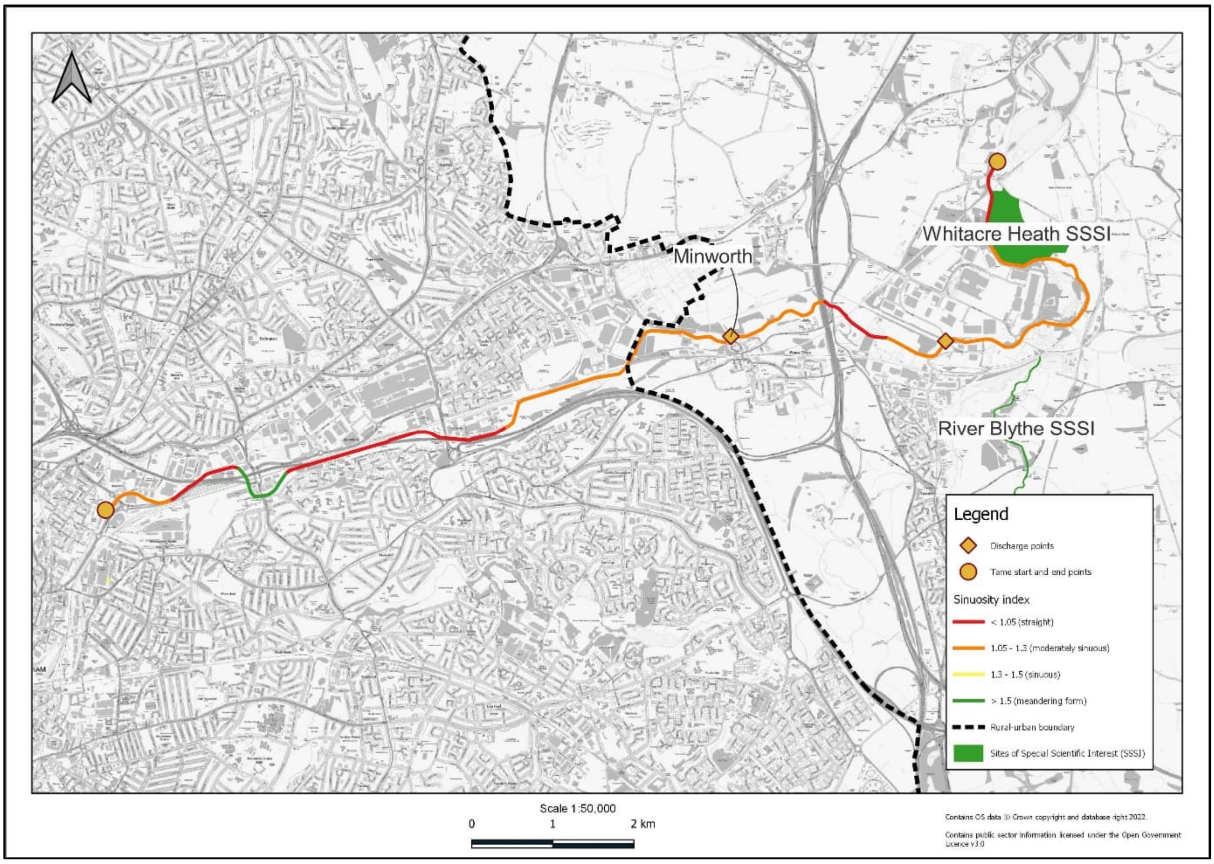


Figure 3-1 Designated areas within the Tame study area

3.2.5 Figure 3-1 illustrates the nature of the Tame in this area, particularly the transition between Birmingham and the surrounding countryside, and that the Minworth STW is on the boundary of this transition.

3.2.6 The condition of the channel is broadly represented by a ‘sinuosity index’. The natural typology (prior to anthropogenic modifications) is active meandering which would be highly sinuous and dynamic. Generally, the channel has now been straightened, with meandering forms constricted by the urban nature of the surrounding land, especially upstream of Minworth STW, resulting in a modified and impacted channel. The degree of straightening declines with distance downstream, but historic modifications continue, for example due to extensive floodplain gravel mines which have also required channel realignment and floodplain disconnection. There are also numerous weirs, which have the potential to disrupt downstream connectivity within the Tame, notably in the downstream area surrounding Lea Marston lakes (Ref. 3).

WFD Status of waterbodies

3.2.7 There are three waterbodies through which the Tame flows within the study reach:

- Tame – R Rea to R Blythe (GB104028046841)
- Rea from Bourn Brook to River Tame (GB104028042550)
- Tame from R Blythe to River Anker (GB104028046440)

3.2.8 Figure 3-2 shows the Tame within the study area along with these three waterbodies.

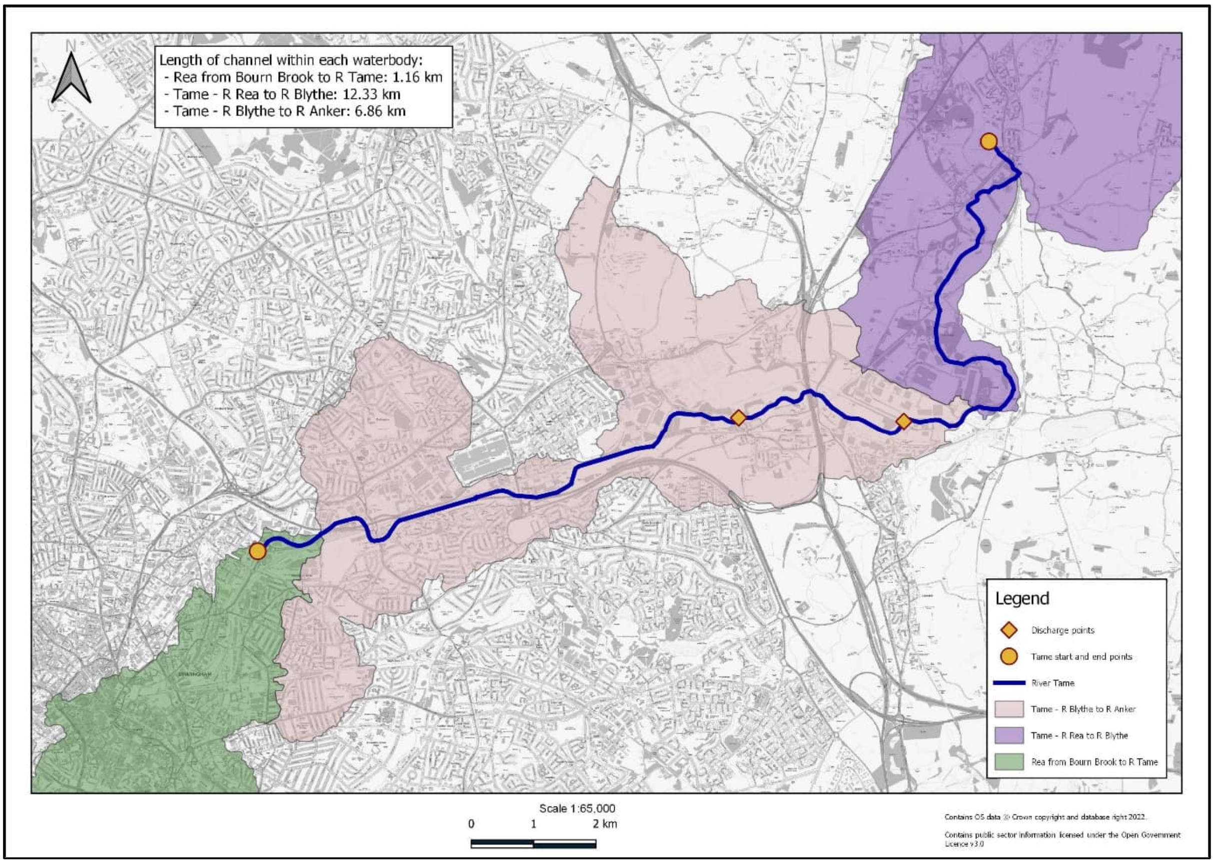


Figure 3-2 WFD waterbodies underlying the Tame study area

3.2.9 The WFD status of these water bodies is shown below in Table 3-2, Table 3-3, and Table 3-4.

3.2.10 Two of the water bodies are designated as Heavily Modified Water Bodies (HMWBs). The Tame from River Blythe to River Anker is not designated as heavily modified, but still has considerable anthropogenic influences that will affect sedimentation processes (Ref. 6).

Table 3-2 Overview of WFD quality elements of the Tame – R Rea to R Blythe (GB104028046841) WFD waterbody

WFD Parameter	Status / Summary
Water Body ID	GB104028046841
Water Body Name	Tame - R Rea to R Blythe
Water Body Type	River
Water Body Length / Area	14.359 km / 32.476 km^2
Hydromorphological Designation	Heavily modified
Overall Ecological Status	Moderate
Current Overall Status	Moderate
Status Objective (overall)	Moderate by 2015
Biological Quality Elements	Poor
Physico-chemical Quality Elements	Moderate (2019); High (2014)
Hydromorphological Quality Elements	Supports good
Chemical	Fail in 2019 due to three Priority hazardous substances (Mercury and its Compounds; Perfluorooctane sulphonate (PFOS); Polybrominated diphenyl ethers (PBDE)) and two Priority substances (Cypermethrin; Nickel and its Compounds).

Table 3-3 Overview of WFD quality elements of the Tame from R Blythe to River Anker (GB104028046440) WFD waterbody

WFD Parameter	Status / Summary
Water Body ID	GB104028046440
Water Body Name	Tame from R Blythe to River Anker
Water Body Type	River
Water Body Length / Area	18.096 km / 61.659 km^2
Hydromorphological Designation	Not designated artificial or heavily modified
Overall Ecological Status	Poor (2019); Moderate (2013)
Current Overall Status	Poor
Status Objective (overall)	Poor by 2015
Biological Quality Elements	Poor (2019); Moderate (2013)
Physico-chemical Quality Elements	Moderate
Hydromorphological Quality Elements	Supports good
Chemical	Fail in 2019 due to three Priority hazardous substances (Mercury and its Compounds; Perfluorooctane sulphonate (PFOS); Polybrominated diphenyl ethers (PBDE)). Good in 2016.

Table 3-4 Overview of WFD quality elements of the Rea from Bourn Brook to River Tame (GB104028042550) WFD waterbody

WFD Parameter	Status / Summary
Water Body ID	GB104028042550
Water Body Name	Rea from Bourn Brook to River Tame Water Body
Water Body Type	River
Water Body Length / Area	8.278 km / 15.357 km^2
Hydromorphological Designation	Heavily modified
Overall Ecological Status	Moderate (2019)
Current Overall Status	Moderate
Status Objective (overall)	Moderate by 2015
Biological Quality Elements	Bad (2019)
Physico-chemical Quality Elements	Moderate (2019)
Hydromorphological Quality Elements	Supports good (2019)
Chemical	Fail in 2019 due to three Priority hazardous substances (Mercury and its Compounds; Perfluorooctane sulphonate (PFOS); Polybrominated diphenyl ethers (PBDE)). Good in 2016.

3.2.11 All three waterbodies fail to achieve Good Status (for non-HMWBs) or Potential (HMWBs). The reasons for this for are shown in Table 3-5, Table 3-6, and Table 3-7 (Ref. 6).

3.2.12 Failure to achieve Good WFD Status or Potential is generally associated with urbanisation and other catchment uses. In terms of sedimentation, the catchment scale modifications contribute an enormous amount of excess fine sediment to the river, much of which is contaminated. Channel deepening and floodplain embankments also concentrate fine sediment in the channels, by disconnecting floodplain sequestration zones. Coarse sediment is generally depleted, mainly due to channel realignments and scour protection, gravel quarrying, channel dredging for flood capacity, and weir impoundments. The combined result is severe excess fine sediment in the channels, highly disproportionate to natural coarse substrate that typically forms higher quality habitats.

Table 3-5 Reasons for not achieving good (RNAG) for the Tame – R Rea to R Blythe (GB104028046841) WFD waterbody

Surface water management issue	Activity	Category	WFD classification element
Physical modification	Urbanisation – urban development	Urban and transport	Fish
Point source	Sewage discharge (intermittent)	Water industry	Ammonia
			Invertebrates
			Phosphate
Diffuse source	Contaminated land	Urban and transport	Nickel and its Compounds
		Industry	Zinc
Point source	Sewage discharge (continuous)	Water industry	Phosphate
			Zinc
			Nickel and its Compounds
Diffuse source	Urbanisation – rural development	Urban and transport	Fish
			Invertebrates
			Ammonia
			Phosphate
			Zinc

Table 3-6 Reasons for not achieving good (RNAG) for the Tame from R Blythe to River Anker (GB104028046440) WFD waterbody

Surface water management issue	Activity	Category	WFD classification element
Diffuse source	Urbanisation – urban development	Urban and transport	Phosphate
			Invertebrates
			Macrophytes and Phytobenthos Combined
			Dissolved oxygen
Physical modification	Quarry	Mining and quarrying	Dissolved oxygen
Physical modification	Urbanisation – urban development	Urban and transport	Dissolved oxygen
Point source	Trade/industry discharge	Industry	Dissolved oxygen
Point source	Misconnections	Domestic General Public	Dissolved oxygen
Point source	Sewage discharge (continuous)	Water industry	Dissolved oxygen
			Invertebrates
			Phosphate
			Macrophytes and Phytobenthos Combined
Point source	Sewage discharge (intermittent)	Water industry	Dissolved oxygen
			Macrophytes and Phytobenthos Combined
			Phosphate

Table 3-7 Reasons for not achieving good (RNAG) for the Rea from Bourn Brook to River Tame (GB104028042550) WFD waterbody

Surface water management issue	Activity	Category	WFD classification element
Diffuse source	Contaminated water body bed sediments	Industry	Zinc
	Contaminated land		
Physical modification	Urbanisation – urban development	Urban and transport	Invertebrates
Point source	Sewage discharge (intermittent)	Water industry	Zinc
			Ammonia (Phys-Chem)
			Invertebrates
Diffuse source	Transport drainage	Urban and transport	Zinc
Diffuse source	Urbanisation – urban development	Urban and transport	Phosphate
			Invertebrates
Physical modification	Urbanisation – urban development	Local and central government	Mitigation Measures Assessment
Physical modification	Flood protection	Urban and transport	Mitigation Measures Assessment
Diffuse source	Urbanisation – urban development	Urban and transport	Ammonia (Phys-Chem)

Land use

3.2.13 Land-use across the three waterbodies shows a clear transition from an urban to rural environment as the Tame flows downstream, as shown in Table 3-8.

Table 3-8 Predominant land-use within the three WFD waterbodies within the Tame study area

Landcover Class	Rea from Bourn Brook to River Tame (GB104028042550)	Tame - R Rea to R Blythe (GB104028046841)	Tame from R Blythe to River Anker (GB104028046440)
Urban	77.4%	36.0%	9.4%
Suburban	18.9%	26.7%	21.9%
Arable	0.2%	15.3%	30.8%
Improved grassland	2.4%	13.9%	19.3%
Deciduous woodland	0.7%	4.8%	8.1%
Freshwater	0.4%	3.2%	10.5%

3.2.14 As the Tame flows downstream, land-use clearly transitions from urban to rural. Within the Rea from Bourn Brook to River Tame, landcover is almost entirely urban and suburban, which drops to around 60% in the Tame – R Rea to R Blythe and 30% in the Tame from R Blythe to River Anker, with the remaining proportion of these waterbodies made up of arable, improved grassland, deciduous woodland, and areas of freshwater. Urbanisation and arable agriculture tend to contribute excess fine and contaminated sediment from catchment surfaces to river channels.

Geology

3.2.15 Bedrock geology varies somewhat between the three waterbodies. Triassic bedrock dominates the two most upstream waterbodies but is of reduced extent downstream of Minworth STW in the Tame and R Blythe to River Anker waterbody, where the Warwickshire group becomes common.

3.2.16 The resulting composition of the bedrock geology is shown in Table 3-9 (Ref. 7).

Table 3-9 Bedrock geology of the three WFD waterbodies within the Tame study area

Bedrock geology	Description	Rea from Bourn Brook to River Tame	Tame - R Rea to R Blythe	Tame from R Blythe to River Anker
Triassic mudstone, siltstone, and sandstone	Formed 200 – 251 Mya. Local environment dominated by hot deserts.	75.25%	96.30%	48.21%
Triassic sandstone and conglomerate	Formed 200 – 251 Mya. Local environment dominated by rivers.	24.75%	3.70%	0.95%
Pennine lower coal measures formation	Formed 318 – 319 Mya. Local environment dominated by swamps, estuaries, and deltas.	0.00%	0.00%	2.85%
Pennine middle coal measures formation	Formed 309 – 312 Mya. Local environment dominated by swamps, estuaries, and deltas.	0.00%	0.00%	6.31%
Permian sandstone and conglomerate	Formed 251 – 299 Mya. Local environment previously dominated by rivers.	0.00%	0.00%	0.19%
Tremadocian mudstone, siltstone, and sandstone	Formed 479 – 488 Mya. Local environment previously dominated by open seas with pelagite deposits.	0.00%	0.00%	1.37%
Warwickshire group – mudstone, siltstone, sandstone, coal, ironstone, and ferricrete.	Formed 271 – 312 Mya. Local environment dominated by rivers.	0.00%	0.00%	25.06%
Warwickshire group – siltstone and sandstone.	Formed 271 – 312 Mya. Local environment dominated by rivers.	0.00%	0.00%	15.05%

3.2.17 Bedrock and superficial geology vary within the large study area. Parent material yields gravels and natural fine sediment which would be distributed through the entire river system, although fluvio-glacial sand and gravel are more prevalent upstream of Minworth STW. Hydraulic sorting over time results in gravel river beds (since relatively small material is relatively easily transported), which would be naturally transported downstream, but this is discontinuous in the Tame due to weirs and other modifications. Geology also becomes more fine grained downstream, with the amount of till diamicton increasing in turn. The composition of superficial geology is shown in Table 3-10 (Ref. 7).

Table 3-10 Superficial geology of the three WFD waterbodies within the Tame study area

Superficial Geology	Description	Rea from Bourn Brook to River Tame	Tame - R Rea to R Blythe	Tame from R Blythe to River Anker
Alluvium clay, silt, and sand	Deposited 2 Mya in the Quaternary. Previous environment dominated by rivers.	21.00%	13.35%	14.54%
Glacial sand and gravel	Deposited 2 Mya in the Quaternary. Previous environment dominated by ice age conditions.	52.92%	49.97%	0.82%
River terrace deposits sand and gravel	Deposited 3 Mya in the Quaternary. Previous environment dominated by rivers.	0.00%	10.52%	6.82%

Superficial Geology	Description	Rea from Bourn Brook to River Tame	Tame - R Rea to R Blythe	Tame from R Blythe to River Anker
Till diamicton	Deposited 3 Mya in the Quaternary. Previous environment dominated by ice age conditions.	0.10%	9.34%	16.23%
No record	*N/A*	25.98%	16.82%	61.59%

3.2.18 Across the three waterbodies, soils around the channel of the Tame and its tributaries are loamy and clayey with naturally high groundwater and of medium fertility. Alongside the channel soils are similar, although with purely loamy soils and with a slightly lower fertility. There are also areas of slowly permeable, seasonally wet, slightly acid, but base-rich loamy and clayey soils with impeded drainage (Ref. 8).

Historical channel change

3.2.19 Within large extents of the study area, the Tame exhibits a clearly modified and straightened channel, particularly upstream of Minworth STW. Many of these alterations likely occurred during the Industrial Revolution in the mid-19th century, and so pre-dates available Ordnance Survey mapping. Reviews of series of historic maps from 1900 onwards shows that modifications have continued over the last 120 years, including in recent years with a several major Environment Agency restoration schemes (Ref. 2).

3.2.20 To illustrate the degree of river change, and impacts on channel morphological and sedimentation processes, alterations can be identified by comparing the modern-day channel (2021) to that of 1959 and 1889, as shown in Figure 3-3, Figure 3-4, Figure 3-6, and -7. Where the channels of 1889 or 1959 are not visible, it suggests that it is identical to the modern-day course of the Tame.

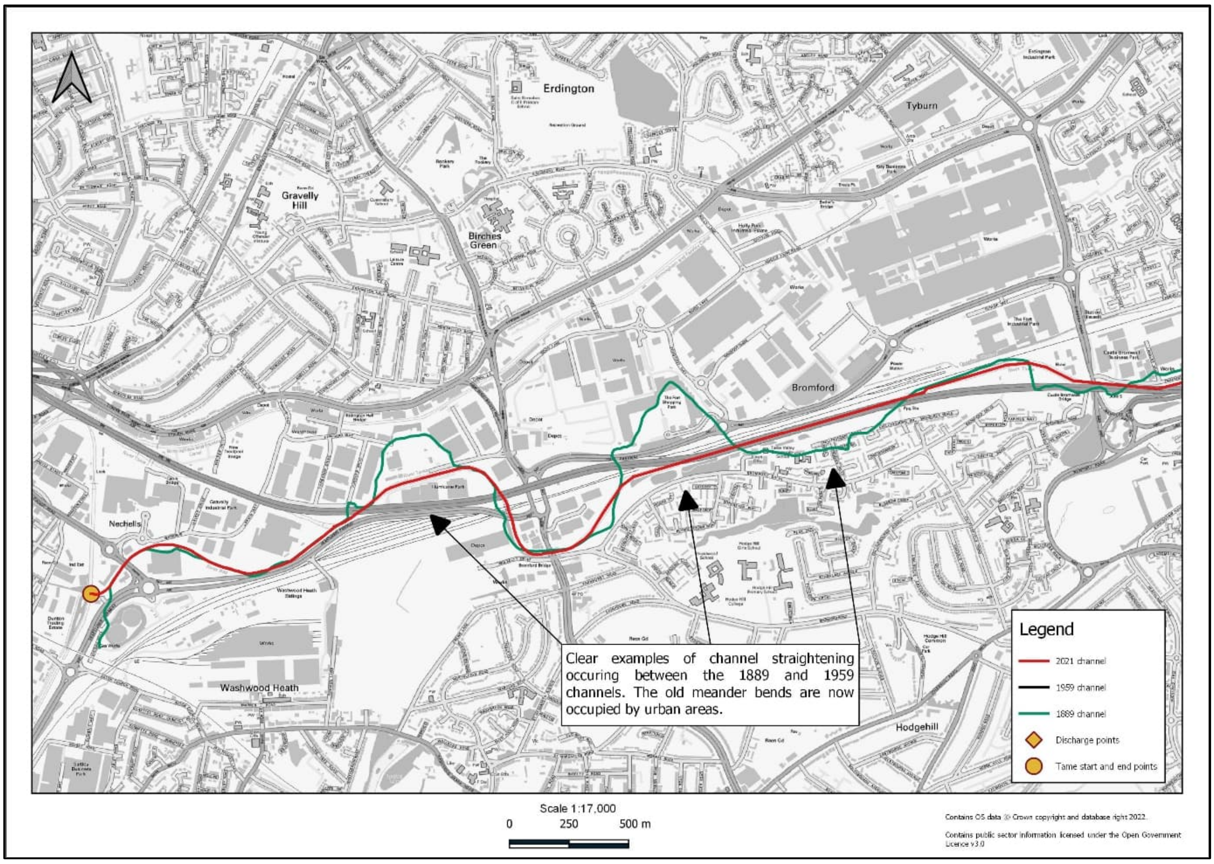
3.2.21 Generally, there has been relatively little channel modification between 1959 (black) and 2021 (red), suggesting the Tame has been fixed in its course for the past 60 years. However, there are two examples of meander cut-offs (SP 1696 9144 and SP 1834 9172), both downstream of Minworth STW (see Figure 3-4). However, a noticeable addition to the study area is the formation of Lea Marston Lakes. These are essentially very large-scale sedimentation ponds, established in 1980 from former gravel extraction pits, with the goal of settling and removing pollutants from the Tame.

3.2.22 Between 1959 (black) and 1889 (green) there are much more marked changes in the Tame's course, both upstream and downstream of Minworth STW. There are several locations where meanders have been removed and replaced with a straightened and more direct channel, as shown clearly in in Figure 3-3, Figure 3-4, Figure 3-6, and Figure 3-7.

3.2.23 The effects these modifications have had on channel length and sinuosity throughout the study area of the Tame are shown in Table 3-11. Channel length has clearly decreased over time as a result of channel straightening, with sinuosity reducing as a result. The majority of these decreases occurred from 1889 to 1959.

Table 3-11 Channel length and Sinuosity Index for 1889, 1959, and 2021

Channel	Length (km)	Sinuosity Index
1889	22.630	1.68
1959	21.022	1.56
2021	20.352	1.51



Clear examples of channel straightening occuring between the 1889 and 1959 channels. The old meander bends are now occupied by urban areas.

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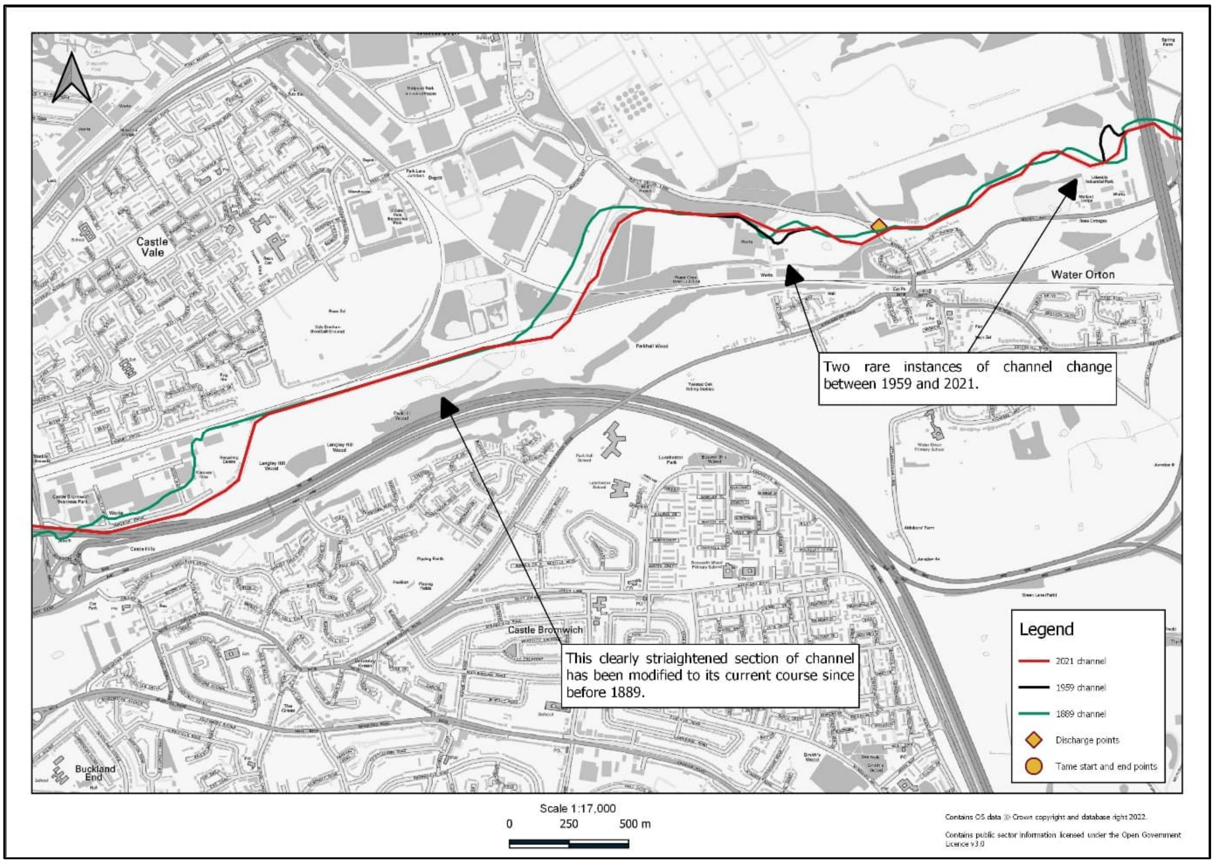
Figure 3-3 Historic channel change of the Tame – section 1



Two rare instances of channel change between 1959 and 2021.

This clearly striaightened section of channel has been modified to its current course since before 1889.

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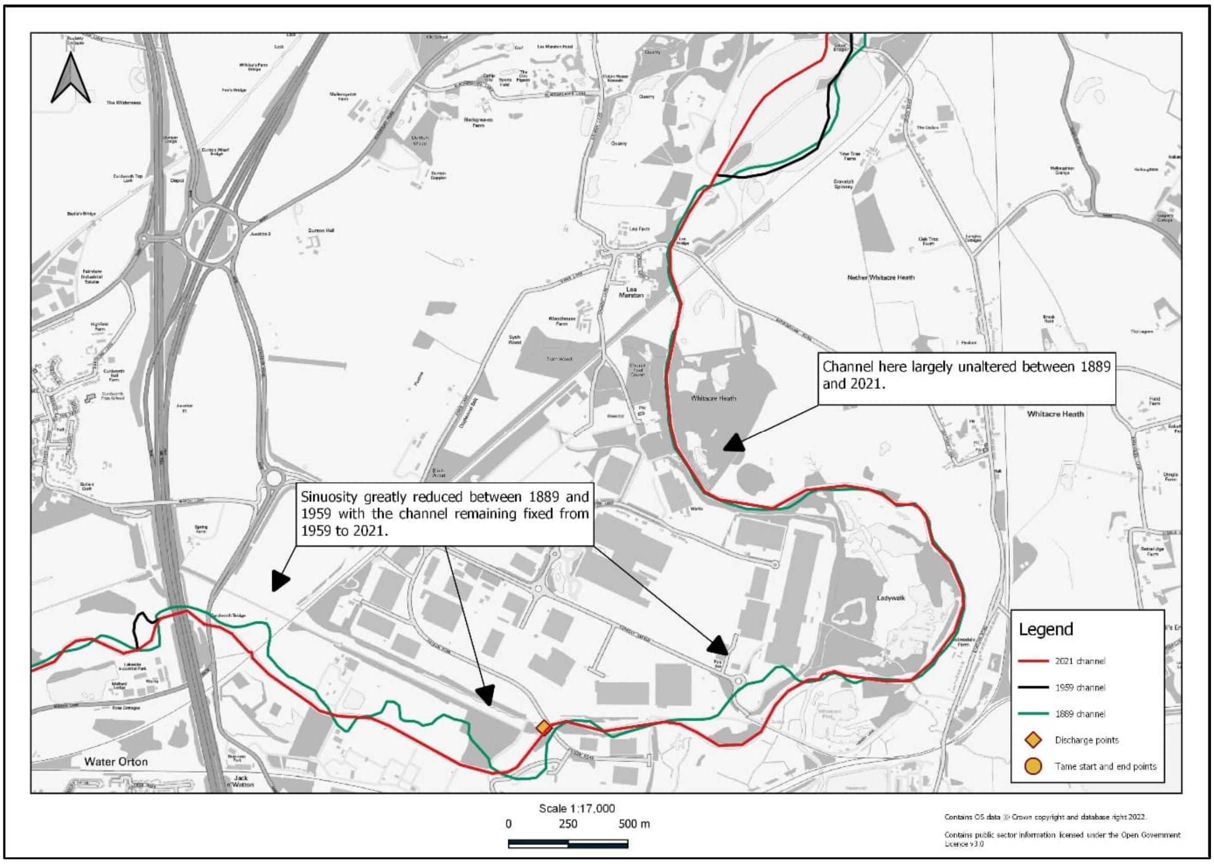
Figure 3-4 Historic channel change of the Tame – section 2



Channel here largely unaltered between 1889 and 2021.

