High Speed Rail: Consultation on the route from the West Midlands to Manchester, Leeds and beyond

Sustainability Statement

Appendix E5 – Water

A report by Temple-ERM for HS2 Ltd

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CONTENTS

1. INTRODUCTION

1.1.1. This report has been prepared to support the HS2 Phase Two proposed scheme for consultation Sustainability Statement (the Sustainability Statement, Volume 1), a report which describes the extent to which the Government's proposed scheme for HS2 Phase Two supports objectives for sustainable development. This document is a technical appendix which summarises the method for the Water appraisal, informing the Sustainability Statement main report. The Sustainability Statement places emphasis on the key impacts only. This technical report summarises all the conclusions relating to the Water appraisal.

2. METHODOLOGY

2.1. River diversions

Screening

2.1.1. The proposed route design has been appraised using the GIS (plan) information and engineering plan and profile drawings to identify locations where the route passes directly above or alongside watercourses at an acute angle. Watercourses have been identified as requiring a diversion or major channel works where the proposed route lies above or close to the river channel. Each watercourse has been assigned a value based on the size of the receiving catchment and level of flood risk, as follows:

- Major Watercourses: Major watercourses are defined as those watercourses that have a catchment area of 50km^2 or greater.
- Medium Watercourses: Medium watercourses are defined as those watercourses that have a catchment area of less than 50km^2, but are either identified as Environment Agency Main Rivers or are associated with an area of flood risk as shown on the Flood Zone Maps (usually any watercourse with a catchment area of 4km^2 or greater).
- Minor Watercourses and Cross Drainage: All remaining watercourses are defined as minor watercourses.

2.1.2. The minor watercourses which may require diversions are presented in table format. A screenshot and brief description is presented within the table. These would usually be conveyed across the line in a culvert of some description, and in most cases some degree of channel realignment would be required which may incorporate small meanders or other ecological mitigation to compensate for adverse impacts of culverts on the Water Framework Directive (hereafter WFD) ecological status. In order to focus on areas where potentially greater work is required, the plan drawings have been used to identify those watercourses where greater-than-usual river works are likely to be required.

2.1.3. All diversions can be located on the detailed overview mapping (see section 10) using the unique watercourse crossing identifier (MDxxxx for the western Leg and LExxxx for the eastern leg).

2.1.4. Appendix B (AoS Method and Alternatives) provides an explanation of the methodology used for the AoS and the rationale behind it.

Exclusions and assumptions

2.1.5. It is assumed that all diversions will be designed with sufficient capacity to convey the full peak flow during the predicted 1 in 100 year rainfall event, including the relevant increase in volume to allow for climate change of 30% for small catchments (less than 4km^2) or 20% for all other catchments, consistent with the approach applied in the HS2 Phase One design.

2.1.6. The analysis currently covers only the likely operational impacts and risks of and to the proposed route. Additional complications and impacts may arise during construction. However, these are not generally expected to require any changes to the overall design of the proposed route, so are not considered within this study.

2.2. Groundwater

2.2.1. This report also provides a high-level screening assessment of the possible impacts of the proposed route on major groundwater abstractions (larger than 1,000 m^3/day) by considering the proposed route in the context of the geology, the relative position of the groundwater, the state of the track (embankment, cut, at-grade, viaduct or tunnel) and the distance from the proposed route centreline to the abstraction point.

2.2.2. It is intended as a reference for potential problems, to inform the detailed design process and to expose any major issues which might require early engagement with regulating authorities or which might require long-term monitoring to establish a baseline.

2.2.3. Due to different levels of information for the potable abstractions and the non-potable abstractions, different methods of appraisal were employed for each and these are set out below. They follow the same basic formula, namely to consider the structure of the proposed route (viaduct, embankment, at-grade, cut or tunnel), where possible to identify the extent and depth of the aquifers from hydro-geological maps and publicly available borehole records, and then use the information to compile a high-level appraisal based on informed professional judgement and basic hydro-geological principles.

Appraisal of potable abstractions

2.2.4. The main difference between the potable abstractions and non-potable abstractions is groundwater Source Protection Zones (SPZ) associated with potable abstractions, while non-potable abstractions have no mapped SPZ. For the purposes of this report, wherever the proposed route centreline passes through SPZ1 or SPZ2 in the Environment Agency GIS database, the associated abstraction has been appraised.

Appraisal of non-potable abstractions

2.2.5. Non-potable abstraction data were obtained from the Environment Agency for all licensed abstractions with maximum allowable daily volumes greater than 1,000m^3/day. The locations of these boreholes were imported into GIS and overlaid on the proposed route. A 500m buffer strip was then added on either side of the proposed route. 500m was chosen as a reasonable nominal distance and this coincides with the minimum radius of SPZ2 for any abstraction greater than 2,000m^3/day. Any non-potable abstraction within 500m of the centreline of the proposed route was selected for investigation.

2.2.6. All of these abstractions are of strategic importance for commercial, industrial and agricultural use and any interruption of this supply is likely to have implications for the industries which rely upon them.

2.2.7. Using the GIS overlay and the engineering plan and profile drawings of the proposed route, the likelihood of impacts of any below-ground works on the aquifers could be considered as a first-pass appraisal to identify cases where there is unlikely to be an impact. Any abstractions which are not filtered out by this first-pass appraisal are then subjected to the same appraisal as that set out for potable abstractions above.

Exclusions and assumptions

2.2.8. While the accuracy of this approach is insufficient for detailed design or groundwater risk appraisal, it is considered to be sufficient for the purposes of the high-level appraisal required for this exercise. Wherever accuracy of the method is judged to be insufficient to draw any meaningful conclusion, this is highlighted for further investigation.

2.2.9. The report is not intended to be a substitute for more detailed groundwater risk appraisal during the EIA and detailed design stages, nor does it attempt to address the usual requirements of development within groundwater source protection zones or the WFD.

2.2.10. It is assumed that standard best-practice construction techniques will be employed in order to protect groundwater resources from pollution, and that specific provisions in this regard will be made clear in a construction waste-management plan and construction method statement.

2.2.11. The analysis currently covers only the potential permanent impacts and risks of and to the proposed route. Based on its current design, additional temporary complications and impacts may arise during construction. However, these are not generally expected to require any changes to the overall design of the route, so are not considered within this study.

2.3. Viaduct crossings

Screening

2.3.1. The proposed route design has been appraised using the GIS (plan) information to determine where floodplain crossings occur, based on the location of Flood Zone 2. The length of each floodplain crossing (in terms of the length of line within Flood Zone 2) was then extracted, and the crossings ranked by length. All viaducts with a floodplain crossing greater than 100m have been identified. These will be considered in detail in due course to assess the feasibility of shortening the viaduct to save costs and reduce visual impact.

2.3.2. All viaducts included in this study can be located on the detailed overview mapping (see section 10) using the unique watercourse crossing identifier (MDxxxx for the western Leg and LExxxx for the eastern leg).

Appraisal

2.3.3. A desk-based study was undertaken at each viaduct location to generate an understanding of the watercourse size and local importance together with likely baseflow and flood flow mechanics using OS mapping, the FEH CD-ROM and ReFH rainfall-runoff model.

2.3.4. Flood water levels (for the 1000 year flood) were estimated by comparing the outline of Flood Zone 2 with the Digital Terrain Model (DTM) by identifying the location of the flood zone edge on the profile drawing and taking the ground level at that point. This was then subject to a “sense check” by comparing the outline with the DTM contours on the plan drawing, and the water level rounded up to the nearest integer.

2.3.5. Aerial and local photography was studied to determine existing floodplain flow restrictions and the location of man-made embankments, flood defences and other infrastructure.

2.3.6. Water Framework Directive watercourse ecological quality information was collected from the Water Framework Directive - River Basin Management Plans map on the Environment Agency website, and the current and predicted ecological status was recorded for each waterbody. The status of measured biological quality elements (fish, macroinvertebrates, macrophytes and diatoms), along with physico-chemical and hydromorphological supporting elements, are detailed for each river. This is relevant information when making recommendations in regard to any in-channel works. It helps to understand the (high-level) ecological strengths and weaknesses of the water body and therefore to identify possible risks of an adverse impact on the ecological status and also to identify opportunities for helping to achieve good ecological status through sensible design. Obviously these data will need to be supplemented with detailed ecological surveys as part of the detailed design.

Exclusions and assumptions

2.3.7. There are some cases where viaducts exist greater than 100m in length where the width of Flood Zone 2 that is crossed is less. It has been assumed in such cases that the viaduct design is long for reasons other than flood risk, and that no alterations would be possible.

2.3.8. The analysis currently covers only the operational impacts and risks of and to the proposed route. Additional complications and impacts may arise during construction. However, these are not generally expected to require any changes to the overall design of the route, so are not considered within this study.

2.4. Stations assessment

2.4.1. The location and extent of each station or depot was considered relative to watercourse and flood zone locations using the latest GIS (spatial plan) data. Each station was assessed and potential issues identified against the following considerations:

- Watercourse crossings – any instances where the footprint of the station falls directly over a watercourse would result in the need, as a minimum, to culvert the watercourse, and potentially result in the need for watercourse diversions;
- Watercourse diversions – in some cases, minor diversions to watercourses can prevent the need for any culverting of a watercourse. Where it is not possible to culvert a watercourse beneath the station structure, or to raise the station onto a viaduct, diversion would be inevitable;
- Flood flow obstruction – where the footprint of the station falls within the functional floodplain of a watercourse (i.e. across a flood flow path, usually defined in the absence of more detailed information as the extent of the 1 in 20 year return period flood, however), flood flow obstructions may result in significant increases in severity and frequency of flooding upstream; and
- Flood storage displacement – any built volume within the floodplain will occupy floodplain storage volume, which results in local increases to flood water levels during given flood events.

Exclusions, assumptions and limitations

2.4.2. The appraisal is limited to the information available on each station or depot design in its current form. For Manchester for example, the currently available information is operational and construction outlines only. It is therefore assumed that the operational outline is the extent of solid construction, except where it is clear that an area is not part of the building. Further, design details such as the level of the concourse and platforms, as well as foundation construction, road diversions and any viaduct type construction have not been made available and any embedded mitigatory effects arising are consequently not included in the appraisal.

3. RIVER DIVERSIONS FINDINGS

3.1.1. Close working between the scheme engineers and AoS water specialists has been successful in avoiding the need for permanent watercourse diversions along most of the route. It should be noted that the following tables use engineering plan and profiles images from January 2013, except locations where the alignment has changed. Therefore, minor differences may exist between the images in the following tables and the consultation plan and profiles. The images are provided for illustrative purposes only.

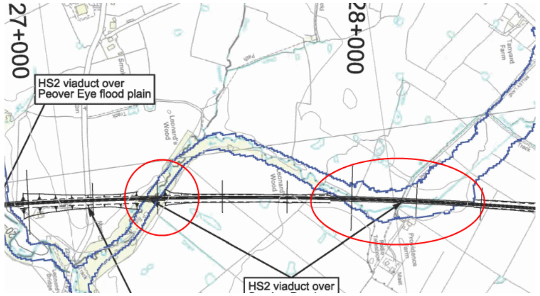
3.1.2. At the EIA stage, any potential river diversions that are still likely to be required will be subject to a detailed assessment (including hydraulic modelling) to determine the measures needed to meet legal and planning policy standards. Where diversions are required, they will be undertaken in accordance with the usual requirements for main river diversions, as specified by the Environment Agency. Opportunities for environmental enhancement will also be explored, particularly in cases where there may be opportunities to improve the WFD status in line with the 2027 targets

3.2. Western leg

3.2.1. In total, the western leg would incorporate a total of 121 separate watercourse and canal crossings. The need for permanent diversions to one medium watercourse (Wincham Brook, discussed below) and 11 minor rivers are envisaged at this stage. No major watercourses (defined as those watercourses that have a catchment area of 50km^2 or greater) are identified that would require potential diversions or major channel works that fall into this category.

3.2.2. Based on the proposed scheme, one moderate watercourse could require diversion.

Table 3.1 - Moderate watercourse and cross drainage diversions, straightening and channel works for the western leg

Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSM10 (Hough to Pickmere)	Wincham Brook	6	Viaduct	The Brook is crossed at three locations: the confluence with Peover Eye, Leanord's Wood and near to Providence Farm. The latter two of these crossings lie along the line of the channel, and watercourse diversions may be required 

3.2.3. Based on the proposed scheme, 11 minor watercourses could require diversion.

Table 3.2 - Minor watercourse and cross drainage diversions, straightening and channel works for the western leg

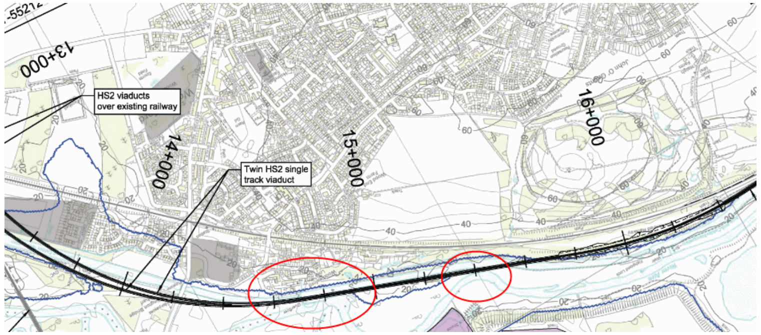
Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSM03 (Streethay to Swynnerton)	Tributary of Bentley Brook (Gorse Hill) (MD0815)	1.6	Culvert	Watercourse sinks upstream and issues underneath alignment footprint. Consideration of underground flow required, as well as headroom available for culvert.
HSM03 (Streethay to Swynnerton)	Tributary of Moreton Brook (Stockwell Heath) (MD0816)	1.53	Culvert	Diverted to create perpendicular crossing.

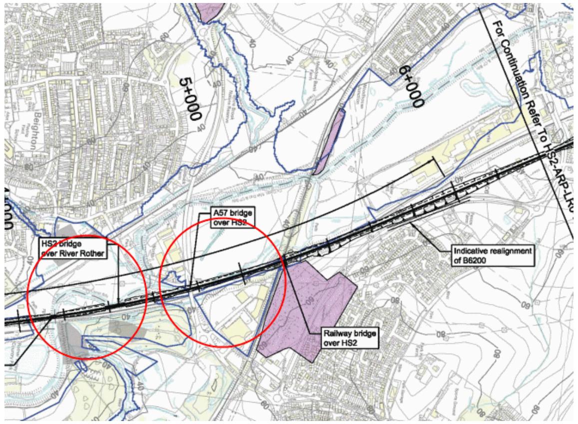
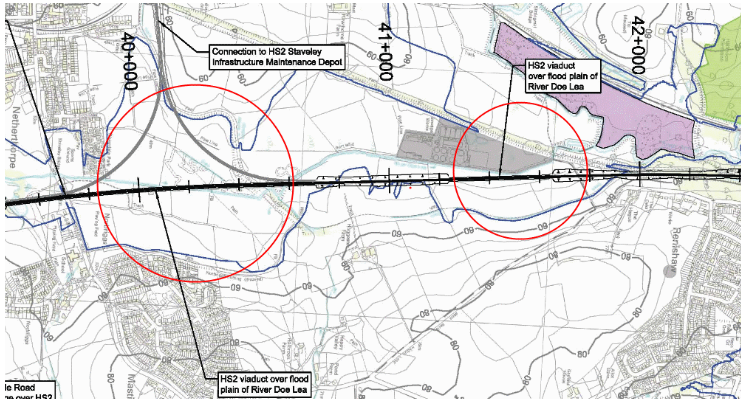
Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSM03 (Streethay to Swynnerton)	Tributary of Moreton Brook (St Stephens Hill) (MD0817)	1.03	Culvert	Divert to avoid crossing.
HSM03 (Streethay to Swynnerton)	Tributary of Moreton Brook (Moreton Fm) (MD0820)	0.51	Culvert	Divert to create perpendicular crossing.
HSM03 (Streethay to Swynnerton)	Tributary of River Trent (Tithebarn Fm) (MD0822)	1.91	Culvert	Divert to create perpendicular crossing.
HSM08 (Madeley to Hough)	Tributary of River Lea (Wrinehill Wood) (MD0864)	1.42	Culvert	Divert to combine crossings
HSM21 (Warburton to Lowton)	Tributary of Carr Brook (MD0263)	0.51	Inverted Siphon or Aqueduct	Collect in cross drainage and/or divert to avoid crossing.
HSM22 (Lowton to Bamfurlong)	Nan Holes Brook (MD0308)	0.51	Culvert	Diverted to create perpendicular crossing. May need reinstatement of meanders.
HSM22 (Lowton to Bamfurlong)	Coffin Lane Brook (MD0314)	2.42	Culvert	Add to existing culvert. Divert channel away from embankment.
HSM28 (Winterbottom to Ardwick)	Tributary of River Bollin (Woodside Fm) (MD0597)	0.66	Culvert	Divert to create perpendicular crossing.
HSM28 (Winterbottom to Ardwick)	Tributary of Sugar Brook (Middle Ho) (MD0603)	0.01	Culvert	Divert to avoid crossing.

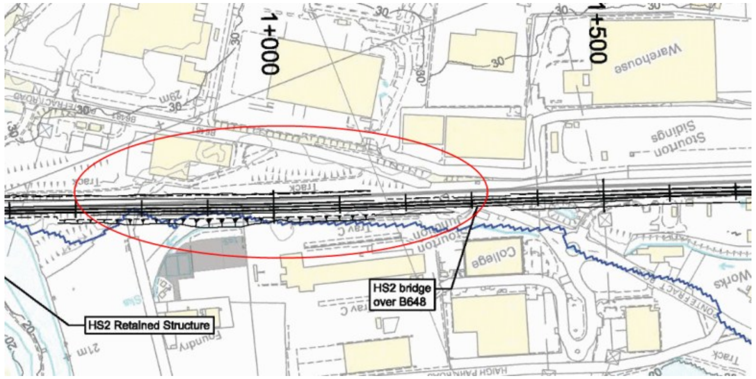
3.3. Eastern leg

3.3.1. In total, the eastern leg would incorporate a total of 146 separate watercourse and canal crossings. Based on the proposed scheme, the need for permanent diversions to five major watercourses (including one due to Meadowhall Station and described in Section 8.2), three medium watercourses and 19 minor watercourses is envisaged at this stage

Table 3.3 - Major watercourse and cross drainage diversions, straightening and channel works for the eastern leg

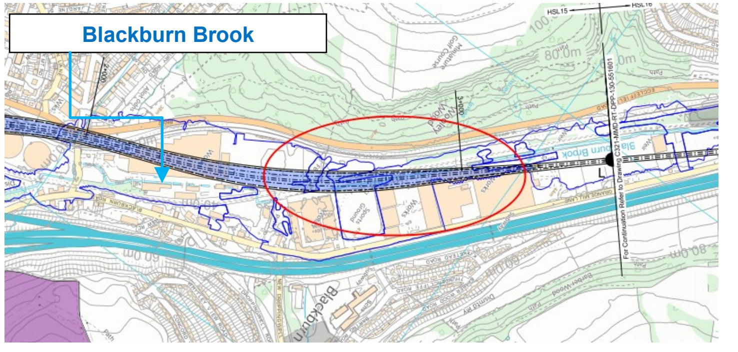
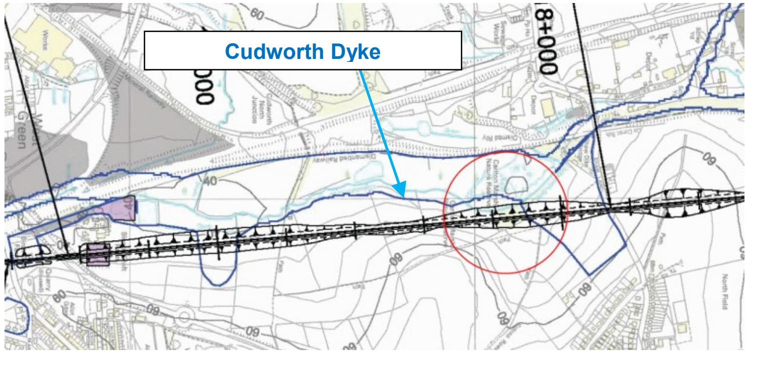
Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL21 (Cold Hiendley to Woodlesford)	River Aire at Woodlesford (LE0992)	860	Viaduct	The entire route section through the valley is on viaduct and is likely to result in a need to divert the River Aire at two locations. 

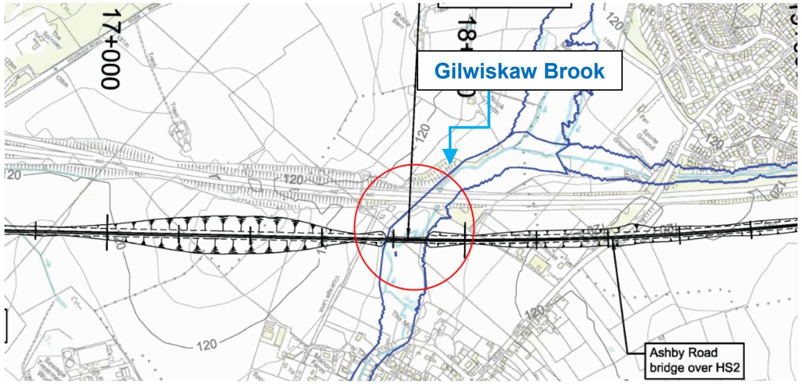
Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL14 (Killamarsh to Tinsley)	River Rother and Beighton Mill Tail Goit (LE0386 and LE0381)	360	Viaduct and embankment widening	In general, all crossings of the River Rother are proposed to be on viaduct. However, there are places where proposed embankment and widening encroach very close to the river banks, especially in the Beighton area. At least one diversion to the River Rother and diversion of the Beighton Mill Tail Goit would be required 
HSL13 (Trowell to Killamarsh)	River Doe Lea (LE1025 and LE1024)	72	Viaduct	The crossing comprises two separate viaducts, the south viaduct crosses at two locations, and may require minor diversions of the channel at the crossing points. The north does not cross the watercourse, although depending on the width of viaduct piers, some channel works could still potentially be required. 

Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL22 (Woodlesford to Hunslet)	Farnley Wood Beck (LE0543)	65	Cutting	On the approach into Leeds, the proposed alignment passes alongside a watercourse in the Stourton Freightliner Terminal area. The earthworks pass directly above the channel location for approximately 400m, a diversion would be required. 

