ANNEX 5

De-culverting Gilwiskaw Brook, Bath Grounds Feasibility Assessment




Report to Trent Rivers Trust

September 2022

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PR120/R1.1/F

Quality Management

Report Title	**De-culverting Gilwiskaw Brook, Bath Grounds Feasibility Assessment**
Client	**Trent Rivers Trust**
Project Reference	**PR120**
Date	**September 2022**
Status	**~~Draft~~ / Final**
Report/Revision	**R1.1**
Authorised by	**Director** Robert McInnes

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Contents

1. Introduction

1.1. Background

1.1.1. A tributary of the River Mease, Gilwiskaw Brook is a lowland river that rises some 3.7km to the north of Ashby-de-la-Zouch, Leicestershire. The brook has a long history of modification, including straightening and culverting. The brook passes under the majority of Ashby-de-la-Zouch in a culvert of some 980m in length from Kilwardy Street (SK35691699) to an outlet immediately north of Lower Packington Road (SK35691606) (Figure 1). Consequently, there are limited areas of open channel throughout the town. Once out of culvert, the brook joins the River Mease some 8.3km approximately downstream the south of Ashby-de-la-Zouch.

1.1.2. For a length of approximately 250m, Gilwiskaw Brook is culverted under an area of public green space called Bath Grounds. The area derives its name from the adjacent Ivanhoe Baths which were formerly housed in neoclassical building overlooking the grounds. The grounds cover approximately 6.2ha and provide an important amenity green space in the heart of Ashby-de-la-Zouch, including the provision of sports, dog walking and other leisure activities.

1.1.3. There is an active 'Friends of Bath Grounds' group who work and campaign to protect and improve the Grounds as a free, public access park and recreational facility for the benefit of the whole community. In particular, the Group:

- Supports enhancement of the Bath Grounds for the benefit of public enjoyment and sporting use.
- Supports community ownership of the Bath Grounds.
- Supports use of the Bath Grounds by community sports organisations provided this does not unduly interfere with enjoyment by other members of the public.
- Opposes the use of any part of the Bath Grounds to build houses and any other non-recreational or non-sporting use.

1.1.4. The River Mease and Gilwiskaw Brook downstream of Packington are classified as both a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC) on account of populations of spined loach *Cobitis taenia*, bullhead *Cottus gobio*, white-clawed crayfish *Austropotamobius pallipes* and otter *Lutra lutra*. The watercourse is considered to represent one of the best examples of meandering lowland river which also supports *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation.

1.1.5. There have been ongoing attempts to enhance and restore the River Mease and its tributaries. As part of an overall Restoration Plan for the River

Mease SSSI/SAC, the vision is to improve the physical function and form of the River Mease and Gilwiskaw Brook. Whilst the reach upstream lies outside of the SSSI/SAC, enhancements to the upper part of the river system will contribute to overall benefits to the downstream designated reaches.

1.2. Terms of reference

1.2.1. The Trent Rivers Trust (TRT) appointed RM Wetlands & Environment Ltd, working in collaboration with 35percent Ltd and Hydro-GIS Ltd, to conduct a feasibility study for the de-culverting of the Gilwiskaw Brook within Bath Grounds. Early in 2018, TRT conducted a 'pre-feasibility' study of the proposal to de-culvert the brook within Bath Grounds and to restore it to a naturally functioning open channel. This study established that the key partners in Ashby were supportive of the proposal and that further work should take place to develop the concept.

1.2.2. The specification required as part of the feasibility assessment needs to address all the following areas of work:

- A detailed topographical survey.
- A ground radar survey.
- Hydraulic modelling and hydrology to assess flood risk (please assume that the EA model is suitable to use). Include recommendations for channel form, bed level at upstream and downstream limits and channel capacity.
- Trial pits
- Concept design sketches.
- A feasibility assessment written up as a report.
- An artistic impression of the de-culverted brook.

2. Information review

2.1. Desk study

Pre-feasibility study

2.1.1. TRT produced a Pre-Feasibility Study report in May 2018. The study set out the initial consultation undertaken in order to develop an understanding of the issues surrounding the de-culverting of Gilwiskaw Brook. The pre-feasibility consultation process reached out to the following consultees:

- Ashby Town Council
- Environment Agency
- Natural England
- Leicestershire County Council
- Friends of Bath Grounds
- Landowner

2.1.2. Predominantly, the consultees were supportive in principle of the suggestion that the Brook is removed from its culvert and 'daylighted'. The Friends of Baths Grounds were interested in the concept but requested further information as the concept designs developed.

Historical maps

2.1.3. The Pre-Feasibility Study assembled several historical maps of Bath Grounds. These include early versions of the Ordnance Survey maps and a historical sewer map for Bath Grounds. Other maps have also been sourced to help understand the historical course of the Brook and to inform possible restoration designs.

2.1.4. Figure 2 suggest that in the late 1880s the course of Gilwiskaw Brook was along the north eastern boundary of the present-day Bath Grounds before bifurcating and flowing in two channels towards the railway embankment. It is not clear whether the eastern of these two channels actually passed under the railway embankment as the channel appears to be truncated where it meets a small copse to the south. By c.1910 the eastern watercourse appears to have been partially infilled with the main course of the Brook flowing through the culvert towards the centre of embankment along the southern boundary of Bath Grounds (Figure 3). However, by the time that the 1925 Ordnance Survey map was published the surface course of the Gilwiskaw Brook no longer exists, suggesting that the stream was culverted at some time between 1910 and 1920 (the date of the survey work to produce the 1925 map).

Geology

2.1.5. The British Geological Survey (BGS) 1:50,000 map describes the bedrock geology underlying Bath Grounds as the Pennine Lower Coal Measures

Formation. This formation characteristically comprises mudstone, siltstone and sandstone. Dissecting Bath Grounds from the north to the south is an area of superficial deposits dominated by alluvium comprising clays, silts, sands and gravels (Figure 4). This area indicates the historical course of the Brook prior to human intervention.

2.1.6. A cable percussive borehole (SK31NE393) was completed approximately 300m north of the site, finding 0.20m of made ground above 0.40m of very silty clay before encountering 2.40m of silty clay to a final depth of 3.00m bgl. No groundwater was encountered during the progress of this borehole. Approximately 600m to the south east, a trial pit (SK31NE433) recorded 0.20m of topsoil above 0.40m of silty gravelly sand, overlying 0.30m silty sand before encountering 1.70m of weakly laminated thinly bedded clay determined to be part of the weathered coal measures to a depth of 2.60m below ground level. No groundwater was recorded during the progress of this borehole either.

Soils

2.1.7. The soils within Bath Grounds are described as being slowly permeable seasonally wet acid loamy and clayey soils[1]. However, given the location in the centre of an urban area, and the potential for anthropogenic changes to have occurred, it is possible that in some areas of Bath Grounds the natural soils may have been altered.

Archaeology

2.1.8. The land within and surrounding Bath Grounds has a history of human development from the Medieval period (12th century). A detailed survey of Bath Grounds was conducted in 2016 by Mercian Archaeological Services[2]. The main findings of their report, with regards to implications for the de-culverting of Gilwiskaw Brook are:

- Multiple features of medieval and later landscapes survive as earthworks or are buried under the present-day ground surface of Bath Grounds.
- The survey detected underground water management features including stone and metal structures.
- Linear, low magnetic anomalies in the south east of part of Bath Grounds align with the former courses of Gilwiskaw Brook, as observed on the historical Ordnance Survey maps.
- Dipolar anomalies oriented north-south suggest that the course of Gilwiskaw Brook may be through a metal culvert.

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[1] www.landis.org.uk/soilscapes/

[2] Mercian Archaeological Services CIC (2017) *Geophysical Magnetometer and Resistance Survey, and Topographic Survey at the Bath Grounds, Memorial Field, Ashby-de-la-Zouch, Leicestershire, 2016*. Unpublished report produced for Friends of Bath Grounds & The Heritage Lottery Fund. 74pp.

- Historical ponds in the south eastern corner of Bath Grounds were formerly fed from Gilwiskaw Brook.

2.1.9. The assessment of the historical features highlighted in the 2017 indicates that there are numerous constraints which need to be taken into account in the design of the de-culverted stream design.

LiDAR

2.1.10. Light Detection and Ranging (LiDAR) data was downloaded and processed to understand the topography of the site. In general, the land slopes from the north to the south from approximately 121mAOD to 119mAOD. There is also a fall in ground levels from the western and eastern margins of Bath Grounds towards the centre of the area (Figure 5).

2.1.11. The LiDAR data also highlights many of the historical and current topographic features within Bath Grounds. For instance, the former courses of Gilwiskaw Brook are clearly visible in the south eastern part of Bath Grounds. Similarly, those less distinct, the LiDAR data detect a linear depression extending from the north to the south of Bath Grounds along the course of the culvert. This probably represents settlement and compaction of the soils above the built culvert. With regards to current features, the extent of the bowling green is clearly observed as a discrete square towards the eastern boundary of the area.

Services

2.1.12. Asset maps from Severn Trent Water have been reviewed to understand the current day water management situation at Bath Grounds. The asset map indicates that there are public combined gravity/lateral drains along the western and eastern perimeters of Bath Grounds (Figure 6). Two public surface water gravity/lateral drains converge in the vicinity of the southern part of the Bath Grounds. This location is depicted in the asset map as on the culverted water course.

2.1.13. The Severn Trent Water asset map also depicts the course of Gilwiskaw Brook as being in two culverts in close proximity to each other which converge at the southern end of the site. The two culverts effective traverse Bath Grounds directly from north to south.

2.1.14. The 2017 archaeological survey report also includes an historical sewer and drainage map produced in 1967 (Figure 7). This map depicts two parallel culverts dissecting the site along a similar route to Figure 6 but with course that is slightly to the east of the information provided by Severn Trent Water.

2.1.15. The two converging public surface water gravity/lateral drains (termed 9" sewers in the 1967 map) in the vicinity of the southern part of the Bath Grounds follow a similar course to the depiction in the Severn Trent Water asset map, but their location in 1967 is shown as being slightly to the north of the current day situation.

2.1.16. The 1967 map also shows a 12" storm sewer in the south east part of Bath Grounds. This occupies a former course of the Brook as shown on the early Ordnance Survey maps (Figures 2 and 3).

2.1.17. Information on other buried services or any land drains has not been reviewed,

2.2. Field surveys

2.2.1. A site visit was undertaken on 14th August 2020. The site visit investigated the soils, the topography, habitats and existing land uses within Bath Grounds. Incidental observations were also made on the public use of the green space.

Topographic survey

2.2.2. A field reconnaissance topographic survey was conducted to verify and ground truth the LiDAR data. A global positioning system (GPS) receiver was used to survey the site. The entire area of Bath Grounds was covered with a grid at a minimum of 10m intervals. More targeted readings were taken in areas of pronounced ground level change or to record specific features such as inspection chambers or trees (Figure 8). The topographic survey also extended along Gilwiskaw Brook both upstream and downstream of its entry and exit from the culvert (Figure 9). Stream bed levels were recorded so that the overall gradient of the stream could be understood in order to inform flood risk modelling and restoration design development.

2.2.3. The results of the field survey were compared with the LiDAR data. Within the open areas of Bath Grounds there was a strong correlation among values suggesting that the LiDAR data is relatively accurate in this area with a similar range in values between c.121 and 119mAOD observed. However, the LiDAR data was considered less accurate in the upstream and downstream reaches of Gilwiskaw Brook where the stream was in an open channel.

Soils

2.2.4. A walkover soil survey was conducted across Bath Grounds. Soils were investigated using a 70mm Dutch auger at several locations. Four summary descriptions were produced (Appendix 1).

2.2.5. The soils were predominantly silty clays, silty clay loams and sandy clays. No water was intercepted in any of the soil survey locations. Some mottling was observed suggesting that in the lower lying areas of Bath Grounds the water table may fluctuate to within 0.3 to 0.5m of the ground surface. Evidence of human disturbance and indications of made or disturbed ground were common with gravel, rubble and bricks common in some areas in the upper 0.4m of the soil profile.

Current land uses

2.2.6. Bath Grounds is a well-used urban green space utilized by the citizens of Ashby-de-la-Zouch, and from further afield, for a range of recreation and leisure activities. The open area has been described as the 'Jewel in the Crown' of the historic market town and has been awarded a Green Flag Award in recognition of its status as a well-managed green space[3]. The area has considerable heritage value, including links with the historic Ivanhoe Baths and Ashby Castle.

2.2.7. The area provides community sports facilities through the maintenance of a cricket pitch, along with a pavilion, and an area used for formal and informal playing of football (Figure 10). Historically, there were two bowling greens, however today there is only one set within a formal area towards the eastern part of the grounds.

2.2.8. There are formal and informal footpaths and trails around and across the area. These are used by a variety of visitors including dog-walkers, joggers and young and old people from the local community. The Friends of Bath Grounds also promote the heritage value of the site through use of guided talks and walks.

2.2.9. Apart from isolated trees and formal flowerbeds, the predominant habitat is that of improved amenity grassland.

Ground penetrating radar

2.2.10. A survey for buried features using electromagnetic, ground probing radar and Sonde location techniques was conducted on 20th January 2021 by Midland Survey Ltd.

2.2.11. The survey applied electromagnetic, ground probing radar and Sonde location techniques to establish the position and depth of the majority of buried main external services that exist within Bath Grounds. The survey approach recognised that in some circumstances it may not be possible to locate all buried services due to instrument limitations, site condition, geology or inaccessibility. The electro-magnetic survey helped to identify:

- Computer cables
- Sewers and drains of 100mm diameter and above where access is possible
- Underground heating pipes
- Metallic water and gas pipes of 38mm and above
- Metallic fuel pipes and mains
- Metallic pumping mains
- Telecom services in ducts
- Electric supply cables of 440v to 66kv, AC, which are live

[3] https://bathgroundsfriends.com/

- Electric cables to street lighting

2.2.12. The real time ground probing radar was used to detect, where archive drawings or local knowledge is available, the approximate location of the following:

- Voids / cavities
- Foundations
- Underground Utilities
- Storage tanks
- Culverts
- Pipe routes (metallic and non-metallic)
- Duct and cable routes

2.2.13. The survey company provided results as a DWG file. Features were mapped as lines only and no information was provided on the depth of features. Some descriptive information was provided for a few of the features. The features have been imported to a geographic information system (GIS) to integrate them with other information on the site (Figure 11).