Sinuosity greatly reduced between 1889 and 1959 with the channel remaining fixed from 1959 to 2021.

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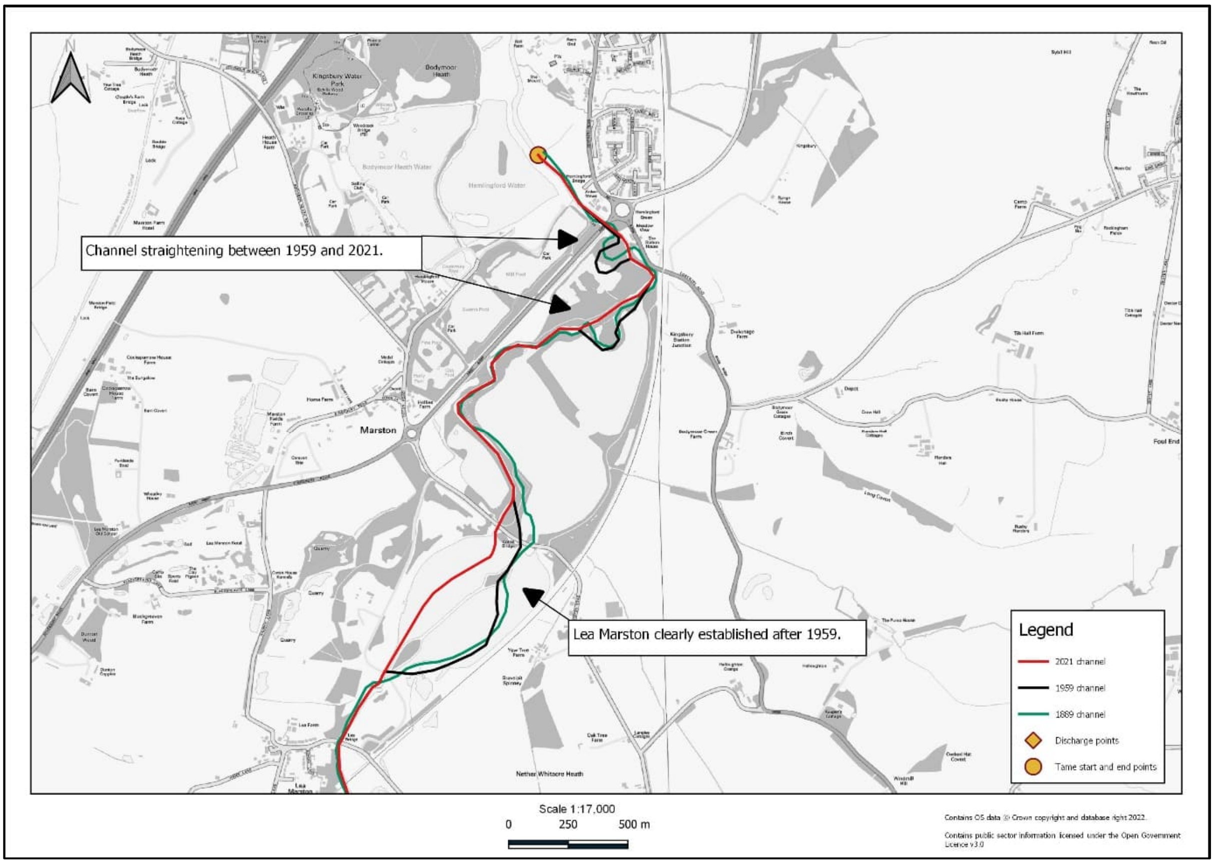
Figure 3-5 Historic channel change of the Tame – section 3



Channel straightening between 1959 and 2021.

Lea Marston clearly established after 1959.

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Figure 3-6 Historic channel change of the Tame – section 4

Floodplain Connectivity

3.2.24 The Tame is a floodplain river, as shown by EA flood zones reproduced in Figure 3-7 (Ref. 9). These maps also illustrate the degree of channel modifications and impacts on natural sediment processes. Prior to any anthropogenic catchment and river uses, the River Tame and tributaries will have actively meandered across these floodplain extents, rather than being straightened and/or realigned to the sides of the valley floors to make space for floodplain development.

3.2.25 The modern floodplains are also highly disconnected, due to channel deepening and flood embankments. This is severely detrimental to floodplain wetland habitats. It also prevents floodplain inundation and delivery of sediment to floodplains to settle, thereby concentrating sediment within aquatic habitats, and depleting nutrient delivery to natural floodplain wetlands. The combined effect is degraded aquatic habitats and wetlands, and degraded floodplain pollutant and carbon sequestration.

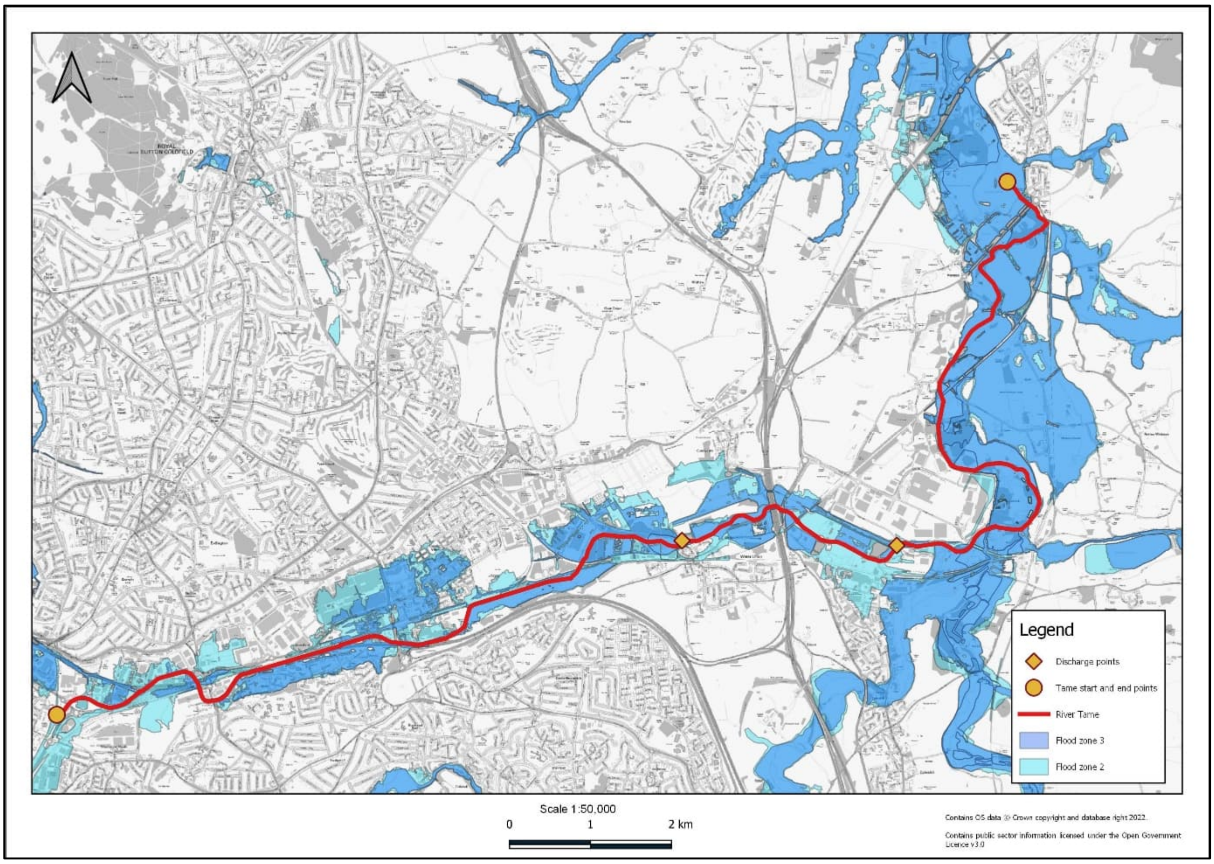

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Figure 3-7 Flood zones in the Tame study area

3.2.26 Ecological Context Table 3-12. There are no additional SACs, Ramsar sites, or protected areas (Ref. 3). Refer also to Appendix A SSSI Interaction, and Appendix B(i) Terrestrial Ecology.

Table 3-12 Designated areas within the Tame study area

Statutory Site Name	Area	Location relevant to study area	Reason(s) for Designation
Whitacre Heath SSSI (SP 208928)	44.1 ha	Located on the western floodplain of the Tame, just downstream of Lea Marston lakes.	The area is an important breeding ground for a range of water birds. The SSSI displays a collection of vegetation types as a result of the differing habitats within the area across the ecotone from open water to seasonally wet meadows (Ref. 4).
River Blythe (SSSI) (SP 2121 9159)	102.2 ha	The Blythe flows into the Tame within the study area at SP 2121 9159, downstream of Minworth STW and upstream of Lea Marston lakes.	The entire 39km stretch of the Blythe, which culminates with its confluence with the Tame, is an example of a lowland clay river, exhibiting natural features such as riffle-pool sequences and meander bends. This diversity in turn supports a range of plant species (Ref. 5).

3.2.27 The wider Tame valley is of significant ecological value and potential, as exemplified by Middleton Lakes RSPB Nature Reserve, located just south of Tamworth. The site’s mosaic of habitats is home to a wide variety of birds, on what was once a gravel extraction area, demonstrating the ability for biodiverse and valuable landscapes to develop in areas confined by industry (Ref. 11).

3.3 Trent

General characteristics

3.3.1 The River Trent is the third longest river in the UK, and within the study area is mainly a low-lying and gently meandering floodplain river with a width generally in excess of 50 metres. The Trent flows northwards from the downstream end of the study area ([redacted]) as far as Cromwell Lock ([redacted]. From this point the Trent continues northwards towards its confluence with the Humber Estuary (S[redacted]Within the study area the Trent splits at [redacted]into two forks, east and a west, before re-converging at S[redacted], around 4.2 km to the northeast. During this split, the eastern fork flows through Newark-on-Trent, the only notable urban space in the study area (Ref. 3).

3.3.2 Including Cromwell Lock at the downstream extent of the study area ([redacted]), there are 4 weirs within the indicative location of the SLR. These are found at [redacted]where the Trent splits downstream of Newark-on-Trent, as well as [redacted] and [redacted], both on the Trent’s eastern fork and so within the town of Newark-on-Trent (Ref. 3).

3.3.3 In addition to these weirs, the Trent is crossed multiple times, mainly by small foot and car bridges within Newark-on-Trent, but also by railway lines on four occasions (SK 77113 53850, SK 80078 55363, SK 80049 55733, SK 79860 56245). The Trent is also crossed by main roads in three locations SK 7810 5284, SK 8015 5531 (both A46), and SK 8054 5672 (A1) (Ref. 3).

3.3.4 There are no Ramsar sites, SACs, or SPAs in close proximity of the Trent study area, however there is one SSSI (Besthorpe Meadows) downstream of Cromwell Lock, shown in Table 3-13 (Ref. 3). Refer also to Appendix A SSSI Interaction, and Appendix B(i) Terrestrial Ecology.

3.3.5 The Trent study area is shown in 3-9, alongside the SLR abstraction point, weirs, and designated areas in the surrounding landscape. The SLR abstraction point shown is based on the current location prosed by Anglian Water.

Table 3-13 Designated area within the Trent study area

Statutory Site Name	Area	Location relevant to study area	Reason(s) for Designation
Besthorpe Meadows SSSI (SK 817643)	9.23 ha	Approximately 2.5 km to the north of Cromwell Lock.	Two unimproved grasslands home to rare plant species, such as great burnet *(Sanguisorba officinalis)* and meadow foxtail *(Alopecurus pratensis)* (Ref. 12).

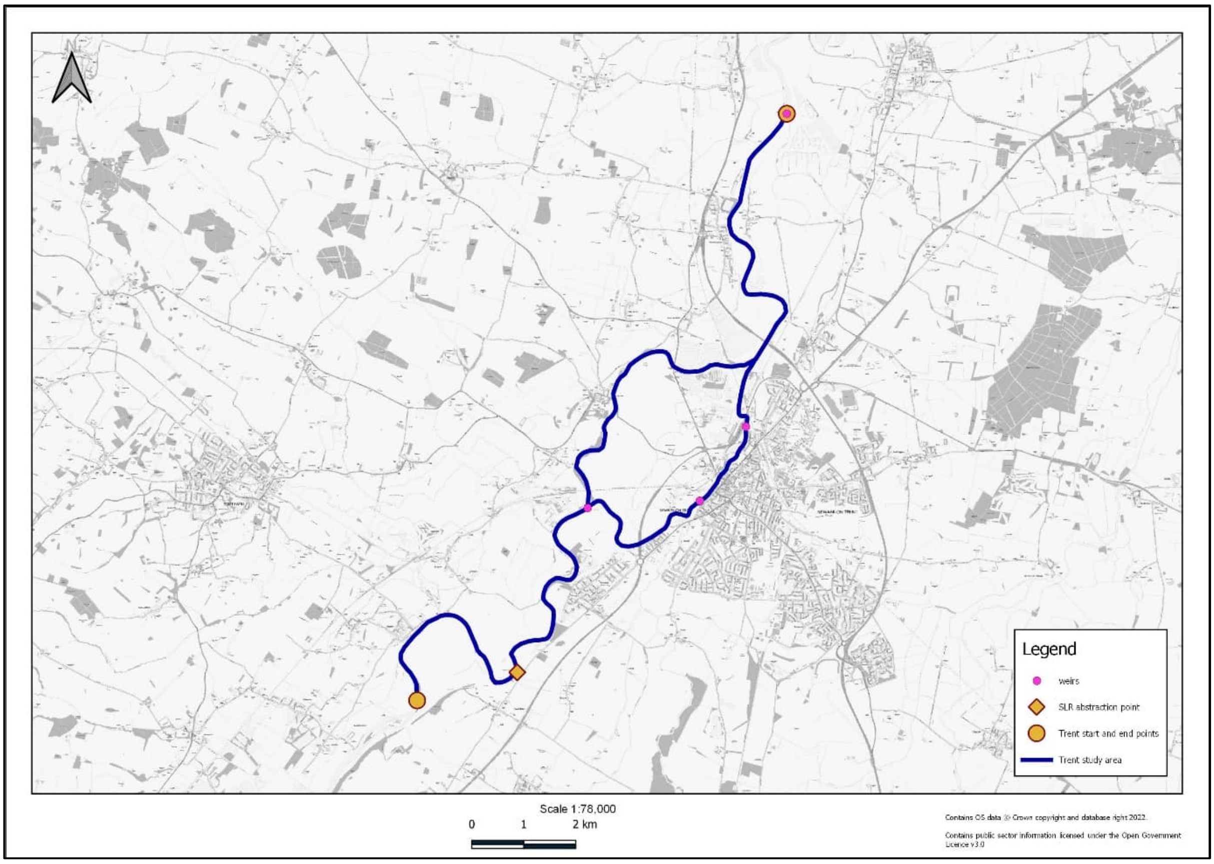

Figure 3-8 Trent study area

WFD Status of waterbodies

3.3.6 There are two waterbodies through which the Trent flows through within the study reach:

- Trent from Soar to The Beck (GB104028053110)
- Trent Bifurcation Pingley Dyke to Winthorpe (GB104028053390)

3.3.7 Figure 3-9 shows the Trent within the study area along with these two waterbodies.

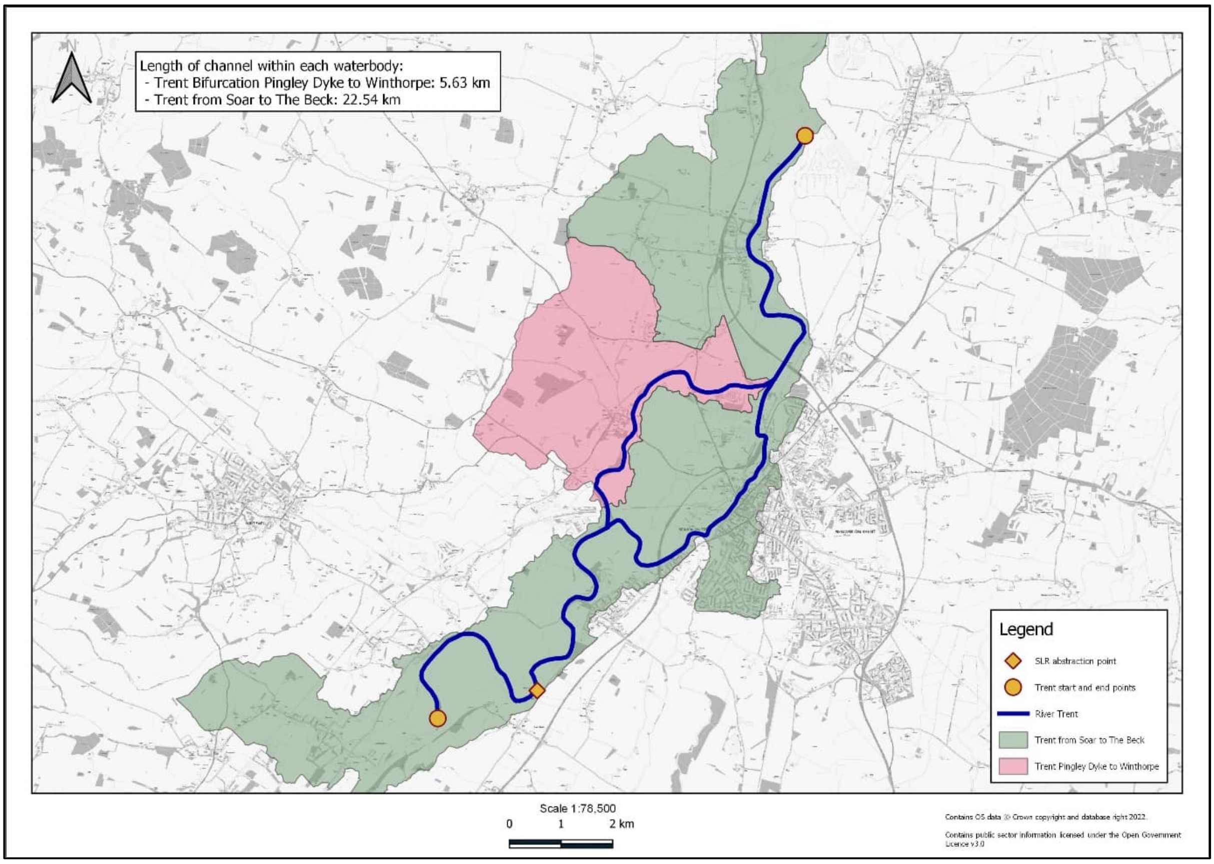

Figure 3-9 WFD waterbodies underlying the Trent study area

3.3.8 Table 3-15. The Trent from the River Soar to The Beck is designated as a HMWB, with the level of modification being particularly notable given the size of the river. The Trent Bifurcation Pingley Dyke to Winthorpe waterbody is not designated as HMWB despite being more urbanised than other areas (Ref. 6).

Table 3-14 Overview of WFD quality elements of the Trent from Soar to The Beck (GB104028053110)

WFD Parameter	Status / Summary
Water Body ID	GB104028053110
Water Body Name	Trent from Soar to The Beck
Water Body Type	River
Water Body Length / Area	71.256 km / 139.732 km^2
Hydromorphological Designation	Heavily modified
Overall Ecological Status	Moderate
Current Overall Status	Moderate
Status Objective (overall)	Moderate by 2015
Biological Quality Elements	Moderate
Physico-chemical Quality Elements	Moderate
Hydromorphological Quality Elements	Supports good
Chemical	Fail in 2019 due to three Priority hazardous substances (Mercury and its Compounds; Perfluorooctane sulphonate (PFOS); Polybrominated diphenyl ethers (PBDE)). Good in 2016.

Table 3-15 Overview of WFD quality elements of the Trent Bifurcation Pingley Dyke to Winthorpe (GB104028053390)

WFD Parameter	Status / Summary
Water Body ID	GB104028053390
Water Body Name	Trent Bifurcation Pingley Dyke to Winthorpe
Water Body Type	River
Water Body Length / Area	5.234 km / 13.223 km ^{2}
Hydromorphological Designation	Not designated artificial or heavily modified
Overall Ecological Status	Moderate
Current Overall Status	Moderate
Status Objective (overall)	Moderate by 2015
Biological Quality Elements	Moderate
Physico-chemical Quality Elements	Moderate
Hydromorphological Quality Elements	Supports good
Chemical	Fail in 2019 due to three Priority hazardous substances (Mercury and its Compounds; Perfluorooctane sulphonate (PFOS); Polybrominated diphenyl ethers (PBDE)). Good in 2016.

3.3.9 Both waterbodies failed to achieve Good Status / Potential. The reasons are summarised in Table 3-16 and Table 3-17. As with the River Tame (and the River Tame is a tributary of the pollution issues in the River Trent) failure to achieve Good is associated with river and catchment uses. The River Trent is recorded as having more physical modifications that the River Tame, with the Trent being a navigable river. Being in a very low-lying region, the Trent also has very extensive floodplain embankments, which are for the purposes of land gain and farming fertile alluvium on naturally broad floodplains and wetlands (Ref. 6).

3.3.10 In terms of the SROs and sedimentation, flows are highly regulated by navigation weirs and flood embankments. These longitudinal and lateral barriers disrupt natural sediment transport and trap fine sediment in aquatic habitats, with excess fine sediment having been delivered to these waters from the entire upstream catchment. Coarse sediment is also depleted, mainly due to channel realignments, scour protection and weir impoundments, although natural bed materials in this regional / topographic setting would be finer than upstream.

Table 3-16 Reasons for not achieving good (RNAG) for the Trent from Soar to The Beck (GB104028053110) WFD waterbody

Surface water management issue	Activity	Category	WFD classification element
Diffuse source	Transport drainage	Urban and transport	Phosphate
Point source	Sewage discharge (continuous)	Water Industry	Phosphate
			Macrophytes and Phytobenthos Combined
Physical modification	Navigation including ports	Navigation	Mitigation Measures Assessment
Physical modification	Flood protection	Local and Central Government	Mitigation Measures Assessment
Physical modification	Urbanisation	Urban and transport	Mitigation Measures Assessment

Table 3-17 Reasons for not achieving good (RNAG) for the Trent Bifurcation Pingley Dyke to Winthorpe (GB104028053390) WFD waterbody

Surface water management issue	Activity	Category	WFD classification element
Diffuse source	Transport Drainage	Urban and transport	Phosphate
			Invertebrates
			Macrophytes and Phytobenthos Combined

Land use

3.3.11 Land-use differs between the two waterbodies, as shown in Table 3-18.

Table 3-18 Predominant land-use of the two WFD waterbodies within the Trent study area

Landcover Class	Trent from Soar to The Beck (GB104028053110)	Trent Bifurcation Pingley Dyke to Winthorpe (GB104028053390)
Urban	11.14%	0.49%
Suburban	25.37%	5.02%
Arable	32.89%	58.60%
Improved grassland	14.00%	20.32%
Deciduous woodland	7.31%	6.94%
Freshwater	8.12%	7.01%

3.3.12 As shown by Table 3-18, the main difference in respective land-use between the two waterbodies is that the Trent from Soar to The Beck is considerably more urbanised than the Trent Bifurcation Pingley Dyke to Winthorpe. By contrast, the latter has a larger arable land use, and so the Trent from Soar to The Beck is relatively much more urbanised than the Trent Bifurcation Pingley Dyke to Winthorpe.

3.3.13 Urbanisation and arable agriculture will contribute excess fine and contaminated sediment from catchment surfaces to river channels, but the main modification impacts on the River Trent in the study are the navigation weirs and floodplain embankments.

Geology

3.3.14 Triassic bedrock dominates both waterbodies, but whereas the Trent Bifurcation Pingley Dyke to Winthorpe waterbody is entirely made up of this bedrock, the Trent from Soar to The Beck waterbody is more varied (as would be expected due its size) and has small pockets of both older and younger bedrocks. The bedrock composition is shown in Table 3-19 (Ref. 7).

Table 3-19 Bedrock geology of the two WFD waterbodies within the Trent study area

Bedrock geology	Description	Trent from Soar to The Beck	Trent Bifurcation Pingley Dyke to Winthorpe
Triassic mudstone, siltstone, and sandstone	Formed 200 – 251 Mya. Local environment previously dominated by hot deserts.	85.68%	100%
Triassic sandstone and conglomerate	Formed 200 – 251 Mya. Local environment previously dominated by rivers.	10.31%	0.00%
Permian sandstone and conglomerate	Formed 251 – 299 Mya. Local environment previously dominated by rivers.	1.53%	0.00%
Permian mudstone, siltstone, and sandstone	Formed 251 – 299 Mya. Local environment previously dominated by lakes and lagoons.	0.12%	0.00%

Bedrock geology	Description	Trent from Soar to The Beck	Trent Bifurcation Pingley Dyke to Winthorpe
Pennine lower coal measures formation	Formed 318 – 319 Mya. Local environment previously dominated by swamps, estuaries, and deltas.	0.08%	0.00%
Pennine middle coal measures formation	Formed 309 – 312 Mya. Local environment previously dominated by swamps, estuaries, and deltas.	2.15%	0.00%
Lias Group (mudstone, siltstone, limestone, and sandstone)	Formed 172 – 204 Mya. Local environment previously dominated by shallow seas.	0.24%	0.00%

3.3.15 Superficial geology also varies. The most noticeable is the widespread presence of till diamicton in the Trent Bifurcation Pingley Dyke waterbody, in contrast to its scarcity in the Trent from Soar to The Beck waterbody, which in turn possess almost twice the amount of alluvium, as well as some sand and gravel. These values are shown in Table 3-20 (Ref. 7).

Table 3-20 Superficial geology of the three WFD waterbodies within the Trent study area

Superficial Geology	Description	Trent from Soar to The Beck	Trent Bifurcation Pingley Dyke to Winthorpe
Alluvium clay, silt, and sand	Deposited 2 Mya in the Quaternary. Previous environment dominated by rivers.	47.27%	25.47
Glacial sand and gravel	Deposited 2 Mya in the Quaternary. Previous environment dominated by ice age conditions.	0.21%	0.00%
River terrace deposits sand and gravel	Deposited 3 Mya in the Quaternary. Previous environment dominated by rivers.	16.16%	0.00%
Till diamicton	Deposited 3 Mya in the Quaternary. Previous environment dominated by ice age conditions.	0.78%	37.83%
No record	*N/A*	35.58%	36.70%

3.3.16 The centre of the Trent Bifurcation Pingley Dyke to Winthorpe waterbody consists of loamy and clayey soils, which are naturally wet due to their high groundwater and of low to moderate fertility. To the west, soils are slightly acidic, with impeded drainage and of moderate to high fertility. Soils are of a similar level of fertility to the east, but are freely draining, characteristic of a floodplain (Ref. 8).

3.3.17 The Trent study site is located solely in the north of the Trent from Soar to The Beck waterbody. In this section of the waterbody, soils are of a similar type to those on the Trent Bifurcation Pingley Dyke to Winthorpe waterbody, with a mix of freely draining and naturally wet soils consisting of loamy and clayey substrates, and a range of fertility (Ref. 8).

3.3.18 Parent material to river sediment is therefore typically fine grained, and this combined with the geologically controlled low relief of the catchment means that the River Trent and its habitats within the study area is dominated by high levels fine sediment.

Historical channel change

3.3.19 Unlike the Tame, the Trent study area exhibits very little historical channel change, as shown when the 2021 channel is overlain on a map from 1889 in Figure 3-10 (Ref. 2). The river is too large to engineer extensively, but its lowland, fine and cohesive sediment setting also means that is generally has a passively meandering typology, rather than actively migrating across its floodplain.

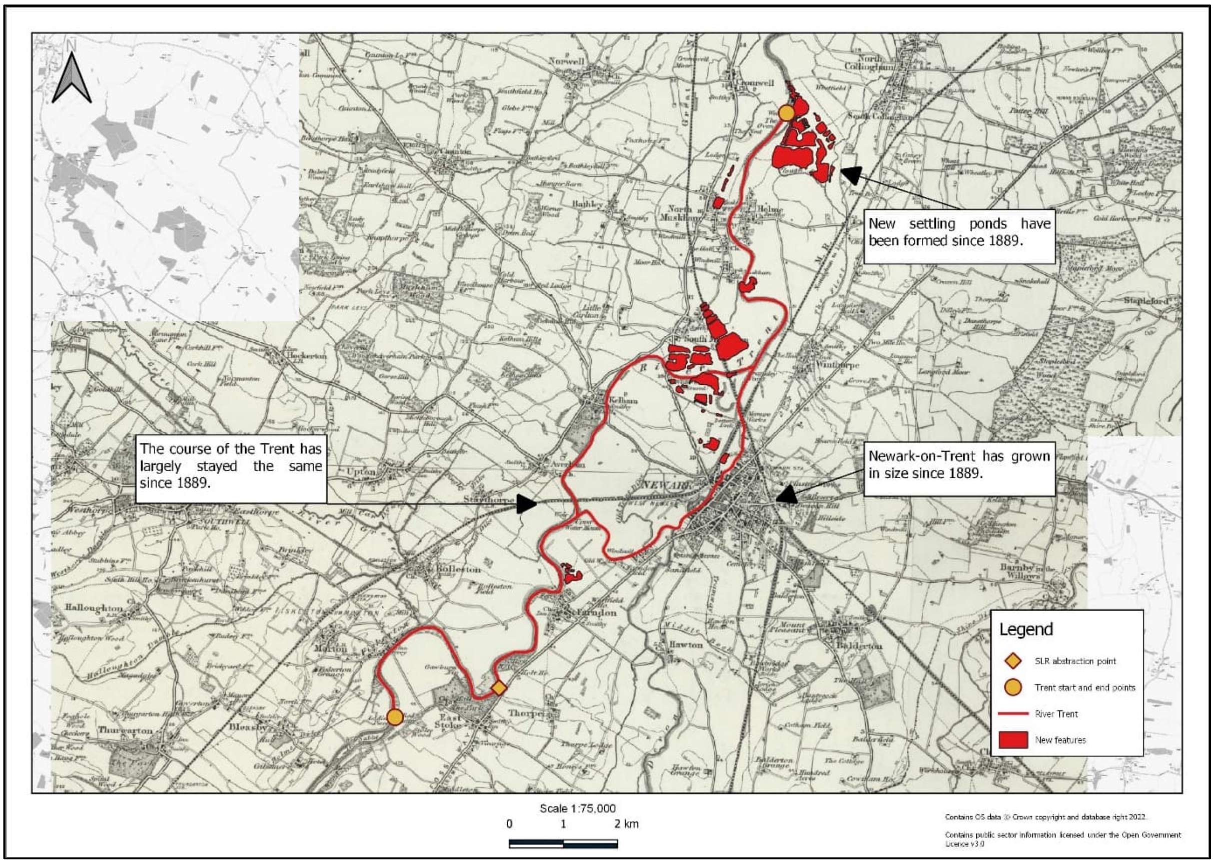

Figure 3-10 Historic channel change of the Trent (Ref. 2)

Floodplain Connectivity

3.3.20 The River Trent is a major river with large floodplains, as illustrated by EA flood zones reproduced in Figure 3-11 (Ref. 9).