3.3.2. Based on the proposed scheme, three medium watercourses could require diversion.

Table 3.4 - Medium watercourse and cross drainage diversions, straightening and channel works for the eastern leg

Route section	**Watercourse Name**	**Catchment Size (km²)**	**Assumed Crossing Type**	**Design Informative**
HSL15 (Tinsley to Blackburn) HSL16 (Blackburn to Cold Hiendley)	Blackburn Brook	40	Viaduct	North of Meadowhall Station, the route passes along the valley of the Blackburn Brook for approximately 2km. The proposed construction is for viaduct along the full length of the valley. The viaduct is roughly parallel to the Blackburn Brook channel, and is located directly above it in places. Consequently, there may be a need for channel and bank works, and potential diversions of the Blackburn Brook.. 
HSL16 (Blackburn to Cold Hiendley)	Cudworth Dyke (LE0797)	25	Embankment	As route passes Cudworth, it runs at the eastern edge of and parallel to the valley of the Cudworth Dyke. Along the majority of the valley, the route is sufficiently offset to the east to be away from the channel and floodplain. However, the footprint of the embankment crosses the Cudworth Dyke for around 200m at the Carlton Marsh Nature Reserve 

Route section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL06 (Birchmoor to Tonge)	Gilwiskaw Brook (LE0626)	14	Viaduct	As the route passes Packington, a viaduct carries the route over the floodplain of the Gilwiskaw Brook. The viaduct is alongside and downstream of the A42. The southern approach embankment lies very close to the channel of the Gilwiskaw Brook, and the viaduct may need to be extended slightly to the south to avoid adversely affecting the watercourse. At the crossing location, a series of sharp meanders in the river channel increase the likelihood that channel works may be required to prevent viaduct piers from obstructing channel flows. 

3.3.3. Based on the proposed scheme, 19 minor watercourses could require diversion.

Table 3.5 Minor watercourse and cross drainage diversions, straightening and channel works for the eastern leg

Route Section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL01 (Water Orton to Birchmoor)	Thistlewood Brook (LE0006)	3.48	Viaduct	Diversion of tributaries around embankment to Perpendicular crossing at viaduct
HSL06 (Birchmoor to Tonge)	Tributary of Bramcote Brook (Lodge Fm) (LE0623)	2.22	Viaduct	Diversion around embankment toe to avoid crossing
HSL09 (Tonge to Long Eaton)	Tributary of Diseworth Brook (Isley Walton) (LE0921)	2.56	Culvert	Diversion along embankment to enable perpendicular crossing
HSL09 (Tonge to Long Eaton)	Tributary of Diseworth Brook (Charnock Hill) (LE0923)	0.48	Inverted Siphon or Aqueduct	Divert to Diseworth Brook to avoid crossing
HSL13 (Trowell to Killamarsh)	Tributary of River Erewash (Trowell) (LE0994)	1.33	Culvert	Divert to avoid crossing
HSL13 (Trowell to Killamarsh)	Nethergreen Brook (LE0999)	2.05	Culvert	Extend existing culvert by 75m upstream. Inspection access may be required. Divert watercourse along embankment to enable crossing, may require some extensive back excavation
HSL13 (Trowell to Killamarsh)	Tributary of Maghole Brook (Hilcote) (LE1005)	0.51	Culvert	Tributary to be diverted to avoid crossing
HSL13 (Trowell to Killamarsh)	Tributary of Normanton Brook (Tibshelf) (LE1009)	0.61	Culvert	Diverted to create perpendicular crossing. May need reinstatement of meanders.

Route Section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL13 (Trowell to Killamarsh)	River Doe Lea (LE1010)	0.71	Inverted Siphon or Aqueduct	Temporary or permanent diversion. Temporary M1 diversion will definitely require the watercourse to be diverted, but it may be reinstated following construction of the retained box if a permanent diversion is not feasible
HSL13 (Trowell to Killamarsh)	Tributary of River Doe Lea (The Hague) (LE1026)	1.4	Culvert	Alongside embankment to avoid crossing, or directly through embankment into River Rother. Subject to further study to determine direction of flow and receiving watercourses.
HSL16 (Blackburn to Cold Hiendley)	Tributary of Harley Dike (Hoyland) (LE0789)	1.15	Inverted Siphon or Aqueduct	Divert around portal head to avoid crossing
HSL16 (Blackburn to Cold Hiendley)	Former Dearne and Dove Canal (LE0794)	0.2	Inverted Siphon or Aqueduct	Intercepts and carries flow. Either provide culvert and create new channel to outfall to either existing watercourse (1 or 2) or divert flows to Dob Sike culvert (3).
HSL17 (Cold Hiendley to Church Fenton)	Tributary of Drain Beck (Wintersett Resr) (LE0933) Drain Beck (LE0934)	0.83 2.75	Culvert	Diversion along embankment toe to enable single culvert for both watercourses.
HSL17 (Cold Hiendley to Church Fenton)	Tributary of River Calder (Goosehill North) (LE0940)	0.49	Inverted Siphon or Aqueduct	Divert to southern tributary where alignment is embankment.
HSL17 (Cold Hiendley to Church Fenton)	Tributary of River Calder (Newland Hall) (LE0941)	0.88	Viaduct	Channel may need realigning around embankment toe

Route Section	Watercourse Name	Catchment Size (km^2)	Assumed Crossing Type	Design Informative
HSL17 (Cold Hiendley to Church Fenton)	Tributary of River Aire (Swillington) (LE0951)	1.16	Culvert	Divert along east side to avoid crossing
HSL17 (Cold Hiendley to Church Fenton)	Tributary of River Aire (Swillington) (LE0952)	0.72	Inverted Siphon or Aqueduct	Diverted to create perpendicular crossing. May need reinstatement of meanders.
HSL17 (Cold Hiendley to Church Fenton)	Tributary of Cock Beck (East Garforth) (LE0954)	1.62	Inverted Siphon or Aqueduct	Diversion will avoid crossing, however culvert still required for tributary
HSL17 (Cold Hiendley to Church Fenton)	Tributary of Stream Dike (Mile Hill) (LE0956)	0.21	Culvert	Divert to avoid crossing

4. VIADUCT CROSSINGS FINDINGS

4.1. Western leg

Viaducts summary table – Floodplain crossings over 100m

4.1.1. Table 4.1 presents a summary of the findings of the floodplain crossing analysis for the proposed route into Manchester and to the WCML. The viaducts are presented in chainage order from south to north along the main route, with the Manchester city centre spur listed from west to east.

4.1.2. The viaduct structure names were devised by the appraisal team for convenience during the course of the AoS. Some names and exact viaduct lengths will vary from those used in more recently issued engineering information. However, the provisional conclusions remain valid. As the scheme designs are developed, these names (and the details of the structure dimensions) would be brought in line to ensure consistency. Where the engineering drawing names are known, these have been indicated as "Also Known As" (AKA).

Table 4.1 - Summary of viaduct findings for the western leg

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
Bourne Brook (MD0807)	Rileyhill Viaduct (AKA Bourne Brook Viaduct)	729	12	A515	Shaw Lane - Floodplain Level	A515 - Floodplain Level	Limited Flood Flow Restrictions in the Area. Detailed modelling required to understand flow mechanisms	The Bourne Brook is currently at 'good ecological status'.
River Trent (MD0812) Luth Burn (MD0813)	Handsacre Viaduct (AKA River Trent Viaduct)	1767	320	A515, Pipe Ridware	None	None	Limited Flood Flow Restrictions in the Area. Detailed modelling required to understand flow mechanisms	Replacing sections of viaduct with embankment may result in culverting or diversion of minor tributaries (including Luth Burn).
River Trent (MD0823)	Great Haywood Viaduct (AKA Trent and Mersey Viaduct)	519	140	Trent and Mersey Canal	Hoomill Lane - Floodplain Level	Mill Lane - Floodplain Level	Limited Flood Flow Restrictions in the Area. Sensitive receptors in floodplain	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
Meece Brook (MD0859)	Whitmore Viaduct (AKA Meece Brook Viaduct)	280	8	None	None	None	No Floodplain Flow Restrictions in the area. Steep Sided Valley suggests Floodplain Compensation would be complex	
River Lea (MD0862)	Hey Sprink Viaduct (AKA River Lea Viaduct)	439	6	WCML and Disused Railway	Branch Line Embankment (at crossing)	WCML Embankment (at crossing)	Viaduct required to cross WCML. Relatively Steep sided Valley	
River Lea (MD0865) Checkley Brook (MD0866)	Madeley Viaduct (AKA Checkley Brook Viaduct)	130	30	None	WCML on Checkley Brook (650m)	Unnamed Road - Floodplain Level	Limited Flood Flow Restrictions in the Area. Narrow floodplain with two channels and central flow area	
River Dane (MD0871)	Middlewich Viaduct (AKA River Dane Viaduct)	770	210	Shropshire Union Canal	None	None	Limited Flood Flow Restrictions in Area. Steep Sided Valley at southern edge of floodplain. North of channel crossing viaduct is away from channel and to the edge of the floodplain.	Should support piers be required within the River Dane channel, consideration of the impact on flow velocities under the WFD may be required
Puddinglake Brook (MD0874)	Whatcroft Viaduct (AKA Puddinglake Brook Viaduct)	130	7	None	Disused Railway Line?	Trent and Mersey Canal (750m)	No vulnerable uses in floodplain within the vicinity of the crossing. Relatively wide flat floodplain for small watercourse	May require diversion if embankment introduced. Detailed WFD assessment may be necessary if culverting or diversion of the brook is required.

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
Gad Brook (MD0875)	Lach Dennis Viaduct (AKA Gad Brook Viaduct)	160	4	None	Boundary Farm Access (600m)	A530 (400m)	No vulnerable uses in floodplain within the vicinity of the crossing. Relatively wide flat floodplain for small watercourse	If embankment with culvert option is pursued, a detailed WFD assessment may be required to ensure no detrimental impact on River Dane downstream.
Wade Brook (MD0877)	Lostock Green Viaduct (AKA Wade Brook Viaduct)	250	18	Holford Brinefield	Moss Lane - Floodplain Level (1000m)	A556 Embankment and Viaduct (500m) Approx 20m wide	Brine works within floodplain with complex network of subsurface infrastructure. Potentially dangerous land uses (gas storage) and underground caverns.	
Peover Eye (MD0878) Wincham Brook (MD0879)	Plumley Viaduct (AKA Peover Eye Viaduct and Smoker Brook Viaduct South)	240	70	None	Linnards Lane/Chester Road (300m)	None	Limited Flood Flow Restrictions in the Area. Narrow floodplain with two channels river confluence beneath crossing. High vertical alignment, embankment would be very wide.	Proposed viaduct alignment is directly over the Peover Eye, and therefore diversion of watercourse(s) may be required. Opportunities may arise to contribute positively to riverine ecology and assist in achievement of future WFD status.
Wincham Brook (MD0880)	Pickmere Viaduct (AKA Smoker Brook Viaduct North)	450	6	Parallel to Channel	Milley Lane (at crossing)	None	Alignment parallel to channel and floodplain flow. Narrow floodplain would be significantly affected by any embankment.	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Bollin (MD0621)	Lymm Viaduct (AKA River Bollin Viaduct West)	340	150	Disused Railway	None	Disused Railway Embankment (250m - 0m)	Wide floodplain with floodplain flow restriction downstream. No vulnerable uses in floodplain in crossing vicinity	Ground levels suggest viaduct may be less than 1.5m above flood water level and would obstruct flood flows at the peak. Detailed modelling required to quantify effect and mitigation Consideration of the WFD may be required, should culverting or diversion be required as a result of embankment introduction. Opening up the Old Bollin Brook culvert may contribute positively to WFD.
Warburton Park Brook (MD0256)	Partington Viaducts (AKA Warburton Viaduct And Manchester Ship Canal Viaduct)	160	1	None	None	Warburton Park Access Track Embankment	Floodplain heavily influenced by Manchester Ship Canal. Flooding arising from downstream, or slow moving floodwaters	Detailed WFD assessment may be necessary if option is taken to culvert the brook.
Manchester Ship Canal (MD0257)		1239	860	MSC Clearance Hollins Green	None	None	No scope to shorten due to other constraints	
Blackburn's Brook (MD0600)	Rostherne Viaducts (AKA Blackburn's Brook viaduct And Birkin Brook Viaduct)	100	8	None	None	M56 Embankment and Culvert/Viaduct	Flood flows restricted downstream by M56. Steep sided valleys. Detailed modelling would be required to understand flooding mechanisms	Ground levels suggest viaduct may be less than 1.5m above flood water level and would obstruct flood flows at the peak. Detailed modelling required to quantify effect and mitigation
Birkin Brook (MD0601)		157	50	None	None	M56 Embankment and Culvert/Viaduct		

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
Corn Brook (MD0617)	West Gorton Cutting	562	21	Between tunnel and station			Flooding arises from Corn Brook "lost watercourse" and open channel upstream. Flood depths and hazards at the crossing are significant. Flood defences would be required. Residential land uses within the floodplain and limited space for floodplain compensation	

4.2. Eastern leg

Viaducts summary table – Floodplain crossings over 100m

4.2.1. Table 4.2 presents a summary of the findings of the floodplain crossing analysis for the proposed route into Leeds and to the ECML. The viaducts are presented from south to north in chainage order along the main route, with the Leeds city centre spur listed from east to west.

4.2.2. The viaduct structure names were devised by the appraisal team for convenience during the course of the AoS. Some names and exact viaduct lengths vary from those used in more recently issued engineering information. However, the provisional conclusions remain valid. As the scheme designs are developed, these names (and the details of the structure dimensions) would be brought in line to ensure consistency. Where the engineering drawing names are known, these have been indicated as "Also Known As" (AKA).

Table 4.2 - Summary of viaduct findings for the eastern leg

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Tame (LE0005)	Kingsbury Viaduct	1276	330	Bodymoor Heath Road	None	M42 Embankment (crossing location)	M42 Embankment creates barrier to floodplain flow. Proposed HS2 crossing immediately upstream. Replacing viaduct with embankment mirroring M42 embankment would not create additional floodplain obstructions	Change to embankment may result in a need to divert minor tributary. Detailed WFD assessment may be required if culverting or diversion of River Tame is necessary. Diversion may present opportunities to enhance current 'poor' ecological status.
Thistlewood Brook (LE0006)	Kingsbury North Viaduct	334	2	Watercourse Channel	Tamworth Road (crossing location)	None	Narrow floodplain, with route running parallel to valley bottom. An embankment would obliterate the watercourse and completely fill the majority of the floodplain. There is vulnerable development nearby (Kingsbury). Limited scope for floodplain compensation	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Anker (LE0008)	Polesworth Viaduct	631	140	WCML and Linden Lane	None	M42 Embankment (crossing location)	M42 Embankment creates barrier to floodplain flow. Proposed HS2 crossing immediately upstream. Replacing viaduct with embankment mirroring M42 embankment would not create additional floodplain obstructions	The viaduct needs to fully cross the Bramcote Brook to avoid any channel or confluence works.
Bramcote Brook (LE0009)					Linden Lane (Crossing location)			
Bramcote Brook (LE0010)	Austrey Viaduct	321	6	None	M42 Embankment	None	M42 embankment creates barrier to flow upstream.	Change to embankment would result in the need to culvert Bramcote Brook and detailed WFD assessment may be required.
River Mease (LE0625)	Measham Viaduct	130	23	None	Tamworth Road (600m)	A42 Embankment (500m)	Restrictions to floodplain flow present both upstream and downstream. Flood Zone 3 has been reduced in width since design based on more recent hydraulic modelling. European Habitat (SAC) rules out culvert. Vulnerable land use within the floodplain, though some distance from crossing	Potential shading of the river by the crossing structure would be an important consideration in the final scheme
Gilwiskaw Brook (LE0626)	Packington Viaduct	131	8	None	Packington (250m)	A42 (crossing location)	A42 embankment creates barrier to floodplain flow upstream. Viaduct lies directly over the current course of the channel	Any reduction in viaduct length would result in a potentially significant diversion over approx 100m. Detailed WFD assessment is likely to be required, given the poor biological status and downstream SAC.

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Soar (LE0928)	Ratcliffe on Soar Viaduct	3419	410	M1, Local Roads, River Channels	A453 Embankment (crossing location)	None	Strong interactions between Soar and Trent floodplains. Complex network of tributaries. Floodplain well confined between high embankments (M1, A453, Melbourne Line railway). Detailed 2D hydraulic modelling required to understand flooding mechanisms	Diversion of Lockington Brook may be required if converting design to embankment at this location. Detailed WFD assessment may therefore be required to ensure no detrimental impact to Lockington Brook or to River Soar downstream.
River Trent (LE0930)	Long Eaton Viaduct	1716	1800	Trent Flood Defences, Midland Main Line and other railways, Cranfleet Cut, Trent Meadows	Midland Mainline Embankment (250m to 500m)	None	South of Midland Main line Crossing Potential to shorten viaduct with sections of embankment due to upstream floodplain flow restrictions, though hydraulic modelling would be required to determine extent of impact and mitigation required North of Midland Mainline Crossing (Long Eaton) Area is heavily built up with sensitive receptors on both sides of the line all within the floodplain. The exact flooding mechanism is unknown, although the Erewash Valley Line may restrict functional flows. No space for floodplain compensation for built volume.	Ground levels suggest northern area of crossing within Long Eaton would be at risk of flooding. Provided that all structures are clear-span, implications on the WFD should be minimal. However should support piers be necessary within the River Trent, detailed WFD assessment may be required.

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Erewash (LE0689)	Sandiacre Viaduct	709	100	Erewash Canal, Erewash Valley Railway	None	Erewash Valley Railway (crossing location)	Upstream of existing restriction to floodplain flows. Very little space for floodplain compensation therefore built volume within floodplain needs to be minimised. Vulnerable residential development within the floodplain upstream: may need to provide flood defences. Northern section of viaduct required to cross railway and canal	Ground levels suggest viaduct may be less than 2m above flood water level and would obstruct flood flows at the peak. Detailed modelling required to quantify effect and mitigation
River Erewash (LE0993)	Stanton Gate Viaduct	940	100	Erewash Canal, M1	M1 (crossing location) - to be diverted	Local Road Crossing	Proposed viaduct should replicate existing M1 embankment as far as possible to prevent increasing flood risk downstream. Detailed 2D hydraulic modelling is likely to be required	Any diversion required to facilitate crossings would need detailed assessment under the WFD.
River Doe Lea (LE1020)	Poolsbrook Viaduct	809	54	M1, Disused Railway Line	M1 (Crossing location)	Great Central Mainline Embankment (crossing location)	Within Upper Don Catchment Flood Management Area. Floodplain compensation required for southern approach embankment. Limited space for floodplain compensation at viaduct. Confined floodplain, with no vulnerable development.	Within Upper Don Catchment flood management area, due consideration needs to be taken in design. Diversion of the River Doe Lea may be required depending on embankment location (if design changed to embankment) and detailed WFD assessment may be necessary. Opportunities to open the Hawke Brook culvert could have positive implications on riverine ecology.
Hawke Brook (LE1021)					None	Great Central Mainline Embankment (crossing location)		

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Doe Lea (LE1024)	Staveley Viaduct South	1243	57	A619	None	None	Viaduct lies along the river channel and diversion would be required. Replacing the viaduct with an embankment would require two culverts or viaducts to convey the Doe Lea to the eastern side of the line and back to the west. The viaduct is potentially low relative to the flood water level and the viaduct deck may obstruct flood flows at the highest flood levels	Ground levels suggest viaduct may be less than 2m above flood water level and would obstruct flood flows at the peak. Detailed modelling required to quantify effect and mitigation. Replacement of viaduct with embankment would result in the need for a 1km diversion of the River Doe Lea. Diversion is likely to require detailed WFD assessment; however may present opportunities to enhance existing ‘poor’ biological quality. Additionally, culverting of the River Doe Lea would require consideration of the impact on hydromorphology and riverine ecology.
River Doe Lea (LE1025)	Staveley Viaduct North	416	57	None	None	None	Any embankment would cut off a large area of floodplain to the east of the embankment. Continuity should be ensured across the floodplain. Limited space for watercourse diversion or floodplain compensation.	
River Rother	*Various*						*ALL RIVER ROTHER CROSSINGS SUBJECT TO MORE DETAIL ON ROTHER/DON FLOOD ALLEVIATION SCHEME, AS WELL AS CANAL RESTORATION*	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Don (LE0093)	*Meadowhall Viaduct South*	950	360	*Multiple*	*Raised ground and ongoing development*	*Meadowhall shopping centre*	*Refer to section 8.2 of this report for comments on Meadowhall station and impacts on these rivers and the associated design considerations*	
Blackburn Brook			31	*Multiple*	*Culvert*	*River Don*		
Blackburn Brook	*Meadowhall Viaduct North*	+/- 2000	32	Multiple	Various	Various	Narrow floodplain, with route running parallel to valley bottom amd directly over watercourse for extended length	
River Dearne (LE0795)	Barnsley Viaduct (AKA Lundwood Viaduct)	237	63	Sewage works	Dismantled Railway Embankment (650m)	Dismantled Railway - Viaduct (300m)	Existing upstream restrictions, but steep sided valley and limited space for floodplain compensation. Rail level suggests the embankment would be wide due to height above ground level (13m high). Sewage works in floodplain and residential property at risk upstream	
Cudworth Dyke (LE0797)	Cudworth Viaduct	254	17	None	Station Road (250m)	North Midland Railway (250m)	No floodplain flow restrictions immediately adjacent to crossing but within 250m both upstream and downstream. No vulnerable land uses within Flood Zone 3, although some properties at Station Road are in Flood Zone 2. Relative space for floodplain compensation	Provided Cudworth Dyke is crossed on clear-span structure, implications on the WFD should be minimal
Haw Park Beck (LE0805)	Wintersett Viaduct	152	3	Cold Heindley Reservoir, Barnsley Canal	Wintersett Reservoir (crossing location)	Cold Heindley Reservoir (crossing location)	Viaduct required to cross Reservoir and Canal	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Calder (LE0943)	Bottom Boat Viaduct (AKA Woodhouse viaduct, Normanton Viaduct and Bottom Boat Viaduct)	1160	550	Aire and Calder Navigation, Floodplain Lakes, Flood Defences, Three Channel Crossings	None	None	Limited space within floodplain, occupied by canal, channels and lakes, Constrained Floodplain. Minimal space within main floodplain area for floodplain compensation. Floodplain area south of canal may not carry functional flows.	Assuming piers are not present within the River Calder, implications on the WFD should be minimal.
Oulton Beck (LE0948, LE0990)	Oulton Viaducts (AKA Oulton Viaduct East (upline) and Oulton Viaduct West (downline))	255	15	None	None	Metro railway line (500m)	Triple crossing would result in very wide embankment, especially when combined with height of track above ground level (approx 16m). Any culvert would be very long, with potential implications on fish habitats. Downstream culvert appears to be sunken or inverted siphon, fish migration may already be compromised. Space available for floodplain compensation and no vulnerable development within floodplain upstream	WFD implications due to long culverts if embankment option is pursued. Triple viaduct preferred as clear-span crossings should have minimal implications under WFD
River Aire (LE0950)	Woodlesford Viaduct (AKA Mickledown Viaduct and Swillington Viaduct)	1057	610	Metro Railway Line, Aire and Calder Navigation, Swillington Lakes, Flood Defences	None	None	Limited space within floodplain, occupied by canal, channels and lakes, Constrained Floodplain. High flood flow velocities likely. Minimal space for floodplain compensation. Vulnerable land uses within the floodplain including residential at Woodlesford and Fleet Oil Depot	