2.2.14. The survey identified the following features:

- Surface water sewer
- Foul water sewer
- Electric services
- Unidentified features

2.2.15. The survey confirmed some of the previous information, particularly the Severn Trent Water assets map (Figure 6) and the historic sewer map from 1967 (Figure 7). For instance, the courses of the southern surface water sewers reflect the information on the 1967 map and the Severn Trent Water assets maps. It also concurred with some of the findings in the 2017 archaeological survey report. The line of the culvert also reflects the depiction in the 1967 map. However, it differs slightly to the lines indicated on the Severn Trent Water asset map.

2.2.16. The survey also shed new light on certain features. Electric services were identified on both the western and eastern margins of Bath Grounds. A, presumed to be, foul water sewer was observed to the north of the bowling green. A 600mm diameter surface water sewer was identified traversing the cricket ground from the centre of the western margin of Bath Grounds to the point where the culvert passes under the railway embankment. The most northern section of this sewer appears to partially follow the line of a path indicated on the 1967 map (Figure 7). However, this feature does not appear on any other sources.

3. Constraints assessment

3.1. Defining constraints

3.1.1. The objective of de-culverting the stream extends beyond simply removing the culvert and allowing the Brook to follow the same linear course. The intention is to restore a functioning stream ecosystem that will provide multiple benefits to the people of Ashby-de-la-Zouch. To achieve this a broad footprint for the potential course of the daylighted Brook needs to be defined. The information assembled in the desk and field studies was used to identify possible constraints on the future course of the restored watercourse.

3.2. Constraint mapping

3.2.1. The desk and field studies identified a variety of constraints that need to be considered. These included:

- Features of heritage or archaeological interest
- Buried services
- Recreation uses

3.2.2. In addition, consideration has been given to the broader informal uses of the important urban greenspace and particularly the routes people walk and the need to allow free movement around Bath Grounds. Other issues considered included the need to ensure that flood risk is reduced and that human health and safety concerns are addressed with regards to reinstating an open water course through a public greenspace.

3.2.3. A series of overlays have been produced in the GIS to assist with mapping and describing the constraints. Following consultation, the extent of constraints was revisited to ensure that local views were included (Figure 12). Constraints are defined as being existing features or uses that would potentially be problematic or challenging to the creation of a new course for the de-culverted Gilwiskaw Brook. Therefore, these areas are considered best avoided. Obviously, not all constraints will be known, particularly with regard to buried features of possible heritage value. However, based on the available evidence there are areas where currently there are limited known constraints. Similarly, it is possible that the entire area of greenspace could be considered as a constraint if society preferred to see the status quo maintained. However, this evaluation has focused on defining the practical rather than societal constraints on identifying a new course for the de-culverted Brook.

3.2.4. The land within Bath Grounds has been categorized into two categories:

- Limited known constraints
- Potential constraints

3.2.5. The areas categorized as 'Limited known constraints' are considered to possess limited constraints to construction of a new course for the Brook. However, these may be as yet unknown constraints in these areas, but on the balance of evidence currently available there are limited known constraints.

3.3. Conclusions

3.3.1. The information integrated into Figure 12 defines an envelope within which stream restoration could be implemented. The restoration envelope excludes the major formal recreational areas of the cricket pitch and the bowling green but would impinge on areas used for playing football. The restoration envelope also avoids areas of known archaeological interest. However, the restoration envelope traverses the former course of Gilwiskaw Brook towards the southern part of the site and any excavations in this area would need to be carefully undertaken.

3.3.2. Furthermore, the northern part of the existing culvert would need to be removed. The existing evidence is unclear as to the exact nature and route of this culvert, with differing sources providing slightly different information. The balance of evidence suggests that in this part of the site Gilwiskaw Brook flows through two near parallel culverts which converge towards the southern margin of Bath Grounds. With regards to the daylighting of the stream, this has limited implications as both culverts would need to be excavated and removed to allow a single channel to pass through Bath Grounds.

3.3.3. At the southern end, where the stream would remain in a culvert under the railway embankment, it is possible that there would be some ingress into an area of known constraint, namely the outfield of the cricket pitch. Additionally, the presence of surface water sewers, which currently pass under the southern parts of Bath Grounds, would need to incorporated into the final design of the restored channel.

3.3.4. Whilst there are no formal routes or paths, the daylighting of Gilwiskaw Brook would create a barrier to the west to east, and vice versa, movement of people across the greenspace. Therefore, within any designs there would be the need to ensure that crossing points providing access for all were provided. Similarly, management activities within the greenspace, such as grass cutting, would necessitate the movement of vehicular maintenance vehicles across Bath Grounds.

4. Concept development

4.1. Proposed channel

4.1.1. The potential restoration envelope described in Figure 12 provides the limits within which the route that the restored channel can be defined. The upstream (at the point the channel would emerge from the culvert(s)) and downstream (the point where the channel would re-enter the existing culvert under the railway embankment) bed levels are fixed and define the vertical fall of the channel. Within the restoration envelope, the sinuosity of the channel will define its overall length and, consequently, the gradient and energy regime of the channel.

4.1.2. The planform of the channel has considered both the original course of the Brook within Bath Grounds and also the course of the Brook upstream and downstream of Ashby-de-la-Zouch where a more natural channel exists. However, analysis of existing maps suggests that over much of the downstream course of the Brook the channel has been straightened or altered. Upstream of the town, a similar situation is also observed but with the added challenge that the surrounding topography comprises land with steeper slopes than the area around Bath Grounds. Consequently, using the planform of the existing channel elsewhere in the system is not possible.

4.1.3. The cross-sectional profile of the restored stream considered two main factors. Firstly, given the urban location and current usage of the area, steep bank gradients were considered inappropriate to possible health and safety implications. Secondly, the gradient and length of bank slopes was dictated by the predicted channel bed level and the excavated depth needed to achieve this level. Therefore, the actual bank-top to bank-top width is dictated by the existing ground levels, the desired bank gradient and the proposed channel bed invert level.

4.1.4. Information on appropriate bank gradients for de-culverted stream within an urban park setting was gathered from similar projects undertaken elsewhere in England (Appendix 2). Maximum bank gradients are proposed not to exceed 1:1 and ideally will be between 1:2 and 1:3 or more.

4.1.5. A conceptual channel planform with illustrative cross-sectional profiles was produced to demonstrate the potential configuration within the restoration envelope (Figure 13). This was essential to inform both the overall future design but more important to facilitate a robust assessment of the potential flood risk associated with the proposals.

4.2. Flood risk assessment

Hydrology

4.2.1. The site is located within the catchment of the Gilwiskaw Brook, approximately 12km east of the main channel of the River Trent. The catchment draining to the Bath Grounds covers 7.10 km^2, as shown in Figure 14. The boundary was defined using the Flood Estimation Handbook (FEH) web service (CEH, 2020) but modified to fit to the boundary of the study area based on the 1m digital terrain model (DTM). Parameters from the FEH show the catchment has a relatively low annual average rainfall of 679mm and an urban extent of 14.76% since it covers a significant part of Ashby -De-La-Zouch. The base flow index of 0.597 show there is a significant groundwater component to the flow. This parameter ranges from 0 to 1 with zero being entirely surface water fed and 1 being entirely groundwater fed. The various sandstone formations known to present in the area are classified as principal aquifers.

4.2.2. Neither the Gilwiskaw Brook, nor the River Mease, are gauged, and there are no gauging stations on a neighbouring river which drains similar areas. The nearest gauging station is on the River Trent at Drakelow Park (28019) with records dating back to 1959. Here, the Trent drains a catchment of 3,072km^2. The NRFA (2020) lists a mean flow of 36 cumecs and a median annual flood (a 2-year return period) 177 cumecs. The maximum flow on record was gauged as 385 cumecs in November 2000, with other recent high flows above 300 cumecs in November 2012 and July 2007, as shown in Figure 8. The Gilwiskaw Brook may also have experienced high flows during this time, but a few days before the Trent given the time lag for the water to find its way into the larger river channel.

4.2.3. The Gilwikskaw Brook is culverted for a length of 980m from the south of Kilwardby Street some 500m north of the site (Figure 1), to an outlet 217m to the south of the site (Figure 1). This incorporates a c.250m culverted section through the Bath Grounds. The exact date the culvert was installed is uncertain but it is expected to be sometime during the early 20th Century. Prior to that the brook had a course to the eastern part of the Bath Grounds, as shown in historical maps (Figure 2 and Figure 3).

Historical Flooding

4.2.4. As part of a Flood Risk Assessment the risk of flooding at the site from all sources needs to be considered, including incidents of historical flooding at the site. Records of historical flooding on the Gilwiskaw Brook are fairly sparse given the lack of any flow monitoring. There are no entries for the Gilwiskaw Brook or Ashby-de-la-Zouch in the British Hydrological Society chronology of hydrological events. A strategic flood risk assessment (SRFA) was completed by Atkins (2015) on behalf of North West Leicestershire District Council. The SRFA recorded instances of significant flooding of roads from Gilwiskaw Brook, notably in July 2001 when one property and five gardens flooded. The report anticipates that climate change will increase extent of flooding in Ashby-de-la-Zouch from Gilwiskaw Brook. June 2016 saw flash flooding across the Midlands, including in Ashby-de-la-zouch (ITV, 2016).

River Flooding

4.2.5. Flood risk maps provided by the Environment Agency (EA) show the current risk of flooding from rivers and are available in digital format on the internet. The EA define the severity of the flood by its return period. A flood with a 1 in 100-year return period is expected to occur on average just once in a period of 100 years and is referred to as a 100-year flood in this report. The map in Figure 15 shows the flood zones which are defined as flood zone 3 – high risk (the area within the 100-year flood extent), flood zone 2 – medium risk (between the 100-year extent and the extreme flood outline) and flood zone 1 – low risk (outside the extreme flood outline. The extreme flood outline is a combination of the predicted 1000-year flood extent and the worst historic flood outline.

4.2.6. The EA (2020) flood risk map (Figure 15) suggests that the majority of the Bath Grounds is within flood zone 2, having a medium probability of flooding (1 in 100 to 1 in 1000 annual probability of flooding). Further data provided by the EA produced by 2-d hydrodynamic modelling as part of the Ashby Hazard Mapping Study in 2105 confirmed this assumption (Figure 16 and Figure 17). The 2-d modelling provides flood levels for locations around the Bath Grounds for both the 100-year +20% and 1000-year floods. The levels range from 119.73m AOD to 121.52m AOD for the 100-year + 20% scenario, and from 120.44 to 121.76m AOD for the 1000-year scenario. These are absolute flood levels and should be considered with the LiDAR DTM shown in Figure 5 which shows the normal ground levels rising from less than 120mAOD to slightly in excess of 122mAOD.

Surface Water Flooding

4.2.7. Surface water flooding directly from the overland flow and ponding of heavy rainfall is also a risk which needs to be considered, especially after the floods of June and July 2007 where many areas were flooded through this mechanism. Surface water flooding is commonly experienced in urban areas where the impermeable surfaces promote the flow of water over the surface. In 2013, the EA released maps of surface water flooding (Figure 18). The maps are generated by considering the flow pathways of extreme rainfall over the land surface. The map shows the Bath Grounds to be in an area of moderate to high risk of surface water flooding. The surface water flooding will largely follow the extent of the valley of the Gilwiskaw Brook, although as Bath Grounds is a broader flatter area confined by the railway line embankment this would cause surface water to spread out over most of its extent. The surface water flood maps however do not consider the permeability of surface as the Bath Grounds is not an impermeable urban area the surface water would be able to infiltrate into the soil.

4.2.8. Incidents of surface water flooding are dependent on the occurrence of intense rainfall, normally associated with convective storms over the summer months. Incidents of extreme 24-hour rainfall are available from the British Rainfall Digital Archive (OasisHub, 2020). Extracts from the archive for rainfall around the Bath Grounds shows four events where more than 50mm of rain fell in 24 hours were observed over the past 130 years (Table 1)

Table 1. Extreme Rainfall from the British Rainfall Digital Archive.

Location	Date	24-hour Rainfall (mm)	Distance from Bath Grounds
Ashby, Coal Hall	11/07/1893	56.4	1km south
	05/10/1913	60.2	
	21/05/1932	59.7	
Church Gresley	06/07/1957	69.9	5.5km west

Design Flow Estimates

4.2.9. Since the Gilwiskaw Brook is un-gauged, estimates of flow for the design 100-year flood plus a suitable allowance for climate change have to be generated from rainfall-runoff modelling. This has been done using the ReFH2 software (WHS, 2019) from the FEH, which is the standard method for UK flood estimation in small catchments. The software generated a 100-year flood hydrograph from a 7-hour critical duration rainfall of 52.2mm. This rainfall is considered an appropriate estimate given the observations over the longer 24-hour period shown in Table 1.

4.2.10. The latest climate change guidelines (Environment Agency 2021) give a range of allowances depending on the region, the timeframe and the purpose of the assessment. In this case, the Gilwiskaw Brook in Ashby-de-la-Zouch is in the Tame, Anker and Mease catchment region, the range of climate change allowances for this area are shown in Table 2. It is expected that the de-culverting of the stream will be a permanent measure so the time-frame should be considered up to the end of the century. The allowance categories are given by the EA in relation to development, and the higher categories are required for more critical or vulnerable developments such as flood defences and care homes. As the primary purpose of the work is to re-establish a more natural course of the Brook this does precludes any development in the form a built structures. However, the channel will be passing through a well-used public area and its design will have implications on the residential areas of the town adjacent to Bath Grounds. Therefore, a higher central allowance of 30% was selected. The Upper allowances are recommended for critical infrastructure and vulnerable developments in high-risk flood zones.

Table 2. EA Climate Change Allowances for the Tame, Anker and Mease catchments.

Epoch	Percentage increase of flow per time period (%)		
	Central	Higher	Upper
2020s	10	15	24
2050s	11	17	30
2080s	22	30	51

4.2.11. The ReFH2 hydrographs are shown for the 100-year and 100-year plus 30% flood events in Figure 19. The modelled peak flow for Gilwiskaw Brook for the 100-year flood is 3.60 cumecs, and for the 100-year +30% it would be 4.68 cumecs.