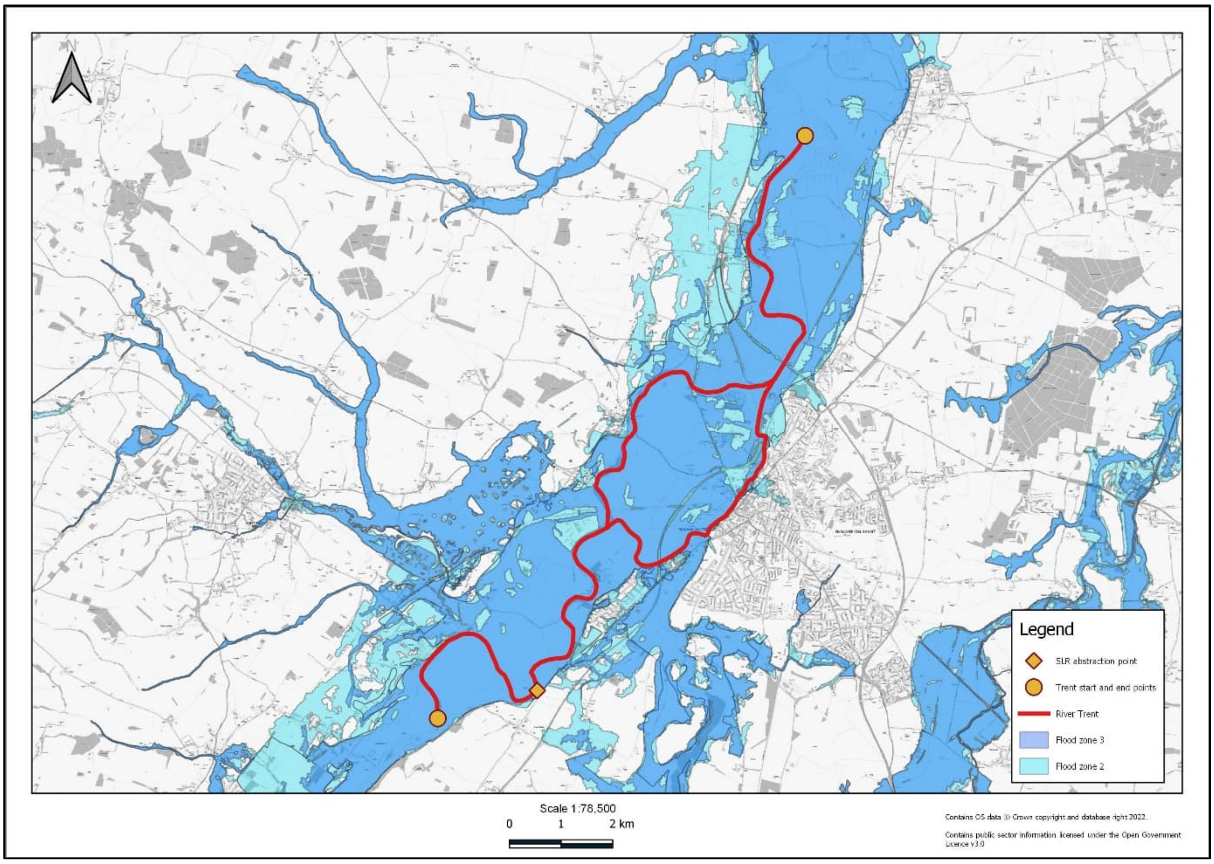

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Figure 3-11 Flood zones in the Trent study area

Designations

3.3.21 There is one SSSI within the Trent study area, as shown in Table 3-21. There are no additional SACs, Ramsar sites, or protected areas. Refer also to Appendix A SSSI Interaction, and Appendix B(i) Terrestrial Ecology.

Table 3-21 Designated area within the Trent study area

Statutory Site Name	Area	Location relevant to study area	Reason(s) for Designation
Besthorpe Meadows SSSI (SK 817643)	9.23 ha	Approximately 2.5 km to the north of Cromwell Lock.	Two unimproved grasslands home to rare plant species, such as great burnet *(Sanguisorba officinalis)* and meadow foxtail *(Alopecurus pratensis)* (Ref. 12).

4. Fluvial Geomorphology

4.1.1 This section summarises the geomorphological and sedimentation processes occurring in both the Tame and Trent study reaches, with particular attention paid to the presence of erosional and depositional features identified during the walkover surveys.

4.1.2 This is assessment is based on initial morphological modelling undertaken at Gate 1, which has been updated with ground-truthing reconnaissance field surveys. Sediment processes have been evaluated using the ST:REAM methodology[4] (Sediment Transport: Reach Equilibrium Assessment Model). This model classifies rivers into stream types based on the balance between erosion, deposition, and sediment transport as follows (Ref. 13):

- Erosional source: erosion dominated, generally found in upland headwaters with no upstream input of sediment. This channel type is rare away from upland headwaters, and not present within the Tame and Trent study area.
- Erosional exchange: both erosion and deposition occur within these reaches, but erosion is dominant such that sediment output is greater than input.
- Balance exchange: both deposition and erosion occur within these reaches, with the two seemingly in equilibrium. These reaches are generally common when the channel boundaries are composed of erodible material, yet channel gradient is moderate enough that just as much sediment is deposited.
- Balance transport: there is little to no erosion or deposition within these reaches, with sediment simply transported downstream. As such, this channel type is only found when both banks are resistant to erosion, sometimes as a result of hard engineering.
- Depositional exchange: both deposition and erosion occur within these reaches, but deposition is dominant such that sediment output is less than input.
- Depositional sink: deposition dominated, usually found just upstream of a lake or sea when transport capacity rapidly diminishes, leading the channel to ‘drop’ much of its sediment. This channel type is rare, and not considered within the Tame or Trent study area.
- Within the study area, most reaches are likely to be classed as balance transport due to the fairly mature and stable nature of the channels, meaning neither erosion nor deposition is likely to be dominant over a reach scale, though there will be some natural variability within this.

4.2 River Tame

4.2.1 For the purpose of this assessment, the Tame can be split into three reaches based on the location of inputs and channel character throughout the wider study area.

4.2.2 Starting at the upstream extent, Reach 1 flows from Nechells (initially as the River Rea; (SP 0968 8928) in inner-city Birmingham as far as the location of the first location of effluent discharge from Minworth STW ([redacted]. As it is upstream of the effluent discharge location, Reach 1’s geomorphological characteristics and processes are independent of the proposed SRO, and so acts as a baseline to help inform the potential impacts of a reduced discharge from the STWs on downstream reaches.

4.2.3 Reach 2 continues from the location of the first effluent discharge as far as the Blythe’s tributary with the Tame at SP 2122 9157, and so also encompasses the second discharge point at SP 20005 9139. As such, baseflow in Reach 2 is theoretically the most dependent on effluent discharge as it is expected that it makes the greatest relative contribution to flow in this location.

4.2.4 Reach 3, coming between the Blythe tributary and study area end point at [redacted] as the Tame flows north past Kingsbury, is home to a number of designated areas such as SSSIs at Whitacre Heath. Due to the small size of the proposed water abstraction relative to the size of the Blythe

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[4] Parker, C., Thorne, C.R. and Clifford, N.J. (2014). Development of ST:REAM: a reach-based stream power balance approach for predicting alluvial river channel adjustment. *Earth Surface Processes and Landforms*, 40: 403-413.

tributary, it is not thought that this reach is as dependent upon water from the STW to maintain baseflows as Reach 2, yet, due to the SSSIs mentioned above, requires careful examination.

4.2.5 Each of these reaches are discussed in the sub-sections below and shown in Figure 4-1.

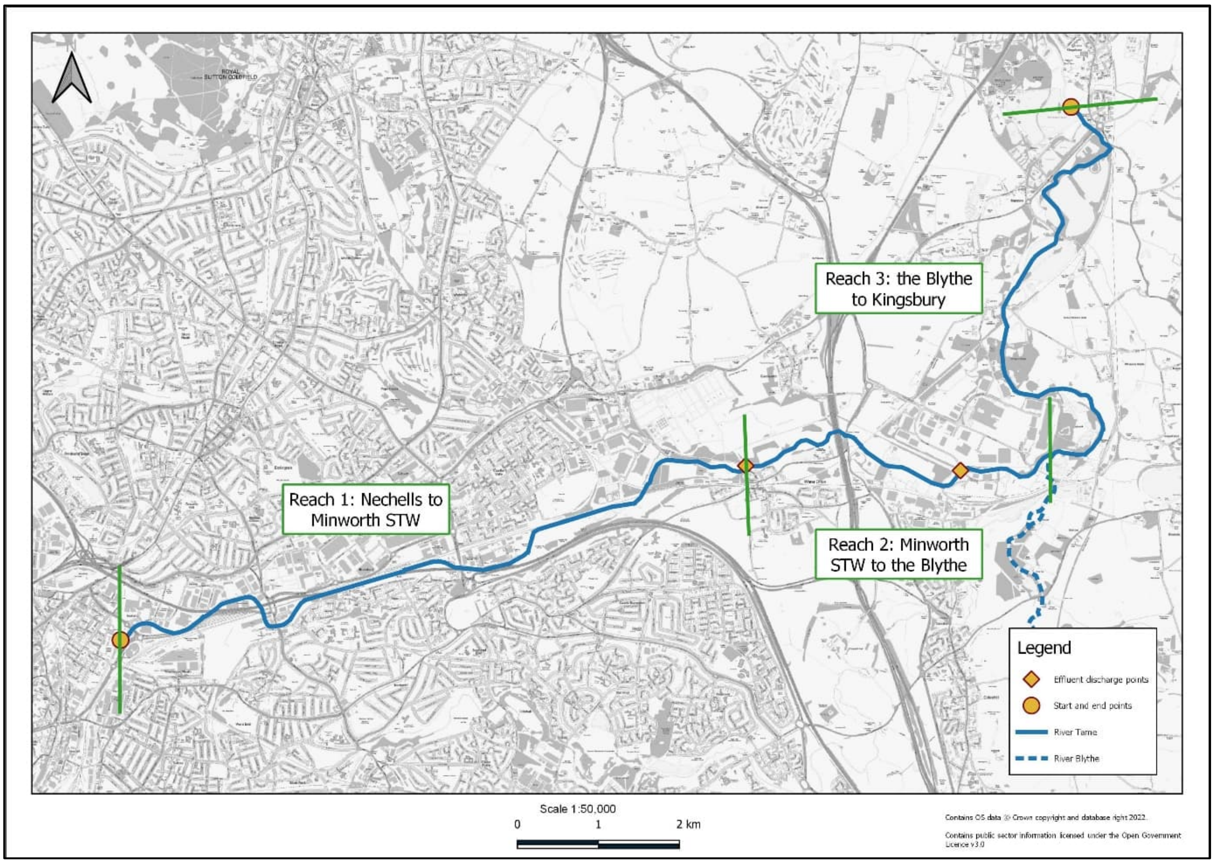

Figure 4-1 Reach breakdown on the River Tame

Nechells to Minworth STW

4.2.6 Running through a heavily urbanised area, Reach 1 shows clear signs of modification, particularly towards the upstream end. This is seen clearly in the artificial banks at some of the locations, as well as the historic maps shown in Figure 3-4 and Figure 3-4 that show how the naturally more sinuous course of the Tame has been confined to a much straighter and homogenous channel. Sediment supply from upstream is low due to the presence of a structure on the River Rea as it passes under the Grand Union Canal (SP 0968 8930), which likely traps most coarse-grained sediment.

4.2.7 Photographed locations from Reach 1 are shown in Figure 4-2.

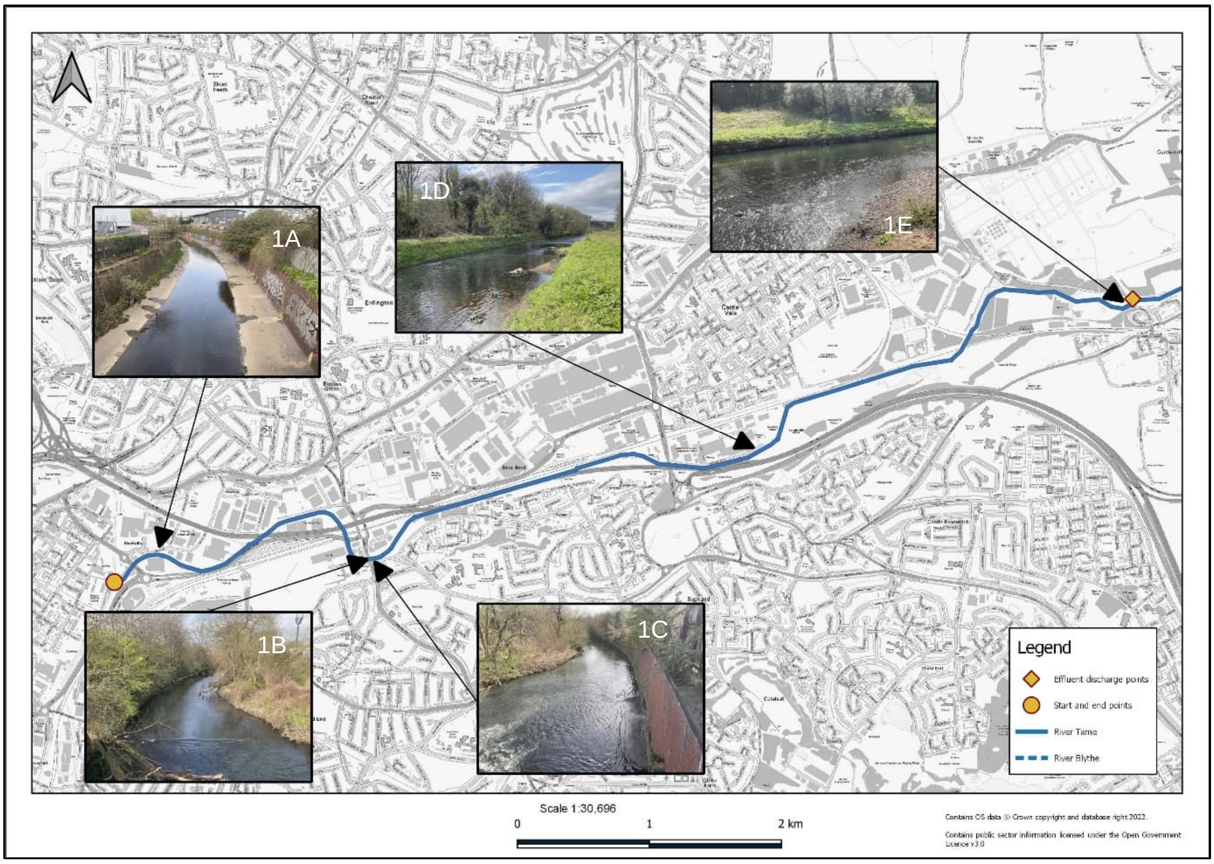

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Figure 4-2 Photographed locations from Reach 1

4.2.8 At the upstream end of the reach (Figure 4-3) the bed and banks are clearly artificial and modified. The concrete used to form the bed and banks here is designed to be resistant to erosion, so little to no sediment will be introduced to the channel from the banks. As mentioned above, a structure on the Rea means that much of the sediment from upstream will be detained, resulting in a low magnitude of sediment transport. The fine sediment that is in the channel will be efficiently transported downstream, with no evidence of significant deposition. As such, using the ST:REAM methodology, this section can be classified as an artificial balance transport reach.

Figure 4-3 Photo 1A: Nechells (looking upstream [redacted]). Note the artificial nature of the bed and the banks

4.2.9 Further downstream at Bromford Bridge (Figure 4 4 and Figure 4-5), the Tame has regained some of its more natural character, with only the right bank composed of hard material. The exposed left bank on the other hand will be subjected to small amounts erosion and so some sediment will enter the channel, though generally the left bank looks extremely stable.

4.2.10 On the right bank in Figure 4-4, some deposition of fine sediment has taken place, though it is possible that this is the result of the bridge from which the photograph is taken, as the abutment on the right side has probably focused much of the flow away from this side. In addition to this, the fallen tree in upstream of the bridge has also entrapped some sediment behind allowing the formation of a small berm around it. The bridge is located at the site of a weir that funnels much of the flow through the middle of the channel. The main obstacle to sediment transport is seen in Figure 4-4 through the form of the ridge perpendicular to the flow but is unlikely to have a severe impact as no build-up of sediment upstream of the weir can be identified. In any case, there are no clear sources of coarse grained upstream of the bridge, and so most of the channel's sediment is likely to be fine. The low levels of deposition and erosion in this section, evidenced in the stable nature of the banks mean that these sections are classified as balance transport.

4.2.11 Sediment deposits are notably fine and dominated by and silt, where the natural typology of this region of the River Tame would be a gravel bed river. This illustrates the influence of upstream urbanisation, and that sediment issues in the river have developed upstream of the SRO area. Flow reductions associated with the SRO may therefore exacerbate existing risks, but the prevailing sedimentation issues are clearly inherited from catchment land use, suggesting that reductions in baseflow (as opposed to peak flood flows) may not be a severe problem.

Figure 4-4 Photo 1B: Bromford Bridge (looking upstream, [redacted] Bank protection on the edge of the right bank is just visible.

Figure 4-5 Photo 1C: Bromford Bridge (looking downstream, [redacted]). Clear right bank protection.

4.2.12 Continuing downstream (Figure 4-6), the Tame has developed a marginally more natural appearance, although hard engineering is just visible at the foot of the right bank. The left bank is left exposed and shows clear signs of erosion. Much of this eroded sediment however appears to have been deposited at the channel margins, often entrapped upstream of junkyard items that are only transported in higher flows. in some places there are signs of an increasing coarseness of the sediment with some small pebbles present. Deposition may be marginally more prevalent than erosion in this location, in part due to a slight widening of the channel compared to upstream, which has resulted in a lower depth across the channel's width and so decreased flow competence. However, taken overall as a wider reach, this location is still classified as balance exchange as deposition is not dominant enough over erosion to warrant a classification of depositional exchange.

Figure 4-6 Photo 1D: Tameside Drive (looking upstream, [redacted]).

4.2.13 Just upstream of the first discharge location (Figure 4-7), deposition continues to be slightly more prevalent than erosion, as seen by the presence of gravel features along the left bank of the river. Both banks appear natural, with the steep right bank seen in Figure 4-6 having now transitioned into a more natural profile than seen upstream. This bank contains a ready supply of gravels that explain the formation of significant gravel features. The left bank appeared eroded in places with a degree of undercutting, and so both erosion and deposition are clearly active in this section. As with the section upstream of this one, deposition is likely to be more active than erosion, but not sufficiently enough to be classed as depositional exchange as the section appears to be broadly well balanced. As such it is classified as balance exchange.

4.2.14 This is a high morphological and ecological quality reach of the River Tame, albeit processes and habitats are constrained due to general catchment modifications. As such, this constitutes a reference reach for the best potential character of the Tame, from which SRO impacts can be considered in the context of other modifications.

Figure 4-7 Photo 1E: Minworth Road (looking upstream, [redacted].

Minworth STW to the Blythe

4.2.15 The second reach, from the first location of effluent discharge from Minworth STW to the Tame's confluence with the Blythe is likely to be the most impacted by any reduction in the discharge from Minworth STW on the basis that a higher proportion of flow comes from the STW compared to Reach 1 (which is upstream of the STW) and Reach 3 (which receives much of its flow from the Blythe). The channel of the Tame in this area is less restricted by the presence of urban development and so has been able to re-find some of its natural character.

4.2.16 Photographed locations from Reach 2 are shown in Figure 4-8.

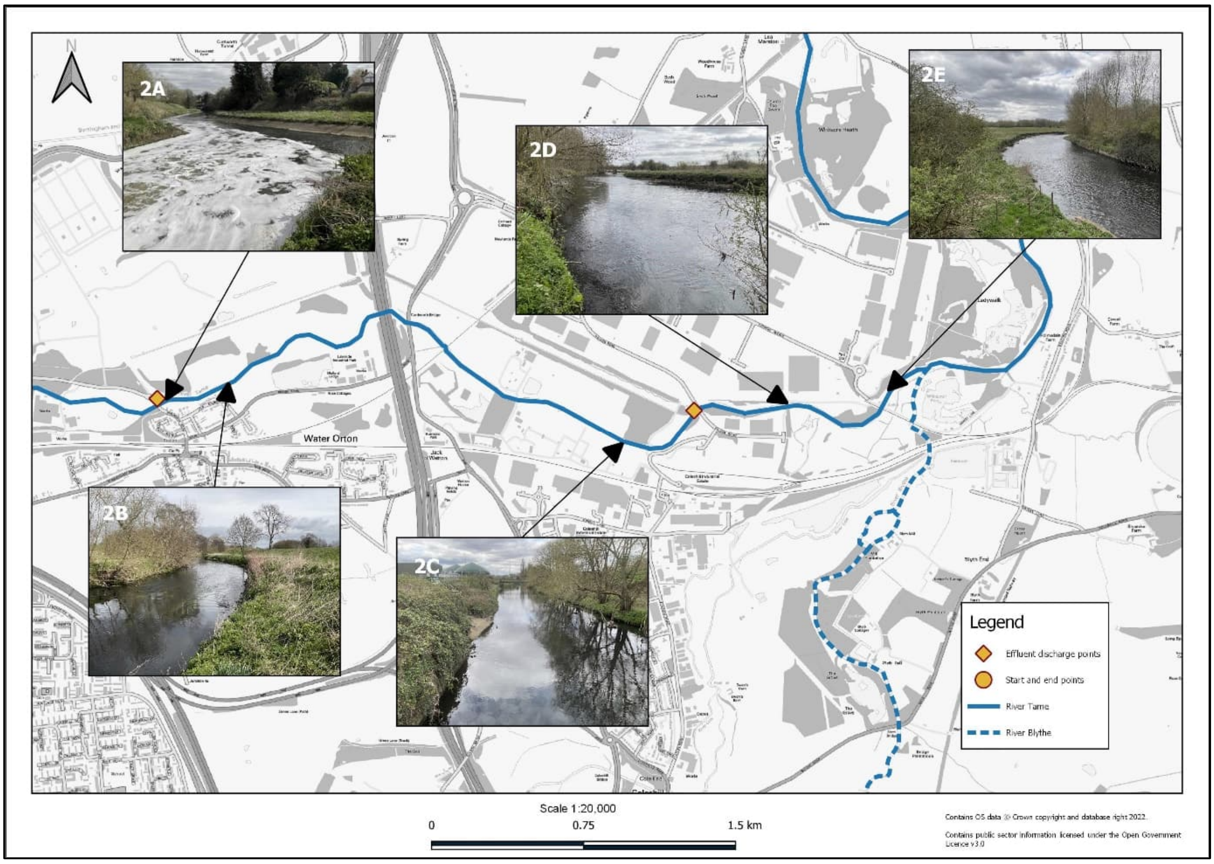

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Figure 4-8 Photographed locations from Reach 2

4.2.17 The upstream Minworth discharge is shown in Figure 4-9. This shows that treated effluent still delivers sediment into the River Tame, which is likely to include a high proportion of organics. Organic and biological substances have an important role in fine sediment flocculation. It is likely that the effluent also contains flocculants added as part of the wastewater treatment process, to increase sediment settling rates for the purposes of separating sediment from water. Sedimentation in the River Tame is therefore likely to be enhanced in the reaches downstream of the discharge, especially where the floodplains are disconnected by embankments, which would concentrate sediment in the channel, rather than allowing it to settle to floodplains. This will have a detrimental impact on local bed habitats, due to increased delivery of physical and bio-chemical pollutants into the channel bed.

4.2.18 Just downstream of the effluent discharge into the Tame (Figure 4-9), erosion is increased relative to deposition due to the increase in water level and depth. The protection on the right bank means there is unlikely to be much bank erosion. The left bank is unprotected, but the direction of the input means much of the flow’s force is directed and so erosion will be minimal when compared to the rate of sediment transport. Furthermore, the high level of flow will make the reach efficient at transporting sediment and so much of the gravels found upstream of here will be transported downstream. The lack of erosion or deposition at this location mean this section is classified as balance transport.

Figure 4-9 Photo 2A: Minworth Road (looking downstream, [redacted]. The added water prevents deposition, note the bank protection on the right bank that will prevent erosion.

4.2.19 Downstream of the effluent discharge location (Figure 4-10) the water level is noticeably higher despite no narrowing in the channel's width, reflecting the channel's increased volume as a result of the effluent discharge from Minworth STW. Gravels from upstream will have been transported to this reach with the slightly rippled and uneven surface of the river in the centre of the picture indicating the presence of gravels on the channel bed, which was just visible with the naked eye. Some of these gravels have been deposited on the margin of the channel (most visibly the right bank), and the unprotected nature of the banks mean there will also be a degree of erosion. These two processes appear to be in equilibrium with each other. Generally, however, the channel boundaries appear extremely stable and artificial, making this reach one of balance transport.

4.2.20 Generally, it is reasonable to assume that reduced flows would be detrimental for river geomorphology and ecology, but the SRO reduction of artificially elevated flows in this area may have some benefit. Riffles in this area are poorly formed due to depleted coarse sediment, so flow dynamics and bed form habitats may become more pronounced by reduced baseflow.

4.2.21 The presence of flood embankments means there would be little change in marginal, riparian and floodplain inundation. The effect of the SRO would be a percentage reduction in baseflow, which would have little to no significant impact on peak flows and inundation frequency.

Grid references for
continued monitoring
locations redacted

Figure 4-10 Photo 2B: Water Orton (looking downstream, [redacted].

4.2.22 Further downstream near Coleshill Parkway train station, the Tame has lost some of its natural character with the presence of hard engineering along the right bank of the river, which will prevent any erosion from this side. Erosion of fine sediment however will occur to some degree on the left bank, though generally the bank appears artificially straight and adjusted. Likewise, small amounts of deposition occur as the depth decreases towards the bank. On the downstream side of the bridge from which this photo was taken, the central abutment has caused the deposition and exposure of coarse gravels and so the channel within Reach 2 clearly has a significant transport capacity. The stable nature of the channel boundaries here suggests this reach is one of balance transport.

Figure 4-11 Photo 2C: Coleshill Parkway (looking upstream, [redacted]). Note the artificial right bank.

4.2.23 This site (Figure 4-12) is downstream of the second discharge location and so a large amount of its flow is made up of discharged effluent. Both banks show some signs of erosion, and there appears to be some deposited material on the far-right bank. In the foreground the channel bed can be made out along the left bank, which consists of gravels and so fine sediment is likely transported downstream efficiently. As both erosional and depositional processes are present, this section is classed as balance exchange. Although relatively stable, the banks are deemed to be free enough to adjust so as not to justify a classification of balance transport, which is generally reserved for reaches exhibiting clear signs of modification.

4.2.24 Potentially, SRO-reduced baseflows would increase sedimentation risks here by virtue of diminished fine sediment transport capacity. This could be detrimental to gravel habitats.

Grid references for continued monitoring locations redacted

Figure 4-12 Photo 2D: looking downstream, [redacted]

4.2.25 The right bank shows the clearest sign of erosion yet seen in the Tame with clear undercutting of the bank along the outside bend of the meander. The tightness of this meander, as well as what appears to be a slight narrowing of the channel compared to upstream, have combined to force much of the flow against this bank, hence the erosion. This is in contrast to the left bank, which is reinforced by concrete in parts and so will produce little eroded material. There are no clear signs of significant deposition in this section, though there presumably is some around the inside bend of the meander, and so erosion is likely the dominant process, making this section one of erosional exchange.

4.2.26 This erosion is important natural process. It is unlikely to be controlled by baseflow, and bank retreat would more likely be episodic and associated with peak flows. The floodplain is also well connected in this area, which would be a natural buffer to channel change by absorbing peak flow energy. The SRO is unlikely have a significant effect on erosion or floodplain connectivity.

Figure 4-13 Photo 2E: Fishery Lane (looking upstream, [redacted]).

Blythe to Kingsbury

4.2.27 Reach 3 runs from the Tame's confluence with the Blythe as far as the end of the study area, which is found at [redacted] to the west of Kingsbury. This section includes the SSSI Whitacre Heath, Kingsbury Water Park Community Wetlands, and Lea Marston lakes, and so is of much greater ecological value than the preceding two reaches. The channel here is much less constrained and has not been artificially modified since at least 1889 (see Figure 3-7) and so there is potential for a much geomorphologically active channel.

4.2.28 Photographed locations from Reach 3 are shown in Figure 4-14 and Figure 4-15. Figure 4-15 does not show the river line of the Tame because this section is not within the sedimentation study area.