Watercourse Name	Viaduct Name	Floodplain Crossing Length (m)	Q100CC (m^3/s)	Design Constraints	Upstream Restriction	Downstream Restriction	Design Informative	Other considerations
River Aire (LE0992)	Woodlesford Spur Viaduct (AKA Woodlesford Viaduct)	2447		Metro Railway Line, Aire and Calder Navigation	None	None	Extremely limited space (width) for embankment where viaduct passes between canal and river channel. High flood flow velocities likely. Minimal space for floodplain compensation. Vulnerable land uses within the floodplain including residential at Woodlesford and Fleet Oil Depot	
Dorts Dike (LE0959)	Church Fenton Viaduct (AKA Church Fenton Viaduct South and Church Fenton Viaduct North)	2253	1	ECML	None	ECML (crossing location)	Wide, flat floodplain. Flood risk may arise mostly from River Wharfe. Crossing at edge of floodplain, unlikely to be on functional flow pathway. Alongside ECML, construction would be mostly widening. Plenty of space for floodplain compensation, although this may have to be away from the rail line due to the width of floodplain	Detailed WFD assessment may be required to appraise impact of culverting watercourse. Extension of existing culverts would require consideration of the impact of elongated length on macrophyte growth and fish migration.
Tributary of River Aire (Hunslet) (LE0542)	Hunslet Cutting (AKA Hunslet Retaining Wall)	457	12	Metro Railway Line?	N/A	N/A	Floodplain is natural valley with no surface watercourse identified. Leeds underground watercourses in this area are very complex, initial information suggests at least four catchments combine and discharge to the east of this location. Flood Zone Maps would not necessarily represent these combined catchments	

5. GROUNDWATER ANALYSIS FINDINGS

5.1. Western leg

Table 5.1 - Summary of potable groundwater abstractions western leg, south to north

Abstraction Name (and location)	Use	Maximum Daily Abstraction volume (m^3/day)	Type	Possible impact
Borehole at Swynnerton 1	Potable Water Supply	10,227	Multiple borehole (3)	The proposed route crosses SPZ2 associated with the three Swynnerton abstraction boreholes in shallow cut and embankment. The proposed cut would extend a maximum of 5m (145m AOD) into the clay drift deposits and is entirely above the phreatic surface of the groundwater (also known as the water table). Consequently, notwithstanding any impacts during construction and the intrusion of any deep foundations, it appears unlikely that the proposed route would have any significant adverse impact on the groundwater abstraction at the three Swynnerton Boreholes.
Borehole at Whitmore	Potable Water Supply	12,420	Multiple borehole	The proposed route remains at or above ground level for the entire length of SPZ1 and SPZ2, and would therefore have no impact on the groundwater flow regime. However, the route passes directly over the existing abstraction point, and as such it may no longer be useable in its current position. It might be necessary to modify or relocate the abstraction borehole. This would require careful consideration in design and close collaboration with the water company.
Borehole at Pocket Nook 1	Potable Water Supply	7,956	Single borehole	The proposed route crosses the SPZs associated with Pocket Nook 1 abstraction borehole in shallow cut. The proposed cutting is likely to be entirely within the clay drift deposits and entirely above the phreatic surface of the groundwater (also known as the water table). Consequently, notwithstanding any impacts during construction and the intrusion of any deep foundations, it appears unlikely that the proposed route would have any significant adverse impact on the groundwater abstraction at Pocket Nook.
Borehole at Slag Lane Lowton Golborne	Potable Water Supply	7,728	Single borehole	The proposed route crosses the SPZs associated with Slag Lane abstraction borehole in shallow cut. The proposed cutting is likely to be entirely within the clay drift deposits and entirely above the phreatic surface of the ground water (also known as the water table). Consequently, notwithstanding any impacts during construction and the intrusion of any deep foundations, it appears unlikely that the proposed route would have any significant adverse impact on the groundwater abstraction at Slag Lane.

Table 5.2 - Summary of non-potable groundwater abstractions within 500m of proposed route, western leg, south to north

Abstraction Name (and location)	Use	Maximum Daily Abstraction volume (m^3/day)	Type	Possible impact
COMMON LANE FARM, KINGS BROMLEY – BOREHOLE NGR location SK127147	**Agriculture** General Farming & Domestic	2,260	Single Point / Multiple Purposes	Proposed route on shallow embankment with centreline approximately 200m from borehole and therefore unlikely to have a significant impact on groundwater flows. Possible direct impact on abstraction during construction could require relocation of borehole or temporary supplementary water supply.
COMMON LANE FARM, KINGS BROMLEY – BOREHOLE NGR location SK127147	**Agriculture** Direct Spray Irrigation	2,260	Single Point / Multiple Purposes	Proposed route on shallow embankment with centreline approximately 200m from borehole and therefore unlikely to have a significant impact on groundwater flows. Possible direct impact on abstraction during construction could require relocation of borehole or temporary supplementary water supply.
BOREHOLES AT ORIGIN DEVELOPMENTS, MANCHESTER NGR location SJ843977	**Industrial, Commercial and Public Services** Non-Evaporative Cooling	1,010	Single Point / Single Purpose	Proposed route and station above ground and approximately 400m from borehole. Groundwater risk assessment would be required but unlikely to have a significant impact on groundwater flows.

5.2. Eastern leg

Summary of potable groundwater abstractions

5.2.1. There are no such occurrences on the Birmingham to Leeds leg and therefore it is considered unlikely that there would be any significant impacts on any potable groundwater abstractions for this leg.

Table 5-3 Summary of non-potable groundwater abstractions within 500m of proposed route, eastern leg, south to north

Abstraction Name (and location)	Use	Maximum Daily Abstraction volume (m^3/day)	Type	Possible impact
ACTON ROAD WORKS, LONG EATON – BOREHOLE NGR location SK495326	**Industrial, Commercial and Public Services** Process water for Leather and textiles industry	1,954	Single Point / Single Purpose	Proposed route on shallow embankment with centreline approximately 190m from borehole and therefore unlikely to have a significant impact on groundwater flows. Possible direct impact on abstraction during construction which may require relocation of borehole or temporary supplementary water supply.
COAL MEASURES, STOURTON, LEEDS NGR location SE332299	**Industrial, Commercial and Public Services** Process water for dairies	1,400	Single Point / Single Purpose	Proposed route on embankment with centreline approximately 170m from borehole and therefore unlikely to have a significant impact on groundwater flows. Possible direct impact on abstraction during construction which may require relocation of borehole or temporary supplementary water supply.
MAGNESIAN LIMESTONE – LEEDS NGR location SE442345	**Agriculture** Direct Spray Irrigation	1,640	Single Point / Single Purpose	Proposed route in shallow cut on approach to A1(M) overbridge with centreline approximately 140m from borehole. Impact on groundwater flows possible, further investigation required. Possible direct impact on abstraction during construction which may require relocation of borehole or temporary supplementary water supply.

Abstraction Name (and location)	Use	Maximum Daily Abstraction volume (m^3/day)	Type	Possible impact
MAGNESIAN LIMESTONE – LEEDS NGR location SE442345	**Agriculture** Direct Spray Irrigation	1,228	Single Point / Single Purpose	Proposed route in shallow cut on approach to A1(M) overbridge with centreline approximately 140m from borehole. Impact on groundwater flows possible, further investigation required. Possible direct impact on abstraction during construction which may require relocation of borehole or temporary supplementary water supply.

6. WESTERN LEG STATIONS

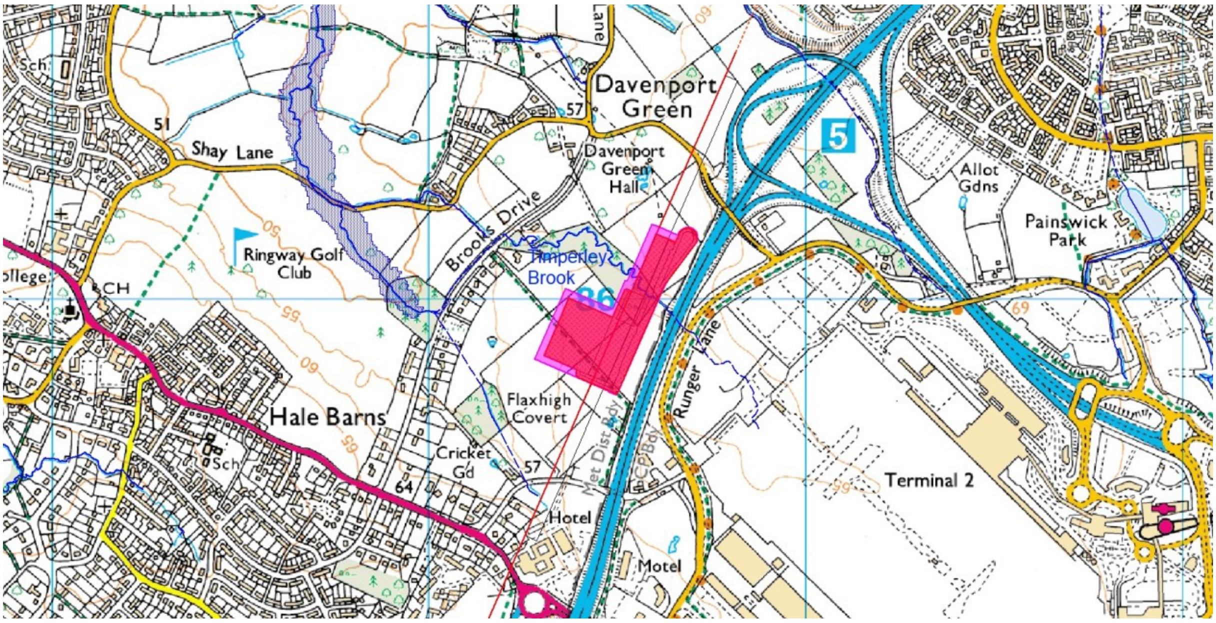
6.1. Manchester Airport High Speed Station

Description

6.1.1. The proposed airport station is located near Davenport Green, just west of the M56 motorway. The station is located close to the south entrance to the Manchester tunnel on the city spur. The location and extents of the station are presented in **Figure 6.1.**

6.1.2. The station has an operational area of 71,000m^2 (0.7ha) and a specific detailed surface water management strategy is therefore not required under the NPPF. However, a strategy would be required as part of the overall scheme design.

Figure 6.1 - Location and extent of Manchester Airport High Speed Station (hatched red)



Watercourse crossings

6.1.3. The operational boundary of the station crosses one watercourse, the Timperley Brook. The crossing is immediately downstream of the M56 motorway, and the brook is assumed to be conveyed beneath the motorway in a suitably sized culvert.

6.1.4. The Timperley Brook has a heavily urbanised catchment with an area of 1.7km^2 and an estimated peak runoff rate of 3.4m^3/s in the 100 year return period event with an allowance for climate change (30% for small watercourses consistent with the approach used in the Phase One design).

6.1.5. In terms of the Water Framework Directive, the upper reaches of the Temperley Brook are not classified, and therefore status is inherited from approximately 2km downstream. The Temperley Brook is designated a 'heavily modified' watercourse, currently classified at 'moderate ecological potential', with this standard remaining in 2015. 'Good potential' is targeted for 2027, with achievement before this deemed expensive and technically infeasible. Measured biological quality elements are presently 'bad' due to bad invertebrate levels.

Physico-chemical elements and specific pollutant levels are both 'moderate' overall and hydromorphological supporting elements are classified as 'not high'.

6.1.6. The width of the operational boundary at the crossing point is approximately 110m. The through line (which bypasses Manchester to the WCML) is approaching the Manchester tunnel at this location, and according to the proposed route profile information, the rail level is approximately 3m below ground.

6.1.7. Due to the station superstructure, platforms and headroom required, it is unlikely that an aqueduct solution would be acceptable at the watercourse location. Without diverting the watercourse, therefore, the only cross drainage solution would be an inverted siphon.

Watercourse diversions

6.1.8. Diversion of the Timperley Brook would not be required were an inverted siphon to be employed at the current watercourse location. However, inverted siphons are the least favourable form of cross drainage, and it would potentially be preferable to divert the watercourse to a location where an aqueduct or simple culvert could be used.

6.1.9. Since there is no above ground construction for some distance in either direction, the best surface option would be to divert the watercourse north to the start of the tunnel. However, this would require a 750m uphill diversion, with associated technical difficulties. Holistically, the best solution would therefore be to divert the watercourse a minimum of 200m north around the operational boundary of the station to a point where the headroom is sufficient to construct a gravity fed aqueduct.

6.1.10. Although the upper reaches are not classified under the WFD, any alterations may have an impact downstream on the classified reach of the Timperley Brook. Provided that sensitive diversion design are undertaken to ensure that existing channel conditions and habitats are maintained as a minimum, and ecological study confirms this has no detrimental impact on riverine ecology, diversion of the tributary should be acceptable under the WFD.

6.1.11. As stated above, an inverted syphon is the least preferable cross drainage solution since the structure can prevent fish migration and disrupt hydrological flow regime. Although a gravity fed aqueduct is by no means a natural solution, at the very least it is an open structure which should not restrict flow or migration.

6.1.12. Further ecological assessment and survey would be required in order to determine the scale and value of any potential impacts, and to determine whether there is likely to be a detrimental impact on the Timperley Brook downstream. Since alternative design options are limited, negotiations with the Environment Agency would be required to discuss what would be acceptable for this crossing in terms of ecology and the WFD.

Flood flow obstructions and floodwater displacement

6.1.13. The Timperley Brook at this location does not have a formally associated fluvial flood risk due to the small catchment size. The cross drainage design should be sufficient to convey the full 100 year return period flow including an allowance for climate change in order to prevent increasing the risk of flooding upstream. Any inverted siphon would need to be subject to a detailed maintenance program to prevent blockages causing upstream flood effects. The upstream culvert beneath the M56 should limit the extent of upstream effects.

6.1.14. Potential increases in conveyance due to low friction culverts or pipes and the loss of natural meanders over around 100m would ideally also be accounted for to prevent increases in peak flows downstream. However, this effect is likely to be extremely localised.

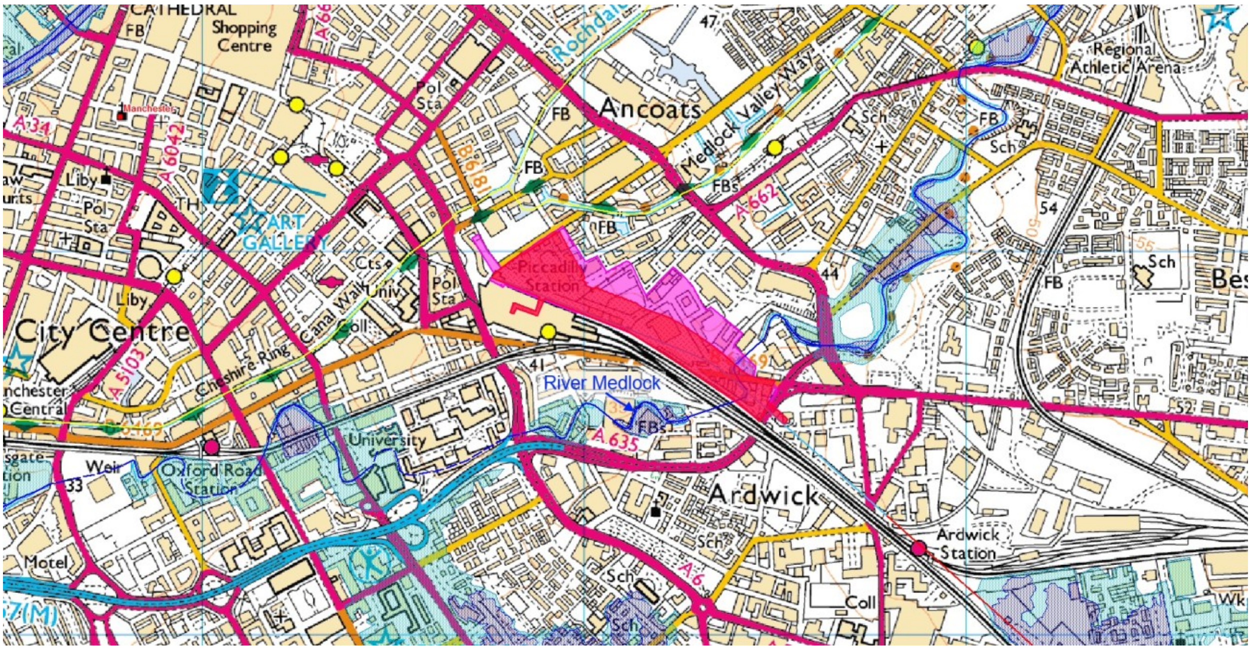
6.2. Manchester Piccadilly Station

Description

6.2.1. The proposed Manchester terminal station is located adjacent to the existing Piccadilly station, on the northern side. The location and extents of the station are presented in **Figure 6.2**.

6.2.2. The station has an operational area of 75,000m^2 (0.8ha). The construction area of the station is significantly greater at 119,000m^2 (1.2ha) and a specific detailed surface water management strategy may therefore be required by the Environment Agency in accordance with the technical guidance for flooding for the National Planning Policy Framework (NPPF).

Figure 6.2 – Location and extent of Manchester Piccadilly station (hatched red)



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Watercourse crossings

6.2.3. The operational outline of the station crosses one watercourse, the River Medlock. The crossing is at the far eastern extent of the station, and immediately upstream of the existing station approaches.

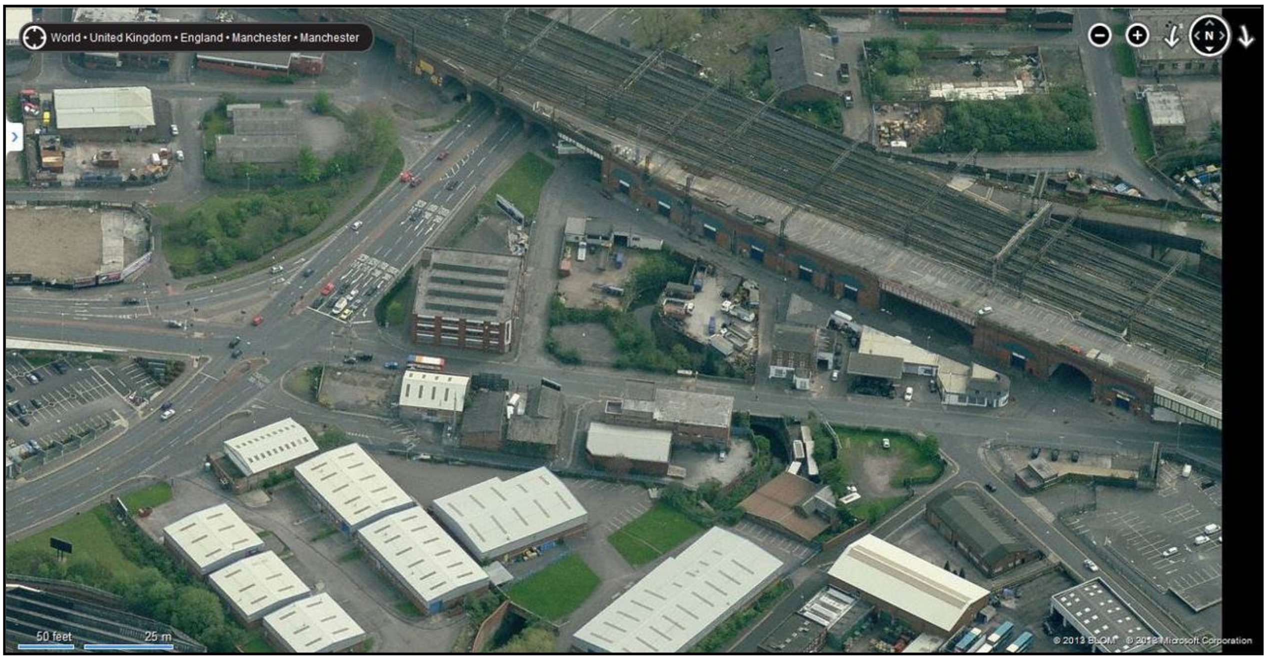
6.2.4. The River Medlock has a very heavily urbanised catchment with an area of 57km^2 and an estimated peak runoff rate of 70m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF). In this area, the river is conveyed within a substantial artificial channel, clearly shown in **Figure 6.3**.

6.2.5. The River Medlock is designated a 'heavily modified' watercourse, and is currently classified as 'poor ecological potential' in terms of the WFD. This standard is anticipated to remain in 2015, with 'good ecological potential' (GEP) targeted for 2027. Achievement of GEP by 2015 is deemed expensive and technically infeasible. Chemical status is not assessed for this waterbody. The watercourse is considered 'at risk' from pressure elements overall.

6.2.6. Measured biological quality elements are presently 'bad' overall due to poor diatom and bad invertebrate levels. Fish are currently at moderate status. Physico-chemical elements and specific pollutant levels are 'moderate' overall, and hydromorphological supporting elements are considered 'not high'. Heavily modified bodies, such as the River Medlock, are therefore unable to achieve their natural targets. As such, these are designated a target of 'good ecological potential' to ensure ecology is protected in so far as possible. Mitigation measures are put in place to ensure that these targets are reached, and currently progress is considered 'moderate' for this watercourse.

6.2.7. The crossing is at the far eastern extent of the station, and the total width of the operational boundary at the crossing point is approximately 80m. The rail construction type at the crossing is a viaduct, suggesting that the station at this location may be raised above surrounding ground on viaduct, consistent with the existing approach viaduct, which can be seen in **Figure 6.3**.

Figure 6.3 – Bird's eye view of existing railway viaduct into Manchester Piccadilly Station



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Watercourse diversions

6.2.8. The River Medlock is contained within an artificial channel of significant capacity, and enters a culvert beneath the existing railway viaduct within the operational extent of the proposed station. The proposed construction type is viaduct, and it is therefore assumed that there is no direct need to culvert the river.

6.2.9. However, due to the sweeping meander that is present within the operational extents of the station, it may inevitably be necessary to reposition the watercourse in order to enable the structure to cross without impeding flows, or alternatively to allow space for extension of the existing culvert. Any diversion (including culverting) should be designed to maintain the capacity and flow mechanics of the existing channel, and detailed hydraulic modelling is likely to be required to demonstrate the impact and assist in the design of mitigation.

6.2.10. Since diversion and possibly culverting of the River Medlock is likely to be necessary in order facilitate the crossing, a detailed WFD assessment would be required. Designs must ensure that there is no negative impact on channel hydromorphology or ecological habitat within watercourse. As biological quality is currently 'bad' within the channel, extra care must be taken to ensure there is no further impact as a result of the works, and where possible, opportunities should be sought to improve conditions.