Hydrodynamic Modelling

4.2.12. In order to assess the potential impact of flooding of a de-culverted Gilwiskaw Brook on the Bath Grounds, a 1-d hydrodynamic model was generated using the FloodModeller Pro software. The orientation of the channel was selected to avoid constraints on the existing land use of the Bath Ground and sub-surface features identified form the GPR survey as shown in Figure 12. The conceptual design of the de-culverted section was based on a two-stage channel to allow low flows to be confined to a narrow channel but to extend into the larger surrounding broadly trapezoidal channel during times of flood (Figure 13 and Figure 20). Design cross sections were kept relatively simple at this stage in order to inform the flood risk modelling.

4.2.13. The existing EA hydrological model of the site, which was used to generate the flood risk maps shown in Figure 16 and 17, was provided and edited to construct the new hydrodynamic model. The EA model is an ISIS(1D)/Tuflow(2D) linked model with the area around the Bath Grounds represented as shown in the schematic in Figure 21.

4.2.14. The original EA model bifurcates Gilwiskaw Brook into two channels within the northwest corner of Bath Grounds. The model depicts two distinct channels through Bath Grounds and extending some distance to the south of the railway embankment (Figure 21). For the purpose of the flood risk modelling one channel was removed as there was no evidence of this from any information reviewed as part of the desk study and from any field observations within Bath Grounds or the wider area. However, there is evidence that suggests that for part of its length under Bath Grounds Gilwiskaw Brook may flow in two near parallel culverts.

4.2.15. The upstream extent of the model was cut to start just upstream of the culverted section. The downstream extent of the model was cut at the railway embankment, the point at which the proposed daylighted section of the channel is likely to connect back to the culvert. The sections of the new de-culverted stream have been included as the dimensions shown in Figure 20, with the gradient based on the existing DTM for the site.

Table 3. Cross section details for the proposed channel.

Section	Cumulative Distance (m)	Bed level (m AOD)
A	0	118.55
B	36	118.48
C	93	118.37
D	120	118.34
E	174	118.29
F	239	118.23
G	325	118.15

4.2.16. A 2m long, 2m wide, 1m high box culvert at section D has been assumed to allow pedestrian access over the de-culverted section within the Bath Grounds. The model then also assumes the addition of a new culvert section connected to an outfall located within the site boundary with an invert level of 118.550 mAOD (the bed level of section A). The proposed sections were added to the model at distances provided and shown in Table 3. For the purposes of modelling, weir unit has been included at the downstream end to drop water from the proposed channel into the existing culvert and a number of interpolation units were added to the proposed channel to aid model stability. The final designs would not include a weir and appropriate profiling of the channel would be included. The design flood hydrographs from Figure 19 were used as the single flow input to the model. As these were generated for the catchment at the southern boundary of the Bath Grounds there was no need to include any lateral inflow from the Bath Grounds area itself. A schematic of the new model with the design sections is shown in Figure 22.

4.2.17. The predicted maximum water levels for each model section under the 100-year and 100-year+30% climate change allowance are listed in Table 4. The flood depth and extent associated with these levels were generated in a GIS using an interpolation routine. The river channel was "burned" into the DTM for the Bath Grounds site based on the proposed two-stage channel geometry. A water surface was generated by interpolating the water levels between the cross sections, with the sections being extended to on average around 75m in width. The DTM was then subtracted from this surface and all negative cell values were removed to show the flood depth.

4.2.18. Maps of the flood depth and extent are shown in Figures 23 and 24. These show where flood water may extend from the de-culverted channel as a result of the high flow in the Gilwiskaw Brook. They do not show the additional effect of any surface water flooding which may occur during the same event purely from the effect of heavy rainfall. Under the 100-year scenario there is a small area of shallow flooding outside of the channel in the southern part of the Bath Grounds. This area extends considerably under the 100-year plus 30% climate change scenario flooding the central area by up to 0.5m deep.

The flooding however is all contained within the area of the Bath Grounds and is not affecting any of the surrounding urban area.

Table 4. Predicted maximum flood levels

Section	Flood level (m AOD)	
	100-yr	100-yr +CC
A	120.15	120.3
B	120.1	120.25
C	120.02	120.17
D (upstream)	119.98	120.13
D (downstream)	119.97	120.11
E	119.88	120.02
F	119.76	119.9
G	119.46	119.61
G (outlet)	118.51	119

4.2.19. Simulations were also undertaken using the culvert as set up in the existing EA model as a baseline scenario. The modelling indicates that during the 1 in 100 year plus climate change scenario, approximately 16,500 m^3 of water would spill from manholes in the upstream section of the culverted stream out into the town causing localised flooding. The results of the modelling suggest that by de-culverting the Gilwiskaw Brook, water levels upstream are lowered and surcharging of manholes would be prevented. It is likely this is due to both increasing the storage available downstream and passing more flow downstream since the effects of surcharging the culverts are reduced.

4.2.20. Further modifications to the channel could be made to reduce the extent of the flooding within the Bath Ground if necessary, and to optimes the type of structures at the upstream and downstream boundaries of the de-culverted section. This work should be conducted as part of the detailed design phase.

Conclusions

4.2.21. The flood risk modelling is based on an initial concept plan. Additional modelling would be required at a detailed design stage. However, based on the initial concept designs, the proposed de-culverting of Gilwiskaw Brook would not increase flood risk upstream or downstream of Bath Grounds. The modelling suggests that by daylighting the Brook, and effectively increasing lost floodplain storage, that there would be a beneficial reduction of flood risk upstream. However, by creating a stretch of open channel increases the flood risk within the confines of the urban greenspace. This increase in flood risk is effectively confined to the area currently used as the cricket pitch.

5. Concept designs

5.1. Overall description

5.1.1. The overall objective is to improve the quality of the water and the habitat in Gilwiskaw Brook in order to benefit the wider River Mease SAC. The daylighting of an urban stream also provides the opportunity to deliver on other benefits for the local community. The principle additional benefit would be to reduce flood risks to property and infrastructure both upstream and downstream of Bath Grounds.

5.1.2. Whilst the removal of the Brook from the culvert within Bath Grounds will still produce a reach that is relatively isolated from the wider river system, there is also the opportunity to enhance the river corridor for the benefit of biodiversity. Within the de-culverted section there is the opportunity to create a diversity of habitats which will support a variety of fauna and flora.

5.1.3. Working within the footprint defined by the constraints analysis, the following design elements have been incorporated into the concept design development:

- A meandering channel set within a river corridor of variable width.
- A diversity of channel profiles and depths.
- A smooth longitudinal gradient between the two sections of existing culvert.
- Low flow and high flow channels which will be inundated to differing depths and duration.
- Different substrates within the river channel.
- A variety of wetland habitats within the river corridor including permanent open water channels, seasonally inundated back channels, tall-herb emergent vegetation, sparsely vegetated gravels, wet woodland and wet meadow.
- Riparian tree planting in strategic locations to enhance connectivity with existing trees and woodland and to provide foraging routes for bats.
- A mix of terrestrial habitats including wildflower grassland, riparian trees and species-rich grassland.
- Disposal of spoil through landscaping to provide low nutrient value substrate for establishing wildflower grassland and to provide a physical deterrent to reduce risk of cricket balls entering the Brook.
- Crossing points to provide good access across the greenspace.

5.1.4. An original concept design was produced (Figure 25). Following consultation, the proposals were modified to retain as much of the informal playing field areas as possible (Figure 26). Illustrative cross-sections are shown in Figure 27.

5.1.5. The potential of the river corridor to store flood water, as based on the flood risk modelling, has been increased and the designs have ensured that the predicted patterns of flooding would be accommodated.

5.1.6. The design of the de-culverted Brook within the river restoration corridor aims to increase greatly the contact time between the water flowing along the Brook and the plants and substrates. The proposed designs will increase this considerably in comparison to the passage of water through the existing culvert. Therefore, the proposals should provide opportunities to improve water quality through the trapping of fine sediment and the removal of nutrients through biogeochemical processes.

5.1.7. Consideration has been given to the current uses within Bath Grounds. Consequently, both pedestrian and vehicular access across the Brook have been provided to allow options for people using the area and also for the movement of maintenance vehicles to facilitate land management activities. Similarly, the recreational uses for sports have been taken into account and these areas have been retained without significant encroachment. A small, low level spoil bund is proposed to the east of the cricket pitch to reduce the risk of cricket balls entering the stream.

5.1.8. Given the urban character of the site, further consultation will be required regarding the necessity for screening on the upstream and downstream ends of the open channel. These will need to designed to the appropriate standard as specified in the CIRIA Culvert, scree and outfall manual (C786).

5.1.9. The creation of open water within an urban setting will attract people to the river corridor. The de-culverted stream will potentially enhance the aesthetics of the urban greenspace by added structural and visual diversity to the landscape. The creation of different habitats will provide conditions suitable for a range of different flowering plants. These plants will be attractive to humans but will also to a range of pollinators including butterflies, wasps and bees. During warm weather, the creation of wetland habitats will also moderate and cool air temperatures within the vicinity of the Brook.

5.1.10. Opportunities will also exist to use the de-culverting of Gilwiskaw Brook to catalyze environmental education opportunities. These could be through informal signage and interpretation, or through more formal linkages with local schools and colleges, the development of citizen science initiatives or guided walks. Such activities would be compatible with the existing programmes of the Friends of Bath Grounds.

6. Conclusions and recommendations

6.1. Conclusions

6.1.1. The feasibility study has demonstrated that there are several constraints to the de-culverting of Gilwiskaw Brook. However, despite a variety of constraints, it is possible to define a potential stream restoration envelope that contains minimal constraints. Within this envelope is possible to define a proposed river restoration corridor and to develop a robust concept design.

6.2. Recommendations

6.2.1. There remain several issues to be resolved before the de-culverting of Gilwiskaw Brook could become a reality. The following activities are recommended.

Concept design review

6.2.2. It is recommended that TRT , along with relevant partners and stakeholders, review the concept designs to ensure that they satisfy their aspirations and address their concerns. Once this review has been concluded, modifications to the concept designs may be required.

Further work

6.2.3. Once a concept design has been agreed, there are several additional studies and pieces of work required. Trial pitting is required to investigate further the ground conditions within the river restoration corridor. At least three trial pits should be dug and recorded. It is recommended that a precautionary approach is take to the trial pitting given the potential to unearth features of heritage value.

6.2.4. Once a final concept design has been agreed, it would be beneficial to produce additional artistic impressions that provide a better context of the scheme within the landscape of Bath Grounds.

6.2.5. The feasibility study has highlighted some outstanding issues that, whilst it is highly unexpected that these would alter the overall outcome of the feasibility study, still need to be resolved. The following outstanding issues require resolution:

- It remains unclear as to whether there is a single culvert or whether the Brook flows under Bath Grounds for part of its course in two, near parallel culverts. Ideally, original design drawings should be sought or a within culvert camera survey conducted to assess this. Additional consultation has been undertaken with the EA to confirm this. Prior to moving to a detailed design, the implications of changes to the culverted watercourse need to be finalized.

- Both the ground penetrating survey work conducted as part of the feasibility study, and the 2017 archaeology report, have highlighted some unknown buried features. These may warrant further investigation.
- Whilst a search for services has been conducted as part of the feasibility study, not all service providers, such as telecommunications, have been assessed. As a precautionary approach, a further services search should be conducted and during any earthworks a pre-dig scan should be conducted.
- Within Bath Grounds there may be sub-surface land drainage which currently drains into the culvert. Whilst it would be relatively easy to accommodate this within any final design, if information exists it would be useful to review.

Next steps

6.2.6. It will be necessary to undertake further consultation with both stakeholders and the users of Bath Grounds. Consultation will be required as part of seeking the necessary planning consents and environmental permission relating the de-culverting of a main river.

6.2.7. Potentially, a more detailed design will be required as part of a planning application. This will need to consider a range of issues, not least health and safety concerns and the interface between the existing culvert and the new channel.

6.2.8. A key part of the design stage will be the consideration of volume of spoil to be generated and options for removal. As described above, some of the spoil could be used for landscaping within Bath Grounds. This could create interesting landforms as well as provide relatively low-nutrient substrates upon which wildflower grasslands could be created.

6.2.9. There may be the need to undertake further geomorphological studies in order to gain the relevant environmental permits. However, it is recommended that the detailed design should avoid being overly prescriptive allow geomorphological processes to evolve naturally over time within the defined river corridor.