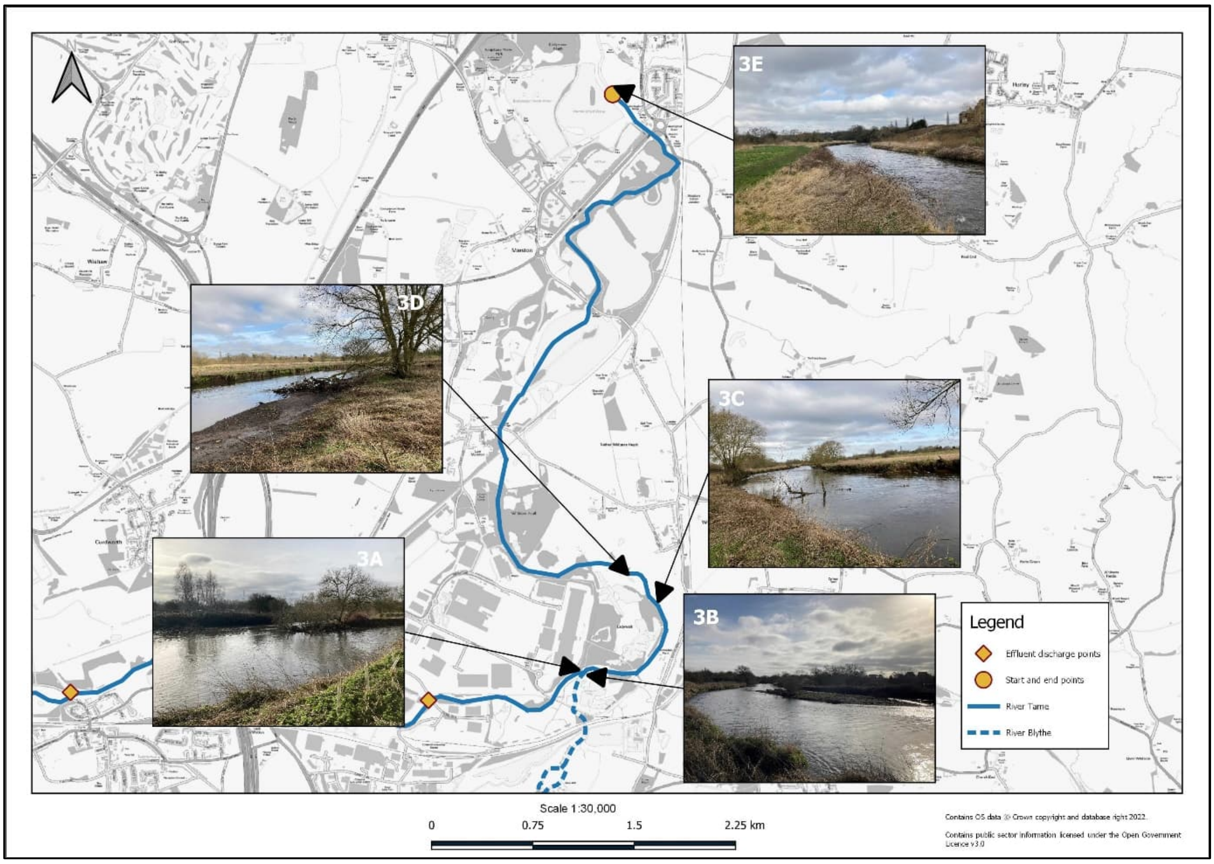

Figure 4-14 Photographed locations from Reach 3 (1)

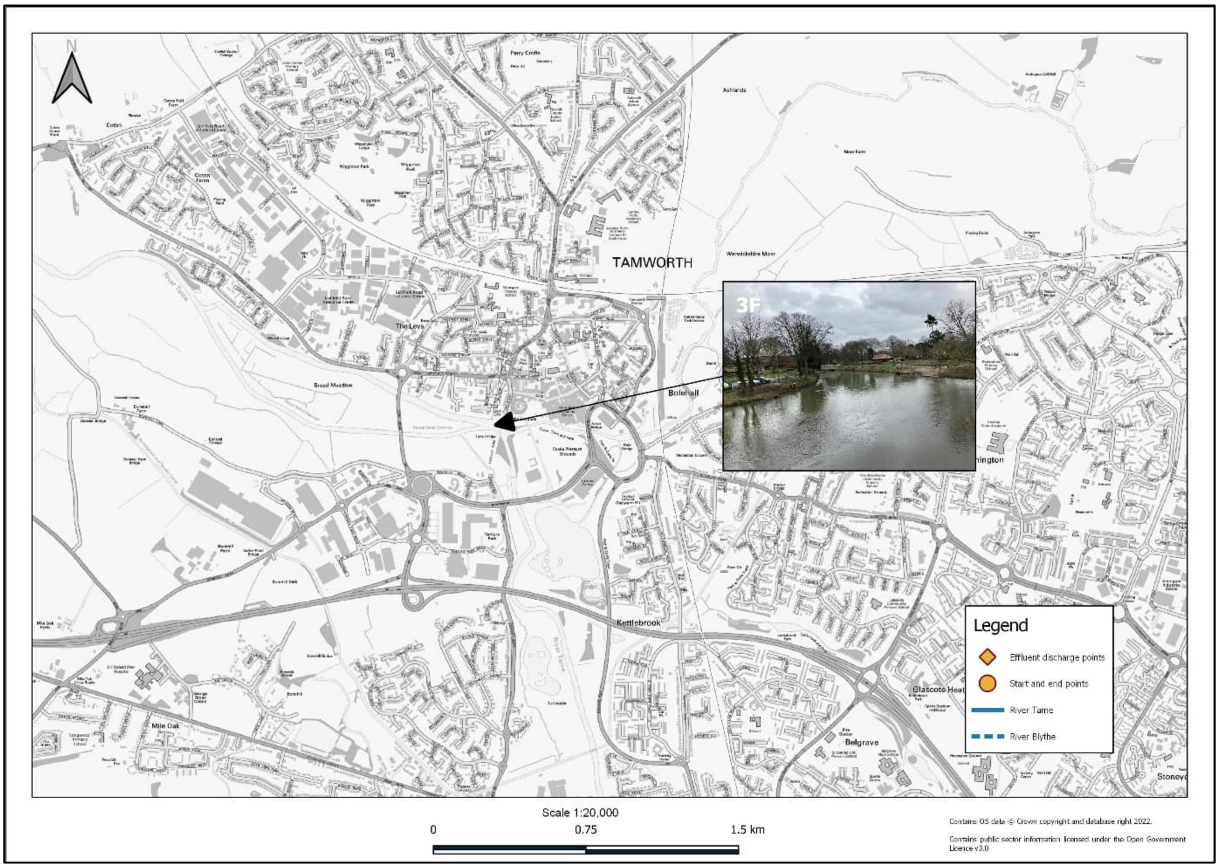

Figure 4-15 Photographed locations from Reach 3 (2)

4.2.29 Photos 3A (Figure 4-16) and 3B (Figure 4-17) are taken at almost the same location as one another, with the former looking upstream and the latter downstream. Both banks of the Tame are unmodified by any hard engineering and no longer possess the unnatural profile seen in places within Reach 1 and Reach 2. This natural state of the banks will allow for a degree of erosion on both sides of the channel. As seen by the formation of the gravel bar in 3B, both the Blythe and the Tame are carrying coarse sediment from upstream into the confluence, which is deposited after the two rivers converge. As there is no sign of extensive erosion along the banks at this location, deposition is the dominant process here, and so this local section is classed as depositional exchange.

Figure 4-16 Photo 3A: Blythe confluence (looking upstream, [redacted])

Figure 4-17 Photo 3B: Blythe confluence (looking downstream [redacted])

4.2.30 As expected, this section (Figure 4-18) appears more balanced than the one seen upstream at the Blythe confluence. The banks still possess a natural character, with the variability and indentations indicating the presence of erosion along the banks. There is no clear evidence of deposition, but it should be noted that this site could only be visited at high flow, and so any gravel features along the channel margins may well be submerged or entrained under these flow conditions. This section is classified as balance exchange.

Figure 4-18 Photo 3C: Ladywalk (looking downstream, [redacted]

4.2.31 There is significant deposition visible in Figure 4-19, which shows a predominantly fine sediment berm / bar along the inside bend of the meander. This is excess fine sediment, and naturally this feature would be a gravel bar (it is likely that gravel exists at this location but is buried by fine sediment). The right bank is eroded in places, suggesting that this section is in balance exchange. The right bank is naturally vertical, unlike several areas of reprofiled channel.

Figure 4-19 Photo 3D: Ladywalk (looking upstream, [redacted])

4.2.32 At this location (Figure 4-20) there appears to be relatively little in terms of erosional or depositional processes compared to the sites further upstream in this reach with the banks appear stable and well established, and no indication of deposition along the channel margins. However, as noted previously, this section of the Tame was surveyed after heavy rainfall and so flows are likely submerging many gravel bed features that are thought to usually be present. Based on this, this section is classed as balance exchange.

Figure 4-20 Photo 3E: Kingsbury (looking downstream, [redacted])

4.2.33 Photo 3F (Figure 4-21) shows the Tame's confluence with the River Anker. The Anker is the channel flowing from the left-hand side of the image, with the Tame coming across from the right. The Anker has a notable green colour compared to the darker waters of the Tame. Banks are composed of erodible sediment, and the presence of the branch in the middle of the image indicates that the channel is not overly deep at the confluence, so deposited gravels are likely visible at lower flows at the point where the two rivers merge due to the slack water they create. This section is classed as balance exchange. Bed features may be exposed by SRO baseflow reductions, which would provide improved habitat diversity.

Figure 4-21 Photo 3F: Tamworth (looking upstream, [redacted].

Summary

4.2.34 The Tame shows a clear transition from an urban, heavily modified channel that is dominated by balance transport reaches to a much less confined and more natural channel. This progression is well illustrated by the photographs shown in Figure 4-2, Figure 4-8, Figure 4-14, and Figure 4-15, and by Figure 4-22, below, which maps the ST:REAM classification given to each section.

4.2.35 Upstream of the Blythe confluence in Reach 1 and Reach 2, the Tame is dominated by balance transport reaches, generally on account of either engineered or heavily modified banks, the stability of which hinder geomorphological process. Further to this, the presence of weirs and the highly urbanised floodplain likely restrict both the downstream transport and introduction of coarse material. It is not until the Tame leaves the city of Birmingham between Photo 1D and 1E that bank structure becomes less modified, allowing the introduction of coarser sediment and a classification that balance exchange as opposed to balance transport sections can consistently be found.

4.2.36 In reach 3, downstream of the Blythe confluence, the Tame has good geomorphological value, such as the large gravel bar at the confluence itself, although morphology is significantly constrained by modifications at catchment scale. This is abetted by the more rural landscape through which the Tame flows, as well as protection and enhancement efforts conducted by the EA in this area.

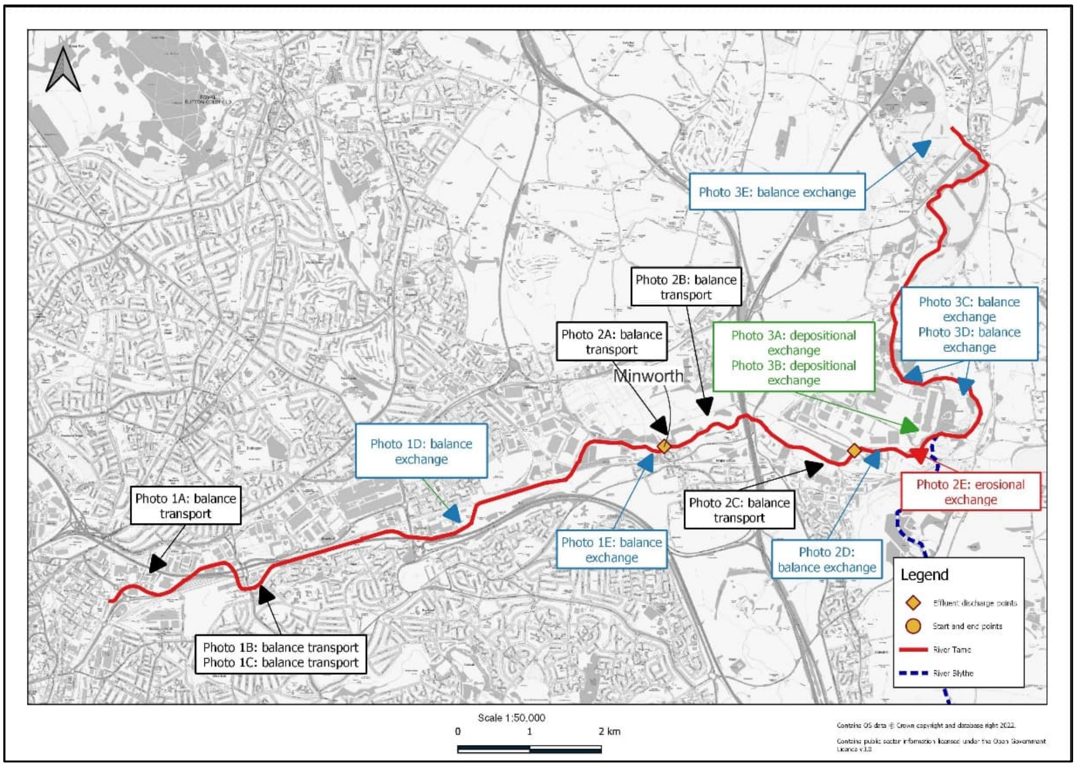

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Figure 4-22 ST:REAM classifications of sections of the Tame. Photo 3F, taken in Tamworth, is not shown, due to its distance from the other sites, and is classed as balance exchange.

4.3 River Trent

4.3.1 Unlike the Tame, which was split into three easily defined sections, the Trent is treated as one reach to reflect its general uniformity and unchanging character. The River Trent is a large, passively meandering floodplain river, and as such habitat conditions generally do not change locally. Historic mapping (Figure 3-10) shows that the Trent's channel has not changed for over a century, and this appears to be due to extensive river training and bank reinforcement.

4.3.2 Photographed locations from the Trent are shown in Figure 4-23.

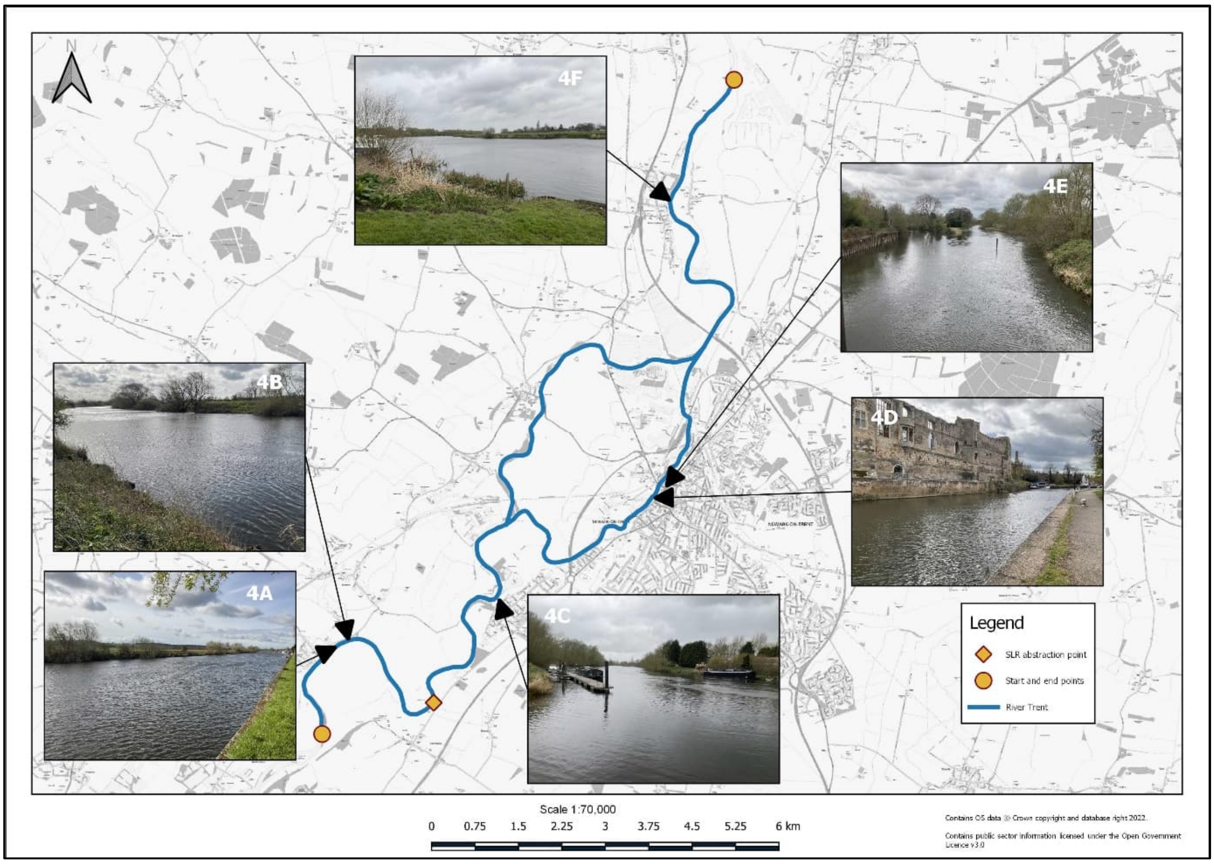

Figure 4-23 Photographed locations from the Trent

4.3.3 Running through Fiskerton (Figure 4-24 and Figure 4-25) the left bank of the River Trent is heavily modified with concrete banks as scour control. Some sediment entrapment is evident around large items of rubbish that is scattered along the bottom edge of the modified bank where the water depth is much lower than across the rest of the channel width. Apart from this there is no visible in-channel sediment deposition along the edge of the left bank, and no berm or bar features are evident through the study area. This is likely to be due to a combination of a naturally deep channel, and flow depths being augmented by navigation structures which artificially raise water levels to weir crest levels.

4.3.4 The right bank of this section has been reinforced with stone, which would control against ongoing channel migration, and would prevent local sediment inputs. There is sporadic and discontinuous bank-top and riparian vegetation, which gives some localised habitat diversity, but this is very minor compared to the scale of the river. Due to the presence of two heavily modified banks and small signs of deposition material this section is classified as balance exchange.

Figure 4-24 Photo 4A: Fiskerton (looking upstream, [redacted])

Figure 4-25 Photo 4B: downstream of Fiskerton (looking downstream, [redacted]).

4.3.5 At Farndon, banks are reinforced to above baseflow level (Figure 4-26). Vegetation is more continuous than upstream, but this appears to be for purposes of root-binding reinforcement of the upper bank profile, rather than natural habitat diversity banks. This is typical of most of the study area, where the River Trent is balance exchange.

Figure 4-26 Photo 4C: Farndon (looking upstream, [redacted].

4.3.6 Running through the centre of Newark (Figure 4-27 and Figure 4-28), the Tame is heavily confined to its channel through the presence of high, vertical, concrete banks that are resistant to erosion. Bed forms are entirely submerged due to water levels being raised by navigation weirs.

4.3.7 Approximately 100 metres upstream, the two forks of the Trent, that had split around 400 metres, re-converge. The right (eastern) fork flows through the centre of Newark and is of similar character to Photo 4D (Figure 4-27). However, the left fork (Photo 4E, Figure 4-28) is of a much more natural character, with hard, concrete banks being absent in favour much more natural, gentler, and vegetated banks, which will supply an amount of erodible material and allow natural processes to occur. This will enable some bank dynamics, but overall, the reach is categorised as balance exchange.

Figure 4-27 Photo 4D: Newark-on-Trent (looking downstream, [redacted]

Figure 4-28 Photo 4E: Newark-on-Tent (looking downstream,[redacted])

4.3.8 Further downstream the River Trent flows through North Muskham (Figure 4-29) where banks appear to have been reprofiled to 45° angles for stability, as opposed to being naturally vertical. No hard protection is visible but is almost certainly present. Some poaching is also present along small bank sections and acts an additional sediment source, however, because neither erosional nor depositional processes appear dominant this section is classified as balance exchange.

Figure 4-29 Photo 4F: North Muskham (looking downstream, [redacted]

Summary

4.3.9 As with the Tame, artificial channel reinforcements and flood embankments render the River Trent virtually devoid of natural geomorphological processes throughout the study area. The channel is naturally low lying and low energy, with a deep, sluggish, and passively meandering channel, but river training in the form of bank reinforcements appear to be almost continuous. Water levels are artificially raised by navigation weirs, which submerge any diversity of bed forms. As such the study reach is balance transport at the majority of the locations described above, as illustrated in Figure 4-30. The exception to this, Photo 4E (Figure 4-28), is a smaller branch of the Trent that flows through Newark, which has unprotected banks that should allow a degree of erosion.

4.3.10 In terms of the SRO, flow and sediment patterns are predominantly controlled by navigation weirs. The weirs will impound sediment, but the lower River Trent is naturally low lying with a high sediment load being delivered to this area from a large catchment. A small reduction in baseflow, when flow levels will continue to be impounded to weir crest levels, is unlikely to have a significant effect on sedimentation.

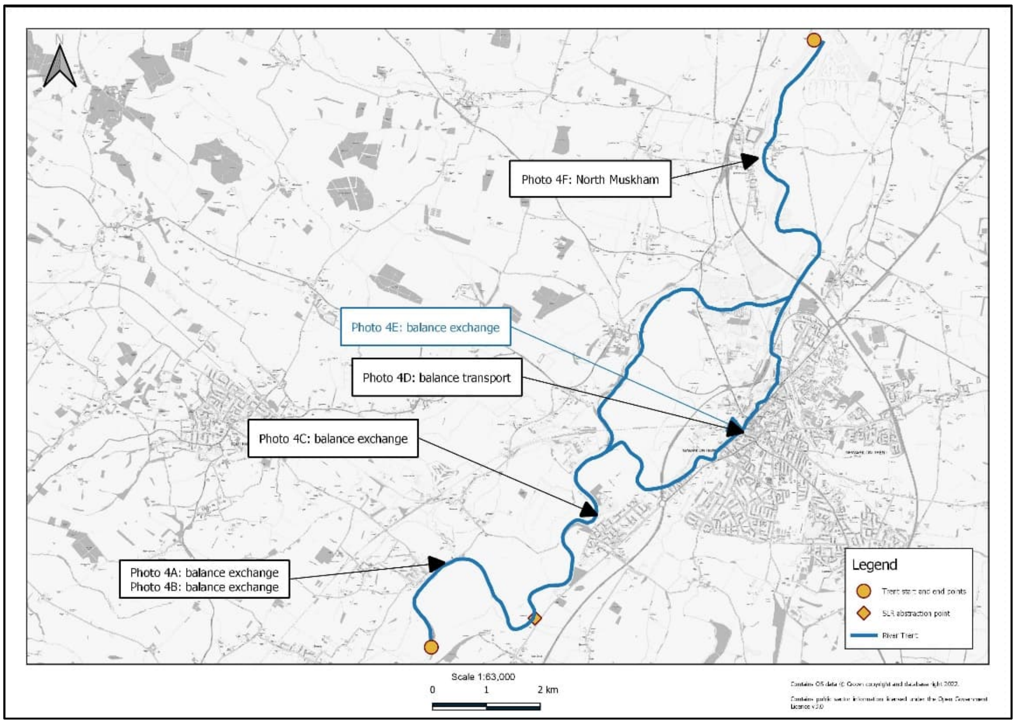

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Figure 4-30 ST:REAM classifications of sections of the River Trent.

5. Assessment of Sedimentation from Hydraulic Modelling Outputs

5.1.1 Hydraulic modelling is being undertaken to investigate the scale of impact of the SROs on current flow rates and depths. At this stage, model results are preliminary, and as such detailed analysis of implications for sedimentation has not been undertaken. Indicative results have been used to make judgements of sedimentation impacts, but these initial appraisals will need be verified when full modelling results are available.

5.1.2 It is intended that sediment transport formulae are applied to the SRO hydraulic model results to provide quantitative analysis of sedimentation effects.

5.1.3 At this stage, initial results have been reviewed for flow depths and velocities, in order to provide commentary on sedimentation risks.

5.2 River Tame

5.2.1 Partly calibrated hydraulic models have been simulated for the River Tame downstream of the second effluent discharge location to assess the potential reduction in water level under two scenarios:

- Scenario A: 115 Ml/d flow reduction at Minworth STW
- Scenario B: 230 Ml/d flow reduction at Minworth STW

5.2.2 These runs were used to calculate the water level and maximum depth percentage change at both Q50 and Q95.

Depth

5.2.3 Flow depth is an important control on boundary shear stress, which in turn exerts control on sediment transport capacity. Available depth results are mapped in Figure 5-1. The full results, showing absolute depth changes and percentage changes at each mapped location for the four models are shown in Table 5-1.

5.2.4 Unsurprisingly, Scenario B (230 Ml/d flow reduction) leads to a greater reduction in depth than Scenario A (115 Ml/d flow reduction), with an average reduction at Q_{95} and Q_{50} of 12.33% and 9.88%, respectively. Furthermore, depth reduction has a greater impact on Q_{95} flow than Q_{50} flow under both scenarios, though this disparity is less than the disparity based on which model scenario is used, as described above.

5.2.5 Overall, the model results show small impacts on flow depths. The greatest percentage reductions are typically highest upstream of Lea Marston lakes. However, absolute values of depth reductions are very small, generally 0.15m or less. Depth changes of this magnitude are unlikely to have any significant impact on shear stress, sediment transport capacity, or sedimentation.

5.2.6 The Minworth discharge appears to artificially elevate baseflows above natural baseline. In this sense, the depth reduction may even support minor improvements in the hydromorphological character of the Tame by reinstating towards a natural baseflow. However, the depth reduction will clearly have some negative effects. Less flow will increase sediment concentrations, reduce sediment transport, and increase sedimentation, but it is anticipated that the effects may not be significant relative to other catchment pressures. Sediment modelling could be beneficial at Gate 3 using the results of detailed hydraulic modelling.

5.2.7 It is emphasised that the SRO impacts would be on baseflow. It is generally expected for most rivers that 95% of sediment transport takes place within 5% of time, i.e. during spate and flood events. Baseflow reductions are unlikely to significantly affect spate or flood events.

5.2.8 It is also emphasised that excess sediment in the river is due to channel and land use modifications at catchment scale over time, so small changes in baseflows are unlikely to have visible or measurable effects on sediment loads.

5.2.9 Floodplain inundation is a critical function in river sediment systems, so in principle, the greatest risk of the SROs is to reducing floodplain inundation frequency, which would reduce floodplain sediment sequestration, and increase channel sediment loads. Model results are not yet available for peak events or floodplain inundation, but a percentage change in baseflow is not anticipated to have a significant effect on flood peak frequency, depth or duration.

5.2.10 In summary, it is not expected that sedimentation risks would be impacted by the SRO options.

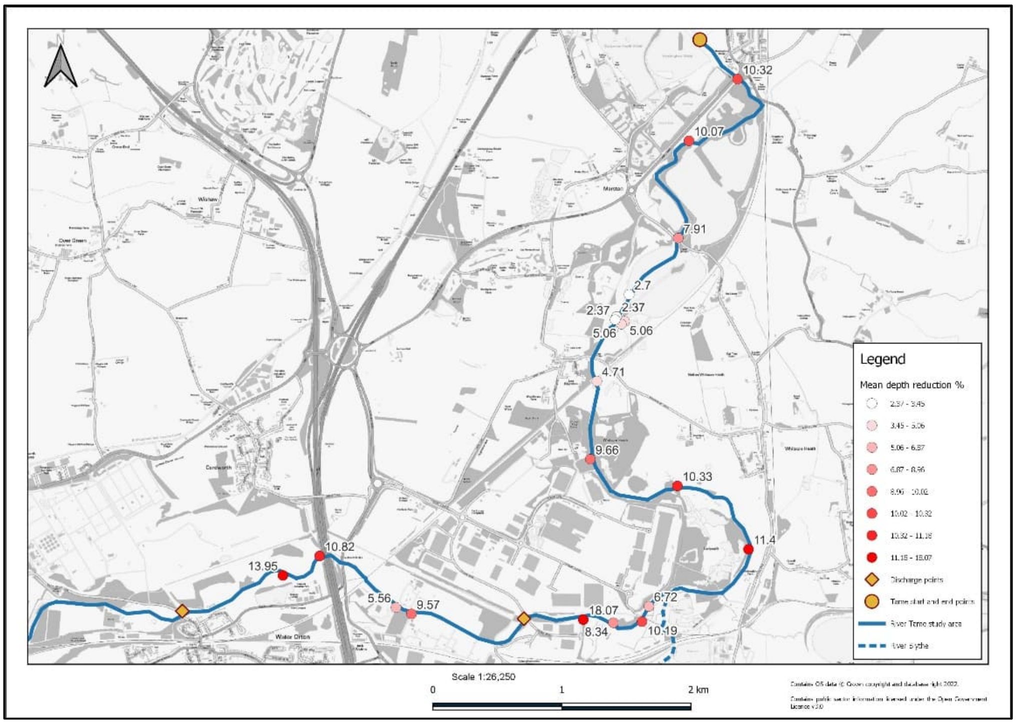

Figure 5-1 Average reduction in depth for the four models. Average calculated from the percentage reduction for Scenario A and B, at both Q50 and Q95.

Table 5-1 Modelled depth reductions in the River Tame. Absolute results are in m.

Cross section	Average depth reduction		Scenario A: Q_{95}		Scenario B: Q_{95}		Scenario A: Q_{50}		Scenario B: Q_{50}	
TM053545	0.051	5.06%	0.036	3.69%	0.074	7.59%	0.031	2.93%	0.064	6.04%
TM063876	0.109	8.34%	0.075	5.88%	0.155	12.16%	0.068	5.01%	0.140	10.31%
TM063654	0.101	10.19%	0.068	7.12%	0.144	15.08%	0.063	6.09%	0.129	12.46%
TM063585	0.097	6.72%	0.066	6.15%	0.141	5.00%	0.059	5.13%	0.122	10.61%
TM062490	0.110	11.40%	0.076	8.42%	0.162	17.94%	0.066	6.32%	0.135	12.93%
TM061662	0.127	10.33%	0.091	7.82%	0.191	16.42%	0.074	5.59%	0.152	11.49%
TM060792	0.106	9.66%	0.075	7.21%	0.157	15.10%	0.063	5.33%	0.130	11.00%
TM060201	0.079	4.71%	0.055	3.40%	0.110	6.80%	0.049	2.82%	0.101	5.81%
LM1B053545	0.051	5.06%	0.036	3.69%	0.074	7.59%	0.031	2.93%	0.064	6.04%
TM053520D	0.057	2.37%	0.040	1.68%	0.083	3.49%	0.035	1.42%	0.072	2.91%
TM053379	0.058	2.70%	0.040	1.92%	0.083	3.98%	0.035	1.60%	0.072	3.30%
LM1B053528D	0.057	2.37%	0.040	1.68%	0.083	3.49%	0.035	1.42%	0.072	2.91%
TM052747	0.083	7.91%	0.058	5.79%	0.126	12.59%	0.049	4.33%	0.101	8.93%
TM051750	0.114	10.07%	0.079	7.31%	0.198	18.33%	0.060	4.88%	0.120	9.76%
TM050791	0.114	10.32%	0.079	7.69%	0.167	16.26%	0.069	5.72%	0.140	11.61%

Cross section	Average depth reduction		Scenario A: Q_{95}		Scenario B: Q_{95}		Scenario A: Q_{50}		Scenario B: Q_{50}	
TM066838	0.115	13.95%	0.076	9.68%	0.161	20.51%	0.074	8.43%	0.151	17.20%
TM066506	0.117	10.82%	0.078	7.49%	0.162	15.56%	0.075	6.63%	0.154	13.60%
TM065758	0.069	5.56%	0.051	4.16%	0.096	7.84%	0.041	3.20%	0.090	7.03%
TM065619	0.110	9.57%	0.073	6.54%	0.165	14.78%	0.067	5.57%	0.137	11.40%
TM064210	0.121	18.07%	0.081	13.00%	0.162	26.00%	0.080	11.05%	0.161	22.24%
	Average		**0.064**	**6.02%**	**0.135**	**12.32%**	**0.056**	**4.82%**	**0.115**	**9.88%**

Velocity

5.2.11 The average modelled reductions in velocity, as a percentage, are shown in Figure 5-2. The full results, showing absolute results and percentage reductions at each mapped location for the four models are shown in Table 5-2. Overall, the model results show there to be small impacts on velocities, with virtually all results indicating that the SRO options would impose less than 0.1 m s^{-1} reduction. As with depth, Scenario B results in a velocity reduction approximately twice as large as Scenario A, which is unsurprising considering it consists of a reduced flow into the Tame of 230 Ml/d as opposed to the 115 Ml/d seen under Scenario A.

5.2.12 The Minworth discharge appears to artificially elevate baseflows above natural baseline, but other modifications as such as channel enlargements mean that baseflows are slower than would be expected in a natural channel of this size and typology. Reduced flows and flow velocities, even a reduction in artificially elevated baseflow, are likely to increase sedimentation to some extent, but it is anticipated that the effects would be minimal. Sediment modelling could be beneficial at Gate 3 using the results of detailed hydraulic modelling.