6.2.11. Should the River Medlock remain in open channel, in theory, as long as conditions and habitats are maintained, diversion of the watercourse should not have a significant impact in terms of the WFD. However, given space constraints, ensuring the meander is maintained within the new platform could be a challenge and therefore sensitive design, with consideration of the WFD throughout, is likely to be necessary.

6.2.12. If a new culvert or extension of the existing culvert is proposed, there may be negative implications in terms of the WFD. Culverting of watercourses can alter hydromorphological conditions, and given the likely length, consideration must be given to any negative impacts on riverine ecology, particularly in terms of light availability and fish migration.

6.2.13. Further ecological assessment and survey may be necessary in order to determine the scale and value of any potential impacts. Negotiations with the Environment Agency may be required to discuss what is acceptable for this crossing in terms of ecology and the WFD. However, it is likely that an open channel solution would be preferable. Although there appears to be little space for significant improvements, careful design of the river diversion could present opportunities to add small areas of ecological habitat.

Flood flow obstructions

6.2.14. According to the flood zone mapping, the capacity of the artificial channel in this area is sufficient to convey the 100 year return period and the majority of the 1000 year return period flood flows without overtopping. Thus, any culvert that may be required due to the proposed station development, so long as it is adequately sized to convey the 1000 year return period flood flow (including allowances for climate change and blockage), would not significantly obstruct flood flows.

Floodwater displacement

6.2.15. Approximately 600m^2 of the operational extent and an additional 1300m^2 of the construction extent for the station fall in the area of Flood Zone 2 that arises upstream of the B6469 Fairfield Street. In general, compensatory floodplain storage provision is not usually required for areas of Flood Zone 2. However, the outline of Flood Zone 2 would sometimes be used as a surrogate outline to account for climate change relative to Flood Zone 3. Depending on the type of construction, a small amount of floodplain compensation may be needed. However, it is likely that this can be incorporated into any river works that are required.

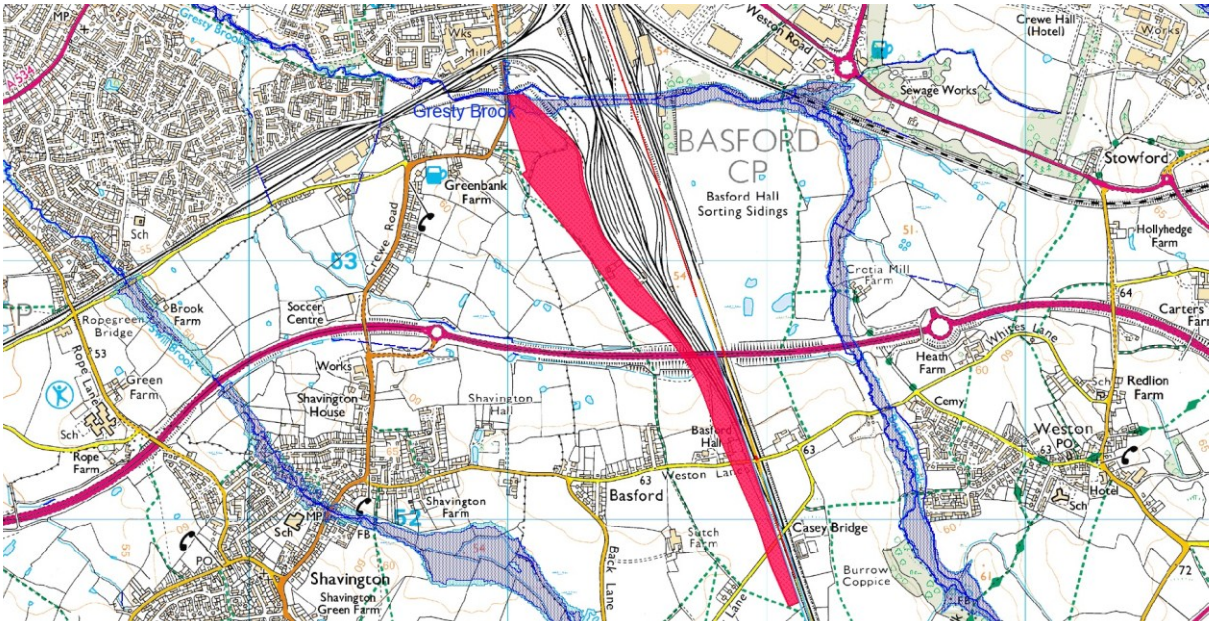
7. WESTERN LEG DEPOTS

7.1. Crewe IMD

Description

7.1.1. The Crewe Infrastructure Maintenance Depot (IMD) is located near Shavington and Weston, south west of Crewe. The depot splits from the route at Casey Bridge, and is positioned alongside existing sidings that serve both the Welsh Marshes Line and WCML, as shown in **Figure 7.1**. It is assumed that the IMD would consist mostly of railway sidings.

Figure 7.1 – Location and extent of Crewe IMD (hatched red)



Watercourse crossings

7.1.2. There are four watercourses within the operational extent of the IMD. The two southernmost watercourses are crossed at their point of origin, which is immediately downstream of existing railway infrastructure on either side of the A500. Due to the location of the proposed depot relative to existing infrastructure, it is unlikely to be necessary to make provision for these two watercourses in the design.

7.1.3. At the northern extent of the IMD, the operational boundary lies alongside the Gresty Brook, with the operational extents occupying an area of the associated flood zones and crossing a significant length of a tributary.

7.1.4. The Gresty Brook has a slightly urbanised catchment with an area of 24km^2 and an estimated peak runoff rate of 9m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF). The tributary has an essentially rural catchment with an area of 1.5km^2 and an estimated peak runoff rate of 1.4m^3/s in the 100 year return period event with an allowance for climate change (30% for small catchments consistent with the approach used in Phase One).

7.1.5. The operational boundary does not cross the Gresty Brook. However, the extent of the operational area lies over approximately 520m of the channel of the tributary, including the confluence with the Gresty Brook.

7.1.6. In terms of the Water Framework Directive, the Gresty Brook is classified under the Wistaston Brook. At the depot location the brook is currently at 'moderate' ecological status, with this standard anticipated to remain in 2015 and good status targeted by 2027. The watercourse is designated ‘at risk’ from pressure elements (including physical or morphological alteration risk). Measured biological elements are currently 'moderate', due to macroinvertebrate levels. Supporting hydromorphological elements are considered 'not high' overall. However, hydrology is presently 'high' and morphology is 'good' and conditions must therefore be protected.

Watercourse diversions

7.1.7. Although the tributary is not classified under the WFD, its potential diversion may have an impact downstream on the Gresty Brook. Consideration of the WFD is required to ensure that there is no negative impact on hydrology, channel morphology or ecological habitat within the tributary or the Gresty Brook. Sensitive diversion design would be required, ensuring that existing channel conditions and habitats are maintained as a minimum. Opportunities to add ecological value as a result of the diversion works could be considered where possible.

Flood flow obstructions

7.1.8. Although the operational boundary of the IMD does not cross the channel of the Gresty Brook, the extents encroach across the majority of the width of the natural floodplain according to the flood zone mapping, which appears to show the natural floodplain crossing the field to the south of the channel.

7.1.9. Due to the existing maintenance sidings, the Gresty Brook has been culverted and diverted slightly from its natural course, as shown in **Figure 7.2.** Detailed hydraulic modelling of the existing scenario would need to be undertaken to design the extent and geometry of the new floodplain.

7.1.10. It appears from **Figure 7.2** that some floodplain re-grading may have already been undertaken. If this is the case, then no work would be required. The initial phase of the hydraulic modelling would determine whether this is the case.

Figure 7.2 – Bird’s eye view of the Gresty Brook at Crewe Road, to the north of the IMD

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Floodwater displacement

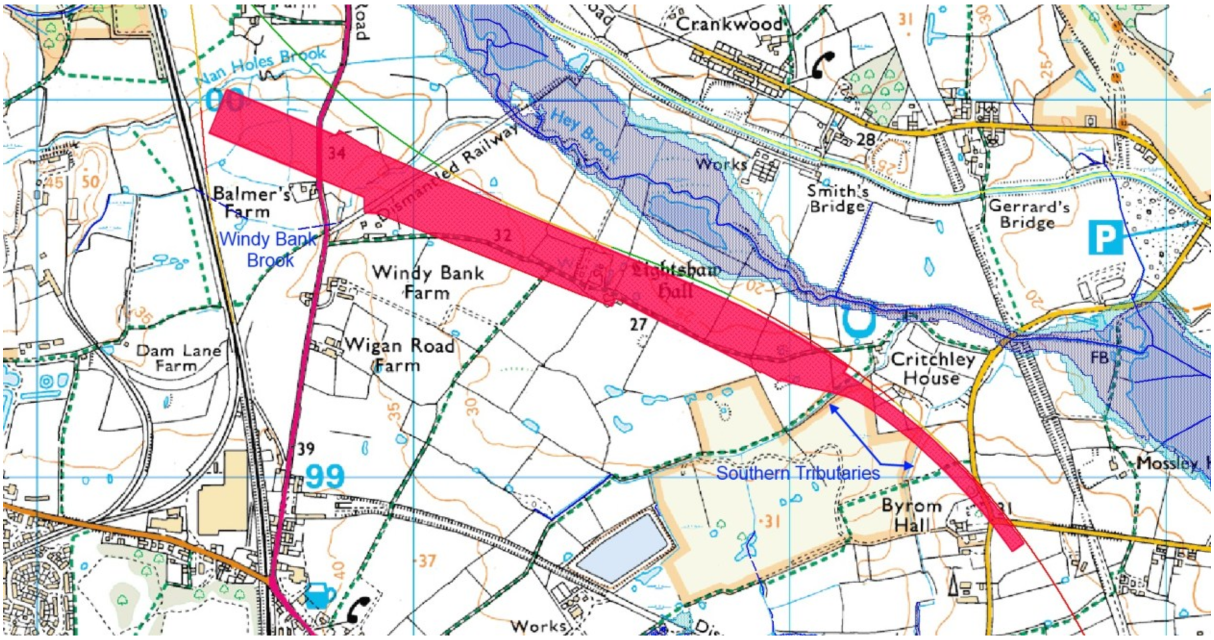
7.1.11. The operational extent of the Crewe IMD occupies approximately 5,000m^2 of Flood Zone 3 and 5,800m^2 of Flood Zone 2. Due to the potential for floodplain flow obstruction, works to re-grade the floodplain would result in the IMD lying outside of the flood zone extents and no additional compensatory floodplain storage provision would be required.

7.2. Golborne RSD

Description

7.2.1. The Golborne Rolling Stock Depot (RSD) is located north of Golborne, adjacent to and south of the proposed route. The depot would also have connections from the WCML from the west. Slag Lane to the east. The location and extent of the RSD is presented in **Figure 7.3**.

Figure 7.3 – Location and extent of Golborne RSD (hatched red)



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Watercourse crossings

7.2.2. The RSD crosses two minor watercourses, each forming part of the Hey Brook catchment. To the eastern end of the RSD, three unnamed tributaries of the Hey Brook are crossed, extending the proposed route alignment crossing. The western end of the depot crosses the Windy Bank Brook. Potential road diversions could also affect watercourses in the area.

Southern tributaries

7.2.3. Two tributaries of the Hey Brook are crossed at the far eastern extent of the RSD. The southernmost tributary has a heavily urbanised catchment with an area of 0.6km^2 and an estimated peak runoff rate of 1.3m^3/s in the 100 year return period event with an allowance for climate change (30% for small catchments consistent with the approach used in Phase One). The second tributary has a moderately urbanised catchment with an area of 1.2km^2 and an estimated peak runoff rate of 2.7m^3/s in the 100 year return period event with an allowance for climate change.

7.2.4. The two southern tributaries are crossed approximately 250m apart by the diverging connections. The RSD would add approximately 40m and 50m respectively to crossings that are already 40m and 50m long respectively, effectively doubling their lengths. According to the proposed route profile information, the through line rail level is approximately 500mm above ground at the southern tributary, and 2m below ground at the second tributary. There would be insufficient headroom above the tracks for an aqueduct at the second tributary and very limited space for a culvert at the southern tributary.

Windy Bank Brook

7.2.5. The Windy Bank Brook is crossed by the WCML connection and the RSD extent. The watercourse has a moderately urbanised catchment with an area of $0.8km^2$ and an estimated peak runoff rate of $1.7m^3/s$ in the 100 year return period event with an allowance for climate change.

7.2.6. The connection and RSD crossings would require culverts in addition to the culvert under the proposed through route.

Watercourse diversions

Southern tributaries

7.2.7. Although the tributaries are not classified under the WFD, the potential diversion of the northern tributary and single crossing may have an impact on the status of the Hey Brook downstream. Consideration is required to ensure that there is no negative impact on channel hydromorphology or ecological habitat within the two tributaries or downstream within the Hey Brook. Fish levels, in particular, are presently ‘good’ within the Hey Brook and must be protected.

7.2.8. The choice of downstream solution will be informed by detailed hydraulic modelling if necessary, and by ecological and habitat concerns. Provided that sensitive diversion design are undertaken to ensure that existing channel conditions and habitats are maintained as a minimum, and ecological study confirms this has no detrimental impact on riverine ecology, diversion of the tributary should be acceptable under the WFD.

7.2.9. Further ecological assessment and survey would be required in order to determine the scale and value of the potential impacts, and to determine whether there is likely to be a detrimental impact on the Hey Brook downstream. Since alternative design options are limited, negotiations with the Environment Agency would be required to discuss what is acceptable for this crossing in terms of ecology and the WFD.

Windy Bank Brook

7.2.10. The brook is not classified under the WFD. However, diversion and culverting of the watercourse may be required and this could have an impact downstream within the classified Hey Brook. In order to avoid negative implications either locally or within the wider catchment, consideration of the WFD is required to ensure there is no impact on channel hydromorphology or riverine ecology.

7.2.11. Sensitive diversion design, featuring creation of additional habitat, could have a positive impact on ecology within the Windy Bank Brook. A culvert would have the potential for negative implications to the watercourse hydromorphology and ecology. Consideration would need to be given to the scale of the impact, and whether this could have a detrimental impact on the status of the Hey Brook. Therefore, this would be subject to further ecological assessment and negotiations with the Environment Agency.

Flood flow obstructions and floodwater displacement

7.2.12. None of the tributaries that are spanned by the RSD extents have a formally associated fluvial flood risk due to the small catchment sizes. All cross drainage design should be sufficient to convey the full 100 year return period flow including an allowance for climate change in order to prevent increasing the risk of flooding upstream. Any inverted siphons would need to be subject to a detailed maintenance program to prevent blockages causing upstream flood effects.

8. EASTERN LEG STATIONS

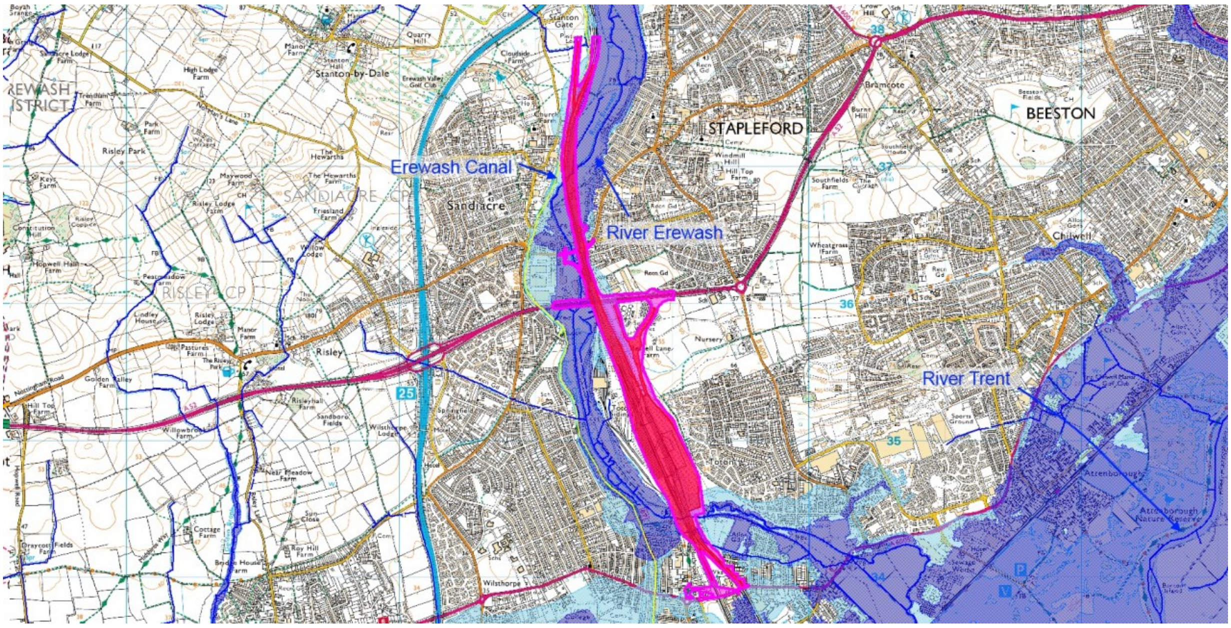
8.1. East Midlands Hub Station

Description

8.1.1. The proposed East Midlands Hub Station at Toton, north of the Trent crossing, is located alongside the existing Erewash Valley railway line, taking in part of Toton sidings, and spans either side of the A52. The location and extents of the station are presented in **Figure 8.1.**

8.1.2. The station has an operational area of 470,000m^2 (4.7ha) and a specific detailed surface water management strategy may therefore be required under the NPPF.

Figure 8.1 – Location and extent of East Midlands Hub Station (hatched red)



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Watercourse crossings

8.1.3. The operational boundary crosses three separate watercourses; the River Erewash and two tributaries; and the Erewash Canal. The River Erewash is crossed twice by the operational boundary of the station. The construction boundary crosses the River Erewash three further times, although all three crossings appear to relate to potential road modifications. The station footprint crosses the flood zones of the River Erewash at both the southern and northern extents, though these areas are rail connections rather than populated station areas.

River Erewash

8.1.4. The River Erewash is crossed by the operational extent of the station at two locations. At the southern, downstream crossing, the river has a moderately urbanised catchment with an area of 190km^2 and an estimated peak runoff rate of 112m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF). At the downstream crossing, the total width of the operational boundary is approximately 130m. However, it is anticipated that this area of the station would be mostly rail connections, with no platforms or other buildings. There are already numerous viaducts crossing the River Erewash at this location, and it is anticipated that the design of the station can be undertaken utilising the existing viaducts or constructing new crossings that replicate the existing conditions. **Figure 8.2** shows the current crossings of the River Erewash. The station's operational footprint extends from the footbridge at the top of the image to the second viaduct from the bottom of the image.

Figure 8.2 – Bird's eye view of existing crossings of River Erewash at southern extent of Toton station

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8.1.5. The northern crossing of the River Erewash occurs where the connections from the station are re-joining the main through line, with an additional connection enabling access to and from the Erewash Valley line. It is assumed that the Erewash Valley connection would use the existing viaduct crossing of the River Erewash, with the HS2 connection raised to pass over both the Erewash Valley line and the Erewash Canal north of the watercourse. The alignment and implications of this crossing are discussed in the consideration of Sandiacre Viaduct in section 6 of this report.

8.1.6. In terms of the Water Framework Directive the River Erewash is designated as 'heavily modified' in this location. It is currently classified as 'moderate ecological potential', improving to 'good ecological potential' (GEP) by 2027. Measured biological elements are considered to be 'moderate' due to moderate invertebrate levels. However, fish levels are high and must therefore be protected. Hydromorphological supporting elements are considered 'not high' at present. Mitigation measures are in place in order to improve ecological potential and these are currently 'good'. It is therefore assumed the watercourse is making good progress towards its 2027 GEP targets.

8.1.7. Tributaries of the River Erewash are not classified under the WFD. However, alterations within these small watercourses can have a wider impact downstream within the River Erewash.

Erewash tributary – south

8.1.8. Approximately 100m south of the downstream River Erewash crossing, the operational boundary crosses a minor tributary of the River Erewash that appears to emerge from culvert just upstream of the existing line. The tributary has a very heavily urbanised catchment with an area of 0.7km^2 and an estimated peak runoff rate of 0.9m^3/s in the 100 year return period event with an allowance for climate change (30% for small catchments consistent with the approach used in Phase One). The width of the operational boundary at the crossing point is approximately 130m. However, the watercourse is already culverted beneath existing railway lines, and no significant additional work to the watercourse is anticipated.

Erewash tributary – north

8.1.9. At the far northern extent of the station, the operational boundary crosses a second tributary of the River Erewash. The tributary has an essentially rural catchment with an area of $0.6km^2$ and an estimated peak runoff rate of $0.8m^3/s$ in the 100 year return period event with an allowance for climate change (30% for small catchments consistent with the approach used in Phase One). The operational boundary appears to be limited to the rail extents at this location, and no work over and above that assessed under the proposed route is anticipated.

Watercourse diversions

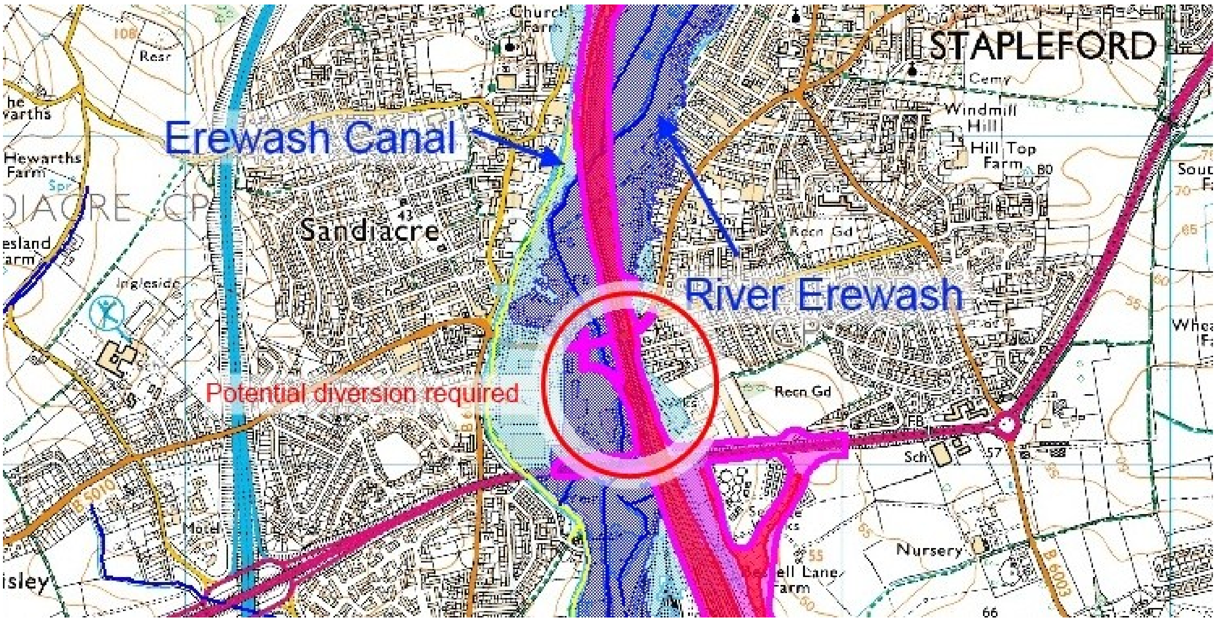
River Erewash

8.1.10. Between the two identified crossings of the River Erewash, the watercourse runs parallel to the proposed station, in places relatively close to the operational boundary, although the boundary does not appear to fully cross the watercourse in any other locations. Although works of any nature should be kept as far away from the watercourse as possible to allow a maintenance and ecological buffer strip, there is only one location where the watercourse would potentially require diversion. Between the A52 Brian Clough Way and Station Road, the channel swings to the east around a rail storage depot. At this location, the operational boundary is sufficiently close to the top of bank that, depending on the type of construction required at this location, the river may need to be re-aligned, as shown in **Figure 8.3**. Due to the density of urban development in this area, space is extremely limited and detailed design of the Station would need to have due consideration to avoiding any need to divert the River Erewash.