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Figures

Appendix 1 Soil descriptions

Location	Bath Ground					
Core no.	S1	Soil moisture	Dry	Type of soil material		Mineral
Depth cm		Matrix colour		Mottle colour	Mineral particle size	Organic matter characteristics
0				Ground level		
10		10YR 4/4 Dark Yellowish Brown		No Mottle	Silty Clay	Roots and Humose. Very friable.
20		10YR 4/4 Dark Yellowish Brown		No Mottle	Silty Clay	
30		10YR 4/4 Dark Yellowish Brown		No Mottle	Silty Clay	Well rounded gravel appearing at 35cm depth. <20mm in size
40		10YR 4/4 Dark Yellowish Brown		No Mottle	Sandy Loam	Large pebbles and rounded gravels at 40cm depth. Some subangular
50						
60						
70						
80						
90						
100						
Notes	Could only dig down to 40cm. Water table not intercepted					

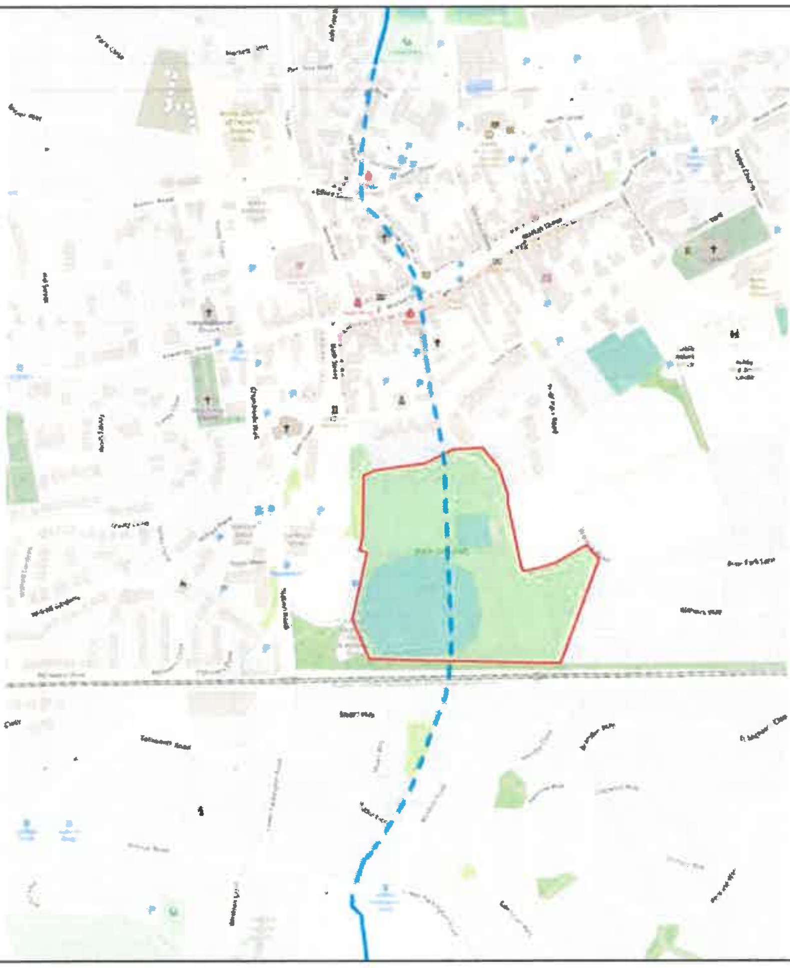
Location	Bath Ground					
Core no.	S2	Soil moisture	Dry	Type of soil material		Mineral
Depth cm		Matrix colour		Mottle colour	Mineral particle size	Organic matter characteristics
0				Ground level		
10		10YR 4/3 Brown		No Mottle	Silty Clay Loam	Roots and Humose. Bricks and gravels
20		10YR 4/3 Brown		No Mottle	Silty Clay Loam	Bricks and gravels
30		10YR 5/2 Grayish Brown		30% 10YR 5/8 Yellowish Brown	Clay Loam	No gravels but bits of bricks
40		10YR 5/2 Grayish Brown		30% 10YR 5/8 Yellowish Brown	Clay Loam	No gravels but bits of bricks
50		10YR 5/2 Grayish Brown		40% 10YR 5/8 Yellowish Brown	Sandy Clay	
60		10YR 5/2 Grayish Brown		40% 10YR 5/8 Yellowish Brown	Sandy Clay	
70		10YR 4/2 Dark Grayish Brown		30% 10YR 5/8 Yellowish Brown	Sandy Clay	Gravels (less than 20%) and pockets of sand (colour 10YR 7/8 Yellow
80		10YR 4/2 Dark Grayish Brown		30% 10YR 5/8 Yellowish Brown	Sandy Clay	
90						
100						
110						
Notes	Went down to 85cm. Water table not intercepted. Also some black mottling bewtten 40cm and 80cm depth					

Location	Bath Ground					
Core no.	S3	Soil moisture	Dry	Type of soil material		Mineral
Depth cm		Matrix colour		Mottle colour	Mineral particle size	Organic matter characteristics
0				Ground level		
10		10YR 4/3 Brown		No Mottle	Silty Clay Loam	Roots and Humose
20		10YR 4/3 Brown		No Mottle	Silty Clay Loam	Small pebbles and gravels <10mm
30		10YR 4/3 Brown		No Mottle	Silty Clay Loam	Small pebbles and gravels <10mm
40		10YR 4/2 Dark Grayish Brown		No Mottle	Sandy Clay	Very occasional pebbles
50		10YR 5/1 Gray		10% 10YR 5/8 Yellowish Brown	Clay	No pebbles
60		10YR 5/1 Gray		10% 10YR 5/8 Yellowish Brown	Sandy Clay	Very occasional pebbles
70	Unable to dig further due to large flints					
80						
90						
100						
Notes	Went down to 65cm. Water table was not intercepted.					

Location	Bath Ground					
Core no.	S4	Soil moisture	Dry	Type of soil material		Mineral
Depth cm	Matrix colour		Mottle colour		Mineral particle size	Organic matter characteristics
0	Ground level					
10		10YR 2/1 Black		No Mottle	Made Ground	Roots and Humose to 15cm
20		10YR 2/1 Black		No Mottle	Made Ground	Gravel and pebbles <1cm
30		10YR 2/1 Black		No Mottle	Made Ground	
40		10YR 2/1 Black		No Mottle	Made Ground	
50		10YR 4/2 Dark Grayish Brown		15% 10YR 4/6 Dark Yellowish Brown	Silty Clay	
60		10YR 4/2 Dark Grayish Brown		15% 10YR 4/6 Dark Yellowish Brown	Silty Clay	
70		10YR 4/2 Dark Grayish Brown		15% 10YR 4/6 Dark Yellowish Brown	Silty Clay	
80		10YR 4/2 Dark Grayish Brown		15% 10YR 4/6 Dark Yellowish Brown	Silty Clay	
90		10YR 4/2 Dark Grayish Brown		15% 10YR 4/6 Dark Yellowish Brown	Silty Clay	Pebbles
100						
Notes	Went down to 95cm. Water table not intercepted.					

Soil profile (SC2) from Bath Grounds.

Appendix 2 River Ravensbourne case study



Bath Grounds
Gilwiskaw Brook
Gilwiskaw Brook – culverted (approx.)

N

0 100 200
m

Notes:
Scale approximate

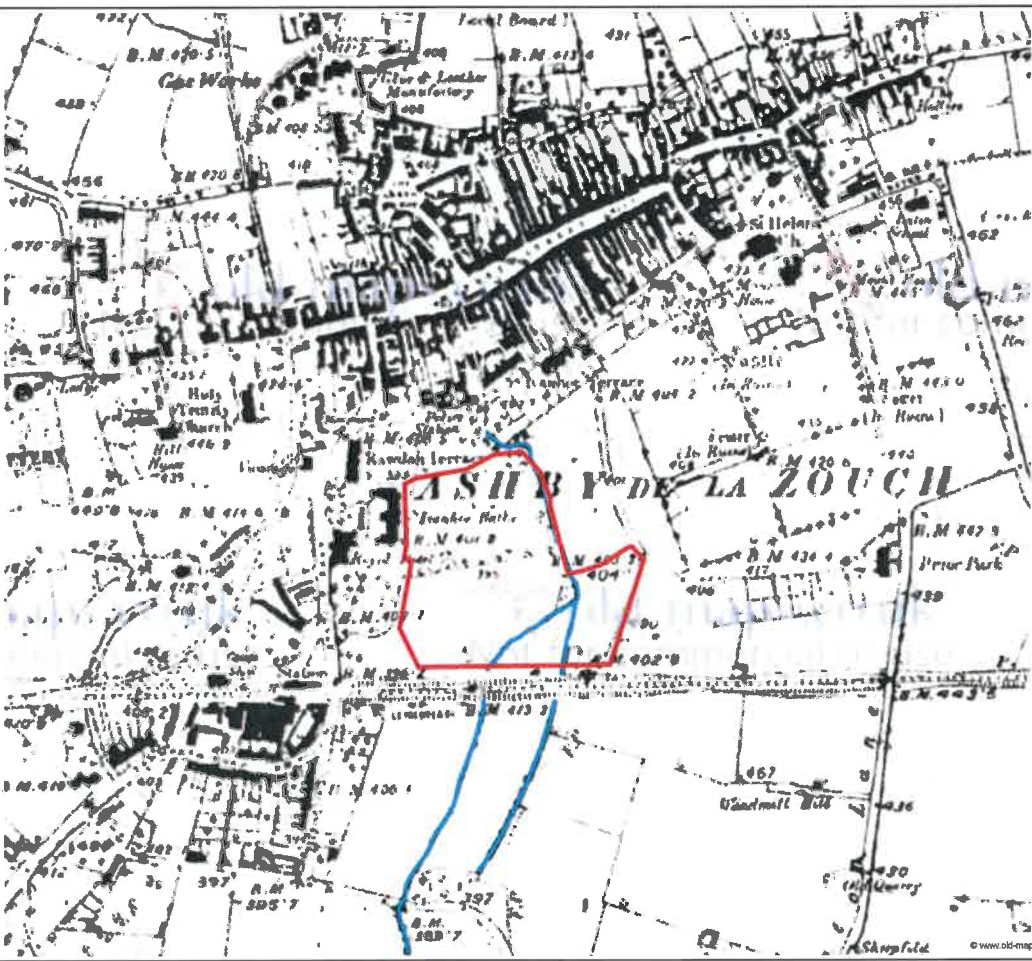
Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 1. Site layout

Drawn: RJM **Checked:** RAW

RM Wetlands & Environment
Ladman Villas, Littleworth, Oxon. SN7 8EQ
T: 01367 248081 E: info@rmwe.co.uk



Bath Grounds (approximate)

Gilwiskaw Brook – Former courses

N

0 150 300

m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 2. 1887-1888 Ordnance Survey map

Drawn: RJM **Checked:** RAW

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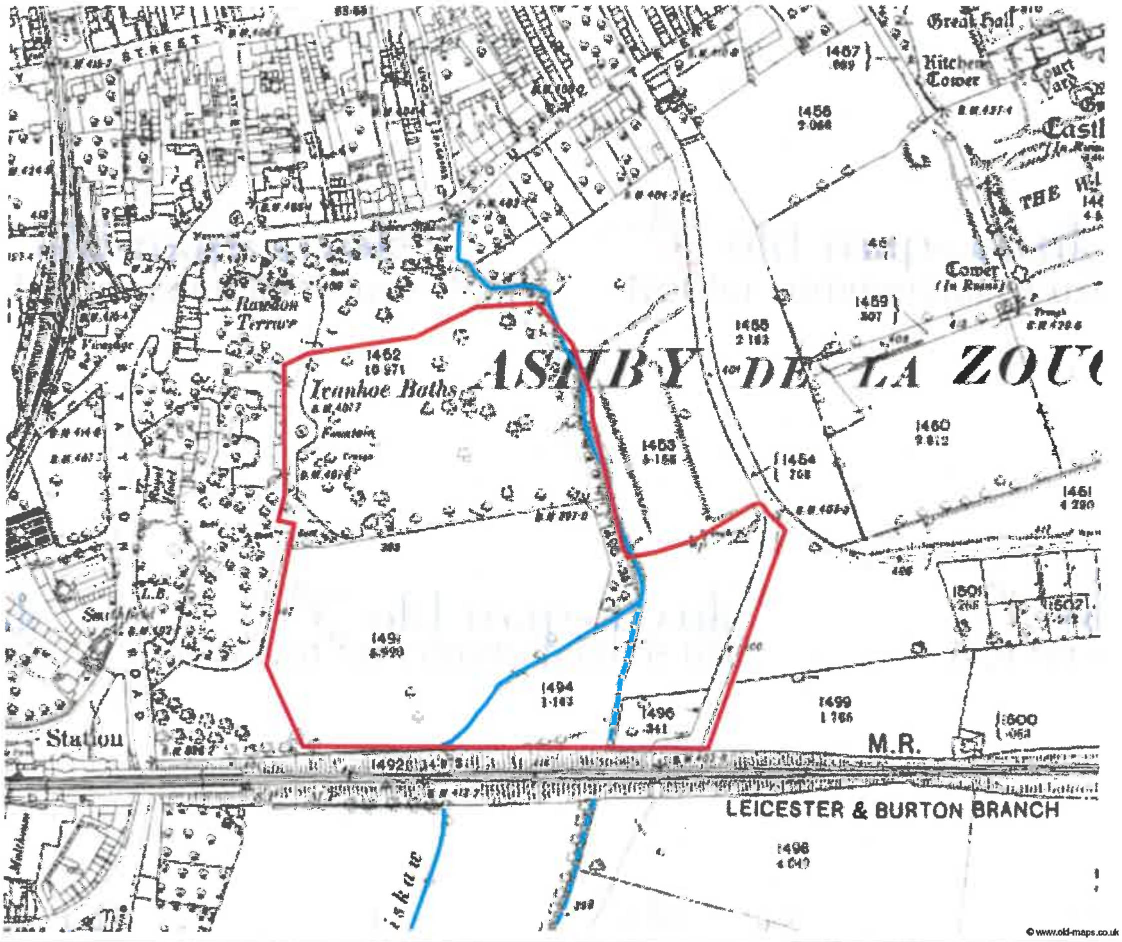

Bath Grounds

Gilwiskaw Brook – Former courses

Gilwiskaw Brook – Former courses infilled

N

0 150 300
m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 3. c.1910 Ordnance Survey map

Drawn: RJM **Checked:** RAW

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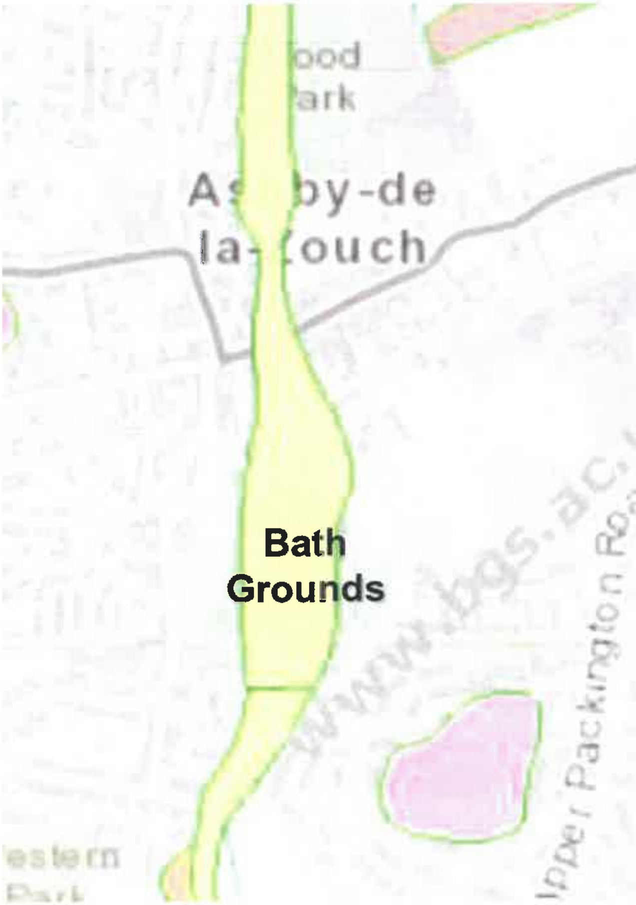