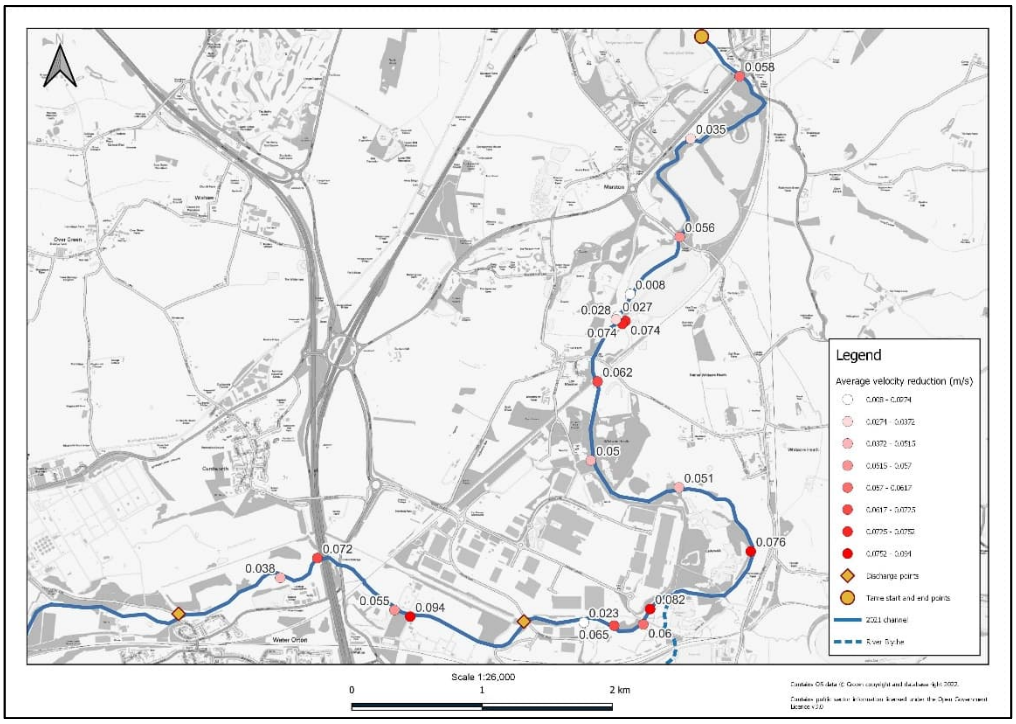

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Figure 5-2 Average reduction in velocity for the four models. Average calculated from the percentage reduction for Scenario A and B, at both Q_{50} and Q_{95}.

Table 5-2 Modelled velocity reductions in the Tame. Absolute values are in m s^{-1}.

Cross section	Average velocity reduction		Scenario A: Q_{95}		Scenario B: Q_{95}		Scenario A: Q_{50}		Scenario B: Q_{50}	
T053545	0.074	19.19%	0.052	15.29%	0.107	31.47%	0.045	9.78%	0.093	20.22%
TM063876	0.065	15.13%	0.044	10.78%	0.095	23.28%	0.039	8.46%	0.083	18.00%
TM063654	0.060	8.06%	0.041	5.66%	0.085	11.72%	0.037	4.78%	0.078	10.08%
TM063585	0.082	14.85%	0.056	10.67%	0.118	22.48%	0.050	8.47%	0.105	17.80%
TM062490	0.076	10.21%	0.055	7.79%	0.119	16.86%	0.040	4.99%	0.090	11.22%
TM061662	0.051	9.18%	0.037	7.01%	0.080	15.15%	0.028	4.75%	0.058	9.83%
TM060792	0.050	9.43%	0.036	7.17%	0.076	15.14%	0.028	5.02%	0.058	10.39%
TM060201	0.062	16.85%	0.044	13.02%	0.094	27.81%	0.035	8.54%	0.074	18.05%
LM1B053545	0.074	19.12%	0.051	15.00%	0.107	31.47%	0.045	9.78%	0.093	20.22%
TM053520D	0.027	20.78%	0.018	16.36%	0.037	33.64%	0.017	11.04%	0.034	22.08%
TM053379	0.008	18.92%	0.006	15.79%	0.012	31.58%	0.004	7.55%	0.011	20.75%
LM1B053528D	0.028	21.06%	0.019	16.81%	0.039	34.51%	0.017	10.76%	0.035	22.15%
TM052747	0.056	16.81%	0.040	13.47%	0.082	27.61%	0.033	8.55%	0.068	17.62%
TM051750	0.035	11.59%	0.025	9.26%	0.045	16.67%	0.022	6.61%	0.046	13.81%
TM050791	0.058	12.22%	0.043	9.79%	0.091	20.73%	0.031	5.87%	0.066	12.50%
TM066838	0.038	4.97%	0.028	3.73%	0.057	7.59%	0.021	2.68%	0.046	5.87%
TM066506	0.072	8.94%	0.051	6.51%	0.119	15.20%	0.035	4.17%	0.083	9.88%
TM065758	0.055	4.95%	0.022	2.03%	0.084	7.73%	0.043	3.78%	0.071	6.24%
TM065619	0.094	14.75%	0.065	10.76%	0.133	22.02%	0.057	8.39%	0.121	17.82%
TM064210	0.023	3.45%	0.015	2.27%	0.041	6.21%	0.010	1.47%	0.026	3.83%
	Average		**0.037**	**9.60%**	**0.081**	**20.94%**	**0.032**	**6.77%**	**0.067**	**14.42%**

Summary

5.2.13 Generally, this decrease in depth and velocity is not expected to have a significant increase on the risk of sedimentation. At most, this manifests it as a reduction in depth of 0.198 m, and a maximum reduction in velocity of 0.133 m/s. This does not necessarily translate to a problematic reduction in sediment transport competence or an increase in sedimentation rates. It will clearly have some effect, since less flow will increase sediment concentrations and less sediment transport will increase sedimentation to some extent.

5.2.14 However, there will still be significant level of flow under all modelled scenarios, and the Minworth discharge actually appears to artificially elevate baseflows above natural baseline. In this sense, the depth reduction may even support minor improvements in the hydromorphological character of the Tame. It was noted during the site walkover that in some locations gravel bed features are only intermittently visible or submerged entirely at baseflow. As such, a reduction in depth could expose these features which would benefit bed habitat diversity.

5.2.15 The Minworth discharge is one modification to the hydromorphology of the River Tame of a broad range of far more extensive physical modifications across the entire catchment. Flow characteristics do not appear to be a primary control on sedimentation risks in the River Tame. Excess sediment delivery from catchment land uses, and over-deep channels with embanked and disconnected floodplains appear to be much more significant risk factors.

5.2.16 Investment in the SRO should therefore consider restoration measures to physical river changes in order to mitigate the effects of catchment water uses. Opportunities to enhance and restore sections of the Tame are provided in Chapter 5.

5.3 River Trent

5.3.1 Hydraulic modelling results are not yet available for the lower River Trent. The forthcoming modelling data will inform on-going assessment post-Gate 2.

6. Opportunities for Mitigation

6.1 River Tame

6.1.1 As set out in section 4, sedimentation risks are mainly caused by physical river modifications other than flow magnitude; mainly land use change, channel deepening and floodplain embankments. Severe impacts on the morphology, water quality and ecology of the River Tame are widely recognised, and the Environment Agency has invested considerably in mitigation and river restoration measures over several decades. The SRO may be an opportunity to support this programme of ongoing actions.

6.1.2 As such, this section proposes future mitigation measures with a focus on sedimentation issues. Historic restoration projects have been reviewed to show previous measures and highlight gaps in restoration efforts to date. Restoration projects and mitigation options are summarised in Figure 6-1, Figure 6-2, and Figure 6-3.

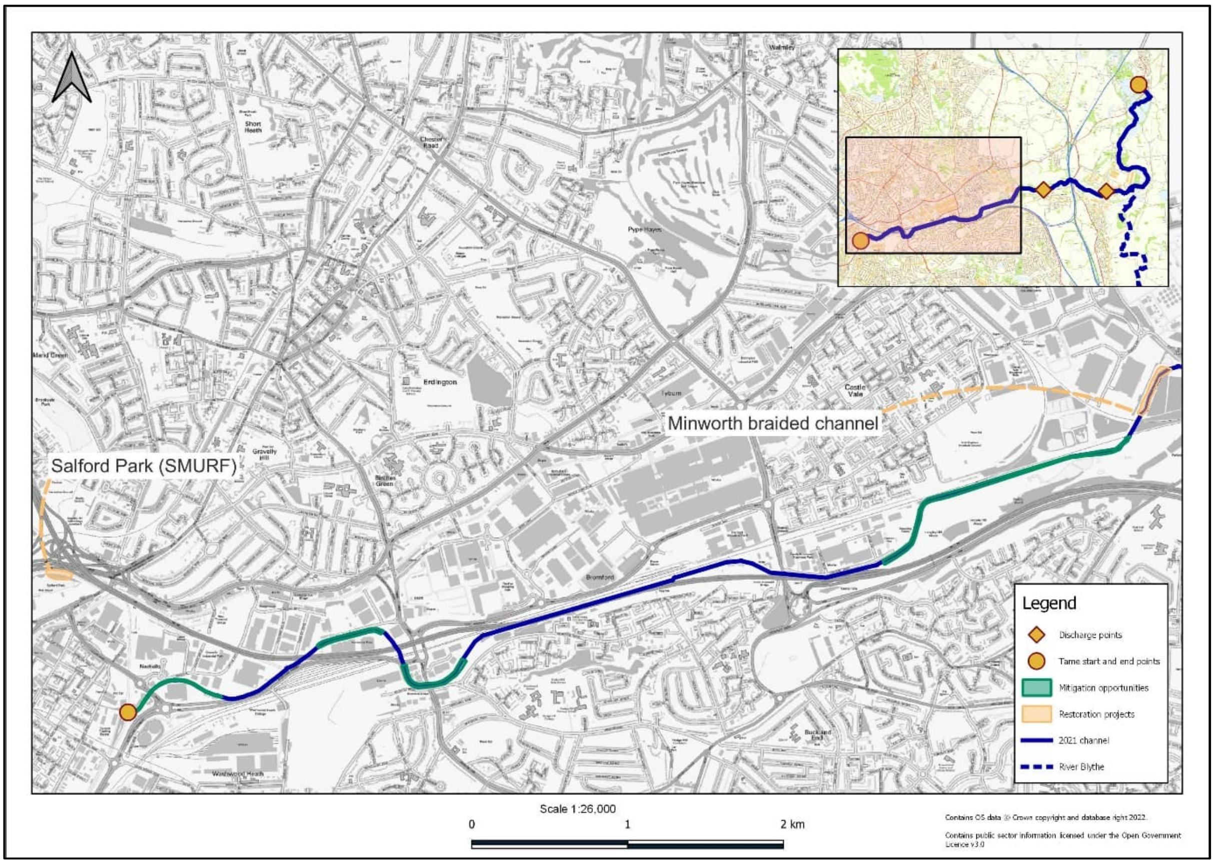

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Figure 6-1 Restoration projects and mitigation opportunities in the Tame study area (1)

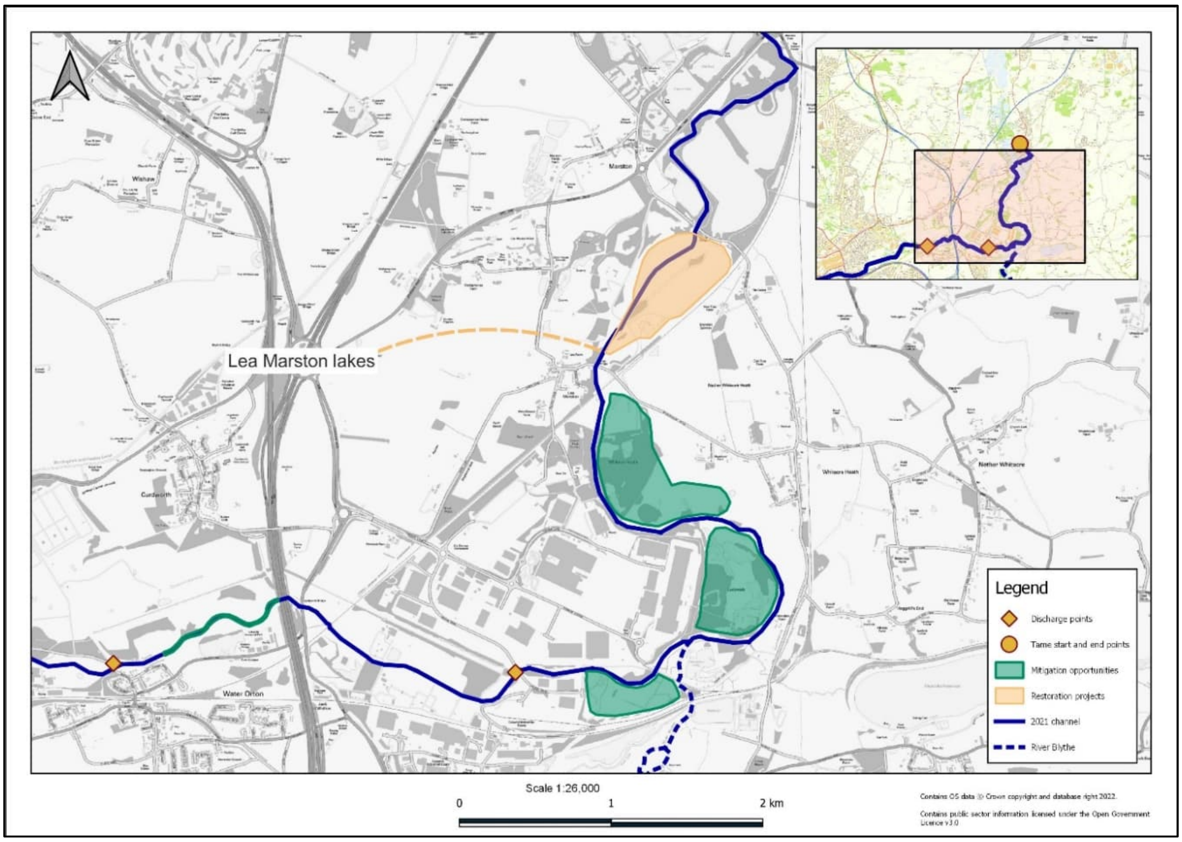

Figure 6-2 Restoration projects and mitigation opportunities in the Tame study area (2)

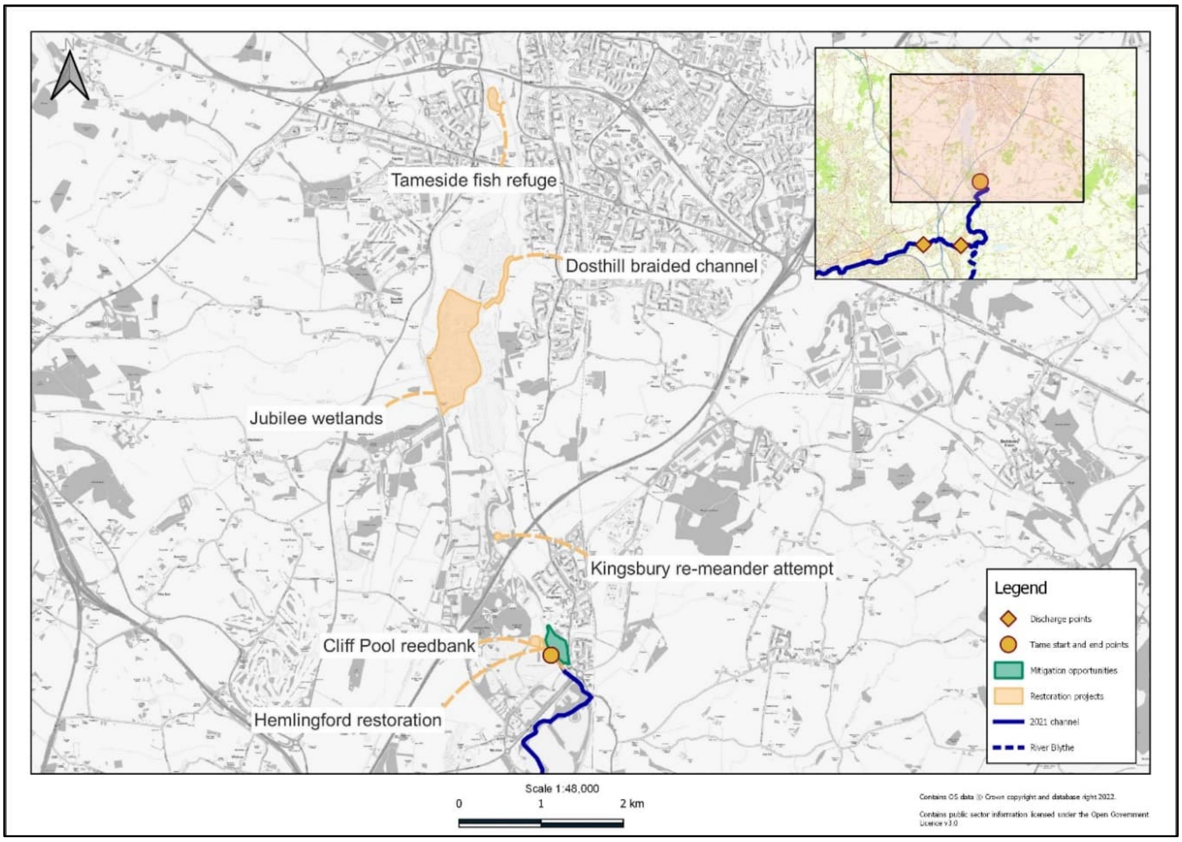

Figure 6-3 Restoration projects and mitigation opportunities in the Tame study area (3)

6.1.3 Restoration attempts to date have historically been focused downstream of the Blythe confluence, where the Tame is less confined by its surrounding land use, and there are fewer urban constraints.

From a geomorphology and sedimentation (as well as ecological) perspective, the Dosthill braided channel between SK 20555 00045 and SK 20971 00708 is a particularly good example of the potential of the Tame. Photographs of this feature can be seen between Figure 6-4 and Figure 6-8.

Figure 6-4 Dosthill Braided channel (1).

6.1.4 The gravel berm feature on the far bank and the relatively shallow far bank that should enable lateral connectivity and provides a sink for fine material to settle out of the channel.

Figure 6-5 Dosthill Braided Channel (2).

6.1.5 The woody vegetation overhanging the channel has helped create slower flowing sections of channel that may act as a refuge for some fish, and so help to create a wider range of habitat and flow type.

Figure 6-6 Dosthill Braided Channel (3).

6.1.6 Channel bed is composed of free gravels, indicating that flow is sufficient to entrain fine sediment that may otherwise have smothered the channel bed, and that the presence of vegetated berms has acted as a ‘magnet’ in attracting and removing fine sediment. The macrophyte has been identified as River Water-crowfoot *Ranunculus* sp., which is an excellent indicator of oxygen-rich and pollutant-free water.

Figure 6-7 Dosthill Braided Channel (4). Exposed gravels can be seen within the near fork.

Figure 6-8 Dosthill Braided Channel (5).

6.1.7 Formation of a sediment berm, with the early signs of succession. This will act as trap to fine sediment, removing it from the bed to expose clean gravel substrate.

6.1.8 As shown by the photographs, Dosthill Braided Channel is of significant geomorphological value. The braided channel means that flow and sediment patterns are diverse, which supports a broad range of physical habitats and biodiversity. In particular compared with upstream, the channels are not single thread and excessively deep, with islands and sediment exposures on the channel margins. This is likely representative of the pre-modified character of the River Tame. Lateral floodplain connectivity in this area is also much greater than upstream, which enables sediment deposition to floodplains outside of the river channel, as well as more natural floodplain habitats.

6.1.9 The Kingsbury re-meander at SP 20778 97331 is shown in Figure 6-9. This was a designed re-meander, although the inside bend of the meander has scoured away down to underlying clay, resulting in a highly widened section of channel. It is likely that the scour is the result of channel straightening and floodplain disconnection for several kilometres upstream, meaning that it is difficult to design against flow patterns that have evolved over several kilometres. The river has space to self-adjust in this area, which is important for sustainable naturalisation, and the resulting river form is highly valuable.

Figure 6-9 Kingsbury re-meander attempt

6.1.10 Although not visible in this photograph, which was taken at a relatively high flow, freely available aerial imagery from the past 10 years suggests that the central part of this channel (where woody debris can be seen resting on the bed) is often exposed as what appears to be a sediment berm, and so in lower flows it may form an effective sink of fine sediment from upstream (Ref. 1).

6.1.11 The examples above show the good potential of the River Tame, and key to successful restoration is consideration of the river (and any river) as a combined channel and floodplain, as influence by its upstream catchment. Making space for water is critical, and opening out river corridors, and setting back or removing embankments to reconnect floodplain wetlands should be considered wherever possible. Opportunity areas will need to consider flood safety and not increasing flood risks to any development and making space for water would make major contributions to natural flood management at catchment scale. They will also need to consider historic land use, and the potential for re-mobilising legacy contaminants, and large tracts of land throughout the Tame valley have historically been used as landfill.

6.1.12 Some of the main areas that could support mitigation opportunities are illustrated in Figure 6-1, Figure 6-2, and Figure 6-3. Development of mitigation measures will require optioneering and feasibility assessment, and a list of possible enhancement techniques is given in Section 6.3, along with an indication of which sections of the Tame they are most suitable for.

6.2 River Trent

6.2.1 As with the River Tame, historic restoration projects have been reviewed as well as areas which have potential for enhancement. Completed areas of restoration and consequent mitigation opportunities are presented in Figure 6-10 and Figure 6-11.

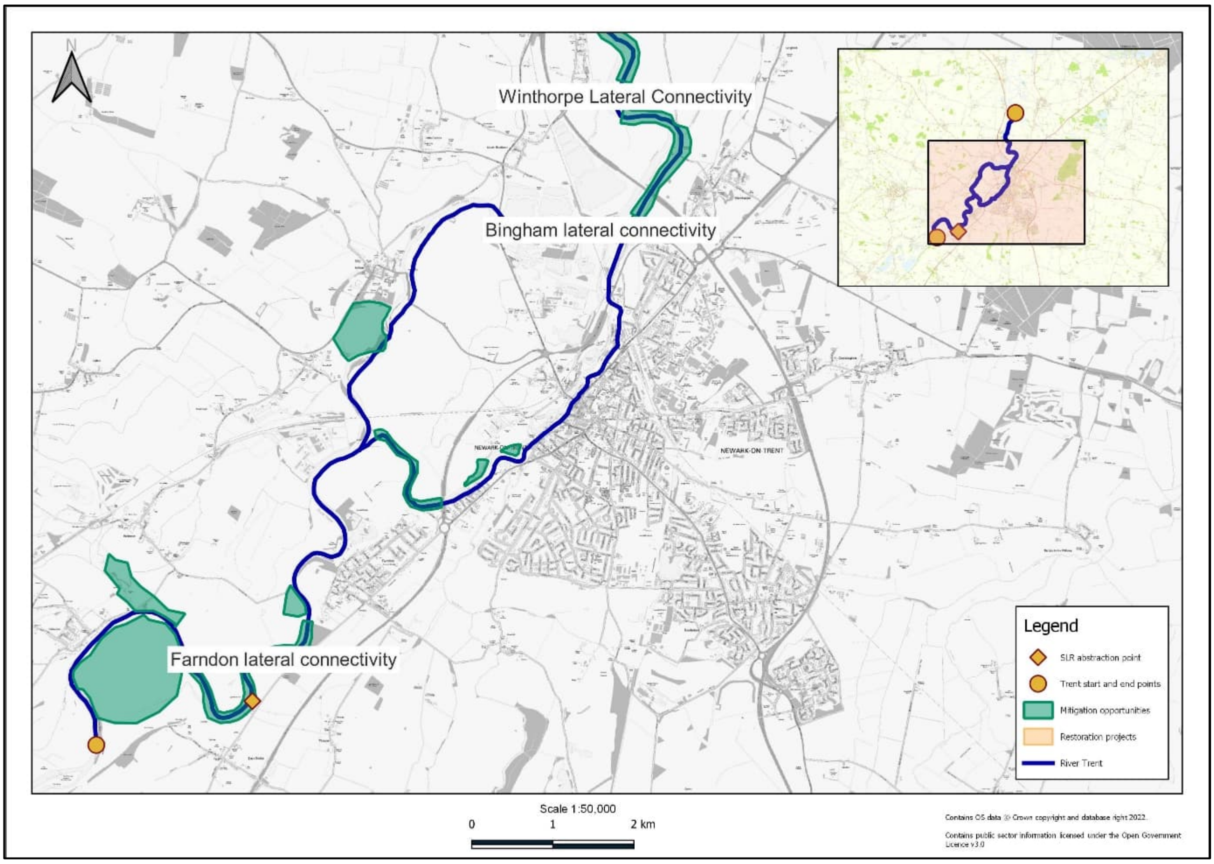

Figure 6-10 Completed and proposed areas of enhancement in relation to the Trent study area (1)

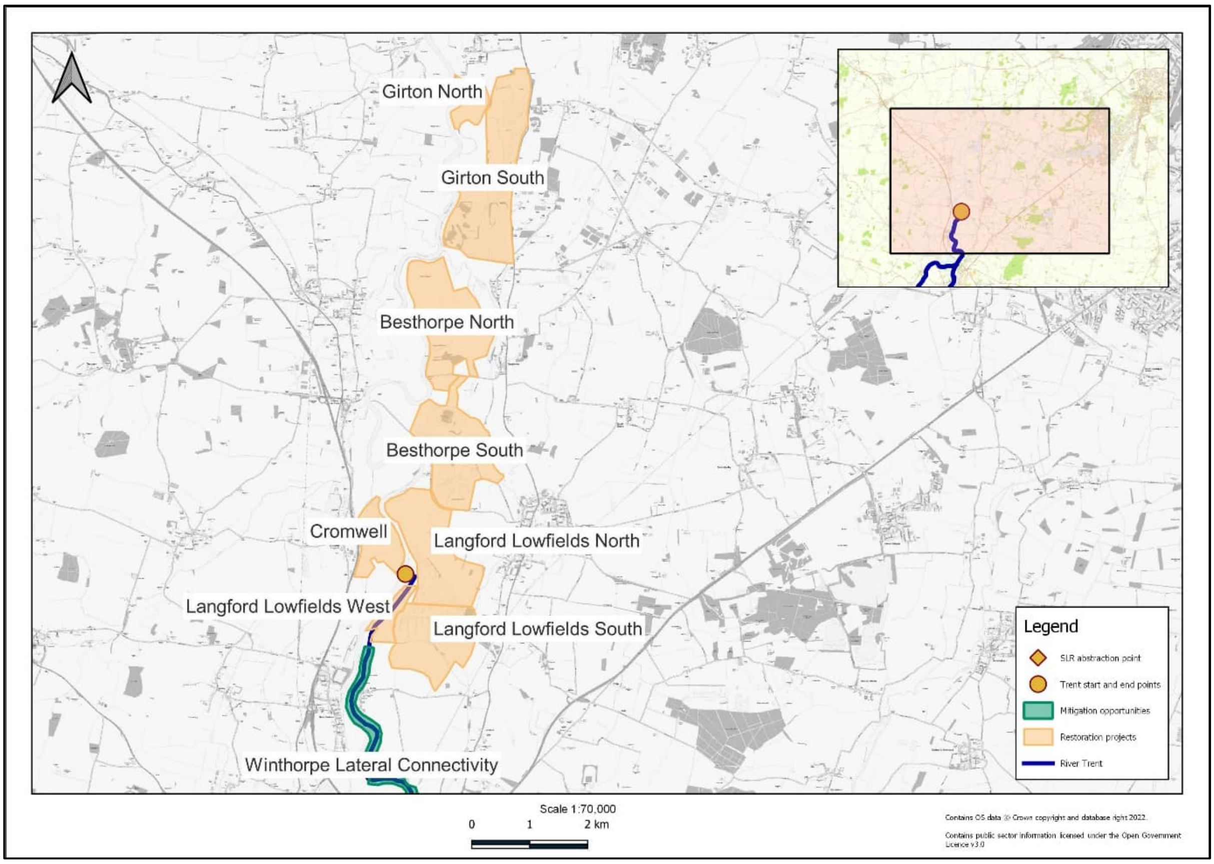

Figure 6-11 Completed and proposed areas of enhancement in relation to the Trent study area (2)

6.2.2 There have been relatively few restoration projects within the study area, with projects largely found downstream of Cromwell weir, though there are a couple of projects that have focused on later connectivity within the study area, notably at Winthorpe, Farndon, and Bingham.

6.2.3 As such there is a large amount of scope for mitigation opportunities, particularly in the rural areas of the study are where projects would be less constrained by urban development. Making space for water is critical, and opening out river corridors, and setting back or removing embankments to reconnect floodplain wetlands should be considered wherever possible. Agricultural land ownership and agreements for converting commercially valuable land use to ecosystem services is likely to have more of an effect on sedimentation in the River Trent than urbanisation, flood risk and legacy contaminants on the River Tame.

6.3 Enhancement techniques

6.3.1 This section summarises a selection of common restoration techniques that could potentially be applied in the Tame and Trent study areas (Ref. 15).

Barrier removal or modification:

6.3.2 Ideally in-channel structures such as weirs would be removed to allow restoration of natural ecological passage and morphological processes. The latter would enable rehabilitation of bed sediment transport and coarse sediment habitats, and removal of fine sediment impoundments. Within the River Tame, there is the potential for weir removal, notably around Lea Marston. However, as a navigable river, weir removal within the River Trent is not feasible and as such is not considered further. Fish passage recommendations are discussed in Appendix B(ii) Aquatic Ecology.

Restoring Meanders:

6.3.3 Restoring meanders to historically straightened and modified channels is an effective way of enhancing natural processes and variability of a channel. Straightened channels, especially in the Tame study area, are highly homogenous and devoid of natural character and process. Restoring meanders helps to improve this by creating greater diversity in flow conditions. For example, at inside bends water depth is shallower and slower which enables the production of natural gravel in-channel structures such as berms and bars. By contrast, the outside bend is deeper and is suitable habitat for adult fish.

6.3.4 Meander restoration would be particularly effective within the Tame, which is historically straightened, as seen in Figure 3-3 through to Figure 3-7 where sinuosity has been measured as being low (Table 3-11). The urbanised nature of these reaches renders this difficult, though there are numerous examples of successful inner city re-meandering projects, and so this technique need not be discounted.

6.3.5 Enhanced meandering sections of the Trent study area, for example by removing hard bank protection, would also be ambitious, yet not unfeasible. The large size of the Trent means more space would be needed for this, though sections of the Trent flow through rural areas and so this should not be a significant issue provided land can be obtained.

In-channel enhancement:

6.3.6 Within Reach 1 and Reach 2 of the Tame, where banks are trapezoidal and often constrained by hard engineering, in-channel enhancement may prove a more feasible option than re-meandering. In-channel enhancement may include a selection of the following:

- **Current deflectors:** artificial shoals projecting part-way across the channel, with wooden log or planks secured on top. This creates a degree of diversity and variability in flow patterns, which can kickstart the initiation of natural processes. If deflectors are placed on alternating banks, a degree of sinuosity is also produced.
- **Narrowing with aquatic ledges:** ledges are created parallel to flow direction alongside the banks of the river. This is particularly common when banks are artificially steep and silty margins, necessary for vegetation establishment, are not present. Wooden stakes are used to place coir matting alongside the channel banks, with pre-planted pallets placed on top. This essentially protects the young plants from the speed and force of the channel, allowing them to develop.
- **Narrowing using groynes:** groynes can 're-energise the channel by providing variations in flow characteristics and trapping sediment both upstream and downstream, which with time narrows the channel. Vegetation can then establish in these marginal areas, providing further protection from fine sediment and pollutant ingress.
- **Stone riffle:** riffles are short sections of channel characterised by a shallow and fast flowing over coarse-grained bed material and provide excellent conditions for fish spawning as the water is very well-oxygenated. Riffles are designed to work with the prevailing flow regime of the reach, in that a suitable sediment mix comprising of appropriately sized particles is implemented. Levels, placement, and size of features are normally informed by 2D hydraulic modelling.
- **Creating a sinuous low-flow channel in an over-widened channel:** low-flow width in wide channels can be constrained by placing boulders at the 'inside' of each meander bend, around which sediment will naturally form. To support this, material can be excavated from the opposite bank.
- **Creation of on-line bays:** an on-line bay creates a degree of shelter from high-velocity flows for small fish and invertebrates, as well as extra water storage capacity, and so are akin to backwaters. They are essentially a localised widening of the channel, not dissimilar to the Kingsbury re-meander attempt though generally on a smaller scale.
- **Raising riverbed levels:** in some instances, narrowing the riverbed may simply result in constricted and deep channels and so a more appropriate technique to improve the morphology

of over deep channels can be bed raising. This can be done by adding appropriate substrate into the channel, ideally in an asymmetric manner so that there is a narrow low-flow corridor.