8.1.11. Although the length of watercourse that coincides with the operational boundary is relatively short, due to the presence of flood defences lining the banks of the River Erewash along this entire stretch, further lengths of the watercourse may need diversion to enable sufficient room for maintenance access to all flood defences.

8.1.12. Should diversion of the River Erewash be necessary, detailed Water Framework Directive Assessment would be required. Detailed diversion design should ensure that existing conditions and habitats are maintained as a minimum. However, space is limited since the River Erewash is largely urbanised in this location. Minor realignment of the channel is not likely to have any future impact on channel morphology or flow regime. With thoughtful design, habitat (particularly for fish) could be maintained or even improved.

Figure 8.3 – Location of potential diversion on the River Erewash



Flood flow obstructions

8.1.13. At the downstream (south) crossing of the River Erewash, the flood zone extents suggest that the channel and viaducts have sufficient capacity to convey the 100 year return period and the majority of the 1000 year return period flood flows without overtopping. Further, it is anticipated that designs would seek to use or replicate the existing viaducts over the floodplain, and no additional obstruction to floodplain or channel flow is therefore expected as a result of this floodplain crossing.

8.1.14. To the north of the station, a length of nearly 2km, starting at the northern extent of the existing Toton sidings area and extending to the Erewash Canal lies within the floodplain of the River Erewash. North of the A52, the station footprint spans Flood Zone 3, initially along the eastern edge of the floodplain, before crossing the floodplain at Sandiacre Viaduct. Based on likely flood flow patterns, and the presence of the existing railway line, the station itself is unlikely to cause significant additional floodplain flow obstruction, except at Sandiacre Viaduct. The effect of Sandiacre Viaduct is considered in more detail in Section 6 of this report.

Floodwater displacement

8.1.15. The operational extent of East Midlands Hub Station occupies approximately 75,000m^2 of Flood Zone 3 and 123,000m^2 of Flood Zone 2 at the northern crossing. An additional 60,000m^2 of Flood Zone 2 east of the operational boundary would potentially be blocked from the floodplain. At the southern floodplain crossing, the operational extent occupies approximately 32,000m^2 of Flood Zone 2. Any built volume within the floodplain would occupy existing floodplain storage volume, resulting in displacement of flood waters onto neighbouring land. This would potentially result in an increase in the frequency and severity of flooding to neighbouring third party property.

8.1.16. The surrounding floodplain extends into densely populated residential areas, and potential increases in flood water levels resulting from losses in floodplain storage would not be tolerated. Consequently, in order to develop in this area, measures would need to be implemented to ensure that there is no increase in the risk of flooding as a result of the station development.

8.1.17. Under normal circumstances, compensatory excavations to return floodplain storage to the system would be undertaken, and due to the extremely close proximity of sensitive receptors within the floodplain, such compensation would need to be widespread along the length of the station boundary to replace losses as close to the source of that loss as possible.

8.1.18. It is clear from the mapping and aerial imagery that there is extremely limited availability of space for any such floodplain compensation, particularly in the area between the A52 and Station Road. The vast scale of the floodwater displacement combined with this lack of available space (sufficiently local to the source of displacement) means that a solution based on traditional compensatory excavations is unlikely to be feasible.

8.1.19. Due to the no-tolerance approach regarding changes in flood risk to third parties integral to national planning policy, alternative mitigation would therefore be required. Provision of upstream attenuation ponds is one such alternative although this has the potential to significantly alter the hydromorphology and ecology of the watercourse, and significant investigation would be required to determine if such a solution would be acceptable. Detailed WFD assessment is likely to be required, in order to ensure there would be no detrimental impact upon the River Erewash as a result of the attenuation ponds.

8.1.20. The most feasible solution, on the basis that flood defences already exist along the channel and within the floodplain of the River Erewash, would be to provide improved hard-engineered flood defences, preferably in the form of bunds, along the River Erewash, as a minimum along the length of channel from Sandiacre Viaduct to the A52. Depending on the range of influence of the proposed station, longer sections of flood defence may be required, together with softer flood defence solutions such as offline balancing and attenuation ponds, and/or areas of traditional floodplain storage compensation. Detailed hydraulic modelling, ideally using a dynamically linked 1-dimensional (channel) and 2-dimensional (floodplain) simulation, would be required to determine baseline conditions, to inform design parameters and to test proposed solutions. All mitigatory works would need to be fully completed prior to initiation of any construction at the East Midland Hub.

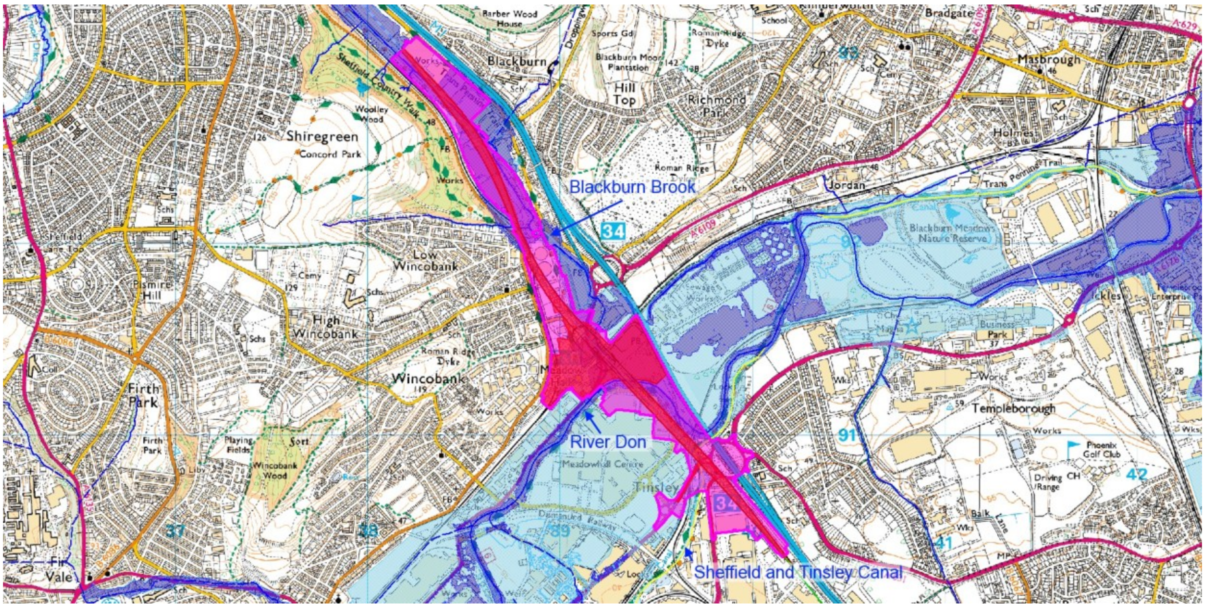
8.2. Sheffield Meadowhall Station

Description

8.2.1. The proposed station at Meadowhall is located immediately north of Meadowhall Shopping Centre, within the River Don and Blackburn Brook valleys. The location and extents of the station are presented in **Figure 8.4**. The Meadowhall Station would be a high-level structure raised above the surrounding ground.

8.2.2. The station has an operational area of 240,000m^2 (2.4ha) and a specific detailed surface water management strategy may therefore be required under the NPPF.

Figure 8.4 – Location and extent of Sheffield Meadowhall station (hatched red)



Watercourse crossings

8.2.3. The operational boundary of the Sheffield Meadowhall Station crosses the Sheffield and Tinsley Canal, the River Don, and the Blackburn Brook. The station footprint lies directly above nearly 600m of the course of the Blackburn Brook.

River Don

8.2.4. The River Don has a moderately urbanised catchment with an area of $408km^2$ and an estimated peak runoff rate of $360m^3/s$ in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF). Although spanned by multiple bridges and viaducts, in the crossing area, the river is relatively wide, and a reasonable access and habitat buffer is sustained, as shown in **Figure 8.5**.

8.2.5. The design of the station has been undertaken with a view to minimising the impact on the River Don by limiting the footprint of the station itself to the north bank. A new viaduct crossing would be required to convey the tracks and connections over the watercourse, and some realignment of the river may be required to accommodate this. The operational extent is tight to the bank of the River Don on the northern side, and it is noted that the Environment Agency would require a maintenance buffer strip along the river bank, and any building in this area would be restricted.

8.2.6. In terms of the Water Framework Directive, the River Don is a heavily modified watercourse currently at 'moderate ecological potential'. This is unlikely to improve before 2015 (due to technical infeasibility and disproportionate expense) and therefore 'good ecological potential' (GEP) is targeted by 2027. Measured biological quality elements are currently 'bad' overall, due to bad invertebrate levels. However, fish levels are high and must therefore be protected. Physicochemical supporting elements are 'moderate' overall, and specific pollutants are considered 'good'. Hydromorphological elements are 'not high' at present, and mitigation measures are currently in place to try and improve physical and chemical properties, in the hope of improving overall ecological potential. The watercourse also fails its chemical assessment.

Figure 8.5 – Bird's eye view of the River Don at Meadowhall Shopping Centre

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Blackburn Brook

8.2.7. The Blackburn Brook has a heavily urbanised catchment with an area of 42km^2 and an estimated peak runoff rate of 31m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF).

8.2.8. The operational boundary suggests that the footprint of the station would lie above the current route of the Blackburn Brook for up to 700m. The Blackburn Brook is a substantial watercourse, although through this section it is frequently culverted, and where the channel is open, appears to be contained within an artificial, rectangular concrete aqueduct. The station development creates an opportunity to open out the Brook wherever possible within and around the operational extent, potentially improving the quality of the watercourse, in combination with restoration works along the length of the Blackburn Brook valley alongside the Meadowhall North Viaduct.

8.2.9. In terms of the WFD, the Blackburn Brook is a designated 'heavily modified' watercourse which is currently at 'moderate ecological potential'. This is unlikely to improve before 2015, and therefore 'good potential' is targeted for 2027. It is considered 'at risk' from pressure elements including physical and chemical alterations to the watercourse. In terms of biological quality elements, only invertebrate levels are monitored and these are classified as 'moderate'. Hydromorphological supporting elements, including hydrology, are 'not high'. Overall physicochemical status is 'good', with ammonia, pH and dissolved oxygen levels at high status. Specific pollutant levels are also classified overall as 'high'. Mitigation measures are currently in place to try and improve hydromorphology and physical and chemical properties, in the hope of improving overall ecological potential.

Watercourse diversions

River Don

8.2.10. The River Don is nearly 30m wide at the viaduct crossing location. It is anticipated that the viaduct would be designed to avoid placing any piers within or in close proximity to the watercourse. However, in the event that this is not possible, channel works would potentially be required to enhance channel capacity and/or straighten the watercourse at the crossing point to enable the watercourse to pass between piers. Any physical modification to the watercourse may require detailed WFD assessment in order to ensure there is no detrimental impact on channel morphology or flow regime, or knock-on impact on riverine ecology, as a result.

Blackburn Brook

8.2.11. The Blackburn Brook would require major channel works along the length of the watercourse that falls within the operational boundary of the station. There is an opportunity to open out the watercourse, which is currently partially culverted and heavily modified.

8.2.12. In the first instance, the Blackburn Brook could be diverted along the north western edge of the operational boundary near Meadowhall Roundabout. It is inevitable that the brook would pass beneath the station structure although on the basis that the Meadowhall Station would be high-level, there is potentially space beneath the station to fully open out the watercourse beneath the building. In the absence of detailed design information, it is difficult to determine the feasibility of any restoration works to the brook, given the likely restriction to natural light beneath the station and potentially contaminated environment. As part of the detailed design opportunities could be sought to create an improved environment and ecosystem based around the Blackburn Brook, although it is acknowledged that this may prove to be technically infeasible.

8.2.13. Major channel works would require a full detailed Water Framework Directive assessment to ensure there is no negative impact on hydromorphology or riverine ecology. Opening up the channel beneath the station could provide additional ecological habitat within an area which is presently very urbanised and could be beneficial in contributing to targets of the WFD. However, given that natural light is likely to be restricted, and water quality could be a concern should the area prove to be contaminated, further assessment would be required to determine the feasibility and assess the scale and value of any benefits on riverine ecology within the brook and the wider catchment.

Flood flow obstructions

8.2.14. The flood zone extents suggest that the River Don channel has sufficient capacity to convey the 1 in 100 year return period flood flow without overtopping, although the extent of the 1 in 1000 year return period flood is significant. The majority of the floodplain extends to the southern side of the River Don channel, which would be spanned by a viaduct, and therefore would result in only minor additional obstruction to floodplain flow for rarer events than the 100 year return period flood. Any solid construction on the north bank would obstruct floodplain flow along the northern floodplain for these return period events.

8.2.15. The potential obstruction to flood flows from the Blackburn Brook is significant. The operational boundary completely spans the extent of the floodplain, and could completely cut off flood flows from the Blackburn Brook to the River Don.

8.2.16. The Meadowhall Station would be constructed at a high level, although details of the foundations and construction types have not yet been made available. It is possible that sufficient flood flow capacity can be maintained by allowing flooding beneath the station building, so long as the design is undertaken with this mechanism in mind, and with due consideration for the potential additional structural loads. In general, voids and space beneath buildings that allow flood water flows are not accepted by the Environment Agency as a permanent solution due to the potential to infill in the future. However, with the appropriate assurances in place this may be acceptable.

Floodwater displacement

8.2.17. The operational extent of Meadowhall Station occupies approximately 140,000m^2 of Flood Zone 3 and 190,000m2 of Flood Zone 2 at the northern crossing. Any built volume within the floodplain would occupy existing floodplain storage volume, resulting in displacement of flood waters onto neighbouring land. This would potentially result in an increase in the frequency and severity of flooding to neighbouring third party property.

8.2.18. The immediately surrounding floodplain does not extend into any residential areas, and the majority falls within the total extent (including the temporary construction boundary) of the station. However, if the operational extent were of fully solid construction, water could be displaced into residential areas nearby, and any such floodwater displacement would not be tolerated. Consequently, in order to develop in this area, measures would need to be implemented to ensure that there is no increase in the risk of flooding as a result of the station development.

8.2.19. Even under the assumed high-level design, there would be significant solid construction at ground level, which would occupy current areas of floodplain storage. However, there could be some demolitions of existing buildings, which would offset this volume significantly. There should be space in the remainder of the area beneath the station to excavate areas for compensatory flood storage. As previously mentioned, voids and space beneath buildings that allow flood water storage are not usually accepted by the Environment Agency as a permanent solution due to the potential to infill in the future. However, with the appropriate assurances in place this may be acceptable.

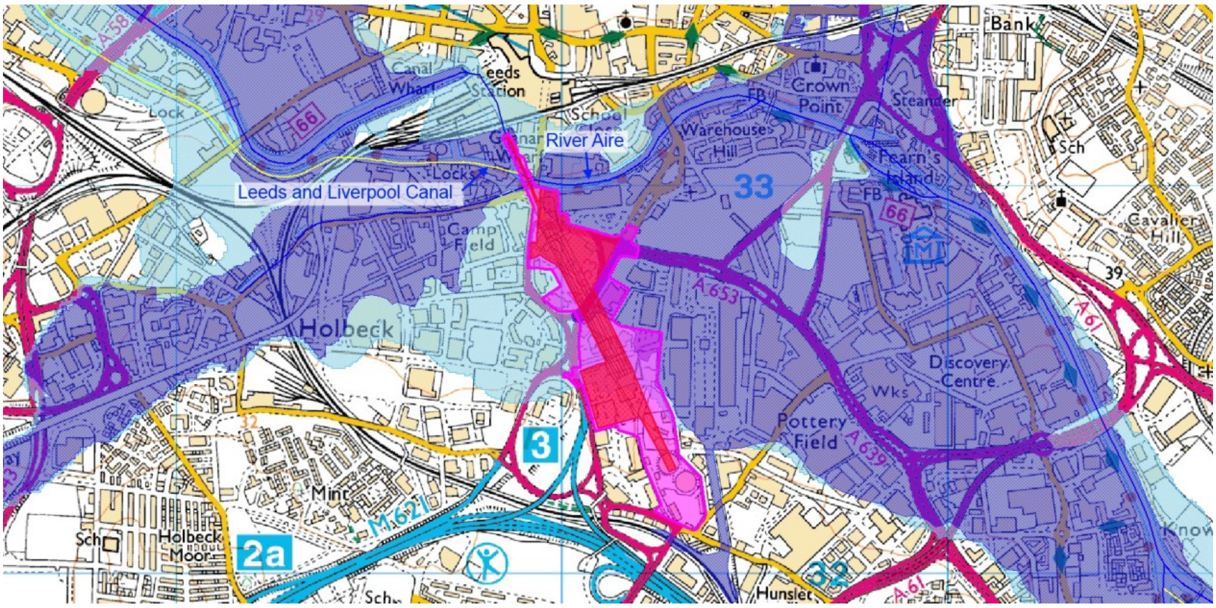
8.3. Leeds New Lane Station

Description

8.3.1. The proposed Leeds terminal station is located immediately south of Leeds Station (national rail), south of the River Aire. The location and extents of the proposed station are presented in **Figure 8.6**.

8.3.2. The station has an operational area of 67,000m^2 (0.7ha). The construction area of the station is significantly greater at 145,000m^2 (1.4ha) and a specific detailed surface water management strategy may therefore be required under the NPPF.

Figure 8.6 – Location and extent of Leeds New Lane Station



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Watercourse Crossings

8.3.3. The operational extent of the proposed station crosses the River Aire at the far north of the station extent, where the Leeds and Liverpool Canal joins the river. This crossing would be a foot access or similar access bridge to the mainline rail station, rather than part of the railway infrastructure or station itself.

8.3.4. The River Aire has a moderately urbanised catchment with an area of 755km^2 and an estimated peak runoff rate of 600m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF). The river in this area is tightly confined with development under variety of land uses extending close to the riverbank as shown in **Figure 8.7.**

8.3.5. The majority of the station's operational area lies to the south of the river. The operational extent extends from the southern edge of the floodplain to abut the channel, with construction assumed to be above ground based on the available construction information. On the basis that the access bridge would be designed to span the watercourse at a high level, and taking into consideration the density of existing development along the banks of the river, it is unlikely that any works to the watercourse, or redesign of the station boundary, would be required.

8.3.6. In terms of the WFD, the River Aire is heavily modified along this reach, and currently at 'poor ecological potential'. It is anticipated that conditions would remain poor in 2015, not reaching 'good potential' until 2027. Measured biological elements in this location (diatoms and macroinvertebrates) are presently at 'poor potential'. The ecological supporting elements; hydromorphology and physico-chemical quality, are classified as 'not high' and 'moderate' respectively. Phosphate levels, in particular, are 'poor'. The overall specific pollutant status for the River Aire is 'moderate'. Additionally, the watercourse fails its chemical assessment. Overall, the watercourse is in a poor state at present, and improvements are unlikely to be made in the near future due to disproportionate expense and technical challenges.

Figure 8.7 – Bird's eye view of River Aire at Leeds City Station

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Watercourse diversions

8.3.7. It is not anticipated that any watercourse diversions would be required, and therefore construction of the station should have minimal implications in terms of the WFD.

Flood flow obstructions

8.3.8. The extents of the latest flood zone maps suggest that the floodplain of the River Aire narrows to the width of the channel just upstream of the Neville Street bridge, widening again on the downstream side. The operational extent of the station is almost completely outside of the extent of Flood Zone 3, and on the basis of the flood zone maps is not on any functional flow path. On this basis, and subject to the access bridge design, there would be no obstruction of floodplain flows as a result of the proposed station.

8.3.9. The Flood Zone maps have recently been revised in this area. In the previous stage of assessment, Flood Zone 3 was significantly wider and floodplain flow from west to east across the operational area of the station was inferred. In that case, an obstruction would potentially be presented by the station, and the station would be designed accordingly. In general, the latest information from the Environment Agency is assumed to be the best available information, and therefore the observation that no floodplain flow obstruction is expected holds true. Nevertheless, it is worth bearing in mind that there is potential for floodplain flow in this area for greater return period events, and applying this as a consideration within the design where practicable.

Floodwater displacement

8.3.10. The operational extent of Leeds New Lane Station occupies approximately 10,000m^2 of Flood Zone 3 and 51,000m^2 of Flood Zone 2. Any built volume within the floodplain would occupy existing floodplain storage volume, resulting in displacement of flood waters onto neighbouring land. This would potentially result in an increase in the frequency and severity of flooding to neighbouring third party property.

8.3.11. The surrounding floodplain extends into densely populated residential areas, and potential increases in flood water levels resulting from losses in floodplain storage would not be tolerated. Consequently, in order to develop in this area, measures would need to be implemented to ensure that there is no increase in the risk of flooding as a result of the station development. There could be multiple demolitions within the area at risk of flooding, and this is likely to significantly offset the amount of built volume added to the floodplain. The construction type for the proposed route is shown as viaduct, and it is assumed that the station would be built at a high level with some form of voided space beneath. Given the type of construction, and the scale of likely demolitions, together with the small footprint area that lies within Flood Zone 3, it is likely that the proposed station design would adequately balance the available floodplain storage, as long as sufficient consideration is made for this within the detailed design.