Alluvium

N

0 150 300
m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 4. Superficial geology

Drawn: RJM **Checked:** RAW

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Bath Grounds

N

0 50 100
m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 5. LiDAR data

Drawn: RJM **Checked:** RAW

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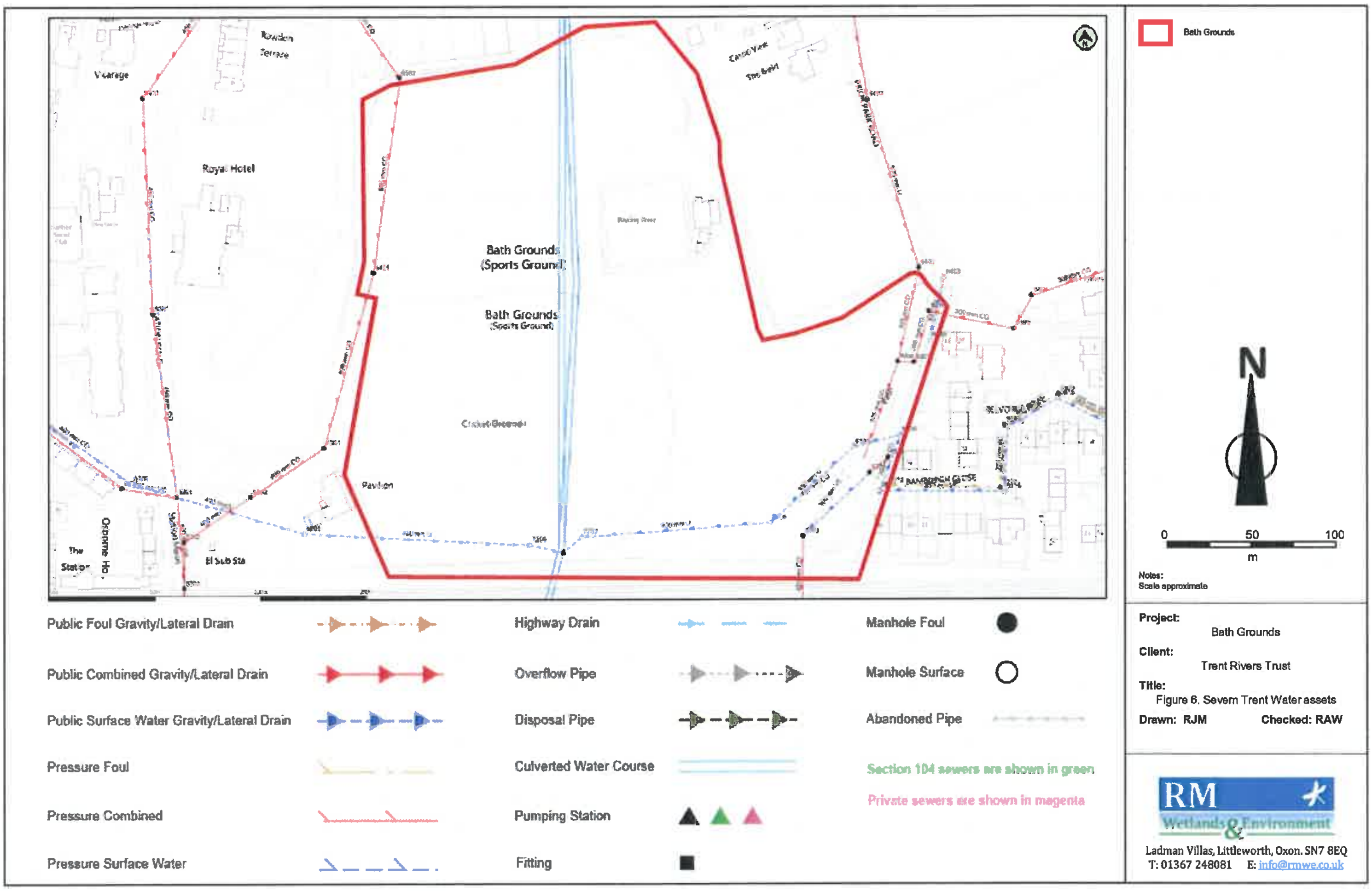

Royal Hotel
Vicarage
Bath Grounds
(Sports Ground)
Bath Grounds
(Sports Ground)
Pavilion
El Sub Sta
Bath Grounds
N
0
50
100
m
Notes:
Scale approximate
Public Foul Gravity/Lateral Drain
Public Combined Gravity/Lateral Drain
Public Surface Water Gravity/Lateral Drain
Pressure Foul
Pressure Combined
Pressure Surface Water
Highway Drain
Overflow Pipe
Disposal Pipe
Culverted Water Course
Pumping Station
Fitting
Manhole Foul
Manhole Surface
Abandoned Pipe
Section 104 sewers are shown in green
Private sewers are shown in magenta
Project:
Bath Grounds
Client:
Trent Rivers Trust
Title:
Figure 6. Severn Trent Water assets
Drawn: RJM
Checked: RAW
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Bath Grounds

N

0 50 100
m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 7. Historical water management

Drawn: RJM **Checked:** RAW

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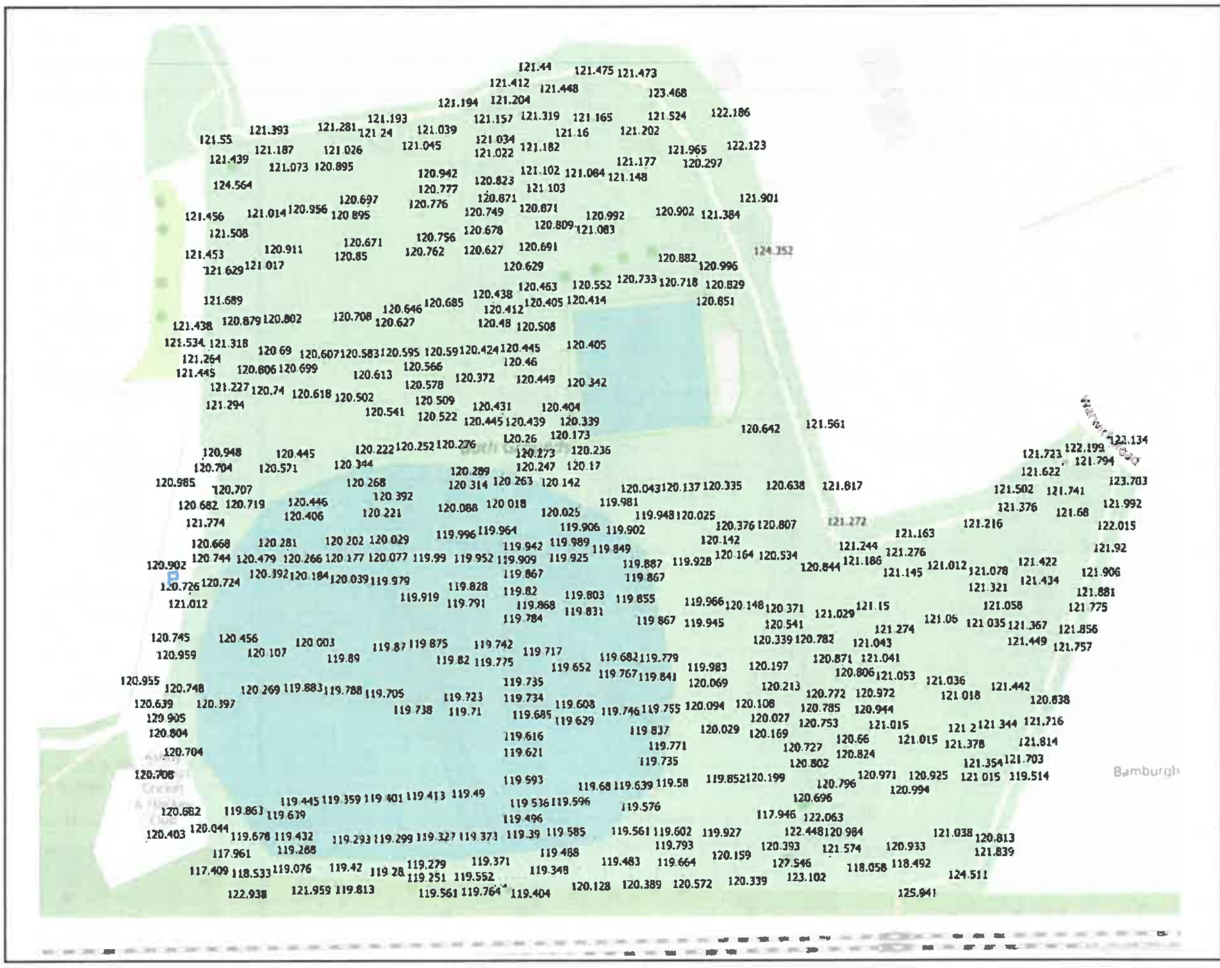

Bath Grounds

. 121.965 Surveyed spot heights (mAOD)

N

0 25 50

m

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 8.Topographic survey data – Bath Grounds

Drawn: RJM **Checked:** RAW

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Bath Grounds

121.965 Surveyed spot heights (mAOD)

N

Notes:
Not to scale

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 9.Topographic survey data - Brook

Drawn: RJM **Checked:** RAW

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South Street
Bath Street
The Royal Hotel
Informal playing field
Bowling Club
Bath Grounds
Cricket pitch
Warwick Road
Bath Grounds
Land use constraint
Linear constraint (formal and informal footpath)
N
Project:
Bath Grounds
Client:
Trent Rivers Trust
Title:
Figure 10. Constraints – Current recreational uses
Drawn: RJM
Checked: RAW
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Bath Grounds
Surface water sewer
Foul water sewer
Electric
Unidentified

N

Notes:
Not to scale
① Culvert
② 600mm sewer

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 11 Ground penetrating radar survey results

Drawn: RJM **Checked:** RAW

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Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 12. Constraints – Summary

Drawn: RJM **Checked:** RAW

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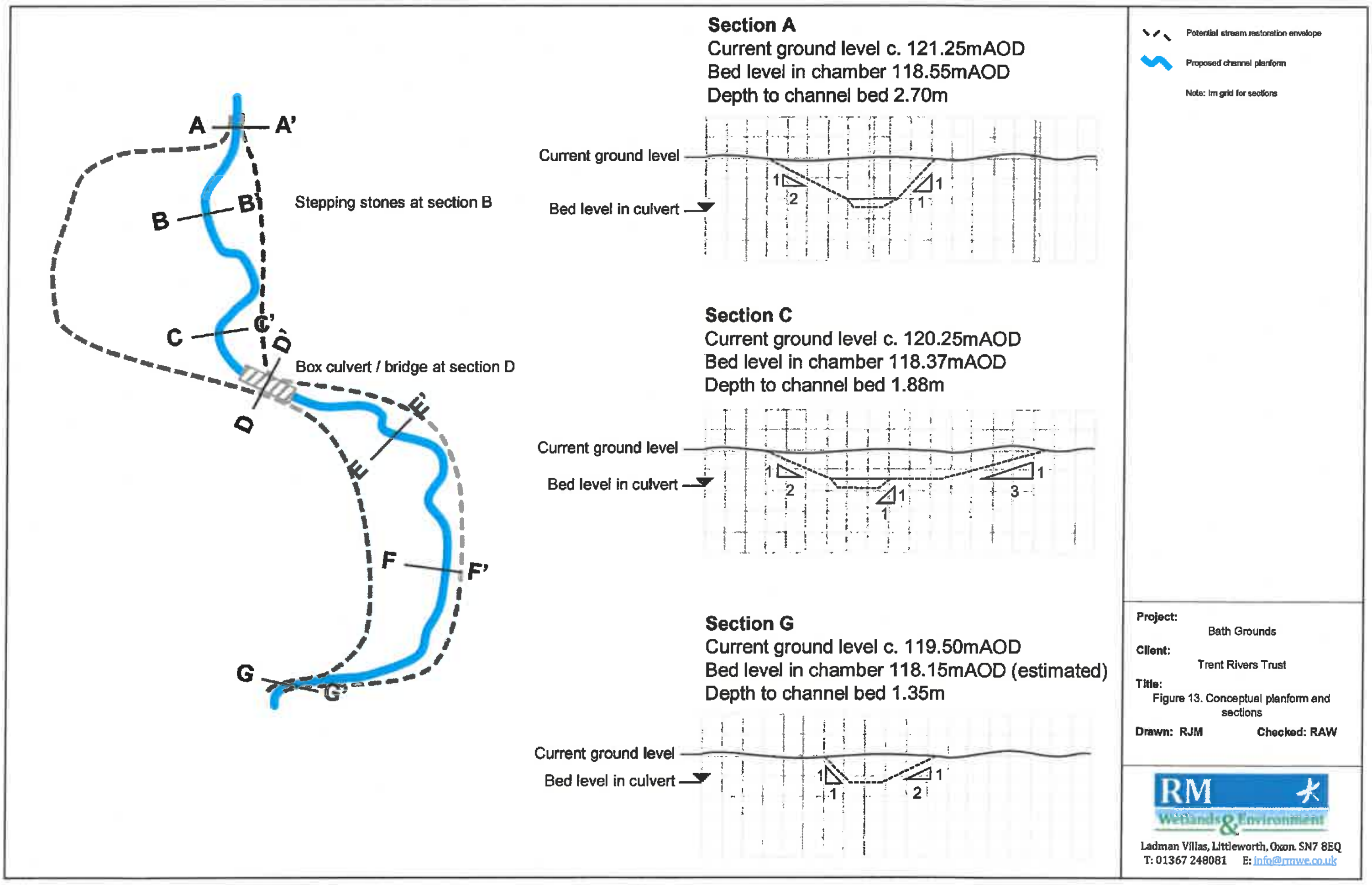