- **Fixing whole trees into the riverbank for flow diversity:** this can be done to introduce diversity in flow conditions and morphology and works in a similar way to current deflectors and narrowing using groynes. Trees are typically fixed and pinned to the banks.
- **Felling and placing trees for habitat and flow diversity:** this technique differs from the above in that tree are not fixed into place, rather left free. The flow diversity created creates some sour and exposure of gravels in some places, as well as sediment entrapping in others.

Creation of backwaters and on-line bays:

6.3.7 On-line bays, backwaters are natural consequences of meandering, where relict channel forms are left partially connected by natural channel migration. Though still connected to the main channel, they are typically deep and still areas of water, acting as a refuge for invertebrates in high flow conditions and as excellent habitat for water birds. Backwaters have already been successfully established on the Tame (e.g., Tameside fish refuge) and are also appropriate along the length of the Trent.

Floodplain Enhancements:

6.3.8 Floodplain enhancement naturally requires areas of land free from human development and can be easily identified by consulting flood zone maps (Figure 3-7 and Figure 3-11). The areas depicted for mitigation within Figure 6-2 and Figure 6-11 are ideal for the following measures, which allow for increased water storage during high flow events, creating a diverse mosaic of valuable habitat types and settling out of fine sediments.

- **Floodplain scrapes:** A scrape is a shallow pond that sits within a floodplain, so that when the channel floods they hold and store water. As such, they are often dry during low flow conditions. They form excellent habitat conditions for plant and animal species alike.
- **Floodplain wetland mosaic:** a wetland mosaic consists of a selection of scrapes, reedbeds, wet grassland, scrub, ponds, ditches, and pools across an extensive area of floodplain and are traditionally of enormous ecological value and potential.
- **Set back flood embankments:** setting back flood embankments allows water to spill out of the channel at specified locations and so allows the activation of floodplain features such as scrapes. Furthermore, this allows an opportunity for fine sediments to settle out of the channel and so reduce sedimentation risk.

Sediment buffer strips:

6.3.9 By planting, establishing, and protecting riparian buffer zones alongside the channel, fine sediment delivery to the channel can be reduced as the vegetation would act as an effective sediment trap. Be keeping fine sediment out of the channel, any risk of gravel features being smothered and submerged would be lessened.

6.3.10 Buffer strips naturally require space alongside the channel in order to be effective, and so may be unfeasible in sections of the study area, notably within Nechells and Newark in the case of the Tame and the Trent, respectively. However, in more rural, open areas, such as Reach 2 in the Tame where there is only a small amount of vegetation in places, this could be a highly effective technique to mitigate sedimentation risk. In the case of the Trent, any section of the channel in proximity to agricultural land, which large sections are, would be well protected by buffer strips as fine sediment ingress is a key risk in places with this land use.

Sustainable Urban Drainage Systems:

6.3.11 Sustainable Urban Drainage Systems (SUDS) could be of particular use in Reach 1 of the Tame, where land-use is covered by urbanised areas. Surface water outfalls, of which there are many within the Tame study area can be amended so as to improve the quality of the discharge in terms of sediments and pollutants. One such design for example, underground outfall chambers, reduce sediment discharge is reduced by trapping it in a sump, and regularly removed using a suction unit. Reedbeds are also an example of SUDS. They act as form of riparian vegetation by entrapping sediments and preventing them from entering the watercourse.

7. Summary

7.1.1 The objectives for the sedimentation assessment, as set out by the Client, are as follows:

- *Assess where to expect impacts to geomorphology based on understanding of the SRO. Clearly low flows occur already, where Minworth discharges are still available to the system. Modelling of impacts of low flows on levels including the HoF at North Muskham is underway. We will incorporate the outputs of this modelling to inform an understanding of how geomorphology would be impacted.*
- *Carry out fluvial audits targeted to the SRO locations to define geomorphological baselines and allow assessments of the effects of the SRO.*

7.1.2 Consultation with the Environment Agency for the Gate 1 assessments for the whole of the Tame and Trent to the Humber identified that geomorphology and sedimentation baseline data for the study area were largely unavailable. Instead, indicative data were synthesised by AECOM, to map areas along the River Tame and River Trent channels that are likely to have relatively high risks of sedimentation and are likely to be sensitive to changes around Minworth and the SLR abstraction.

7.1.3 The Gate 2 sedimentation assessment for the Minworth and SLR SROs builds on Gate 1 scoping, to review targeted impact zones using fluvial audit desk-based surveys and field surveys where the river banks are safely accessible.

7.1.4 River geomorphological information has been obtained by direct correspondence with the EA, including through site walkovers guided by local EA catchment officers. Direct liaison with the EA through Gate 2 has also uncovered considerable historic river information that was not available at Gate 1, including records of historic river restoration schemes, especially through the River Tame, which have been implemented inclusive of sedimentation considerations as a key component of holistic ecological processes. Generally, however, geomorphology studies and especially sediment data are lacking for the River Tame and River Trent.

7.1.5 Sediment monitoring in particular is recommended, since this would provide a quantitative baseline from which the effects of the SROs could be measured, including the performance of mitigation measures.

River Tame Overview

7.1.6 The River Tame is highly urbanised across its upper catchment, and consequently highly modified throughout the study area, including extensive channel straightening, deepening and floodplain disconnection by embankments in more rural areas downstream of Birmingham. Not all River Tame waterbodies are designated Heavily Modified Water Bodies (HMWBs), but all are substantially non-natural, and all fail to meet Good WFD Status / Potential. This is due to intense historic catchment development, physical modifications, and urban (and to a lesser extent agricultural) pollution, across the entire catchment and through the river corridor.

7.1.7 Existing sedimentation risks are generally elevated throughout the river. This has been judged as due to excess sediment delivery from the catchment surface, and channel deepening and embankments that prevent sediment sequestering onto floodplains and concentrate sediment within channels.

7.1.8 The Minworth discharge and Coleshiil discharge deliver treated effluent including sediment into the River Tame, which is likely to include a high proportion of organics. Organic and biological substances have an important role in fine sediment flocculation. It is possible that the effluent also contains flocculants and/or coagulants added as part of the wastewater treatment process, to increase sediment settling rates for the purposes of separating sediment from water. Sedimentation in the River Tame is therefore likely to be enhanced in the reaches downstream of the discharge, especially where the floodplains are disconnected by embankments, which would concentrate sediment in the channel, rather than allowing it to settle to floodplains. This will have a detrimental impact on local bed habitats, due to increased delivery of physical and bio-chemical pollutants into the channel bed. Reducing the Minworth discharge should therefore have inherent benefits for sediment delivery and sedimentation.

River Trent Overview

7.1.9 The River Trent is generally more rural but is similarly affected by the land use changes across the majority of its catchment. Land use is mainly agricultural, which includes extensive flood embankments to enable farming of large fertile floodplains. The majority of the study area lies within the Trent from Soar to The Beck WFD water body, which is a HMWB due to navigation, urbanisation, and flood protection.

7.1.10 Sediment loads are natural high but are elevated due to anthropogenic activities throughout the catchment and tributaries (including the River Tame). The Trent in the study area is navigable, with a series of weirs artificially raising water levels, and these impoundments also increase sedimentation.

SRO Sedimentation Risk Assessment

7.1.11 Hydraulic modelling is being undertaken to investigate the scale of impact of the SROs on current flow rates and depths. At this stage, model results are preliminary, and as such detailed analysis of implications for sedimentation has not been undertaken.

7.1.12 Sediment transport modelling, based on hydraulic model outputs, is not feasible until hydraulic model results are finalised. Sediment transport modelling is highly complex, but high-level assessments would be informative and could be used to quantify the sedimentation effects of the SROs

7.1.13 It is intended that sediment transport formulae are applied to the SRO hydraulic model results to provide quantitative analysis of sedimentation effects. At this stage, initial results have been reviewed for flow depths and velocities, in order to provide commentary on sedimentation risks.

7.1.14 Modelling presently focusses on baseflow hydraulic properties, and does not include sediment transport, spate or flood events, or floodplain inundation events. Floodplain connectivity is a critical component of sediment systems, since floodplain inundation frequencies, extents and durations control rates of out-of-channel floodplain sedimentation.

7.1.15 Initial model results at the time of reporting are only available for the River Tame and upper River Trent. For the River Trent as a whole, flows are controlled by navigation weirs, so any reduction in flow is unlikely to have a significant effect on flow depths and rates, and associated sediment processes.

7.1.16 Flow reductions will clearly have some effect on sedimentation. Less flow will increase sediment concentrations, and reduced flows will have less sediment transport capacity, which will increase sedimentation rates. However, the effects are likely to be negligible in the context of other catchment scale river modifications.

7.1.17 Overall, the model results for the River Tame show small impacts on flow depths. The greatest percentage reductions are typically highest upstream of Lea Marston lakes. However, absolute values of depth reductions are very small, generally 0.15m or less. Depth changes of this magnitude are unlikely to have any significant impact on shear stress, sediment transport capacity, or sedimentation.

7.1.18 The maximum reduction in velocity modelled for the study area is 0.133 m/s. This is a small change and would not necessarily translate to a problematic reduction in sediment transport competence or an increase in sedimentation rates.

7.1.19 The SRO impacts would be on baseflow; however, it is generally expected for most rivers that 95% of sediment transport takes place within 5% of the time, i.e., during spate and flood events. Baseflow reductions are unlikely to significantly affect spate or flood events and are therefore unlikely to significantly affect sediment transport rates.

7.1.20 There will still be significant levels of flows under all modelled SRO scenarios, and the Minworth discharge actually appears to artificially elevate baseflows above natural baseline. In this sense, the depth reduction may even support minor improvements in the hydromorphological character of the Tame. It was noted during the site walkover that in some locations gravel bed features are only intermittently visible or submerged entirely at baseflow. As such, a reduction in depth could expose these features which would benefit bed habitat diversity.

7.1.21 It is important to recognise that excess sediment in the river is due to channel and land use modifications at catchment scale over time, so small changes in baseflows may not have visible or measurable effects on sediment loads.

7.1.22 The SRO effects will be one modification to the hydromorphology of the River Tame and the River Trent of a broad range of far more extensive physical modifications across the entire catchments. Flow characteristics do not appear to be a primary control on sedimentation risks in either river. Excess sediment delivery from catchment land uses, and over-deep channels with embanked and disconnected floodplains appear to be much more significant risk factors.

7.1.23 Floodplain inundation is a critical function in river sediment systems, so in principle, the greatest risk of the SROs is to reducing floodplain inundation frequency, which would reduce floodplain sediment sequestration, and increase channel sediment loads. Model results are not available for peak events or floodplain inundation, but a percentage change in baseflow is not anticipated to have a significant effect on flood peak frequency, depth, or duration.

7.1.24 In conclusion, it is not expected that sedimentation risks would be severely impacted by the SRO options. The SRO effects are likely to be minor, may not be statistically significant in terms of sedimentation, but will undoubtedly contribute to cumulative catchment impacts.

7.1.25 Investments in the SROs should therefore consider river restoration measures to physical river changes in order to mitigate the effects of catchment water uses.

7.1.26 In recognition of severe historic impacts on the morphology, water quality and ecology of the River Tame, and the Environment Agency has invested considerably in mitigation and river restoration measures over several decades. The SRO may be an opportunity to support this programme of ongoing actions, and the restoration efforts to date are valuable for informing future schemes on the River Tame and the River Trent.

7.1.27 For both rivers and SROs, mitigation in terms of making space for water is critical. Opening out river corridors and setting back or removing embankments to reconnect floodplain wetlands should be considered wherever possible.

7.1.28 Opportunity areas will need to consider flood safety and not increasing flood risks to any development and making space for water would make major contributions to natural flood management at catchment scale. Mitigation opportunities will also need to consider historic land uses, and the potential for re-mobilising legacy contaminants. Large tracts of land especially throughout the Tame valley have historically been used as landfill. Agricultural land ownership and agreements for converting commercially valuable land use to ecosystem services are also important considerations, and this may affect the River Trent more than the River Tame.

7.1.29 Development of effect mitigation measures will require feasibility study and optioneering in Gate 3, and are likely to include techniques such as:

- Barrier removal or modification
- Flood embankment removal or set-back
- Floodplain reconnection
- Margin and riparian enhancements
- In-channel enhancements
- Current deflectors
- Narrowing with aquatic ledges
- Narrowing using groynes
- Stone riffle
- Creation of tiered channels
- Creation of on-line bays
- Installation of large woody materials
- Felling and placing trees for habitat and flow diversity
- Bed raising
- Creation of backwaters
- Floodplain enhancements
- Floodplain scrapes
- Floodplain wetland mosaic
- Set back flood embankments
- Sediment buffer strips
- Sustainable Urban Drainage Systems

Sedimentation Risk Maps

7.1.30 Sedimentation Risk Maps, initially produced from morphological risk modelling in Gate 1, have been updated from field studies including consultation undertaken in Gate 2. The updated sedimentation risk maps are provided in Annex A.1.

8. Scoping Checklist – Recommendations and Mitigation Options

8.1.1 This section summarises the requirements for further assessment and mitigation beyond Gate 2.

Table 8-1 Tame and Trent Strategic Resource Options – Scoping Checklist for post-Gate 2 assessment and mitigation

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
Sedimentation						
Tame – R Rea to R Blythe (GB104028046841)	Regional	Minworth	Neutral	Low	Sediment and turbidity monitoring. Analysis of hydraulic modelling results for SRO sedimentation risks. Hydraulic modelling for SRO floodplain inundation effects. Optioneering and feasibility for targeted mitigation areas.	River restoration measures specific to detailed impact assessment. In this area, likely to focus on techniques such as SUDS and in-channel enhancement.
Rea from Bourn Brook to River Tame (GB104028042550)	Regional	Minworth	Neutral	Low	Sediment and turbidity monitoring. Analysis of hydraulic modelling results for SRO sedimentation risks.	River restoration measures specific to detailed impact assessment. In this area, likely to focus on floodplain reconnection

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
				🟩	Hydraulic modelling for SRO floodplain inundation effects. Optioneering and feasibility for targeted mitigation areas.	and geomorphological enhancements.
Tame from R Blythe to River Anker (GB104028046440)	Regional	Minworth	Neutral	Low	Sediment and turbidity monitoring. Analysis of hydraulic modelling results for SRO sedimentation risks. Hydraulic modelling for SRO floodplain inundation effects. Optioneering and feasibility for targeted mitigation areas.	River restoration measures specific to detailed impact assessment. In this area, likely to focus on floodplain reconnection and geomorphological enhancements.
Trent from Soar to The Beck (GB104028053110)	Regional	SLR	Neutral	Low	Sediment and turbidity monitoring. Analysis of hydraulic modelling results for SRO sedimentation risks. Hydraulic modelling for SRO floodplain inundation effects.	River restoration measures specific to detailed impact assessment. In this area, likely to focus on floodplain reconnection and geomorphological enhancements.

Receptor or Feature under Assessment	Significance	Impact Pathway and Source (Minworth and/or SLR)	Scale of Impact (Positive / Neutral / Negative)	Red/Amber/Green rating of Risk to SRO (High / Medium / Low)	Recommendations for Further Assessment	Mitigation Options
					Optioneering and feasibility for targeted mitigation areas.	
Trent Bifurcation Pingley Dyke to Winthorpe (GB104028053390)	Regional	SLR	Neutral	Low	Sediment and turbidity monitoring. Analysis of hydraulic modelling results for SRO sedimentation risks. Hydraulic modelling for SRO floodplain inundation effects. Optioneering and feasibility for targeted mitigation areas.	River restoration measures specific to detailed impact assessment. In this area, likely to focus on floodplain reconnection and geomorphological enhancements.

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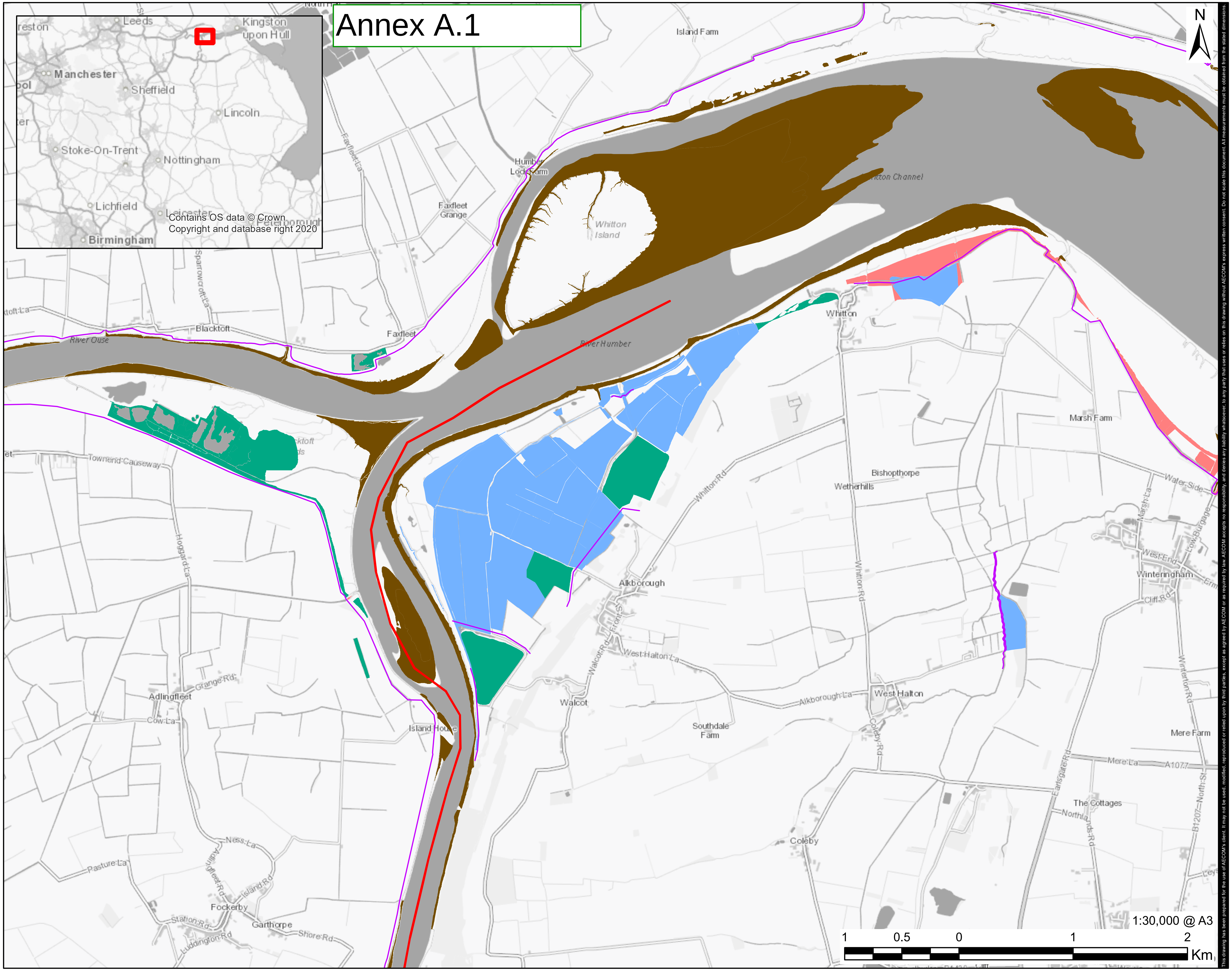
Annex A.1



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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟩
- 🟨
- 🟧
- 🟥
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part A)

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Figure 1A

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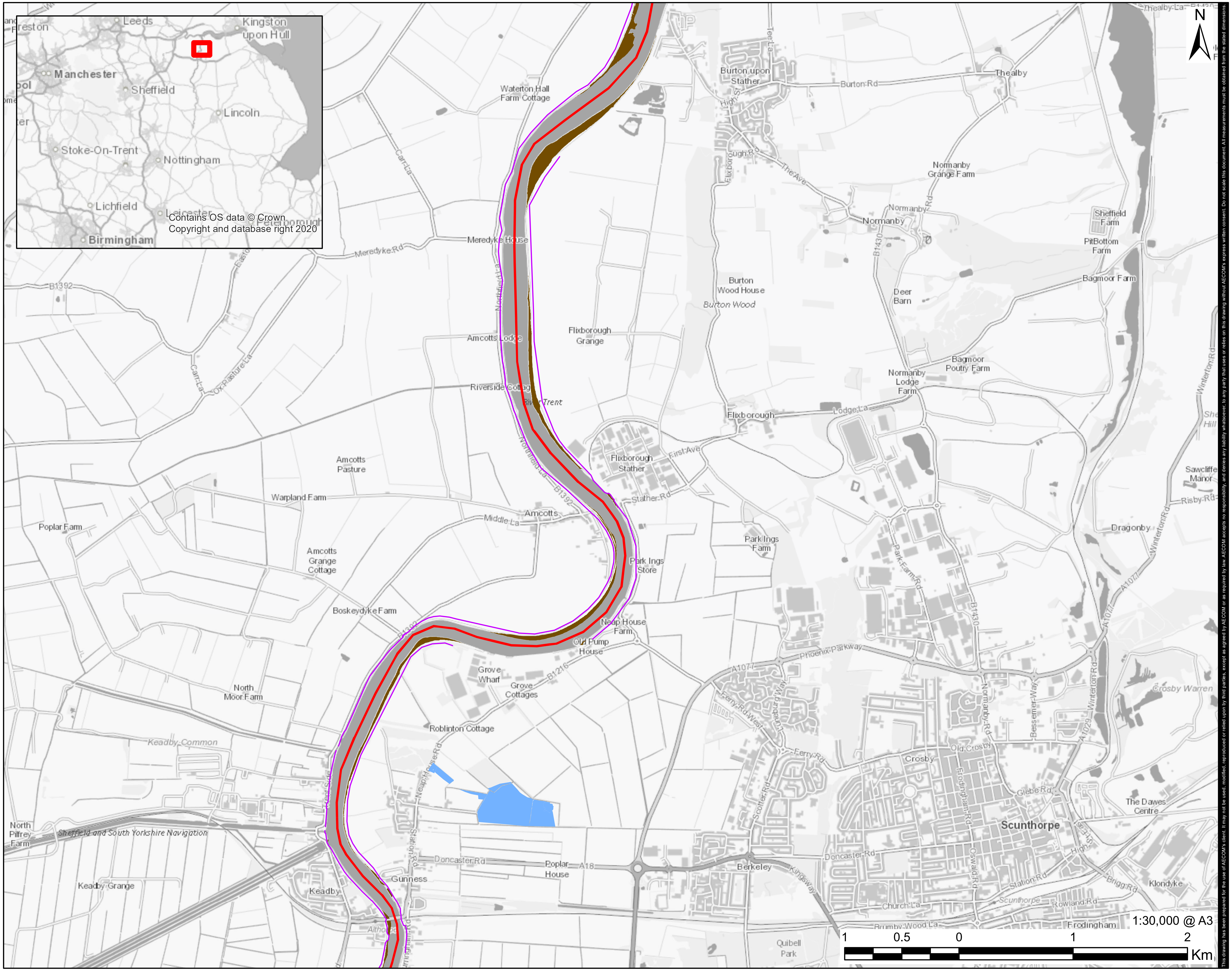

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LEGEND

✚ Potential Salmonid Spawning Site

Assets

🟦 Confluence
★ Intake / Outfall
✚ Outfall
✚ Outfall / Spillway
✚ Outfall / WWTW
✚ Outfall / Water Treatment
✚ Outflow
◆ Sluice
⊕ Weir
⊕ Weir (and potentially fish pass)
▭ Flood Storage
— Flood Defences

Sedimentation Risk

🟩 Low
▬
🟨
🟧
▬
🟥
🟥 High

Priority Habitat

🟦 Coastal and floodplain grazing marsh
▬ Lowland fens
🟫 Mudflats
🟩 Reedbeds

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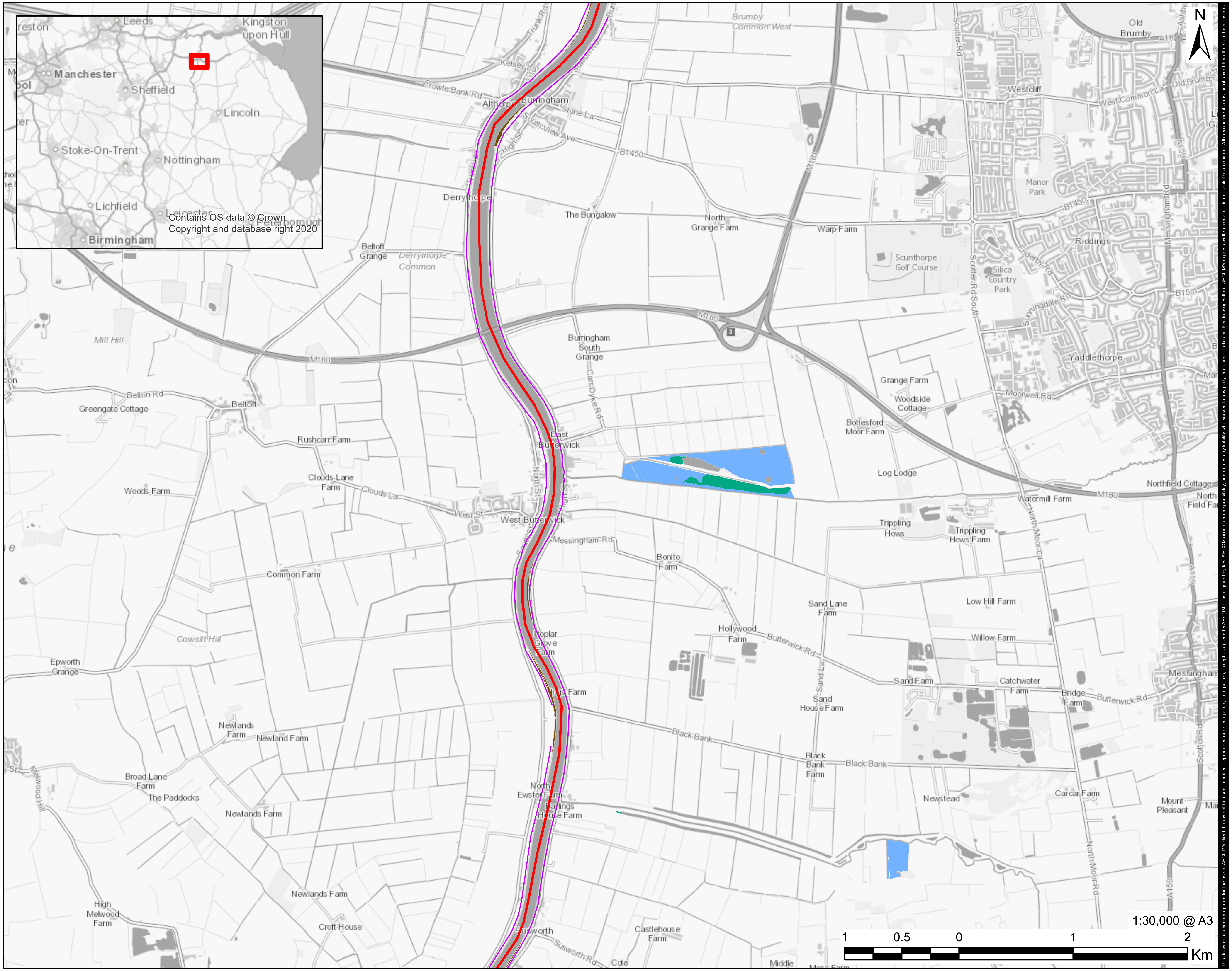
Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part B)

SHEET NUMBER

Figure 1B



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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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Figure 1C

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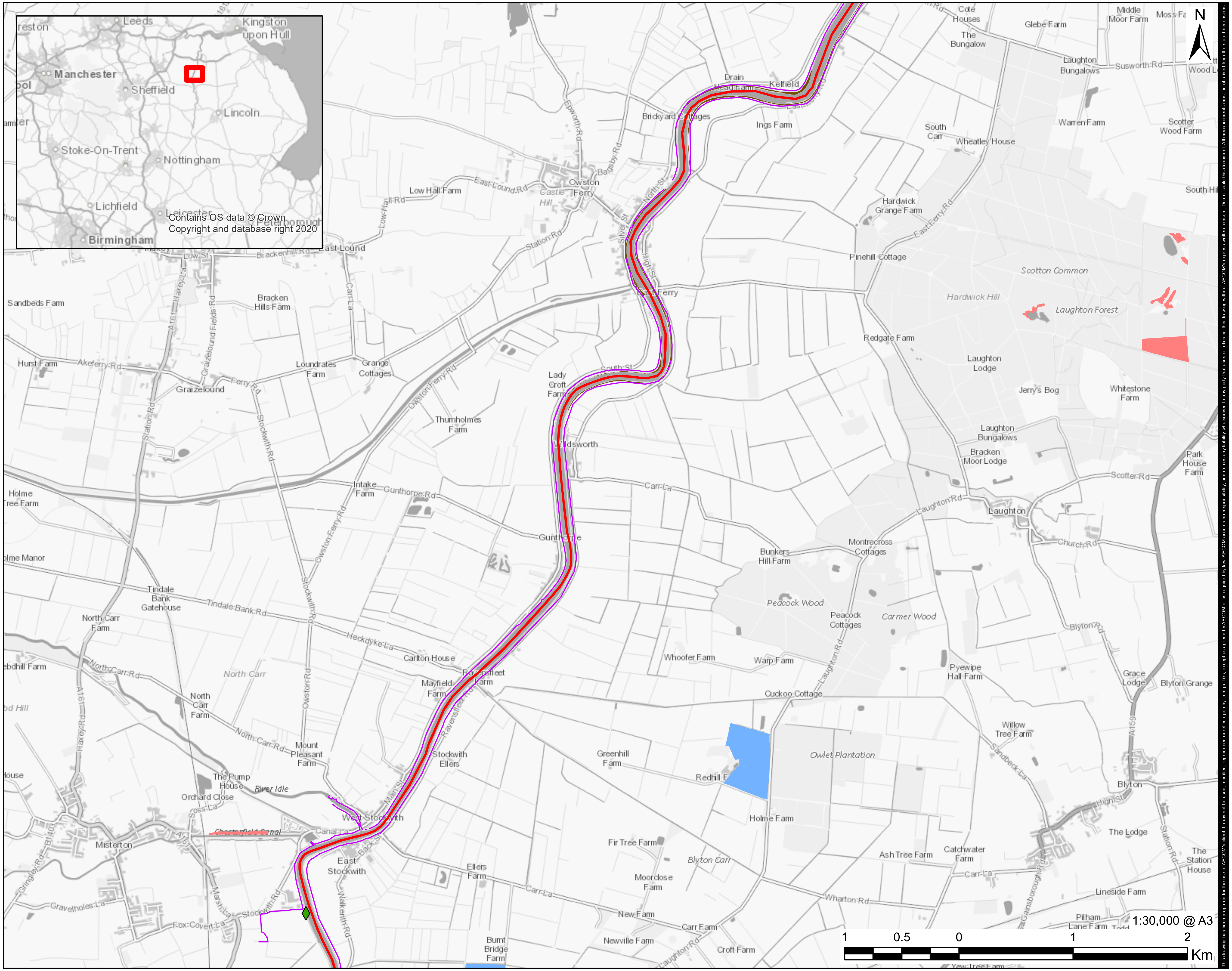