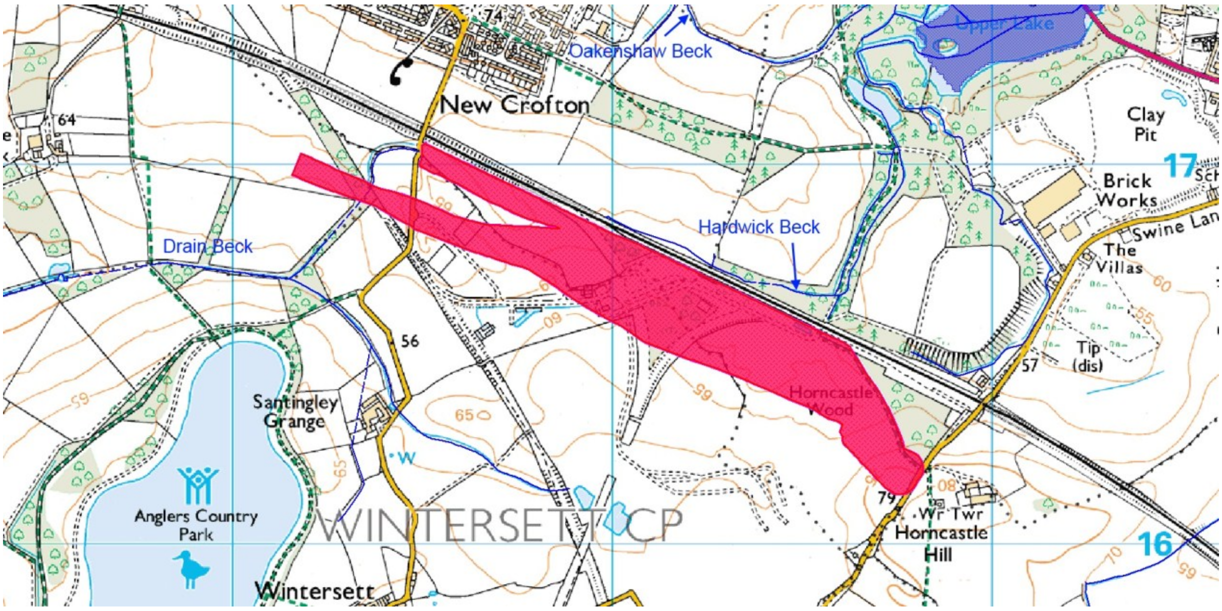
9. EASTERN LEG DEPOTS

9.1. New Crofton RSD

Description

9.1.1. The New Crofton Rolling Stock Depot (RSD) is located between Crofton and Walton, just south east of the urban extent of Wakefield. The depot is located north of the Wintersett and Cold Hiendley Reservoirs, which supply water to the Barnsley Canal. The location and extents of the depot are presented in **Figure 9.1**.

Figure 9.1 – Location and extent of New Crofton depot (hatched red)



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Watercourse crossings

9.1.2. The proposed depot lies on a watershed between the Drain Beck and Hardwick Beck catchments. The natural catchments appear to be altered due to the presence of the existing railway line, however, with the majority of the Hardwick Beck head catchment forced to discharge to the Drain Beck or the Hessle Beck to the east. The Hardwick Beck channels are therefore carrying very low flows, and are only present to the north of the existing railway line. The operational extents of the depot remain south of the existing line, and therefore the Hardwick Beck would not be crossed.

9.1.3. The only watercourse that falls within the operational extent of the depot itself is a minor tributary of the Drain Beck. This watercourse does not have a sufficient natural catchment to be defined in the FEH CD-ROM, the industry-standard resource for assessing the hydrological characteristics of catchments in the UK. The majority of diverted flows from the Hardwick Beck catchments would discharge via the main channel of the Drain Beck, and would therefore not be obstructed by the depot development.

9.1.4. The depot connections cross a tributary of the Drain Beck north of Walton, the Oakenshaw Beck and the Red Beck. The latter two crossings are concurrent with the proposed route crossings. The Drain Beck tributary crossing is approximately 200m upstream of the proposed route crossing.

9.1.5. The tributary has a moderately urbanised catchment with an area of 0.6km^2 and an estimated peak runoff rate of 0.5m^3/s in the 100 year return period event with an allowance for climate change (30% for small catchments consistent with the approach used in Phase One). The watercourse can be seen in **Figure 9.2** and the crossing is likely to be formed of a culvert beneath the proposed connection embankments.

Figure 9.2 – Bird's eye view of Drain Beck tributary

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Watercourse diversions

9.1.6. It is not anticipated that any watercourse diversions would be required.

Flood flow obstructions and floodwater displacement

9.1.7. The local watercourses do not have a formally associated fluvial flood risk due to the small catchment sizes. All cross drainage design should be sufficient to convey the full 100 year return period flow including an allowance for climate change in order to prevent increasing the risk of flooding upstream.

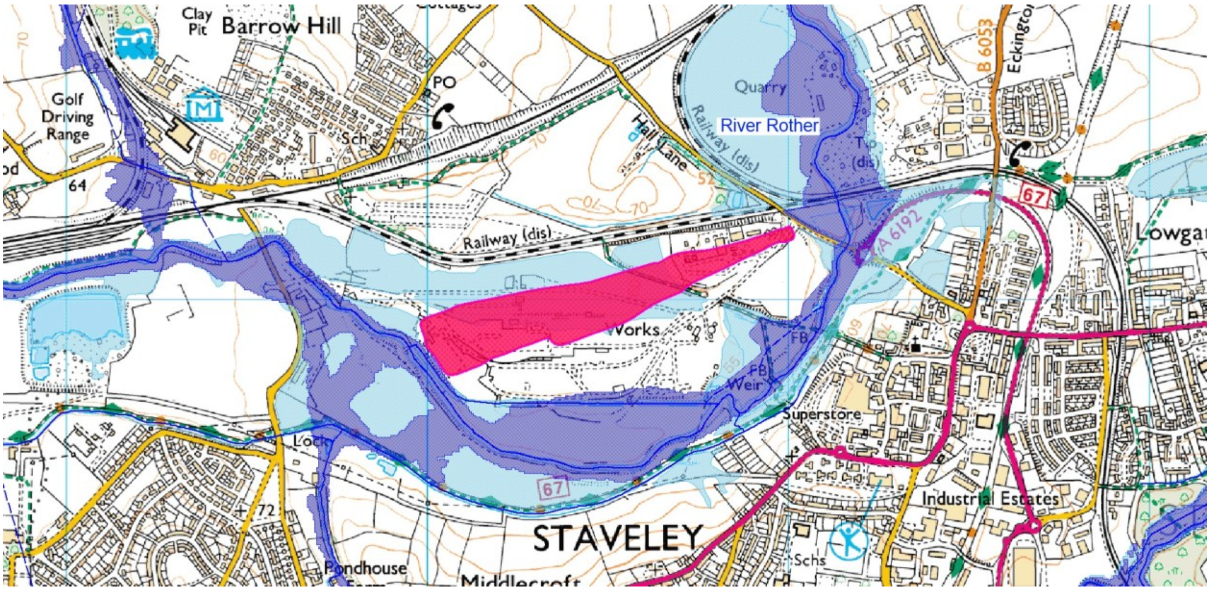
9.2. Staveley IMD

Description

9.2.1. The proposed Staveley Infrastructure Maintenance Depot (IMD) is located near Barrow Hill to the north west of Staveley. The connection leaves the main through route north of Netherthorpe along the River Doe Lea valley, crossing the River Rother alongside the disused Great Central Line connections that connect with the Midland Mainline.

9.2.2. Any potential river and floodplain works along the Doe Lea and Rother valleys by the presence of the Upper Don flood management strategy. Further complications arise due to potential conflicts with the proposed route of the proposed Chesterfield Canal restoration project.

Figure 9.3 – Location and extent of Staveley depot (hatched red)



Watercourse crossings

9.2.3. The depot connections cross the River Doe Lea at two locations and the River Rother. The River Rother crossing would be formed of two separate viaducts. The operational boundary of the depot lies within an area of land bounded by a large meander of the River Rother, with the far western extent adjacent to a secondary channel of the River Rother which appears to serve as an aqueduct carrying water to the works.

River Rother

9.2.4. The River Rother has a moderately urbanised catchment with an area of 185km^2 and an estimated peak runoff rate of 133m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF).

9.2.5. The proposed connections and approach into the depot would cross the watercourse on viaduct spanning the width of the floodplain. The Great Central Railway viaduct crosses the river at the connection crossing as shown in **Figure 9.4**, and it is anticipated that the new connection would make use of or replicate the existing viaduct for the crossing. A new viaduct would be required for the depot approach although this lies between the existing viaduct and a road bridge crossing of the River Rother upstream.

9.2.6. The operational boundary extends to the bank of the secondary channel of the River Rother. This channel (shown in **Figure 9.5**) is designated Main River, and it is noted for consideration that a buffer strip for maintenance access and ecology would usually be required by the Environment Agency, and construction should be kept away from this area.

9.2.7. In terms of the WFD, the Rother is classified as 'heavily modified' along this reach, and currently at 'poor ecological potential'. It is anticipated that conditions would remain poor in 2015, not reaching 'good potential' until 2027. Measured biological elements in this location are poor overall due to diatoms and macroinvertebrates. However, fish levels are presently good and must therefore be protected. The ecological supporting elements; hydromorphology and physico-chemical quality, are classified as 'not high' and 'moderate' respectively. Phosphate levels, in particular, are 'poor'. The specific pollutant status for the River Rother is 'moderate' in this location. Additionally, the watercourse fails its chemical assessment. Overall, the watercourse is in a poor state at present, and improvements are unlikely to be made in the near future due to disproportionate expense and technical challenges.

Figure 9.4 – Bird's eye view of the Great Central Railway crossing of the River Rother

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Figure 9.5 – Bird's eye view of the River Rother dual channel at the western extent of the depot

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River Doe Lea

9.2.8. The River Doe Lea has a moderately urbanised catchment with an area of 71km^2 and an estimated peak runoff rate of 59m^3/s in the 100 year return period event with an allowance for climate change (20% as recommended in the NPPF).

9.2.9. The proposed connections cross the River Doe Lea at two locations, although the northern crossing is adjacent to the proposed main through route. However, it is likely that the River Doe Lea may require diversions in this area, and the extent and nature of any such diversion would potentially be significantly greater as a result of these proposed additional crossings, both due to an increased number of spans and also an increase in the potential crossing width at the northern connection crossing.

9.2.10. In terms of the WFD, the Doe Lea, like the Rother, is 'heavily modified', and currently classified at 'moderate ecological potential'. It is anticipated that conditions would remain moderate in 2015, with GEP targeted for 2027. Measured biological elements in this location are presently at 'poor potential' due to particularly low fish levels. Physicochemical elements are 'moderate' overall, held back by 'bad' phosphate levels despite 'high' levels of both dissolved oxygen and pH. Hydromorphological supporting elements are considered 'not high'. The Doe Lea is deemed 'at risk' overall and mitigation measures are in place in order to improve ecological potential. Chemical status does not require assessment for this watercourse.

Watercourse diversions

9.2.11. It is not anticipated that any watercourse diversions would be required as a result of the proposed depot. However, the existing need for diversion of the River Doe Lea may be exacerbated and the design complicated by the proposed connections. The River Doe Lea diversion is discussed in greater detail in Section 5 of this report.

Flood flow obstructions

River Rother

9.2.12. The viaduct crossings of the River Rother floodplain have the potential to obstruct flood flows. However, since they are located at and between two existing flood flow restrictions, it is not anticipated that there would be any significant further effect arising from the proposed depot. The far western extent of the depot lies adjacent to the River Rother secondary channel, and may obstruct flood flows along the northern bank.

River Doe Lea

9.2.13. It is already noted in Section 6 that the Staveley South viaduct (through route) may be insufficiently raised above the flood water level in the River Doe Lea, and the viaduct capacity may be insufficient to pass peak volume of the design flood. The connections are likely to be at a similar level, and appear to be below the natural ground level at the edge of the floodplain (Flood Zone 2), suggesting that the rails may even be at risk of flooding in the extreme event. The viaducts are between 650m and 750m in length and potentially obstructing this length of floodplain flow at the upper levels could create an increased risk of flooding to residential properties at Netherthorpe.

9.2.14. On the assumption that the viaduct level would be raised above the flood water level, obstruction of flood flows would be limited to the viaduct piers, which should be set away from the channel to avoid significant obstructions. The connection line viaducts should be designed alongside the through route viaduct, with the diversion of the watercourse and potential re-grading of the floodplain being hydraulically modelled alongside the detailed design to ensure no increase in the risk of flooding to third parties.

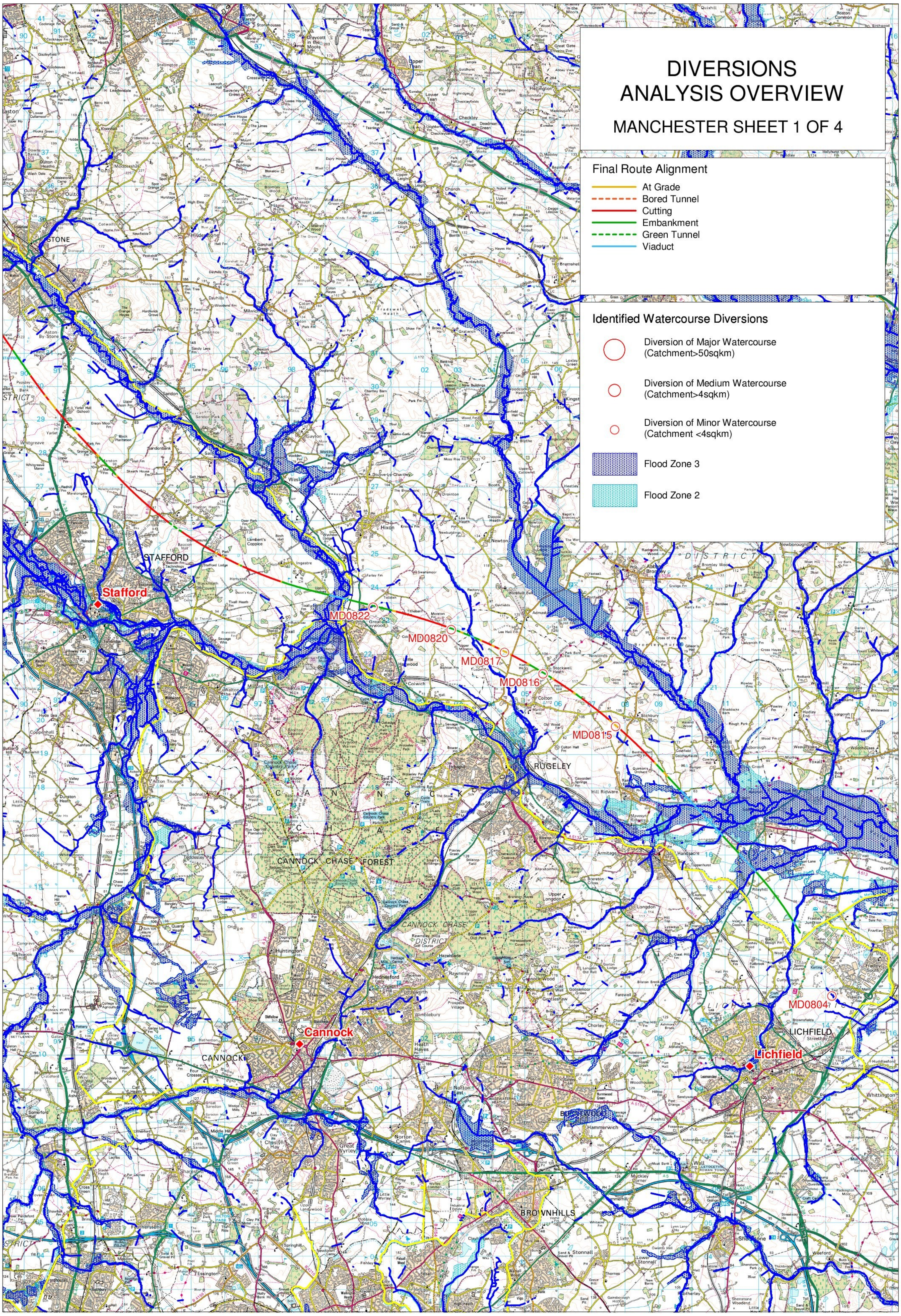
Floodwater displacement

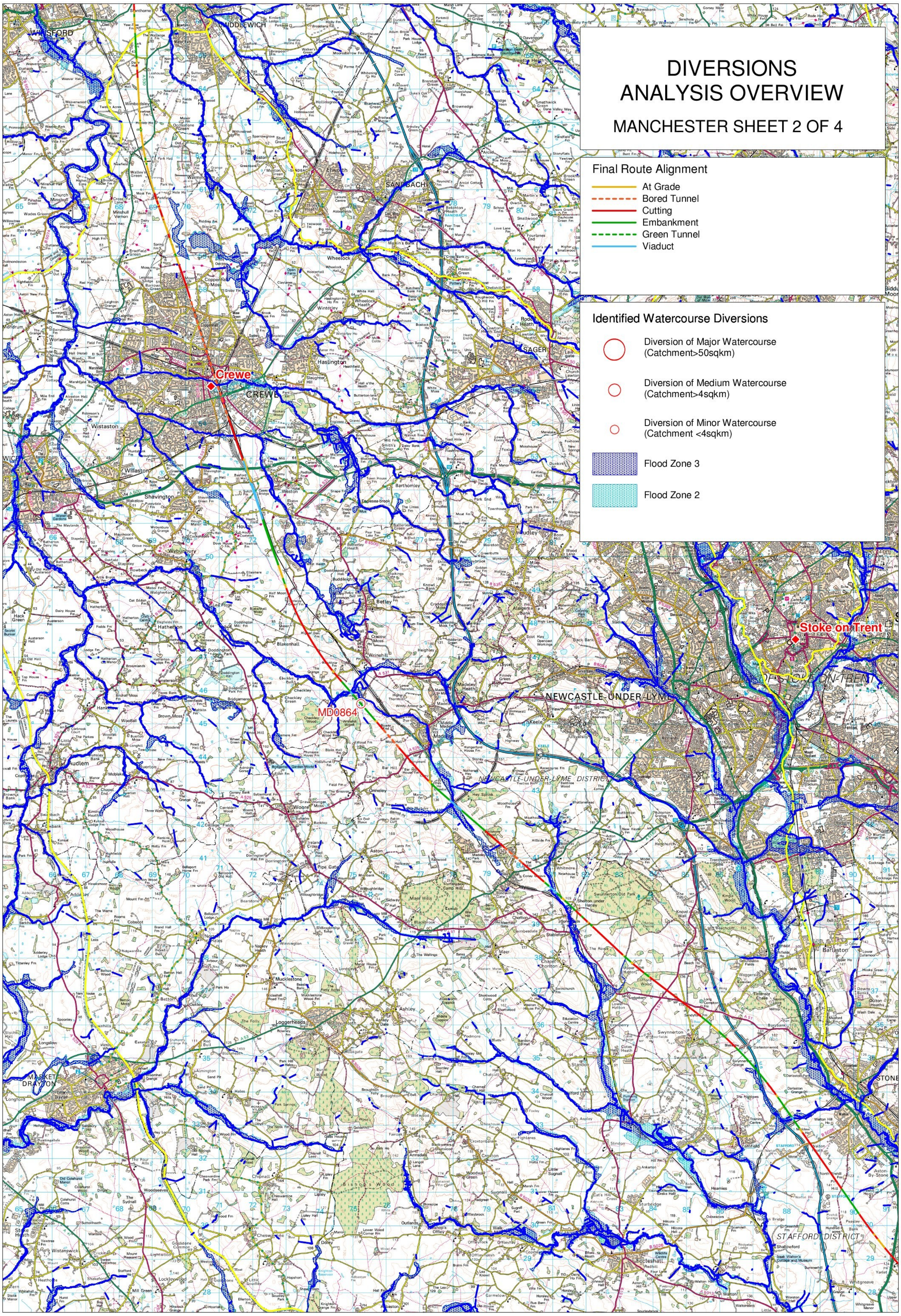
9.2.15. The operational extent of the Staveley depot occupies approximately 67,000m^2 of Flood Zone 2. Any built volume within the floodplain would occupy existing floodplain storage volume, resulting in displacement of flood waters onto neighbouring land. This would potentially result in an increase in the frequency and severity of flooding to neighbouring third party property.

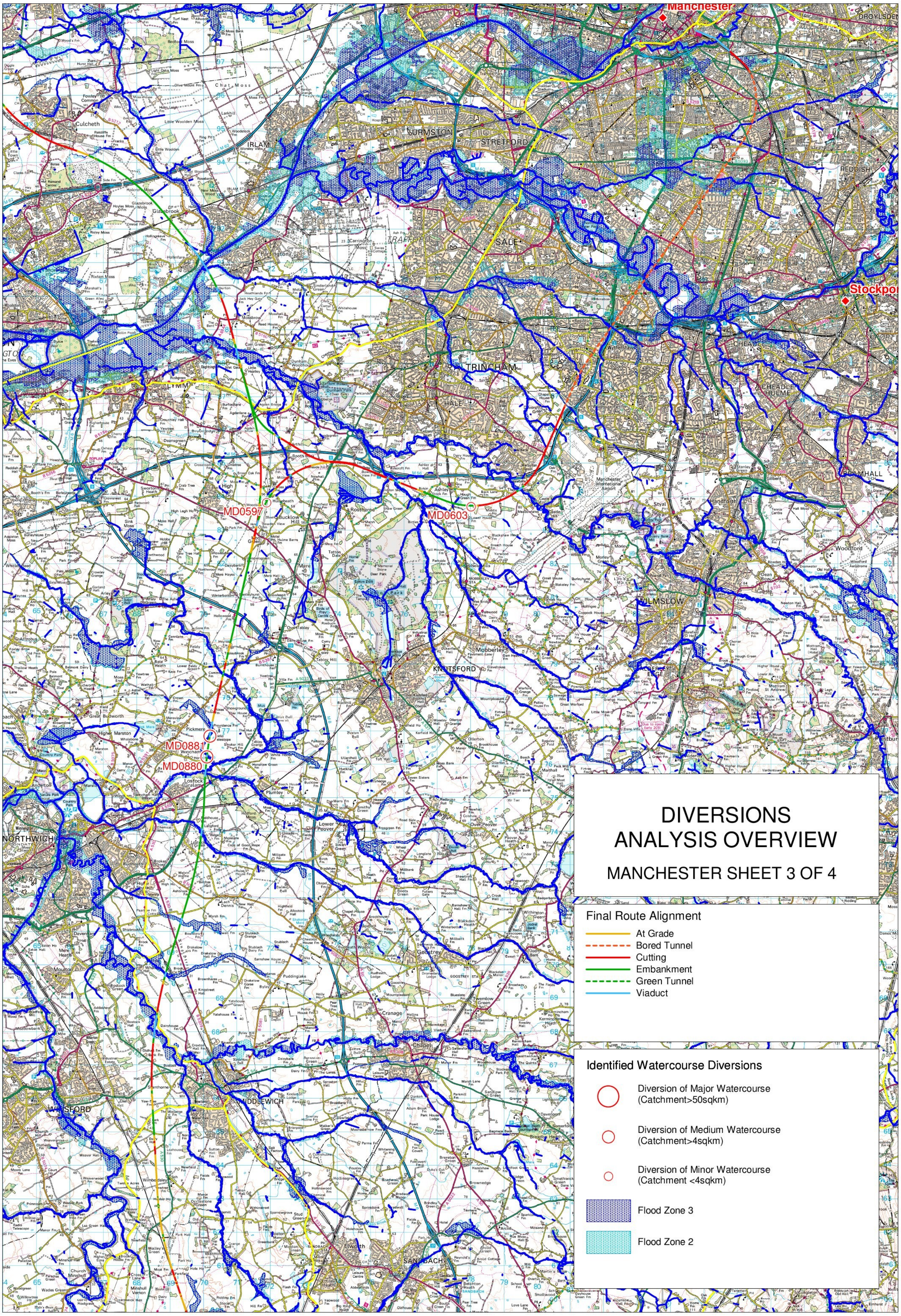
9.2.16. In general, compensatory floodplain storage provision is not usually required for areas of Flood Zone 2. However, the outline of Flood Zone 2 would sometimes be used as a surrogate outline to account for climate change relative to Flood Zone 3. Depending on the type of construction, floodplain compensation may be needed. On the assumption that the works would be decommissioned, there is ample space south of the depot to provide floodplain compensation if required, although it is noted that the area of floodplain arises from north of the depot outline, and flow paths across the site area may need to be maintained.