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 13. Conceptual planform and sections

Drawn: RJM **Checked:** RAW

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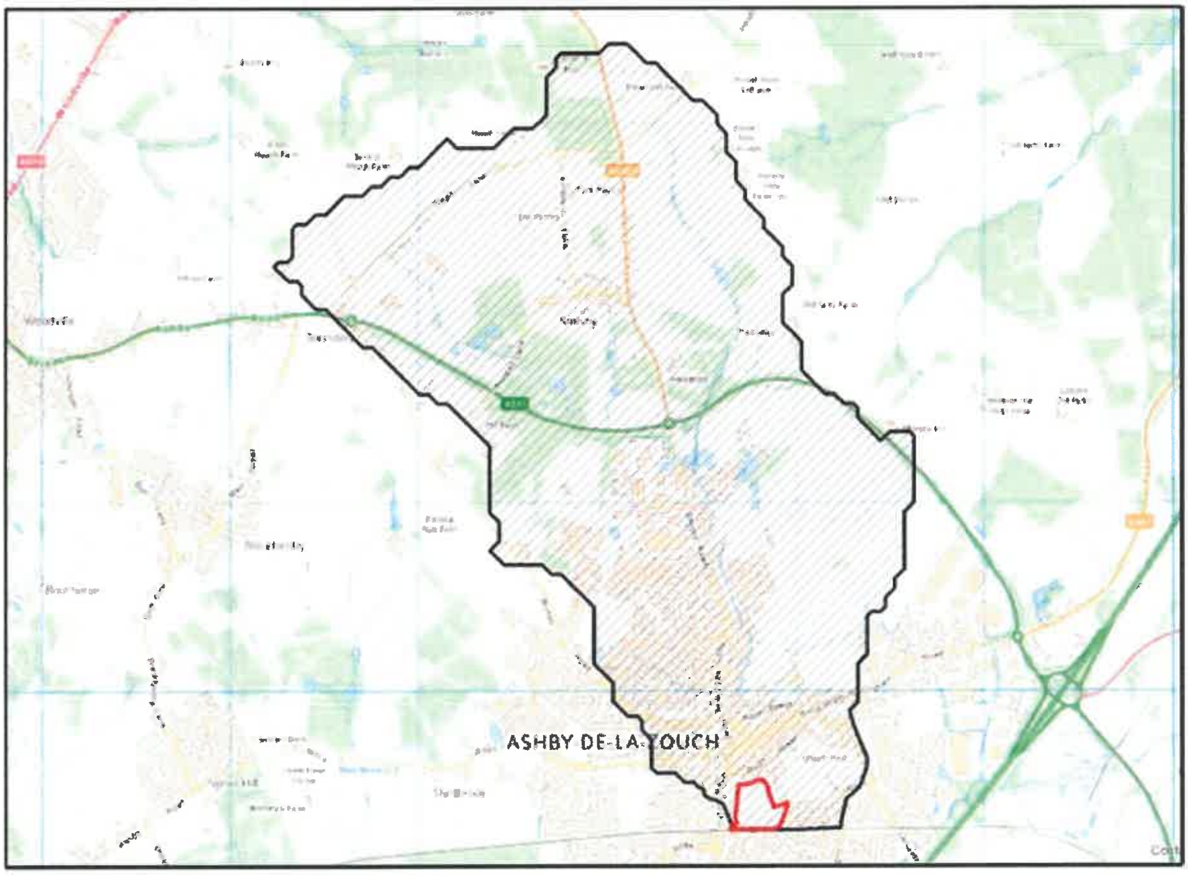

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 14. Gilwiskaw Brook catchment

Drawn: RJM **Checked:** RAW

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Environment Agency

Flood map for planning

Your reference
Bath Grounds

Location (easting/northing)
435799/316421

Scale
1:2500

Created
9 Apr 2020 11:01

- Selected point
- Flood zone 3
- Flood zone 3: areas benefitting from flood defences
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Flood storage area

Bath Grounds

N

0 20 40 60
m

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 15. Environment Agency flood zone map (2020)

Drawn: RJM **Checked:** RAW

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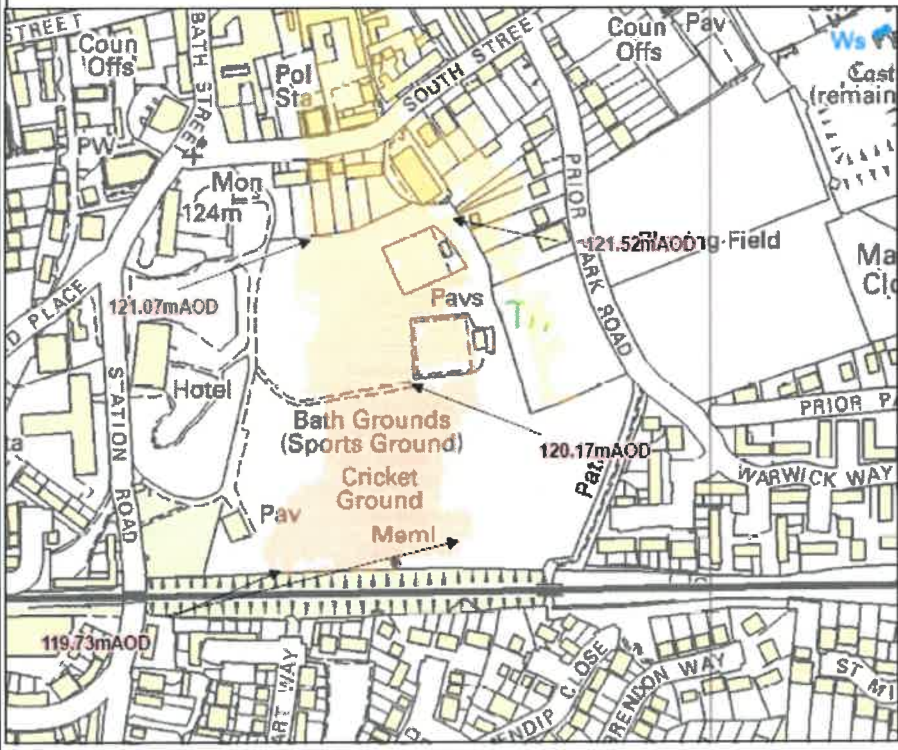
Bath Grounds

Flood Heights map for 1%+20%Climate Change AEP, centred on SK 35700 16300 created 11 August 2020.



Environment Agency

Legend

100+20%CC yr Levels

Value

High : 137.05

Low : 117.26

Scale 1:3,000

West Midlands Area

N

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 16. Environment Agency predicted flood levels (100 year+20%)

Drawn: RJM **Checked:** RAW

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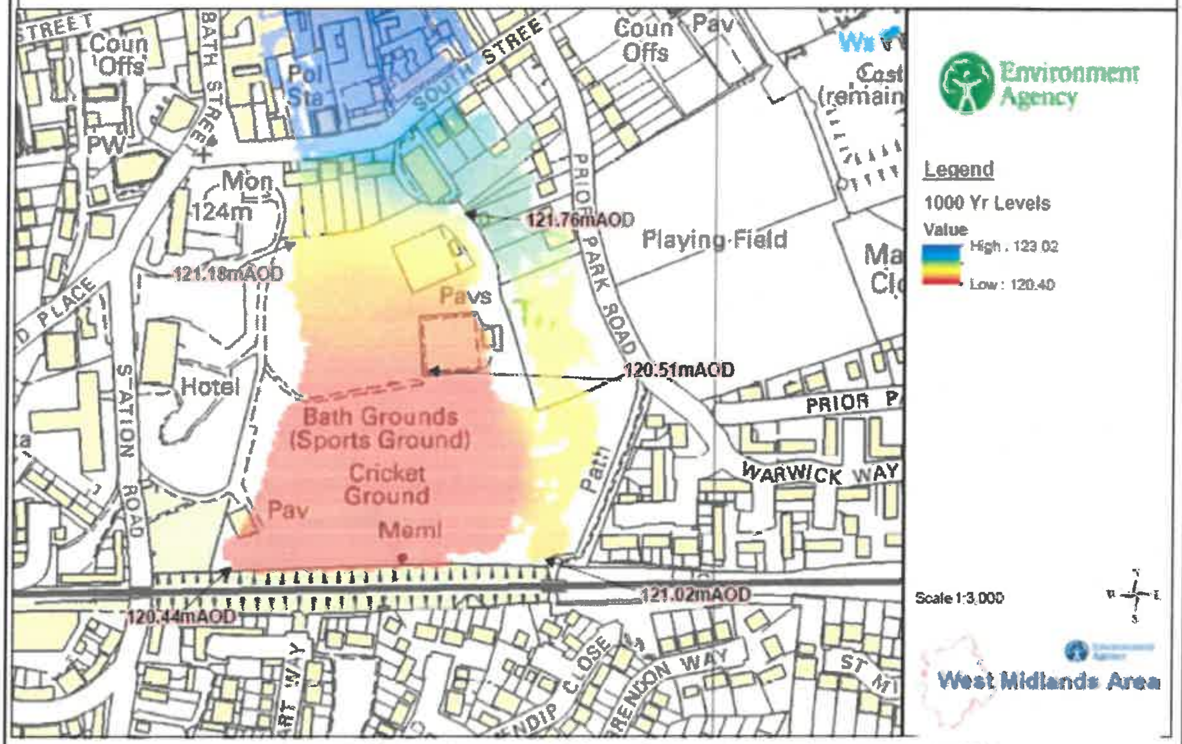
Flood Heights map for 0.1% AEP, centred on SK 35700 16300 created 11 August 2020.



N

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 17. Environment Agency predicted flood levels (1000 year)

Drawn: RJM **Checked:** RAW

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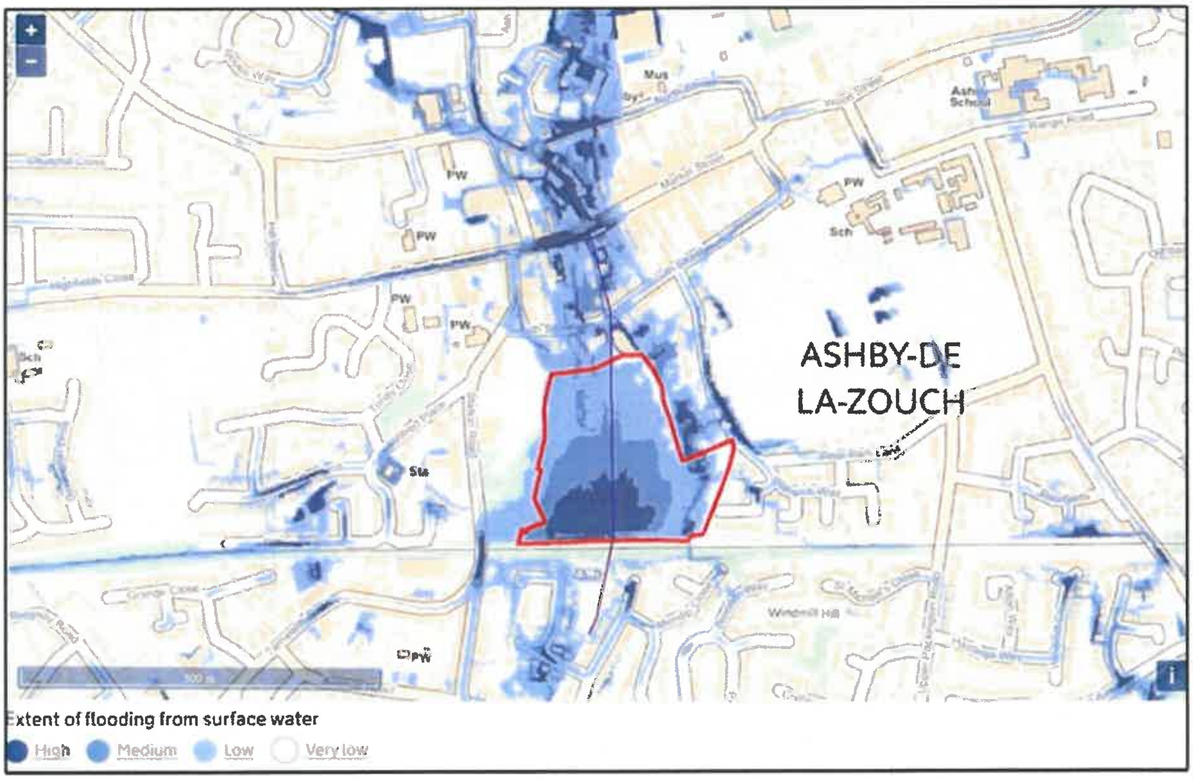
Bath Grounds



N

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 18. Environment Agency surface flooding map

Drawn: RJM **Checked:** RAW

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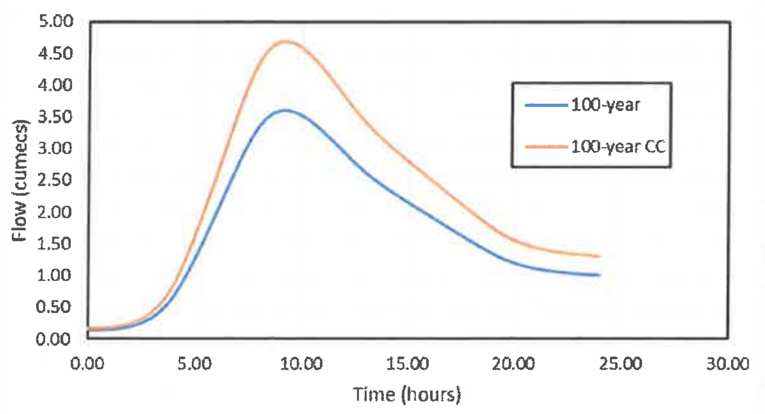

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 19. ReFH2 modelled flood hydrographs

Drawn: RJM **Checked:** RAW

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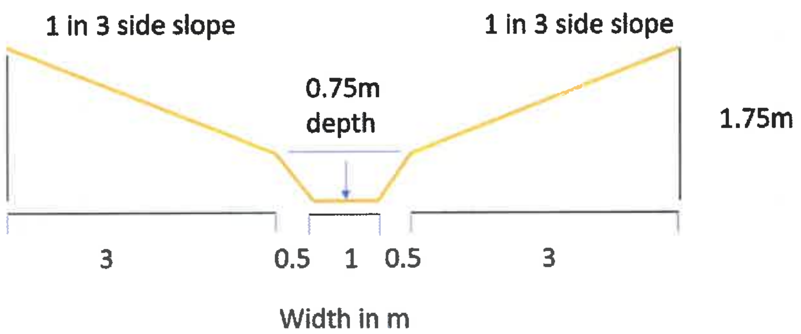
Approximate channel profile for sections A, B, C, E, F, G

Assume grassed channel sides



Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 20. Illustrative channel cross-section.