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ▨
- 🟨
- 🟧
- ▨
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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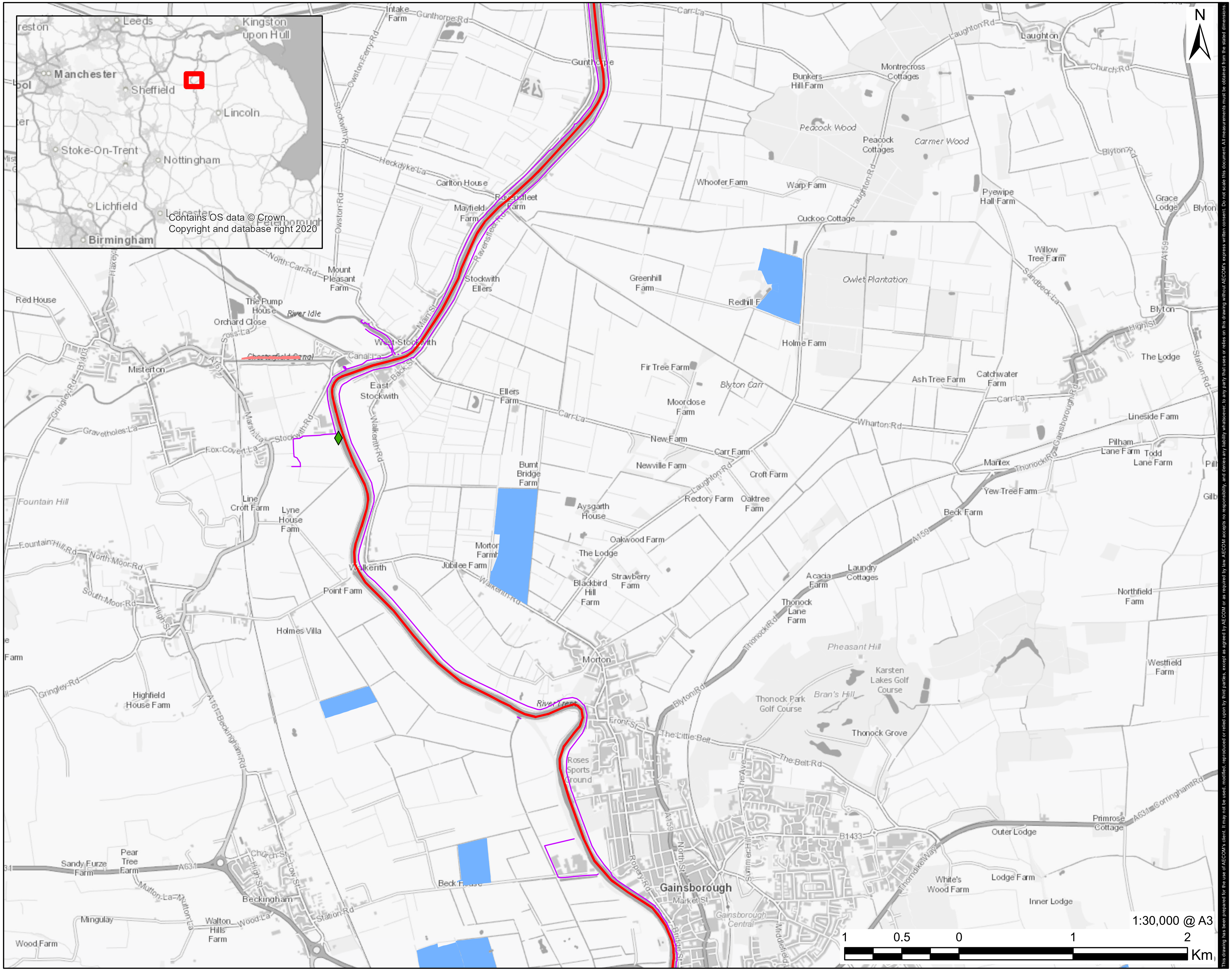
Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part D)

SHEET NUMBER

Figure 1D



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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ▭ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟨
- 🟧
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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Figure 1E

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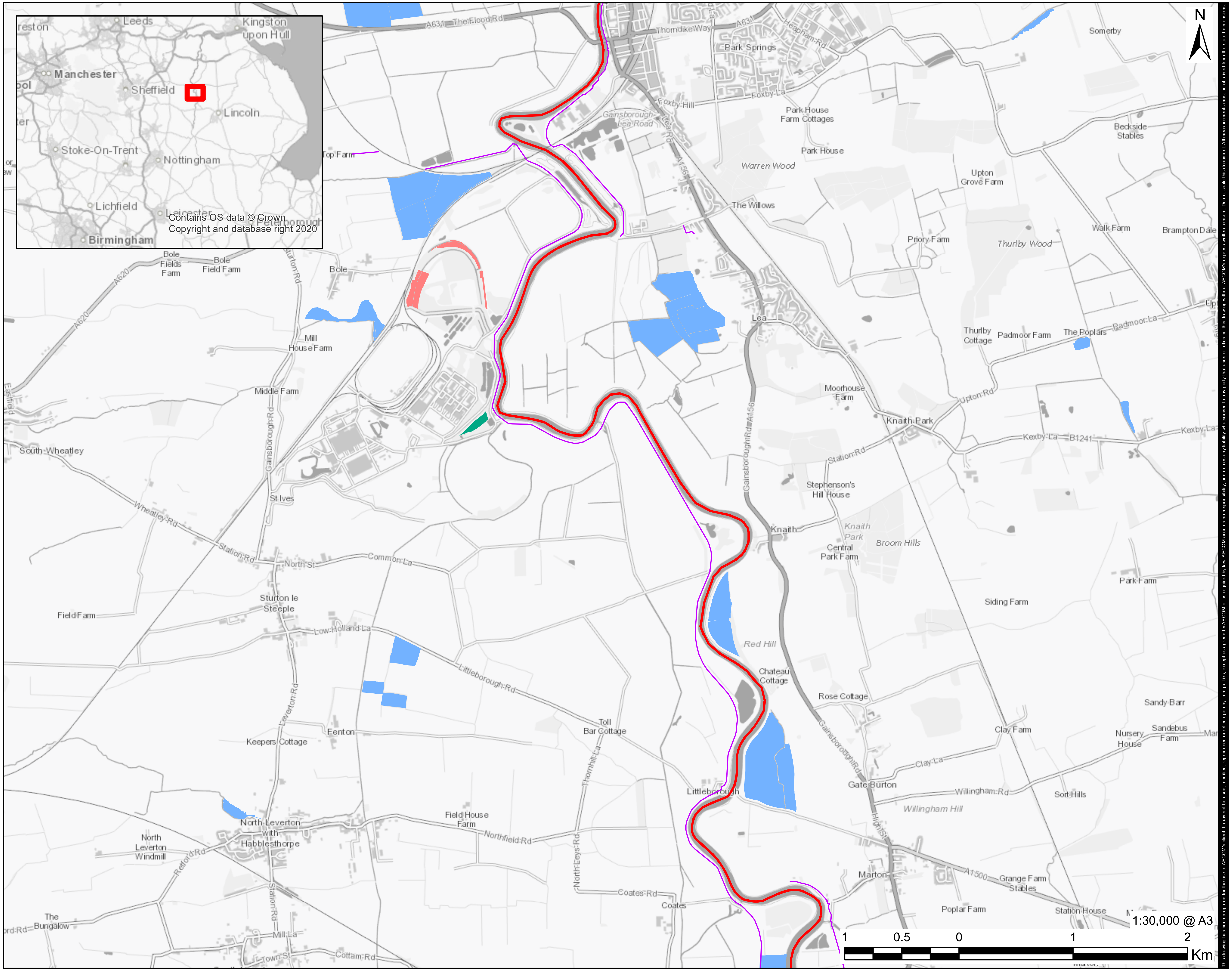

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LEGEND

✚ Potential Salmonid Spawning Site

Assets

- ■ Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ■
- ■
- ■
- 🟥
- ■ High

Priority Habitat

- ■ Coastal and floodplain grazing marsh
- ■ Lowland fens
- ■ Mudflats
- ■ Reedbeds

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Figure 1F

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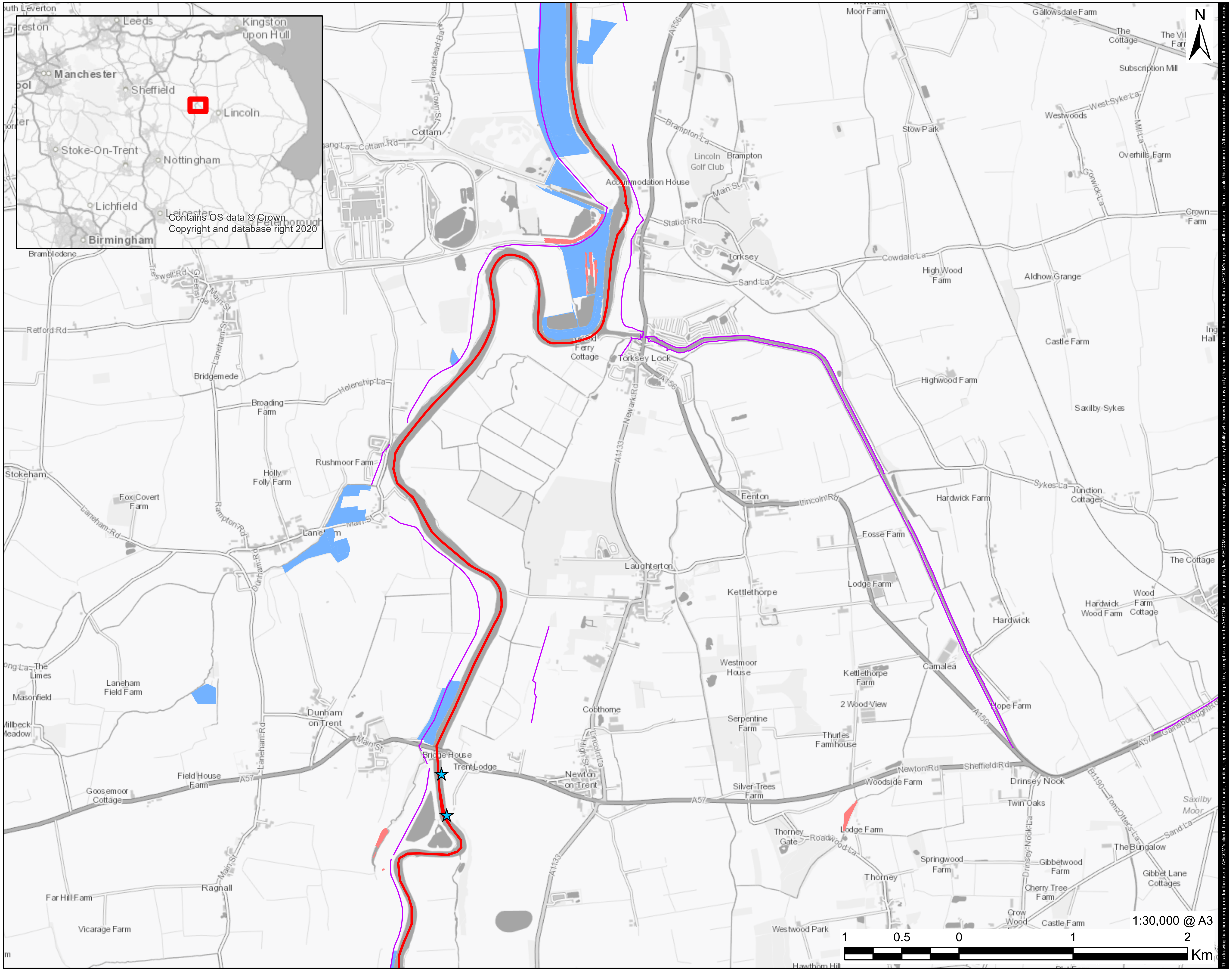

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟨
- 🟨
- 🟧
- 🟥
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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SHEET NUMBER

Figure 1G

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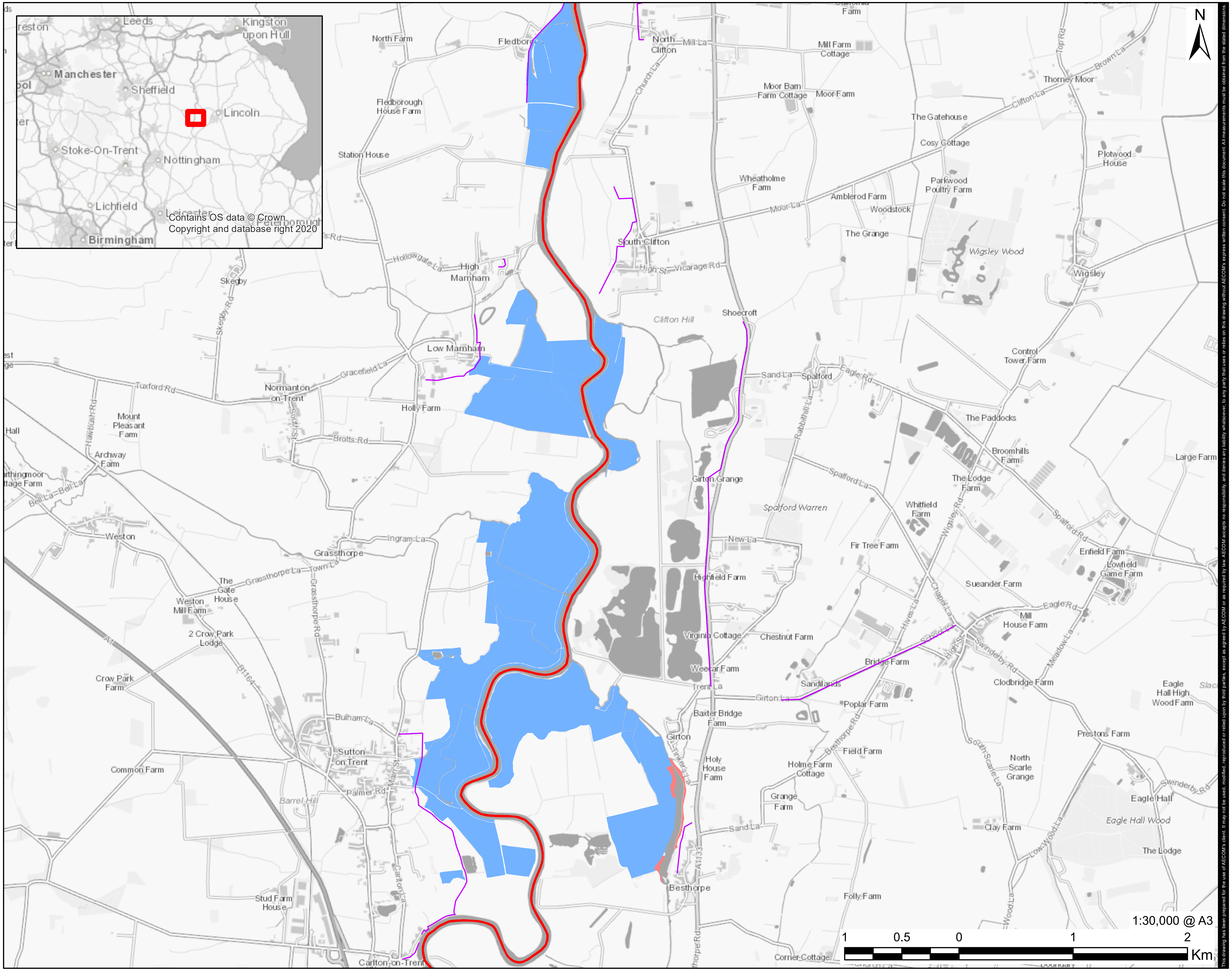

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LEGEND

+ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ▭ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ▨
- 🟨
- 🟧
- ▨
- 🟥
- ▨ High

Priority Habitat

- ▨ Coastal and floodplain grazing marsh
- ▨ Lowland fens
- 🟫 Mudflats
- ▨ Reedbeds

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FINAL

PROJECT NUMBER

60669746

SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part H)

SHEET NUMBER

Figure 1H

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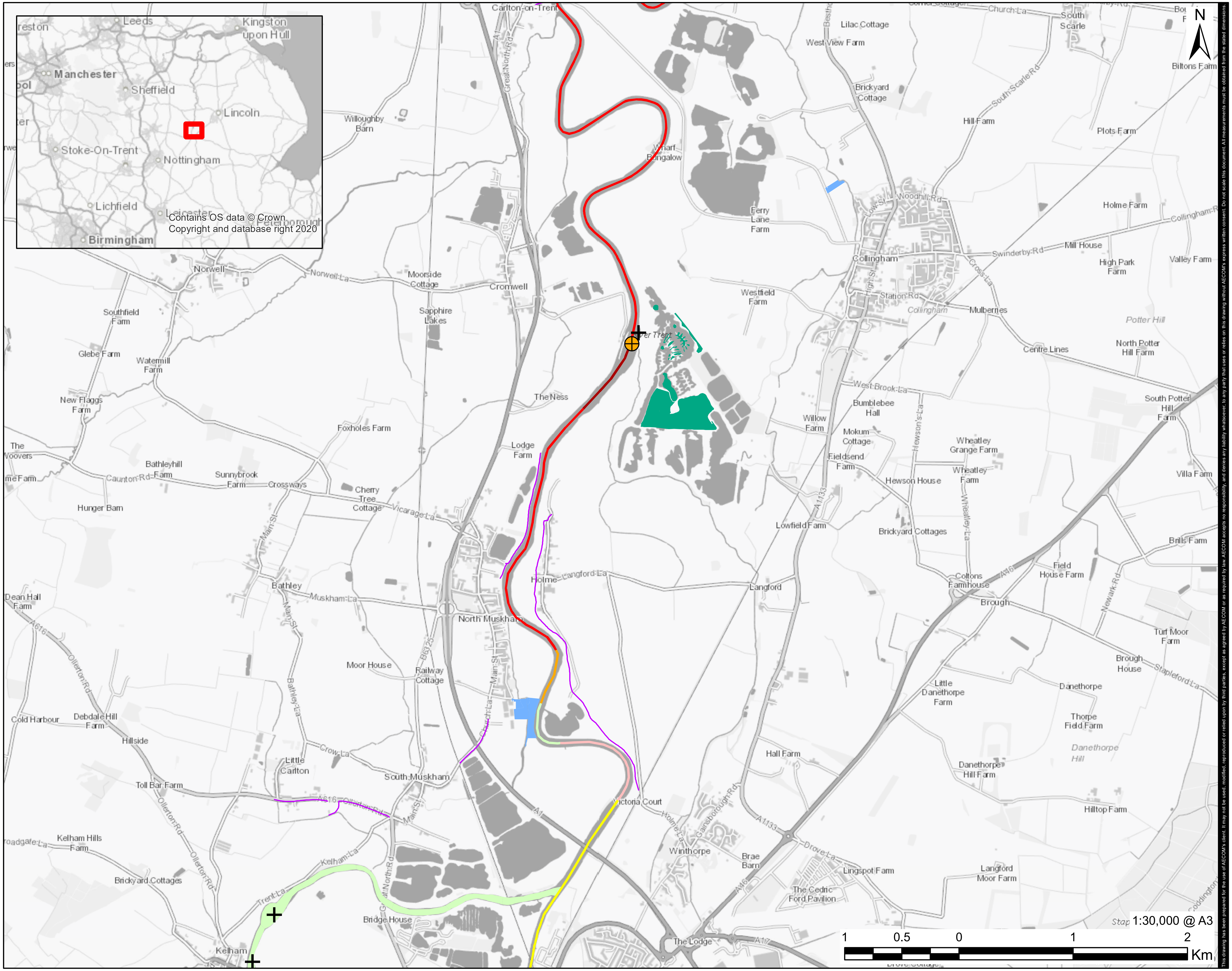

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LEGEND

+ Potential Salmonid Spawning Site

Assets

🟦 Confluence
☆ Intake / Outfall
✚ Outfall
✚ Outfall / Spillway
✚ Outfall / WWTW
✚ Outfall / Water Treatment
✚ Outflow
◆ Sluice
⊕ Weir
⊕ Weir (and potentially fish pass)
☐ Flood Storage Area
— Flood Defences

Sedimentation Risk

🟩 Low
🟩
🟨
🟧
🟥
🟥
🟥 High

Priority Habitat

🟦 Coastal and floodplain grazing marsh
🟥 Lowland fens
🟫 Mudflats
🟩 Reedbeds

NOTES

ISSUE PURPOSE

FINAL

PROJECT NUMBER

60669746

SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part I)

SHEET NUMBER

Figure 1I

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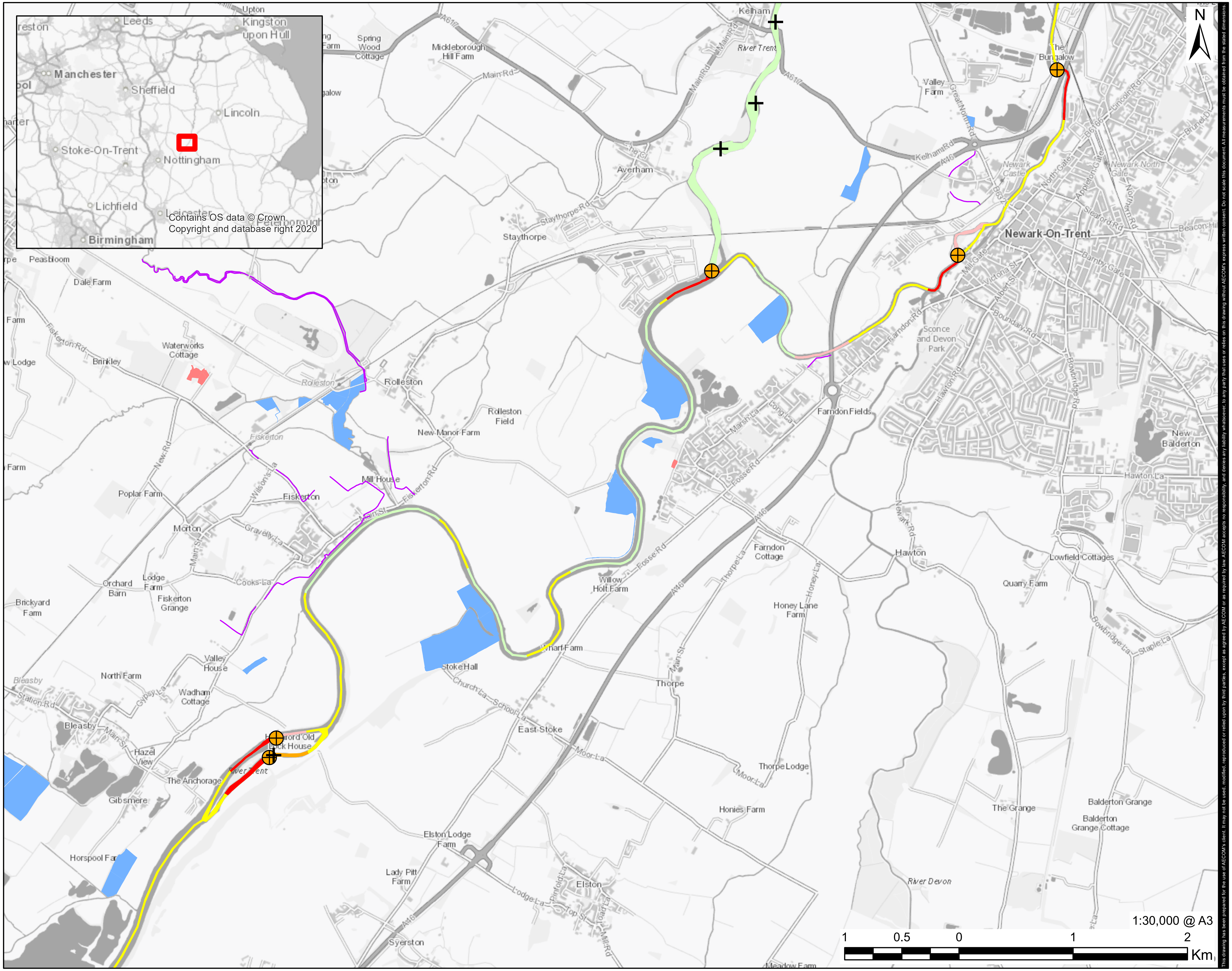

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LEGEND

+ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟩
- 🟨
- 🟧
- 🟥
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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PROJECT NUMBER

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part J)

SHEET NUMBER

Figure 1J

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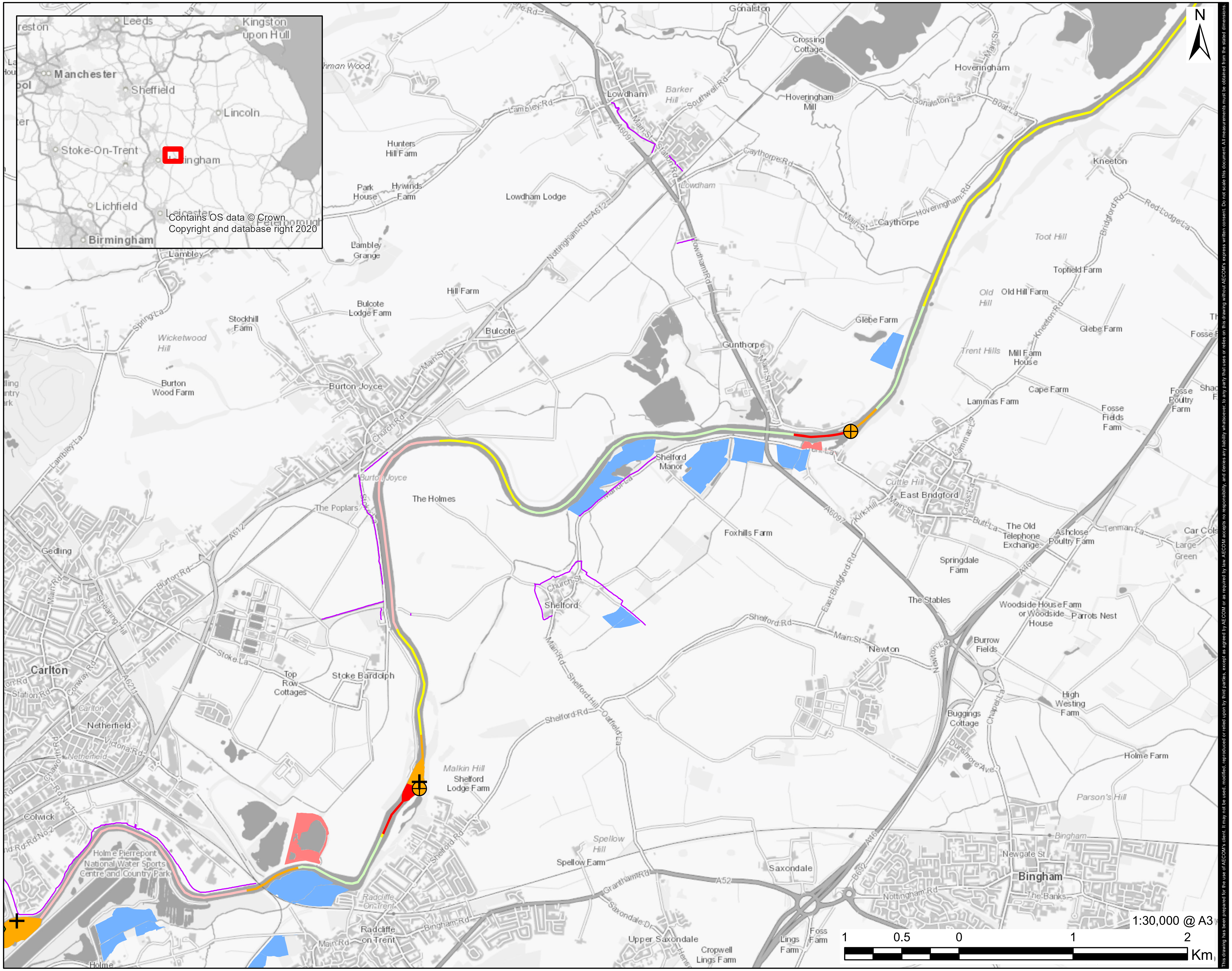

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ■
- 🟨
- 🟧
- ■
- 🟥
- ■ High

Priority Habitat

- ■ Coastal and floodplain grazing marsh
- ■ Lowland fens
- 🟫 Mudflats
- ■ Reedbeds

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PROJECT NUMBER

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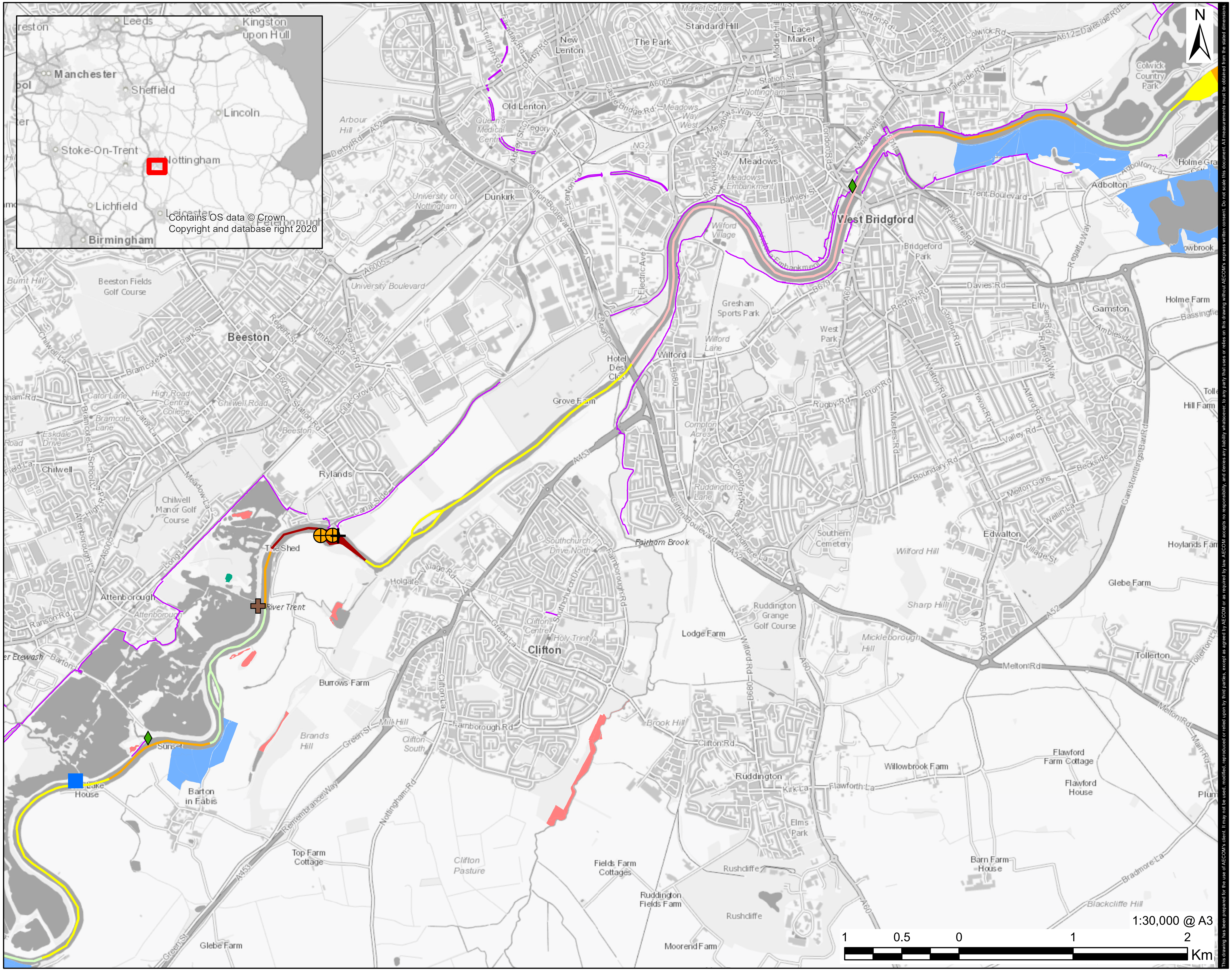
SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part K)