10. OVERVIEW MAPS

10.1.1. The following section presents the overview maps for river diversions, viaduct crossings and groundwater for the western and eastern leg.

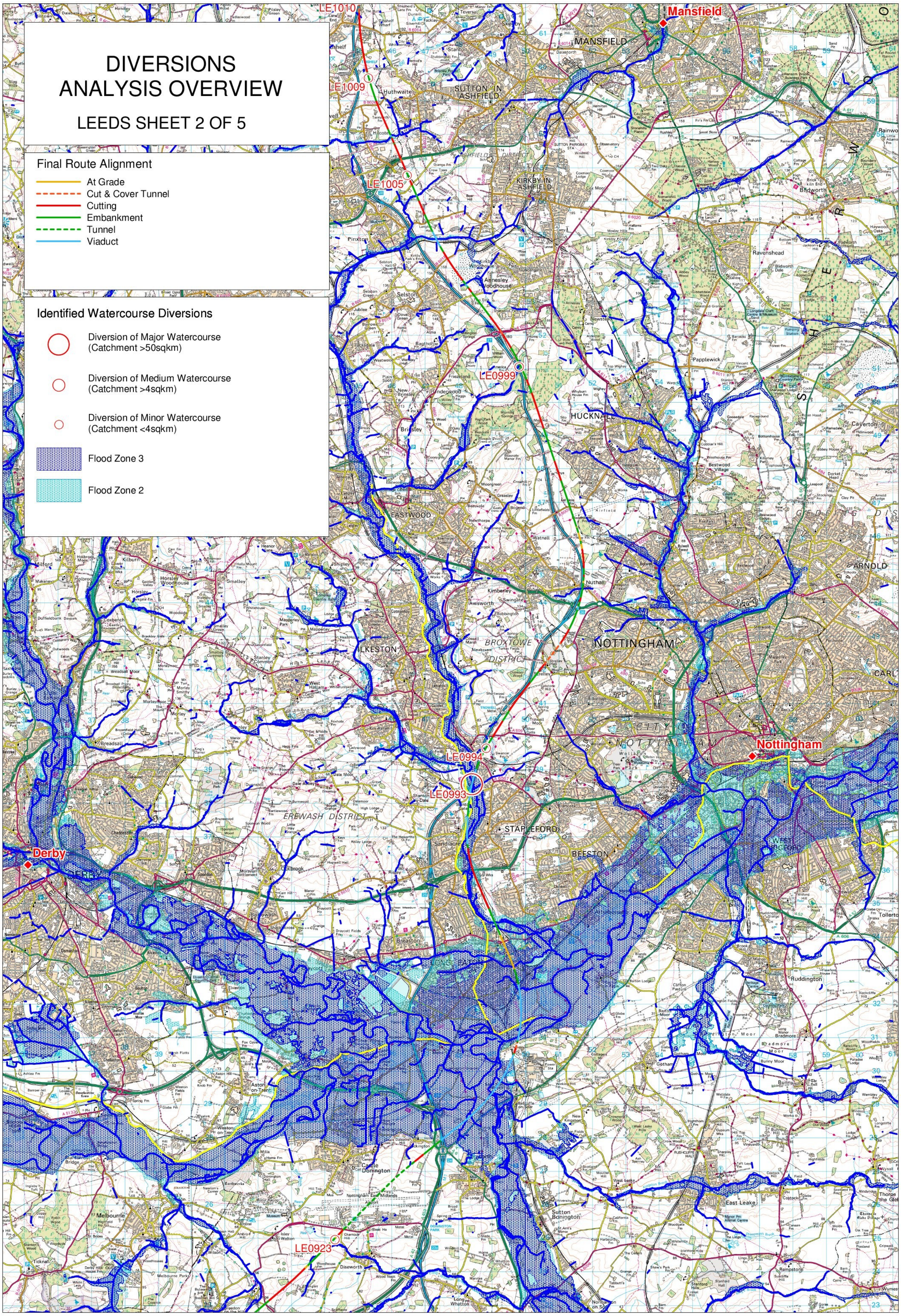

DIVERSIONS
ANALYSIS OVERVIEW
MANCHESTER SHEET 1 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Identified Watercourse Diversions
Diversion of Major Watercourse (Catchment>50sqkm)
Diversion of Medium Watercourse (Catchment>4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
STONE
STAFFORD
Stafford
MD0822
MD0820
MD0817
MD0816
MD0815
RUGELEY
CANNOCK CHASE FOREST
MD0804
LICHFIELD
Lichfield
Cannock
CANNOCK
BROWNHILLS


DIVERSIONS
ANALYSIS OVERVIEW
MANCHESTER SHEET 2 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Identified Watercourse Diversions
Diversion of Major Watercourse (Catchment>50sqkm)
Diversion of Medium Watercourse (Catchment>4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
Crewe
CREWE
SANDBACH
Stoke on Trent
NEWCASTLE-UNDER-LYME
MD0864
STONE


DIVERSIONS
ANALYSIS OVERVIEW
MANCHESTER SHEET 3 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Identified Watercourse Diversions
Diversion of Major Watercourse (Catchment>50sqkm)
Diversion of Medium Watercourse (Catchment>4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
MD0597
MD0603
MD0881
MD0880
Manchester
Stockport
NORTHWICH
KNUTSFORD
WILMSLOW
ALTRINCHAM
SALE
STRETFORD
URMSTON
IRLAM
LYMM
MIDDLEWICH
SANDBACH


DIVERSIONS
ANALYSIS OVERVIEW
MANCHESTER SHEET 4 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Identified Watercourse Diversions
Diversion of Major Watercourse (Catchment>50sqkm)
Diversion of Medium Watercourse (Catchment>4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
MD0314
MD0309
MD0308
MD0263
Warrington
MD0597
MD0603
MD0881
MD0880


DIVERSIONS
ANALYSIS OVERVIEW
LEEDS SHEET 1 OF 5
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Identified Watercourse Diversions
Diversion of Major Watercourse (Catchment >50sqkm)
Diversion of Medium Watercourse (Catchment >4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
LE0626
LE0623
LE0006
Tamworth
Nuneaton
BURTON UPON TRENT
SWADLINCOTE
COALVILLE
HINCKLEY
NUNEATON
THE NATIONAL FOREST
SOUTH DERBYSHIRE
HINCKLEY AND BOSWORTH DISTRICT
NORTH WEST LEICESTERSHIRE DISTRICT
Melbourne
Ibstock
Market Bosworth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LEEDS SHEET 2 OF 5
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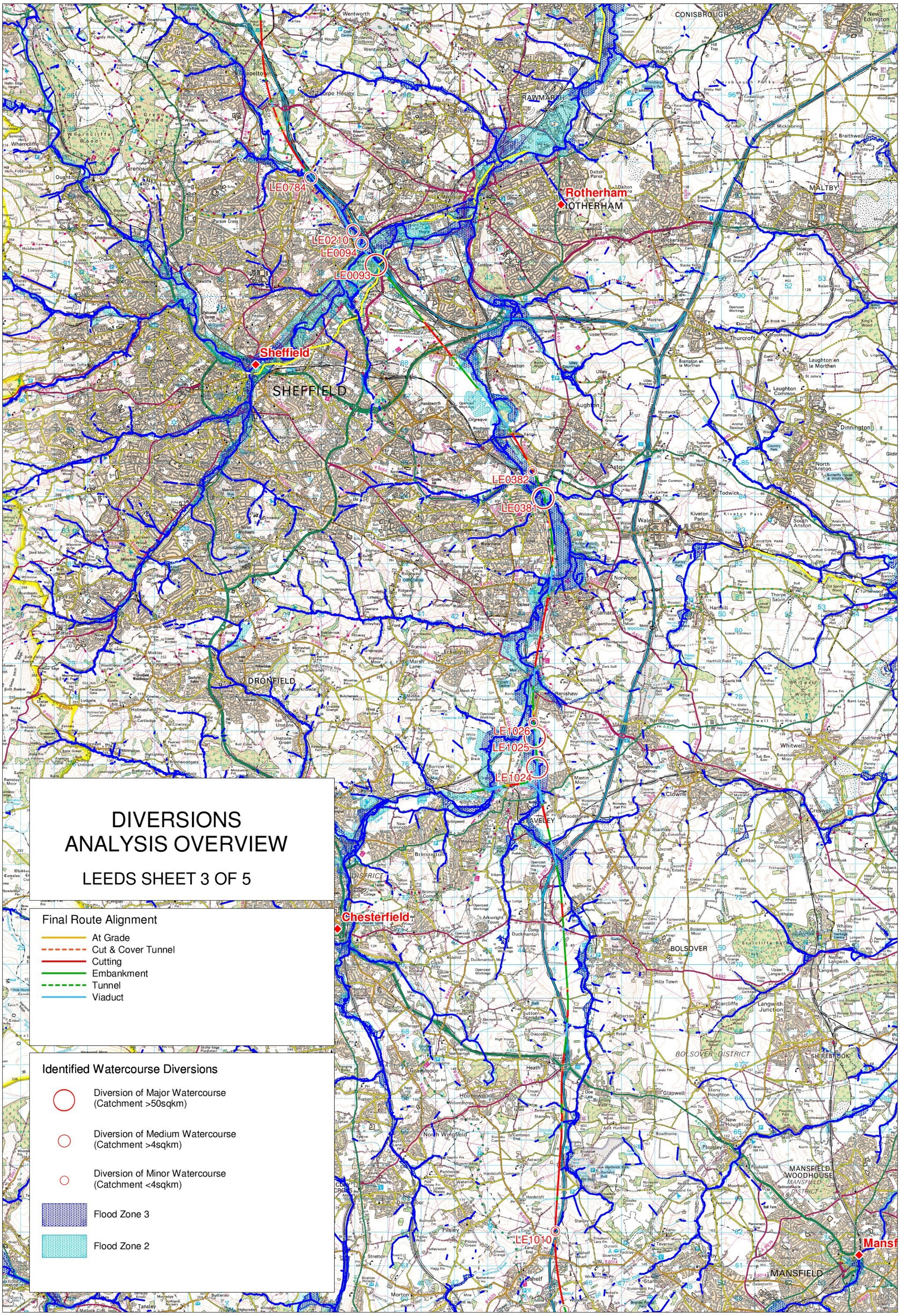
Diversion of Major Watercourse (Catchment >50sqkm)
Diversion of Medium Watercourse (Catchment >4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
LE1010
LE1009
LE1005
LE0999
LE0994
LE0993
LE0923
Mansfield
MANSFIELD
SUTTON IN ASHFIELD
KIRKBY IN ASHFIELD
HUCKNALL
EASTWOOD
ILKESTON
NOTTINGHAM
Nottingham
BROXTOWE DISTRICT
EREWASH DISTRICT
STAPLEFORD
BEESTON
ARNOLD
Derby
Ravenshead
Papplewick
Ruddington
East Leake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LEEDS SHEET 3 OF 5
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Embankment
Tunnel
Viaduct
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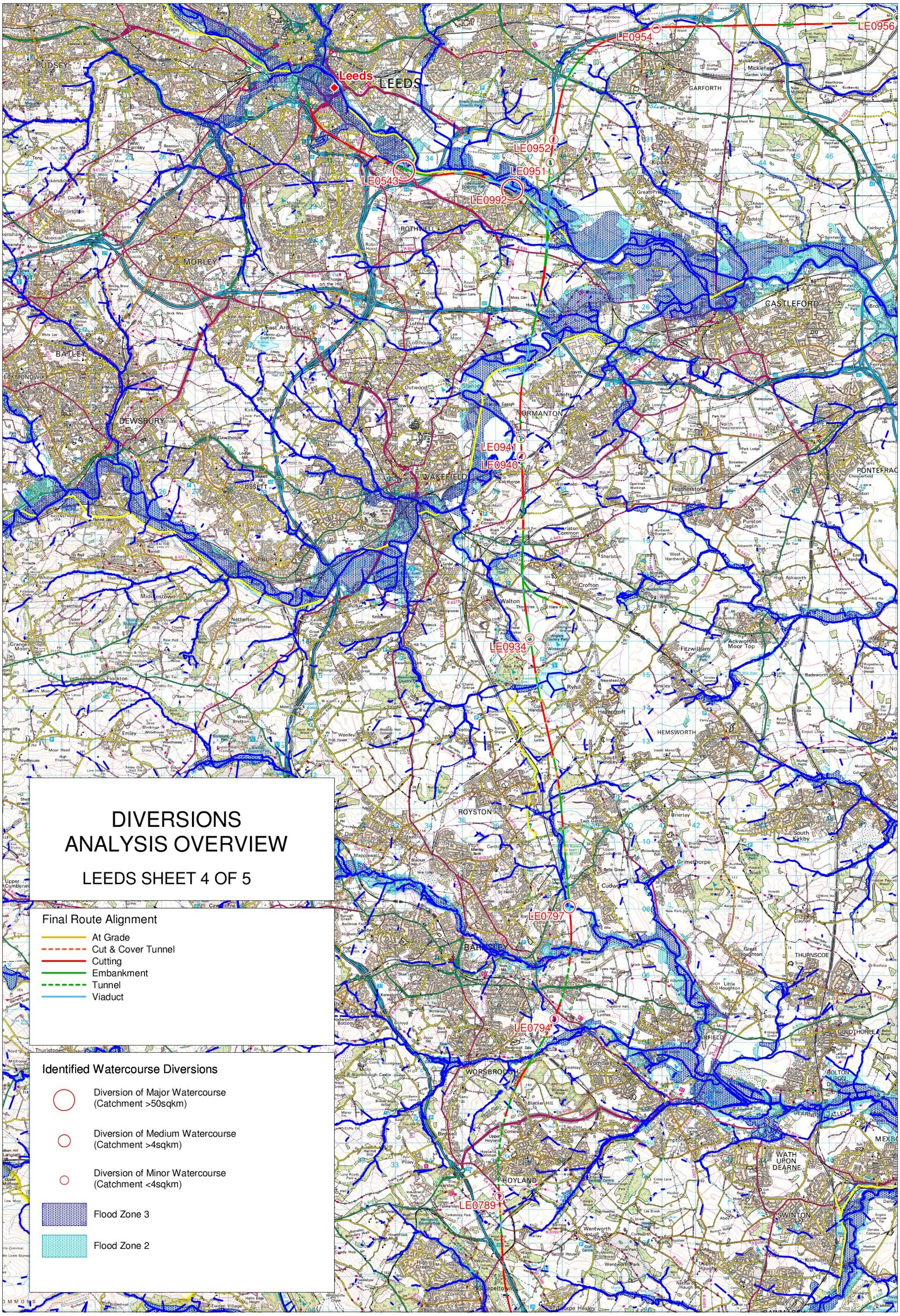
Diversion of Major Watercourse (Catchment >50sqkm)
Diversion of Medium Watercourse (Catchment >4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
Sheffield
SHEFFIELD
Rotherham
ROTHERHAM
Chesterfield
LE0784
LE0210
LE0094
LE0093
LE0382
LE0381
LE1026
LE1025
LE1024
LE1010
DRONFIELD
BOLSOVER
MANSFIELD
CONISBROUGH
MALTBY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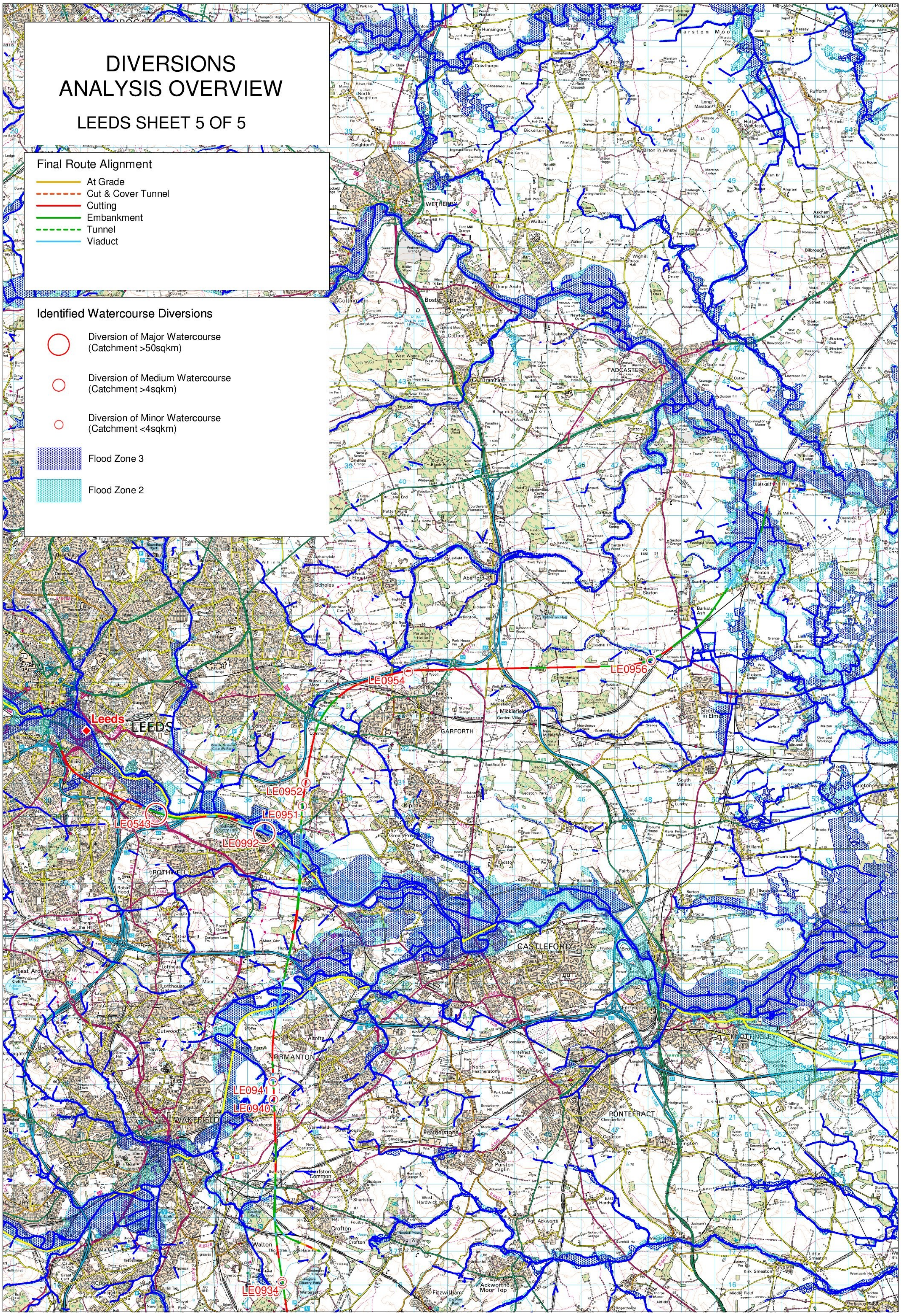
Diversion of Major Watercourse (Catchment >50sqkm)
Diversion of Medium Watercourse (Catchment >4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
LE0956
LE0954
LE0952
LE0951
LE0543
LE0992
LE0941
LE0940
LE0934
LE0797
LE0794
LE0789
Leeds
LEEDS
PUDSEY
MORLEY
BATLEY
DEWSBURY
WAKEFIELD
NORMANTON
CASTLEFORD
GARFORTH
PONTEFRACT
HEMSWORTH
ROYSTON
WORSBROUGH
HOYLAND
THURNSCOE
WATH UPON DEARNE
SWINTON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Cutting
Embankment
Tunnel
Viaduct
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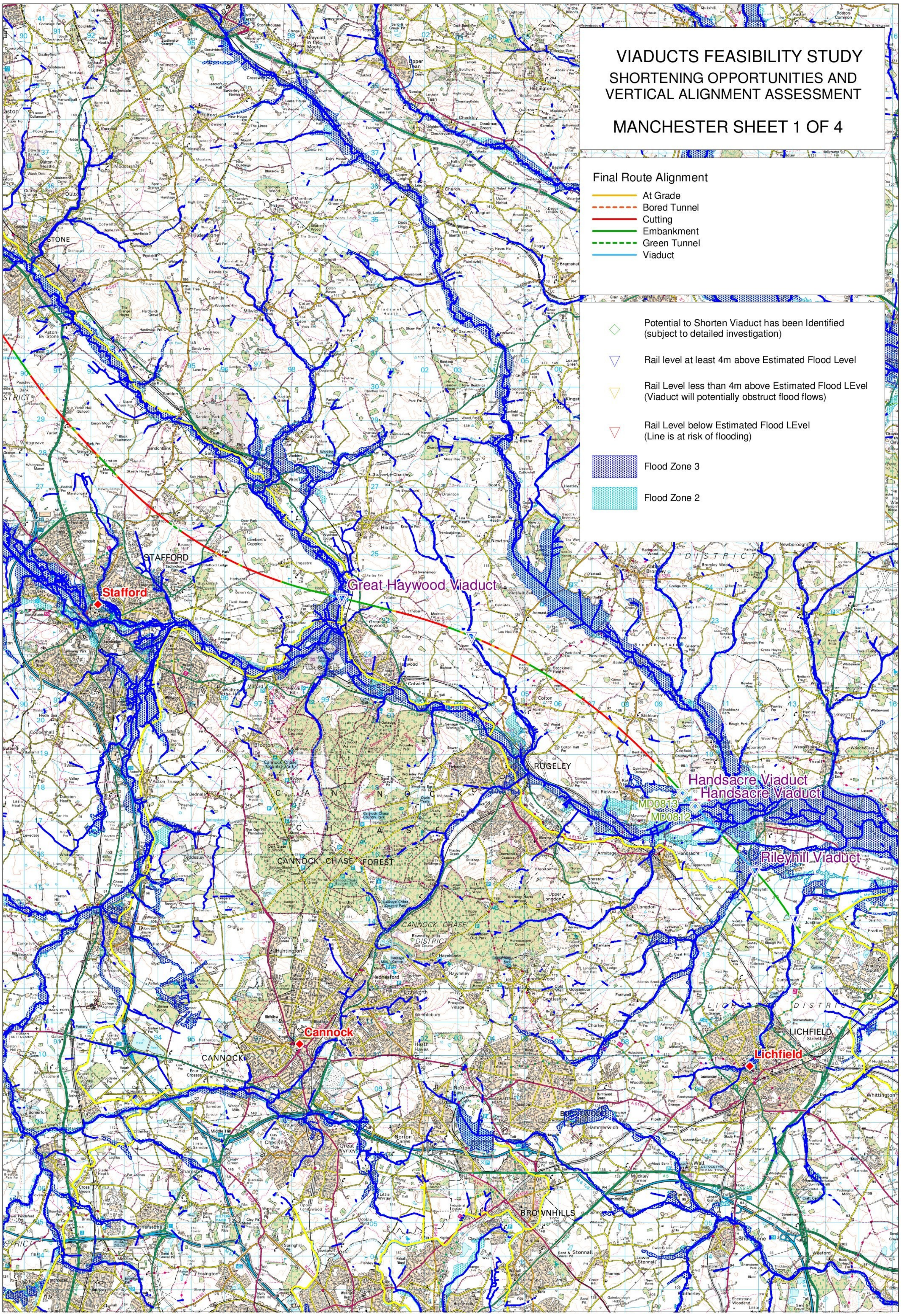
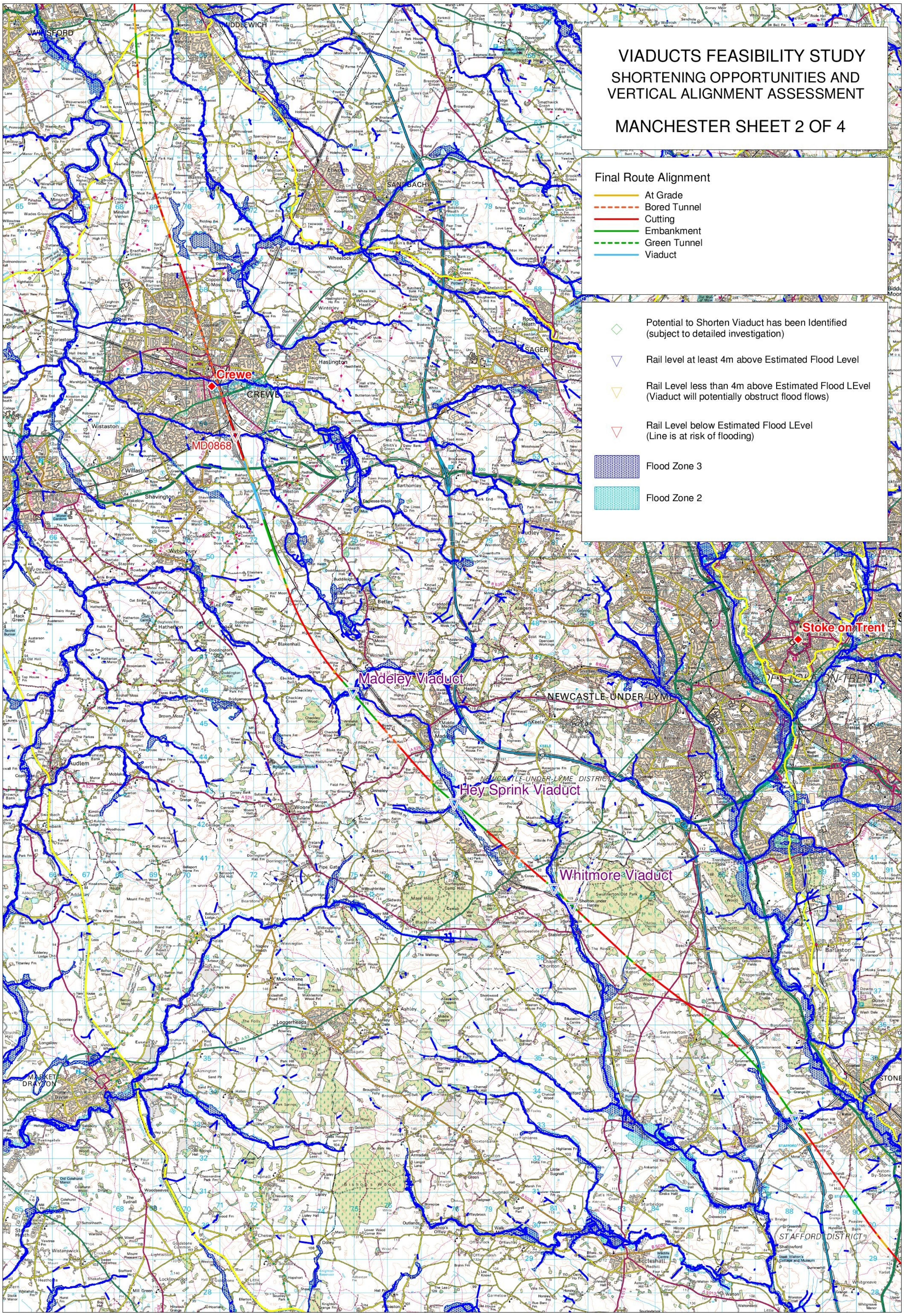
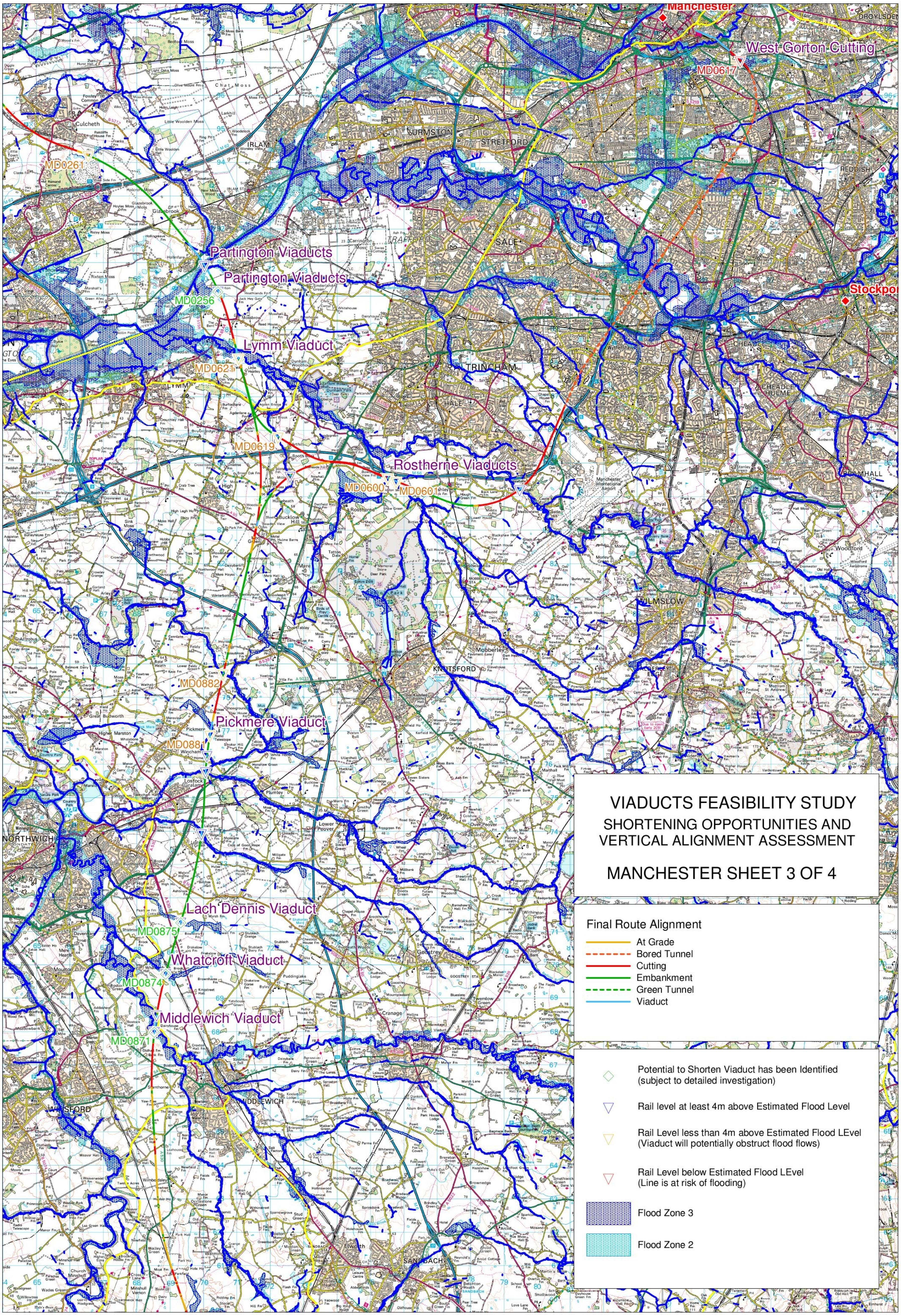
Diversion of Major Watercourse (Catchment >50sqkm)
Diversion of Medium Watercourse (Catchment >4sqkm)
Diversion of Minor Watercourse (Catchment <4sqkm)
Flood Zone 3
Flood Zone 2
LE0956
LE0954
Leeds
LEEDS
LE0952
LE0951
LE0543
LE0992
LE0941
LE0940
LE0934
WETHERBY
TADCASTER
GARFORTH
CASTLEFORD
PONTEFRACT
NORMANTON
WAKEFIELD
KNOTTINGLEY
ROTHWELL