Drawn: RJM **Checked:** RAW

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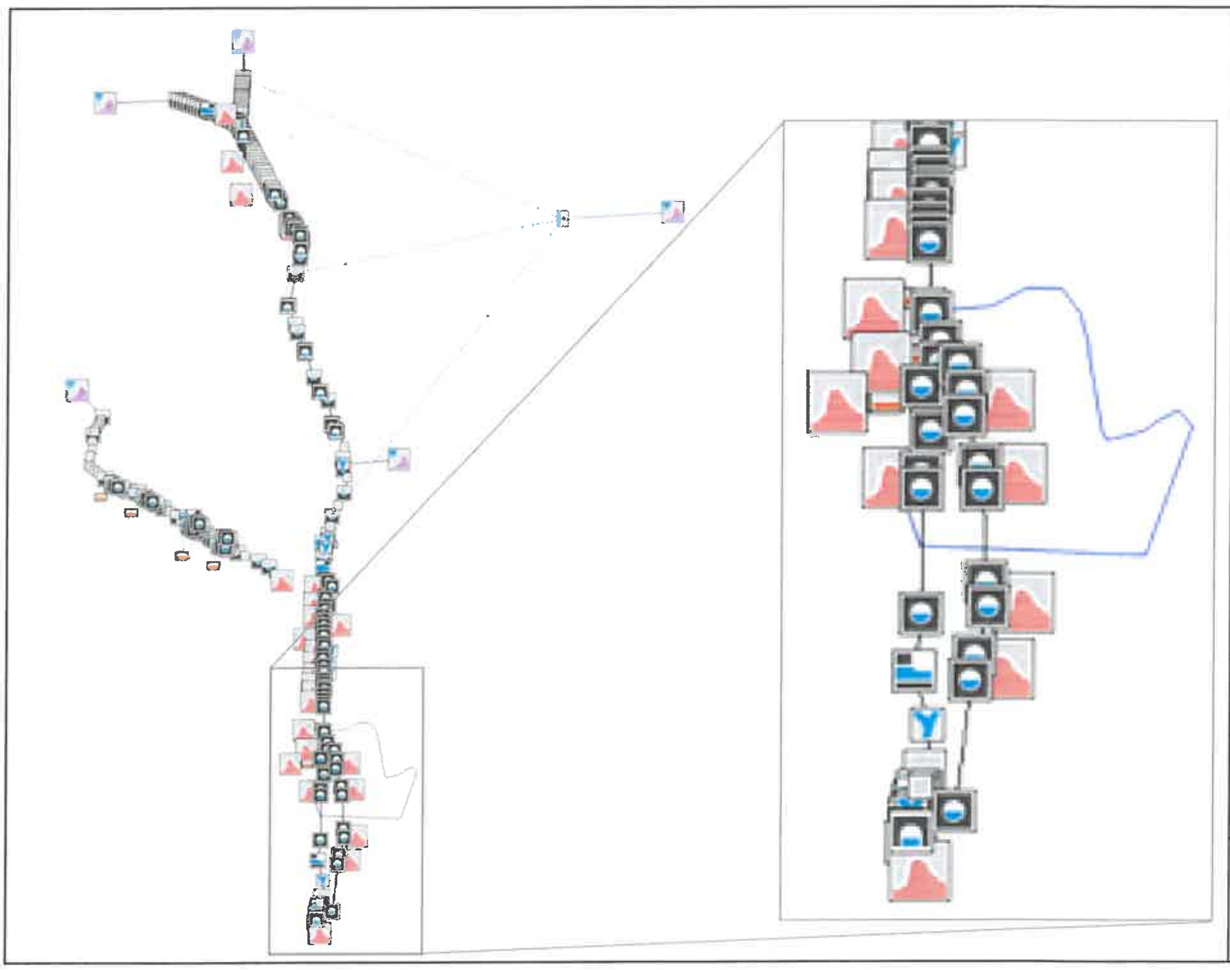

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 21. Environment Agency ISIS/TuFlow model schematic

Drawn: RJM **Checked:** RAW

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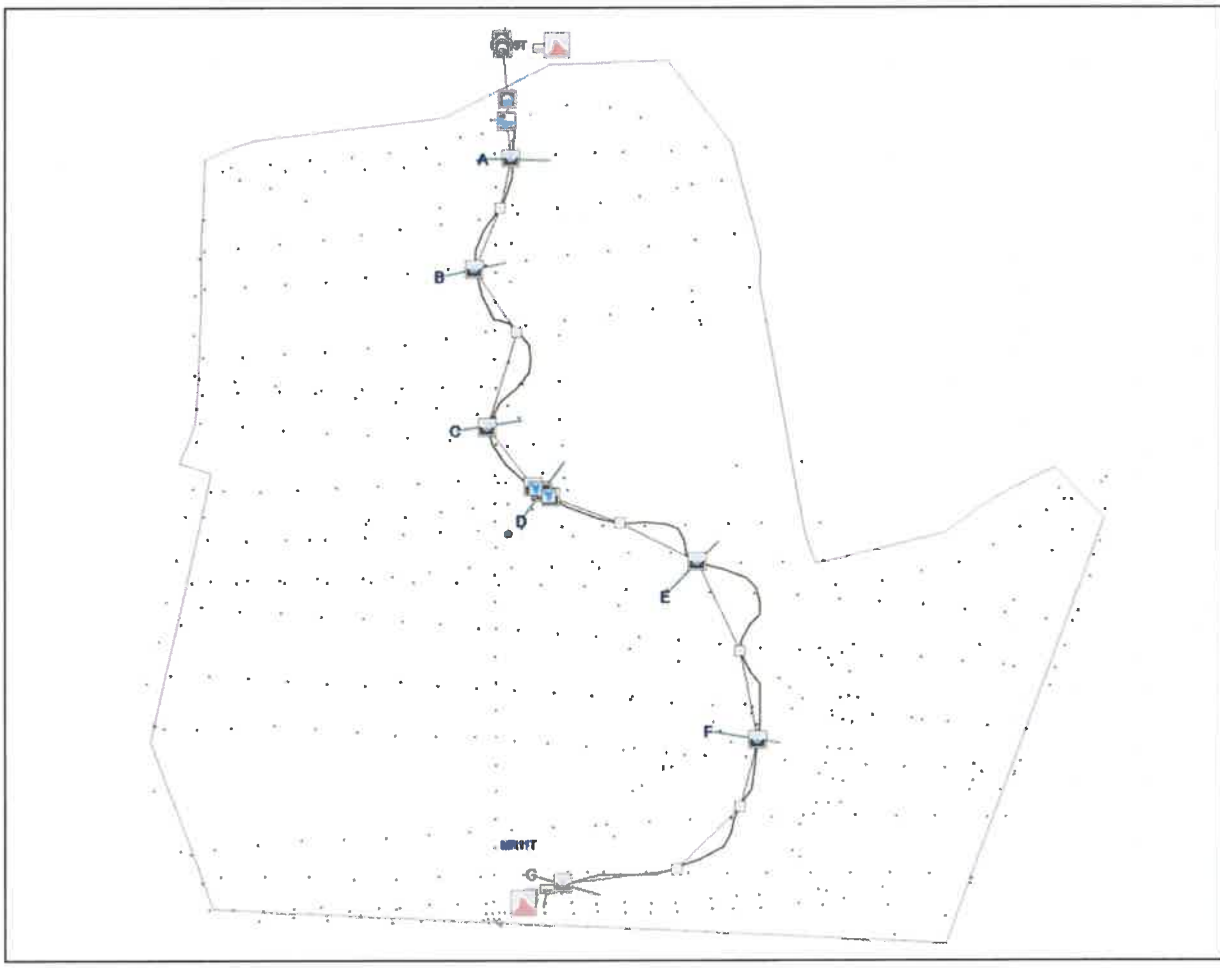

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 22. ISIS/TuFlow model schematic for the de-culverted Brook

Drawn: RJM **Checked:** RAW

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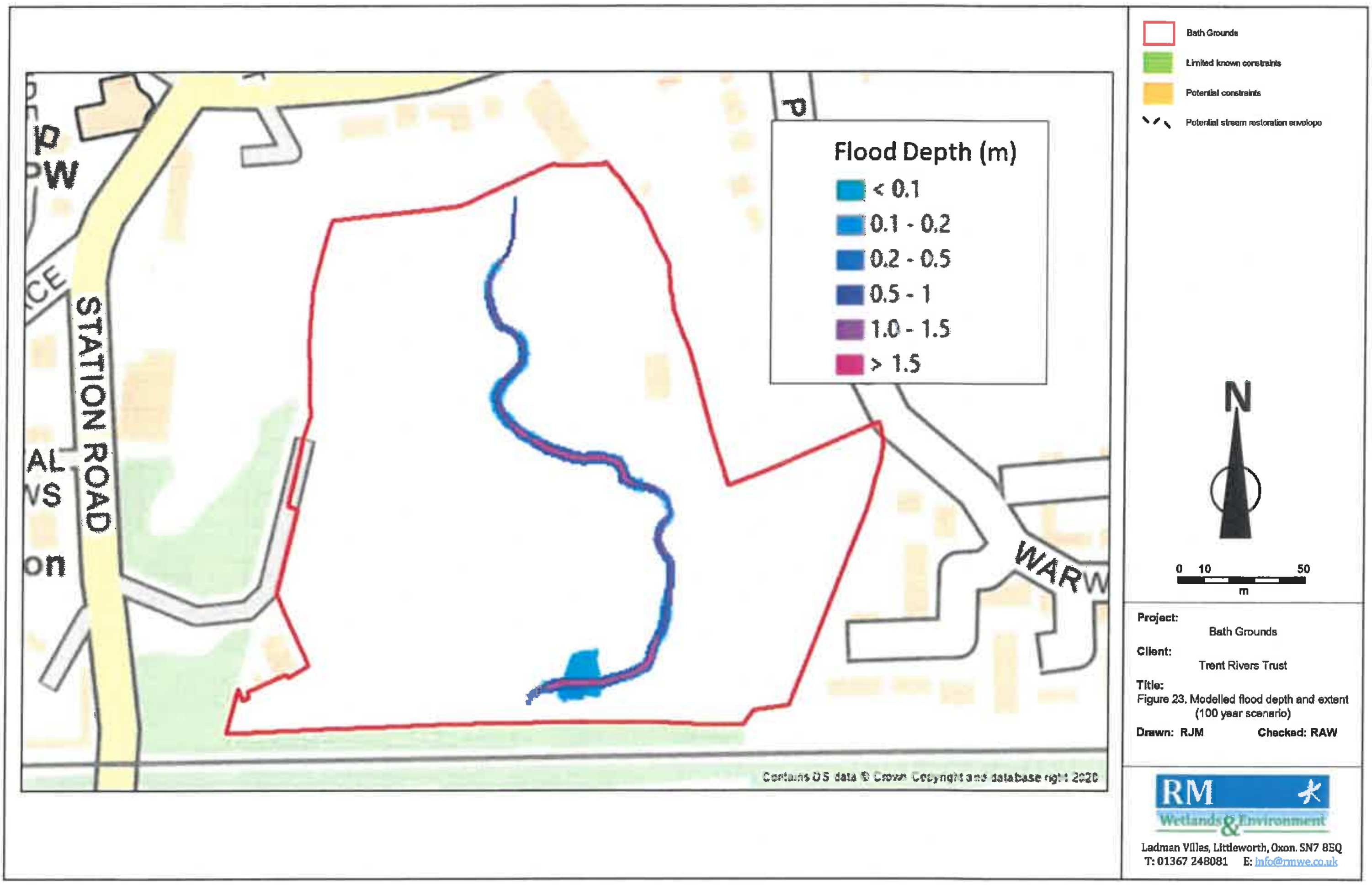
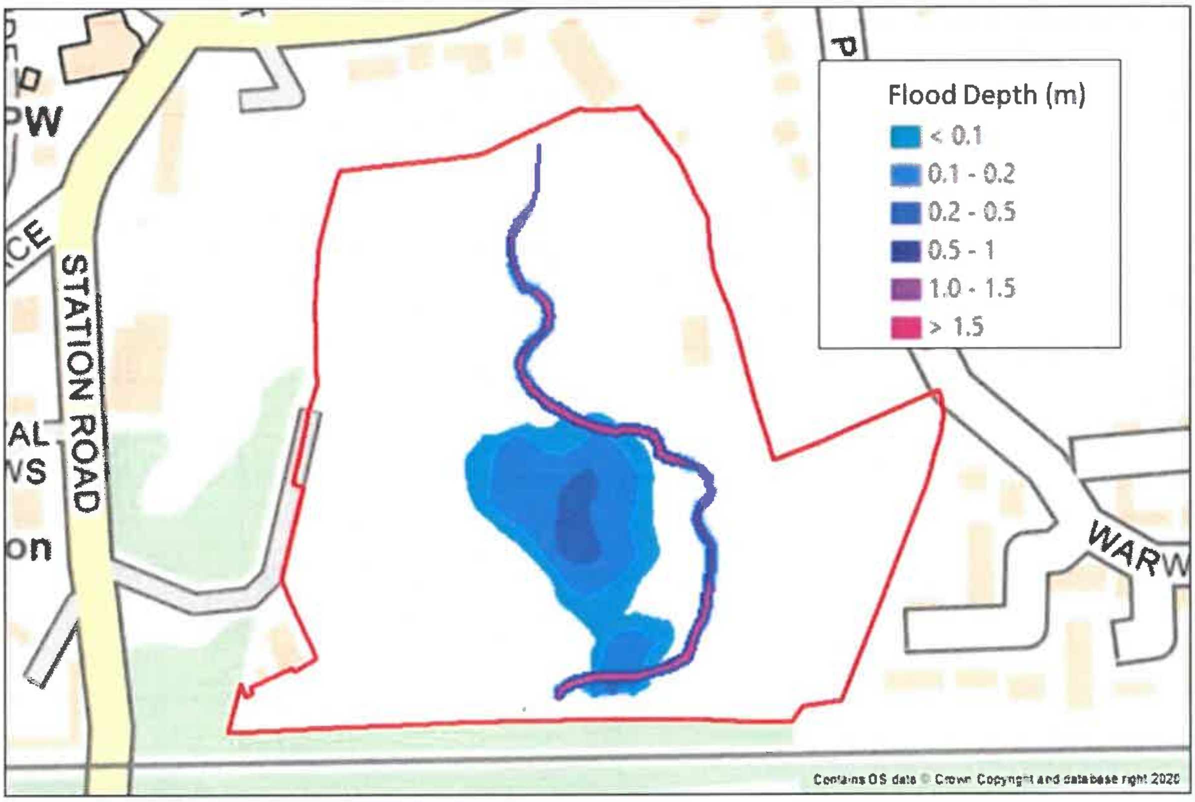