SHEET NUMBER

Figure 1K



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LEGEND

+ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟩
- 🟨
- 🟧
- ▨
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part L)

SHEET NUMBER

Figure 1L

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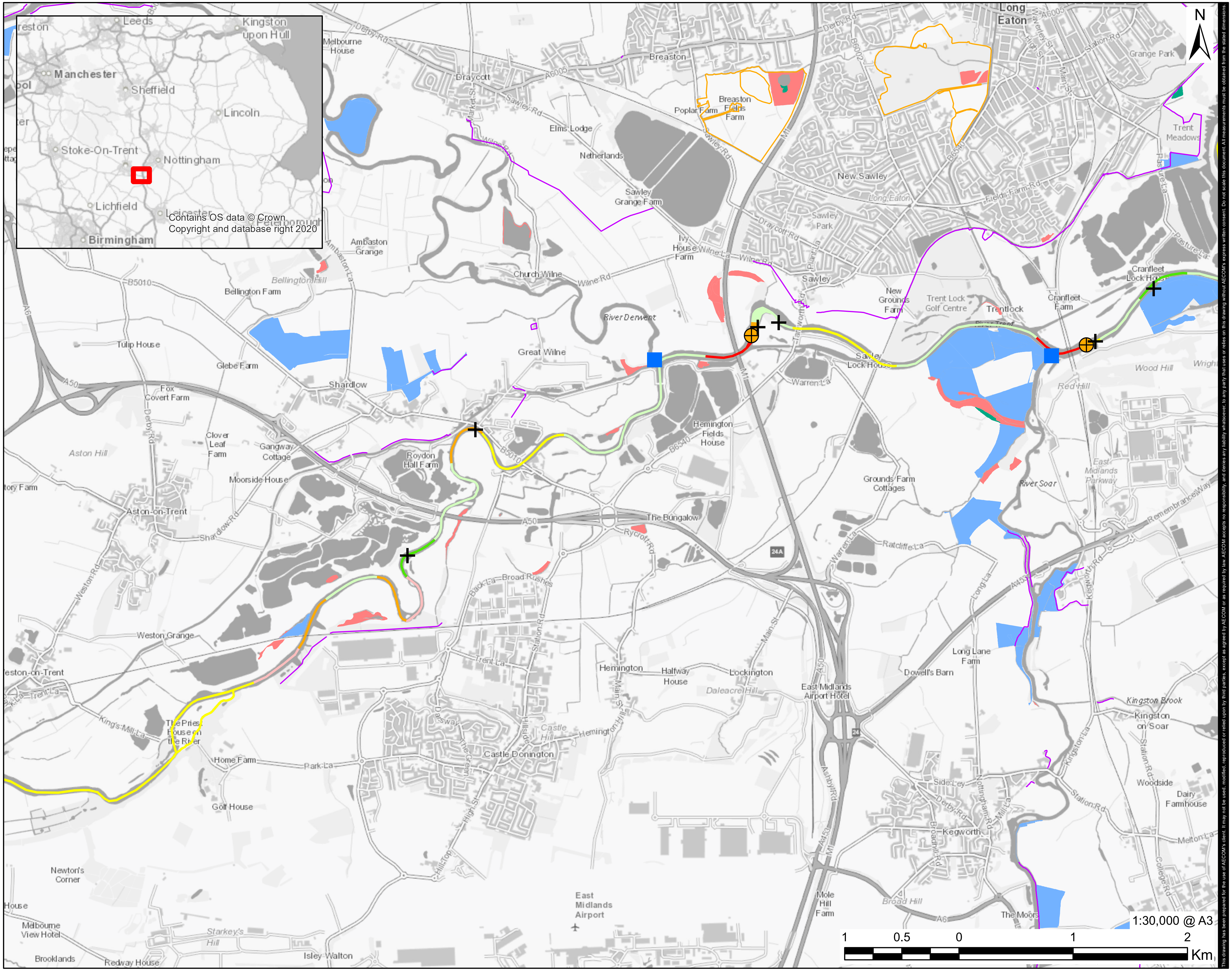

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟩
- 🟨
- 🟧
- 🟥
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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PROJECT NUMBER

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part M)

SHEET NUMBER

Figure 1M

Drawn: LR Checked: NW Approved: PC Date: 28/04/2022

Revision: 1

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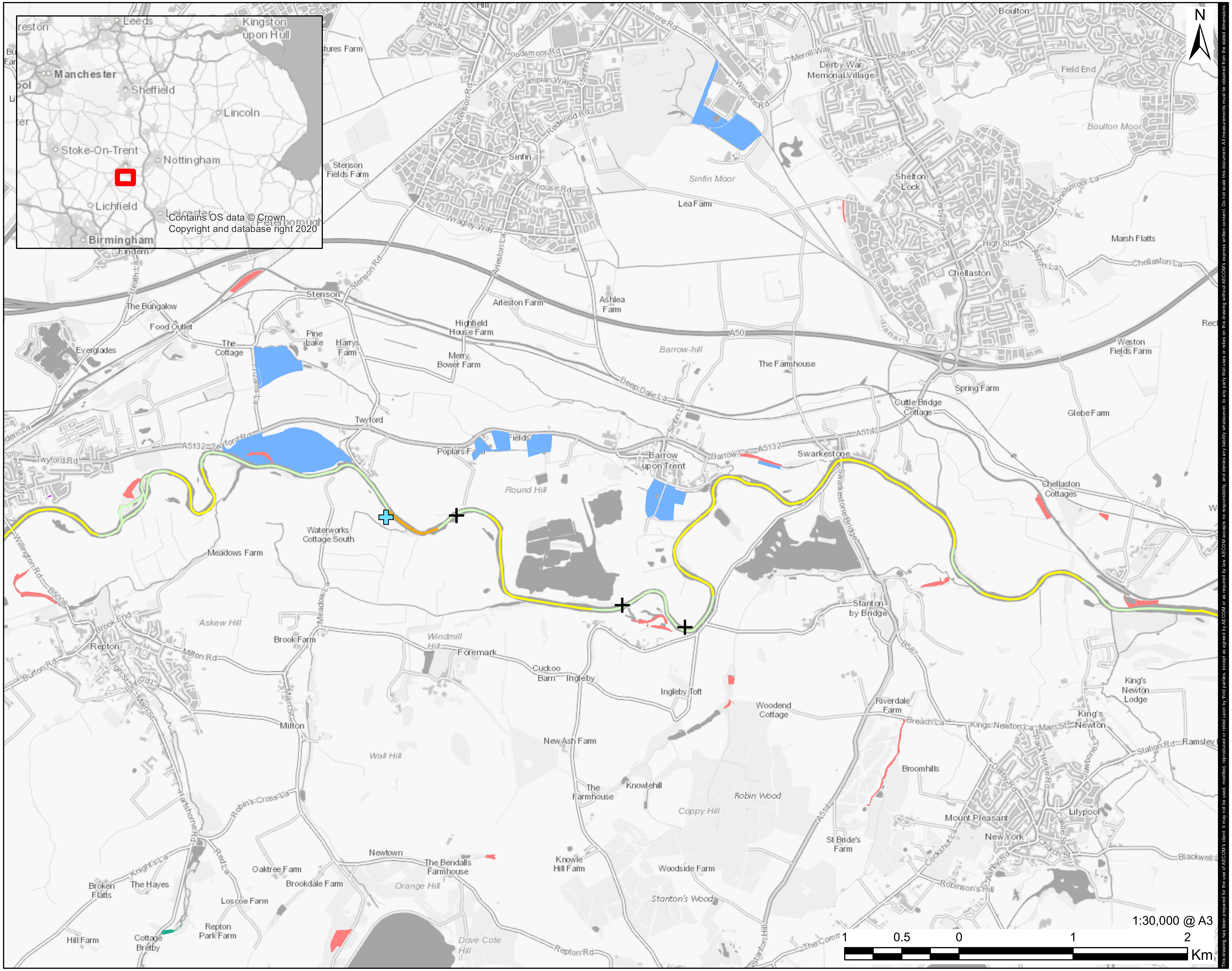

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LEGEND

✚ Potential Salmonid Spawning Site

Assets

🟦 Confluence

★ Intake / Outfall

✚ Outfall

✚ Outfall / Spillway

✚ Outfall / WWTW

✚ Outfall / Water Treatment

✚ Outflow

◆ Sluice

⊕ Weir

⊕ Weir (and potentially fish pass)

▭ Flood Storage Area

— Flood Defences

Sedimentation Risk

🟩 Low

🟩

🟨

🟧

🟥

🟥

🟥 High

Priority Habitat

🟦 Coastal and floodplain grazing marsh

🟥 Lowland fens

🟫 Mudflats

🟩 Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part N)

SHEET NUMBER

Figure 1N

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Revision: 1

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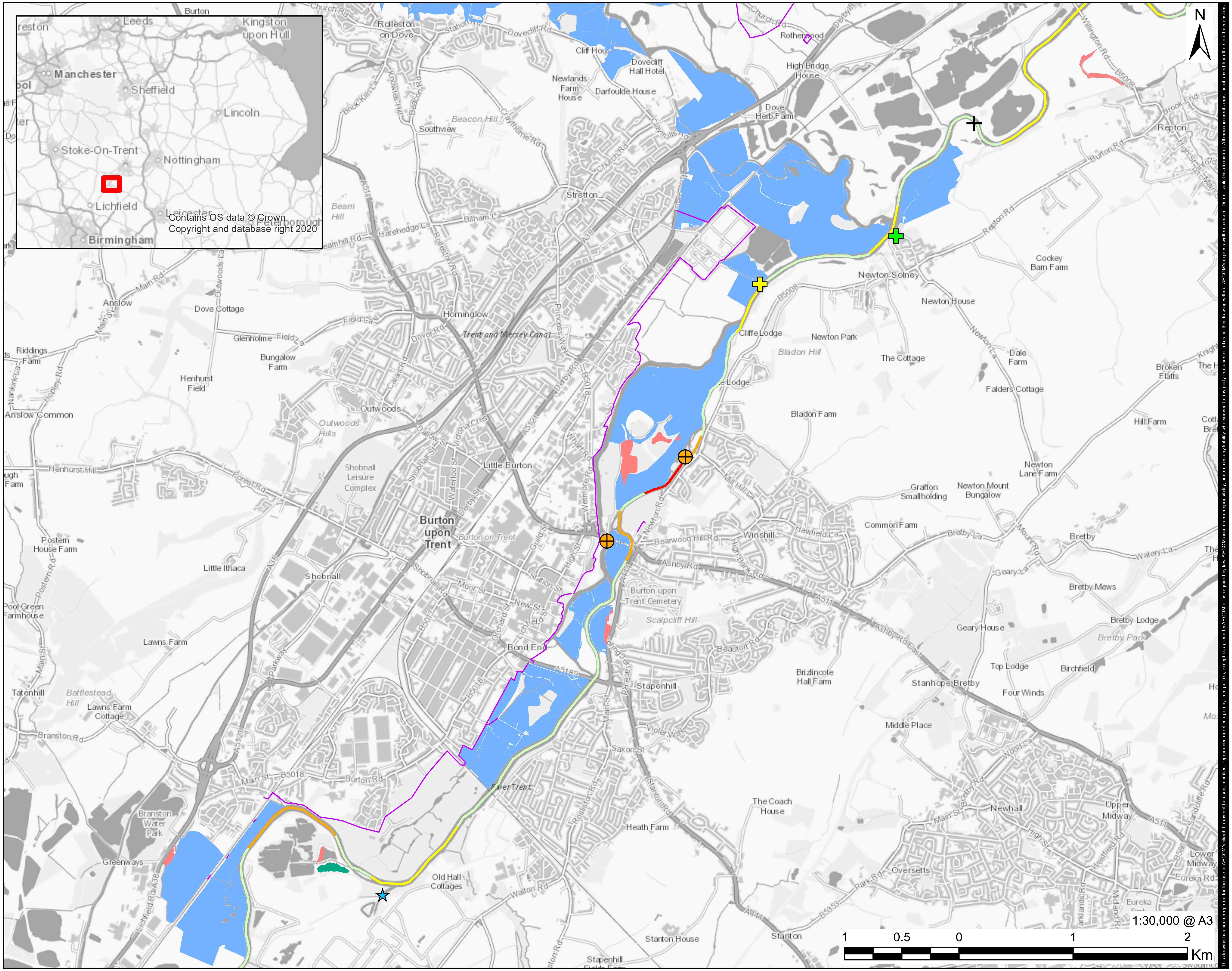

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ■
- 🟨
- 🟧
- ■
- 🟥
- ■ High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- ■ Lowland fens
- 🟫 Mudflats
- ■ Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part O)

SHEET NUMBER

Figure 1O

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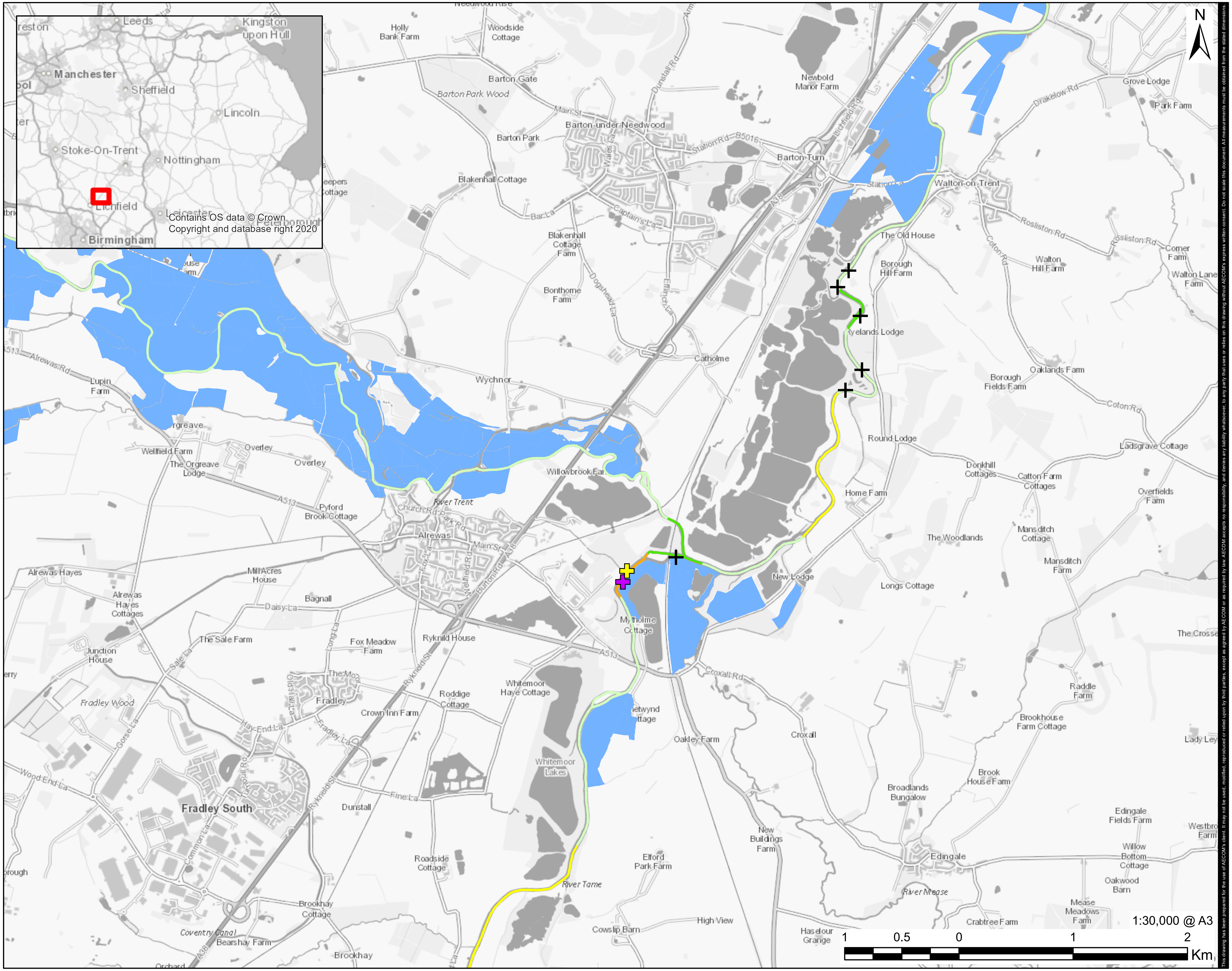

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- ■ Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- ■ Low
- ■
- ■
- ■
- ■
- ■
- ■ High

Priority Habitat

- ■ Coastal and floodplain grazing marsh
- ■ Lowland fens
- ■ Mudflats
- ■ Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part P)

SHEET NUMBER

Figure 1P

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Revision: 1

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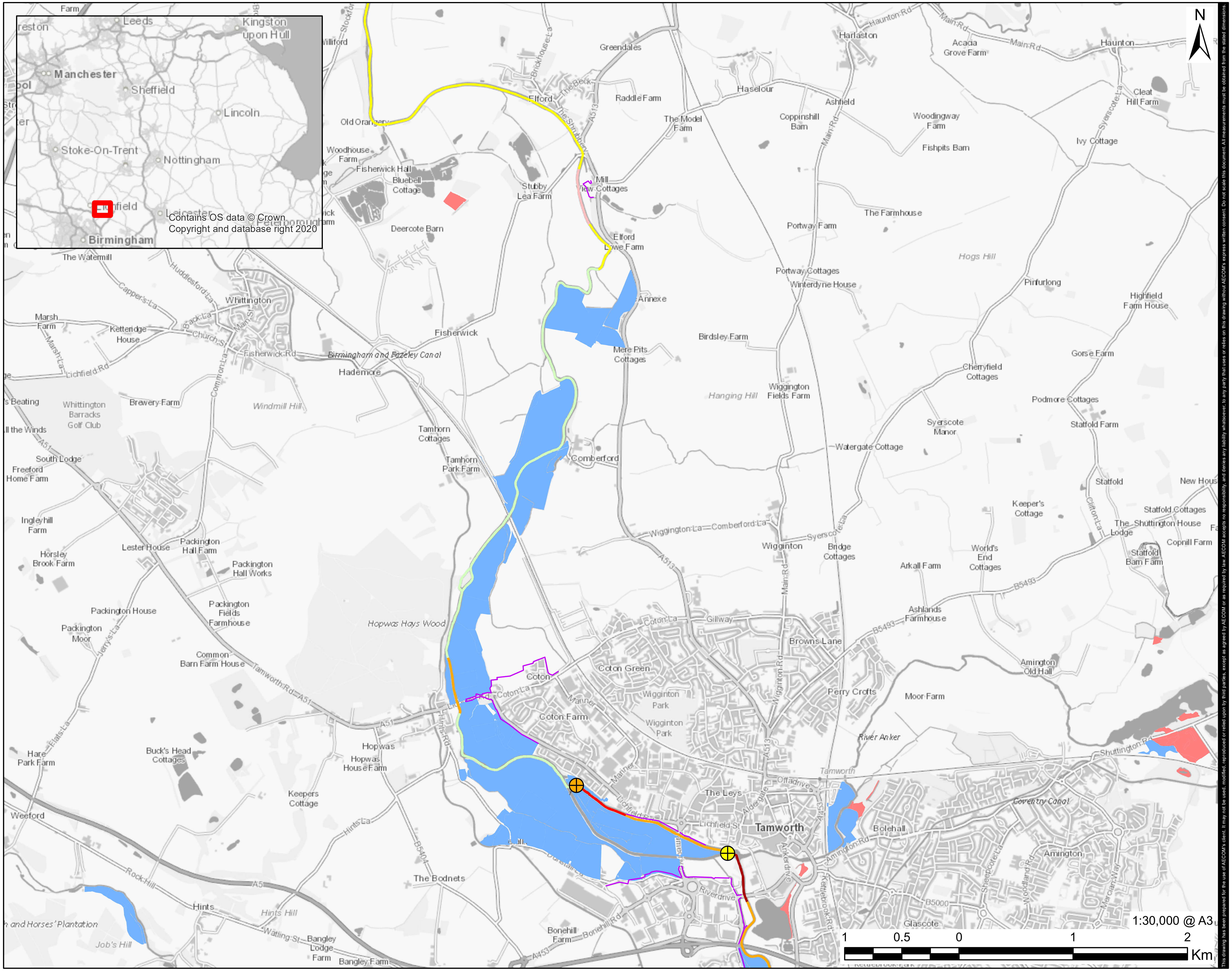

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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- 🟩
- 🟨
- 🟧
- 🟥
- 🟥
- 🟥 High

Priority Habitat

- 🟦 Coastal and floodplain grazing marsh
- 🟥 Lowland fens
- 🟫 Mudflats
- 🟩 Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part Q)

SHEET NUMBER

Figure 1Q

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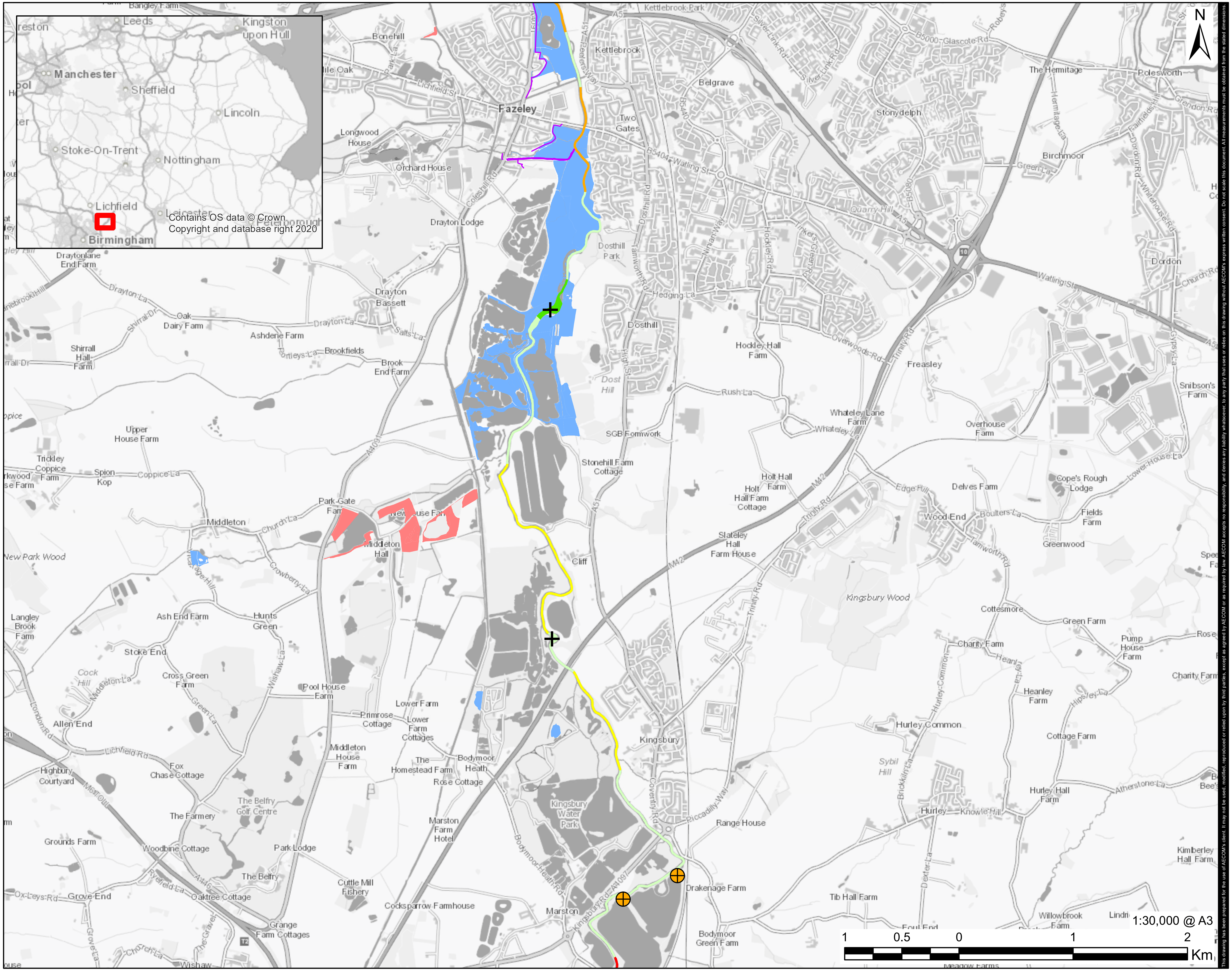
Revision: 1

Drawn: LR Checked: NW Approved: PC Date: 28/04/2022



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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- ■ Confluence
- ☆ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ☐ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- ■ Low
- ■
- ■
- ■
- ■
- ■
- ■ High

Priority Habitat

- ■ Coastal and floodplain grazing marsh
- ■ Lowland fens
- ■ Mudflats
- ■ Reedbeds

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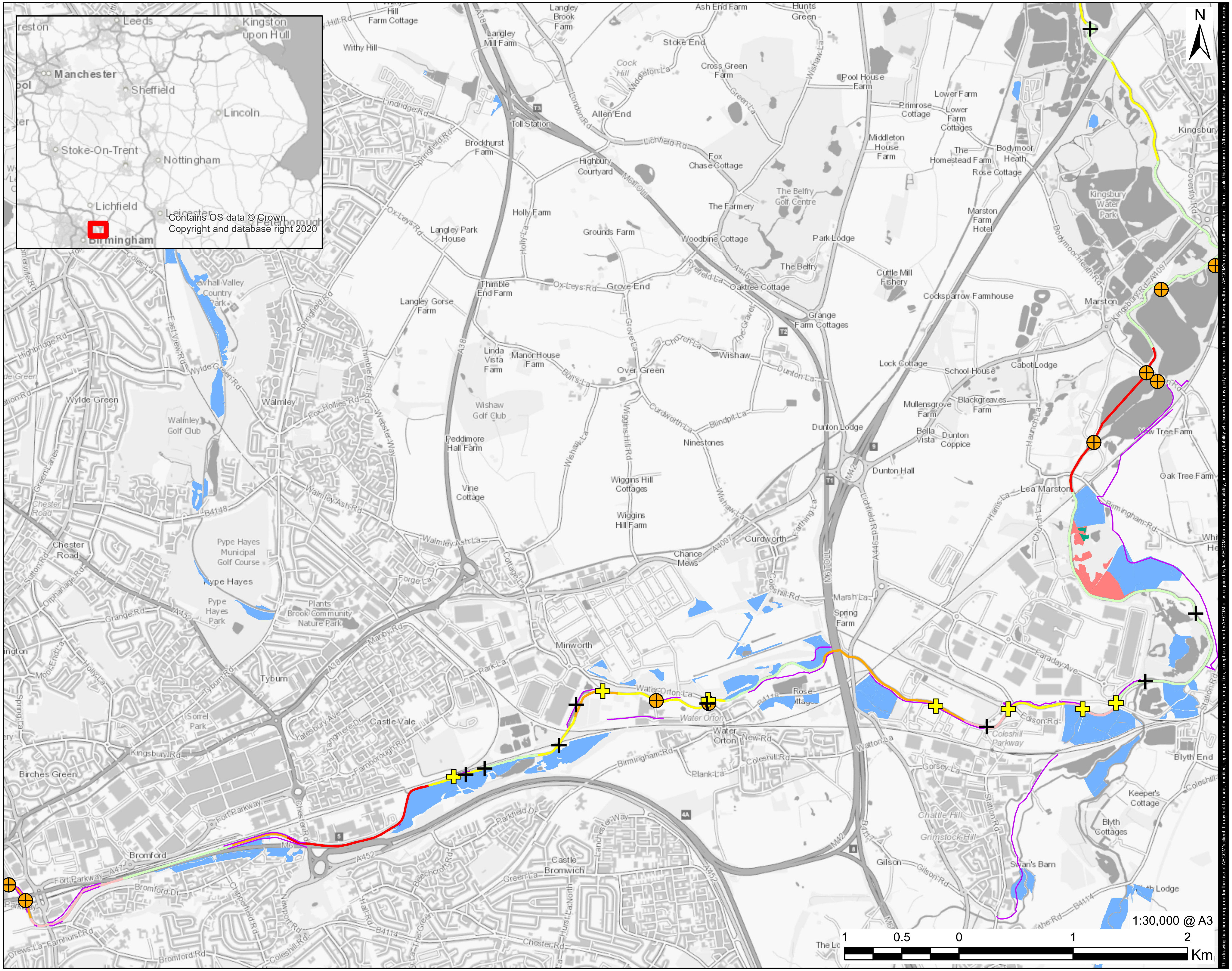
SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part R)

SHEET NUMBER

Figure 1R



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LEGEND

- ✚ Potential Salmonid Spawning Site

Assets

- 🟦 Confluence
- ★ Intake / Outfall
- ✚ Outfall
- ✚ Outfall / Spillway
- ✚ Outfall / WWTW
- ✚ Outfall / Water Treatment
- ✚ Outflow
- ◆ Sluice
- ⊕ Weir
- ⊕ Weir (and potentially fish pass)
- ▭ Flood Storage Area
- — Flood Defences

Sedimentation Risk

- 🟩 Low
- ■
- 🟨
- 🟧
- ■
- 🟥
- ■ High

Priority Habitat

- ■ Coastal and floodplain grazing marsh
- ■ Lowland fens
- 🟫 Mudflats
- ■ Reedbeds

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SHEET TITLE

Indicative Sediment Zones, Key Channel Assets and Habitats for the River Tame and River Trent (Part S)

SHEET NUMBER

Figure 1S

Filename: C:\Users\Liam.Rees\OneDrive - AECOM\Desktop\My files\TTH\Sedimentation\Mapping\Affinity_TTH_Sedimentation_Mapping_Apr2022.mxd

Revision: 1

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