Title: Figure 23. Modelled flood depth and extent (100 year scenario)



Bath Grounds

Limited known constraints

Potential constraints

Potential stream restoration envelope

N

0 10 50

m

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 24. Modelled flood depth and extent (100 year + 30% scenario)

Drawn: RJM **Checked:** RAW

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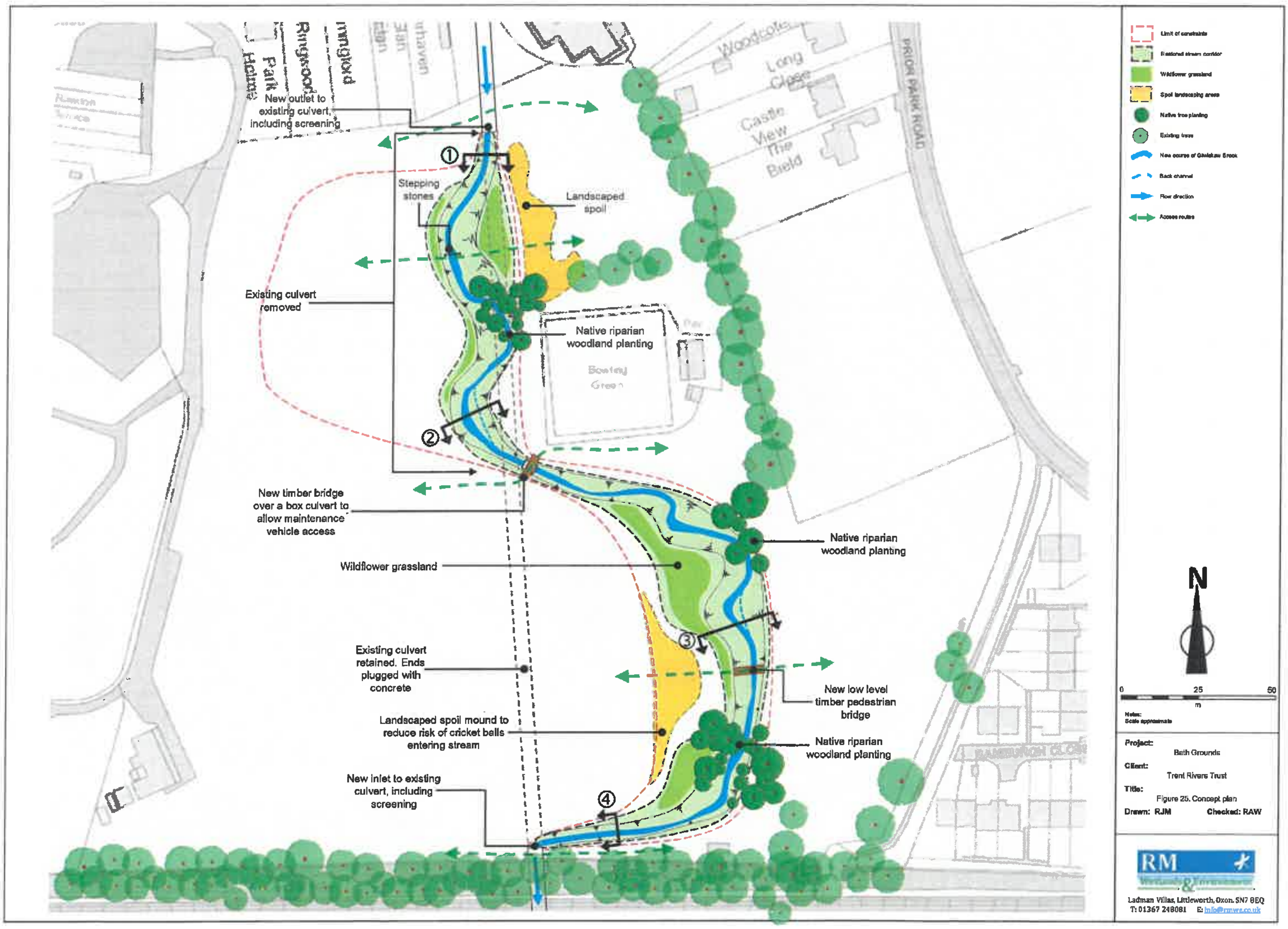
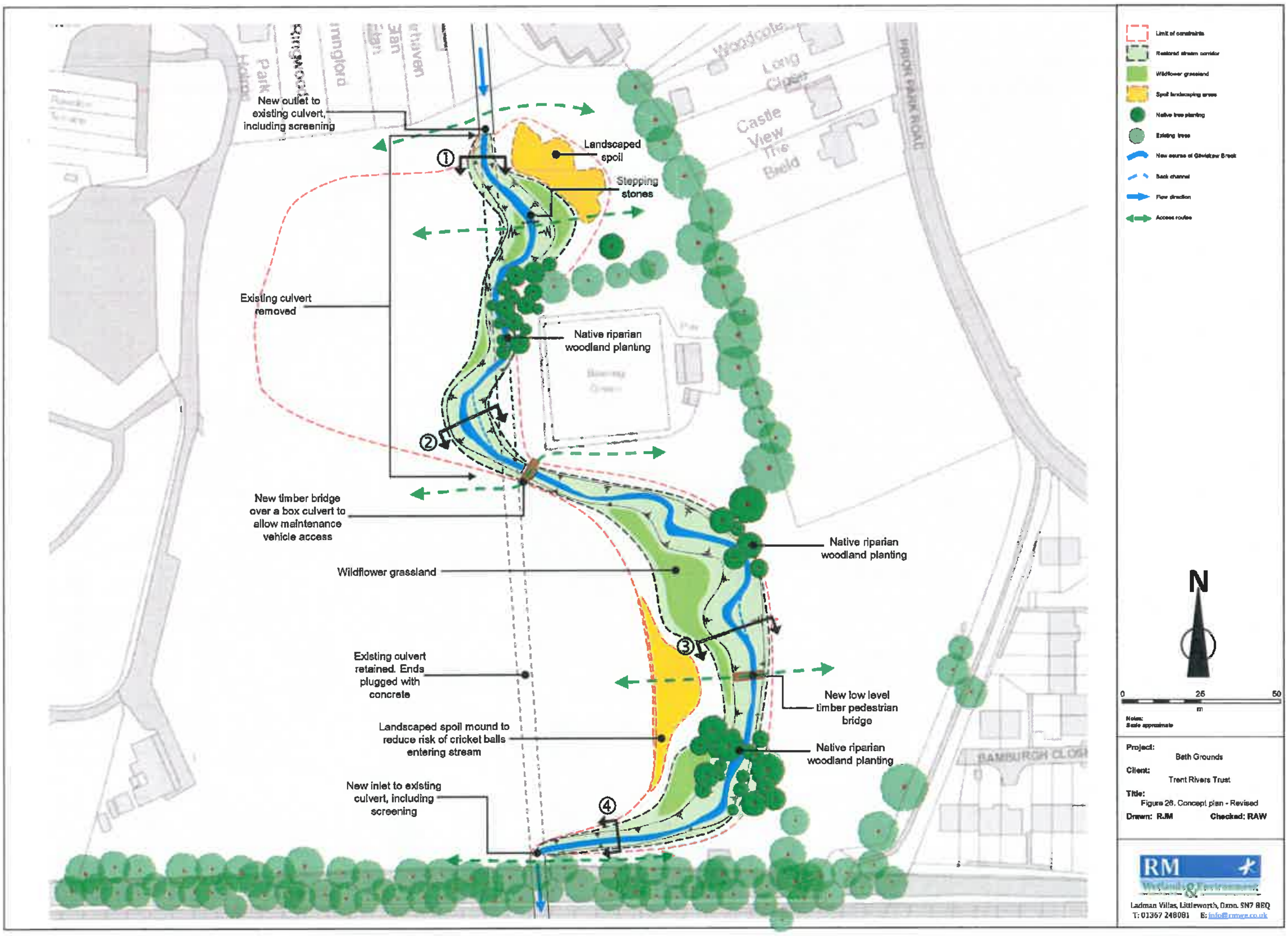


New outlet to existing culvert, including screening
Stepping stones
Landscaped spoil
Existing culvert removed
Native riparian woodland planting
Bowling Green
New timber bridge over a box culvert to allow maintenance vehicle access
Wildflower grassland
Native riparian woodland planting
Existing culvert retained. Ends plugged with concrete
New low level timber pedestrian bridge
Landscaped spoil mound to reduce risk of cricket balls entering stream
Native riparian woodland planting
New inlet to existing culvert, including screening
1
2
3
4
Woodcote
Long Close
Castle View
The Bield
PRIOR PARK ROAD
Ringwood
Park
Holme
Limit of constraints
Restored stream corridor
Wildflower grassland
Spoil landscaping areas
Native tree planting
Existing trees
Back channel
Flow direction
Access routes
N
0
25
50
m
Notes:
Scale approximate
Project:
Bath Grounds
Client:
Trent Rivers Trust
Title:
Figure 25. Concept plan
Drawn: RJM
Checked: RAW
RM
Ladman Villas, Littleworth, Oxon. SN7 8EQ
T: 01367 240081



New outlet to existing culvert, including screening
Landscaped spoil
Stepping stones
Existing culvert removed
Native riparian woodland planting
New timber bridge over a box culvert to allow maintenance vehicle access
Native riparian woodland planting
Wildflower grassland
Existing culvert retained. Ends plugged with concrete
New low level timber pedestrian bridge
Landscaped spoil mound to reduce risk of cricket balls entering stream
Native riparian woodland planting
New inlet to existing culvert, including screening
FRIARS PARK ROAD
BAMBURGH CLOSE
Limit of constraints
Restored stream corridor
Wildflower grassland
Spoil landscaping areas
Native tree planting
Existing trees
Back channel
Flow direction
Access routes
N
0 25 50
m
Notes:
Scale approximate
Project: Beth Grounds
Client: Trent Rivers Trust
Title: Figure 26. Concept plan - Revised
Drawn: RJM
Checked: RAW
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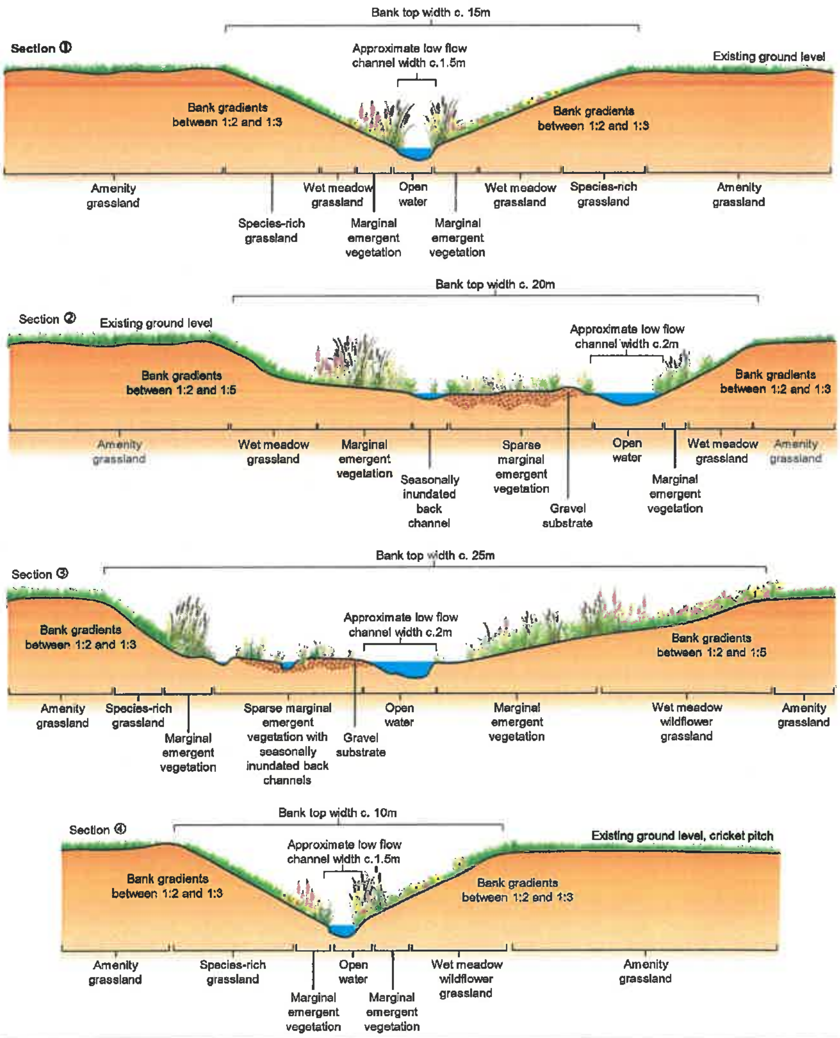

Notes:
Scale approximate

Project: Bath Grounds

Client: Trent Rivers Trust

Title: Figure 27. Illustrative sections

Drawn: RJM **Checked:** RAW

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