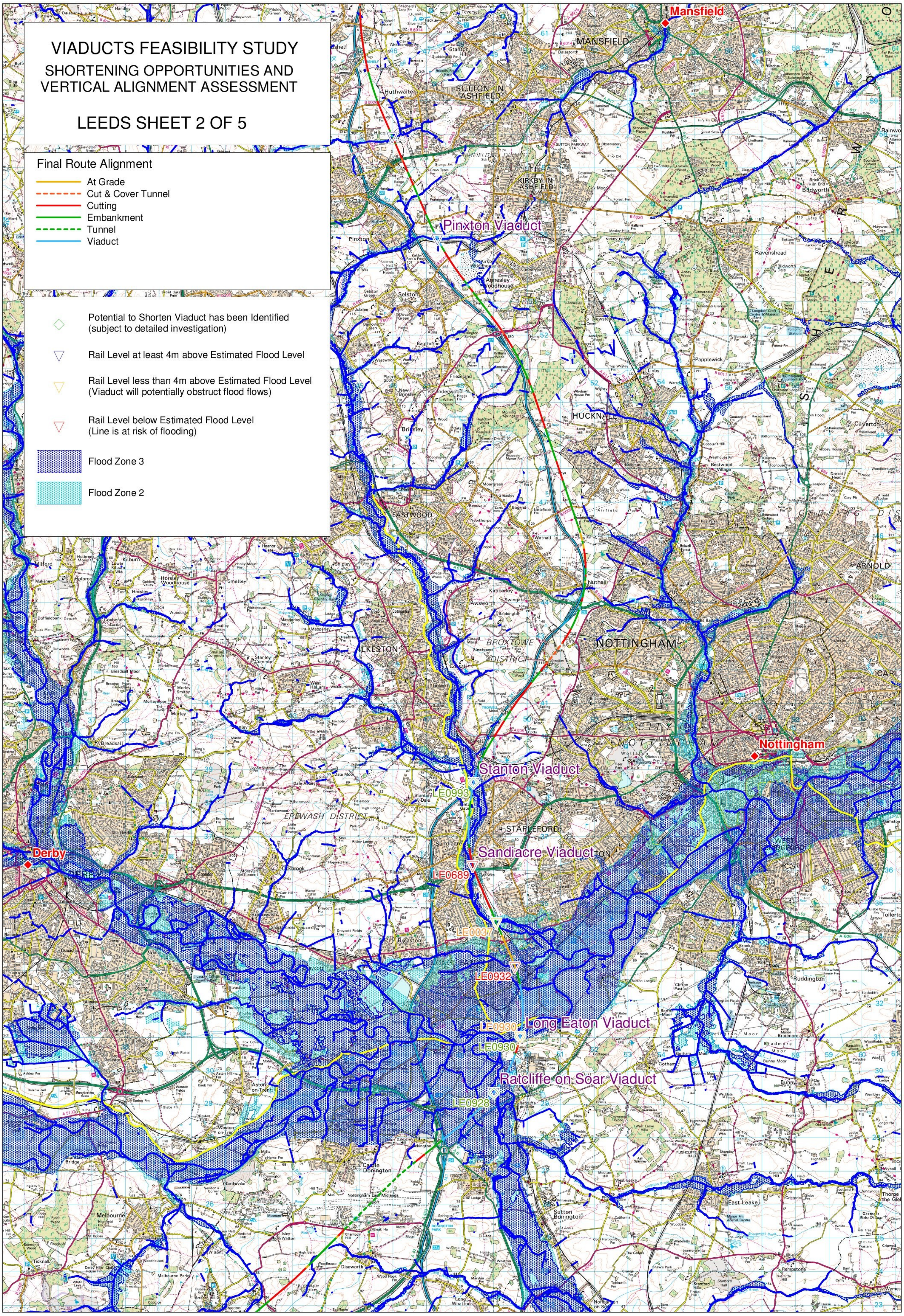

VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
MANCHESTER SHEET 1 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood LEvel (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood LEvel (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Great Haywood Viaduct
Handsacre Viaduct
Handsacre Viaduct
MD0813
MD0812
Rileyhill Viaduct
Stafford
STAFFORD
STONE
RUGELEY
CANNOCK CHASE FOREST
Cannock
CANNOCK
Lichfield
LICHFIELD
BROWNHILLS
BURNTWOOD

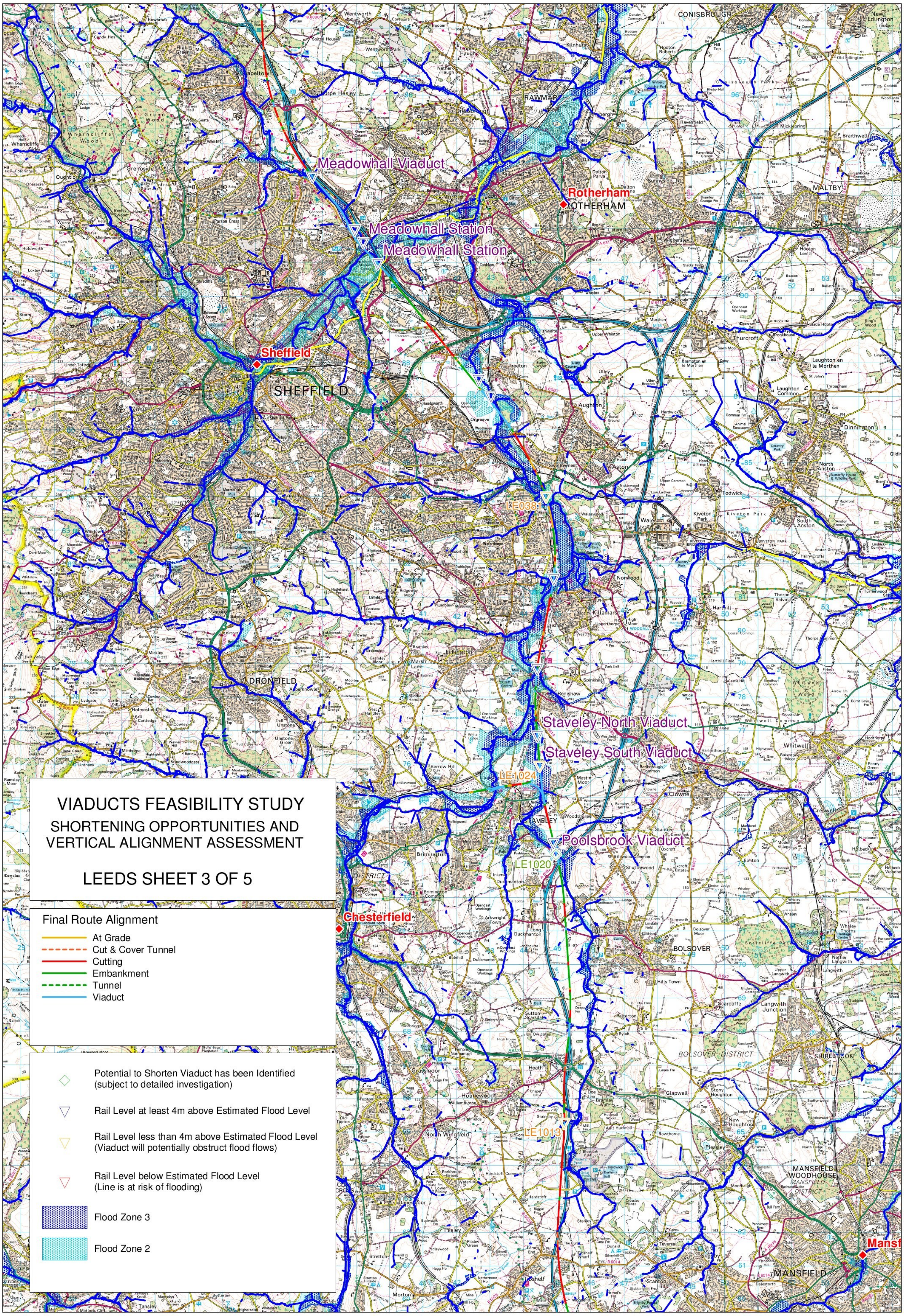

VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
MANCHESTER SHEET 2 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood LEvel (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood LEvel (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Crewe
MD0868
Madeley Viaduct
Hey Sprink Viaduct
Whitmore Viaduct
Stoke on Trent
NEWCASTLE-UNDER-LYME

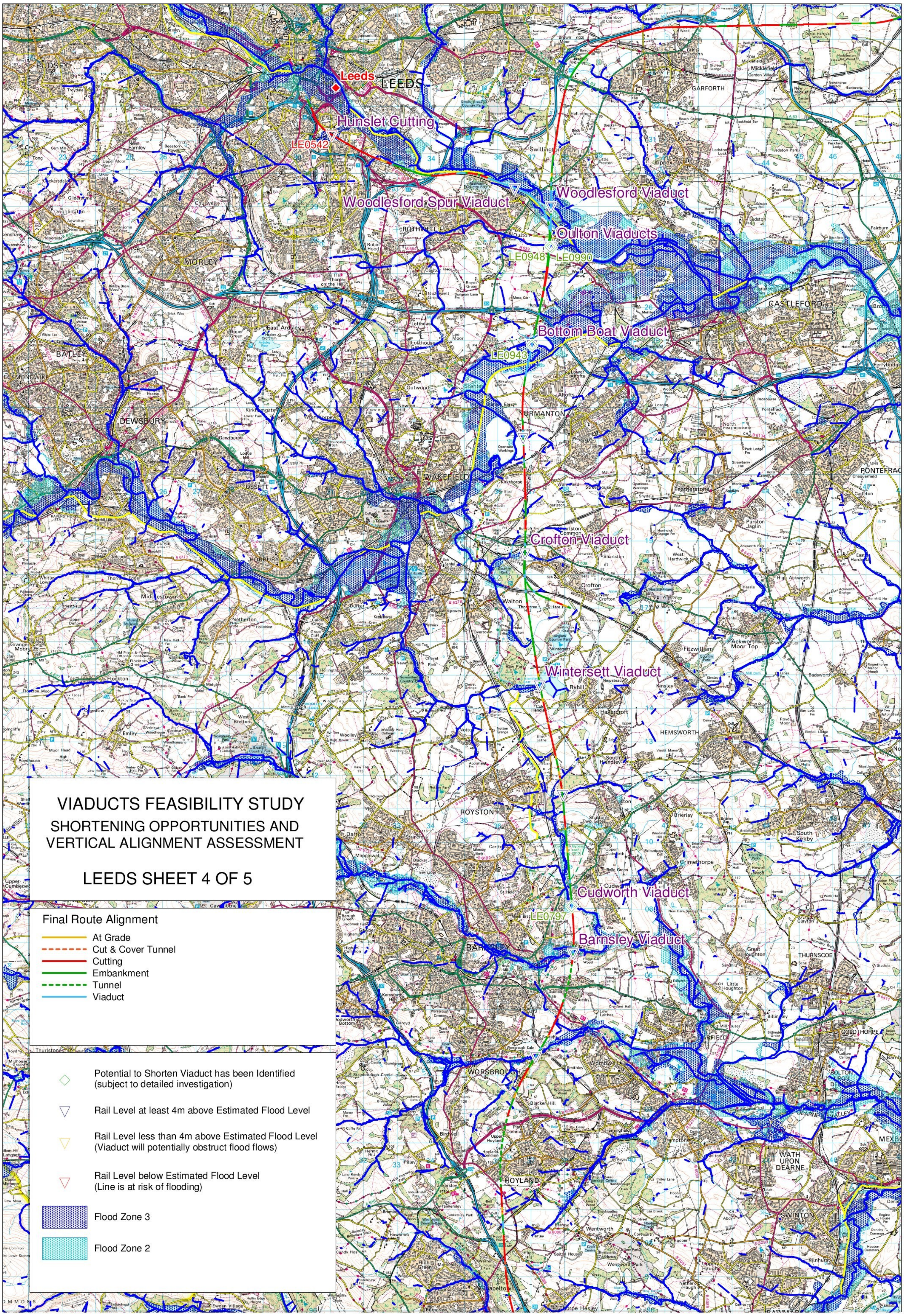

Manchester
West Gorton Cutting
MD0617
MD0261
Partington Viaducts
Partington Viaducts
MD0256
Lymm Viaduct
MD0621
MD0619
Rostherne Viaducts
MD0600
MD0601
Stockport
MD0882
Pickmere Viaduct
MD088
Lach Dennis Viaduct
MD0875
Whatcroft Viaduct
MD0874
Middlewich Viaduct
MD0871
IRLAM
STRETFORD
SALE
TRINCHAM
KNUTSFORD
WILMSLOW
NORTHWICH
MIDDLEWICH
WINSFORD
SANDBACH
VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND
VERTICAL ALIGNMENT ASSESSMENT
MANCHESTER SHEET 3 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood LEvel (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood LEvel (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2

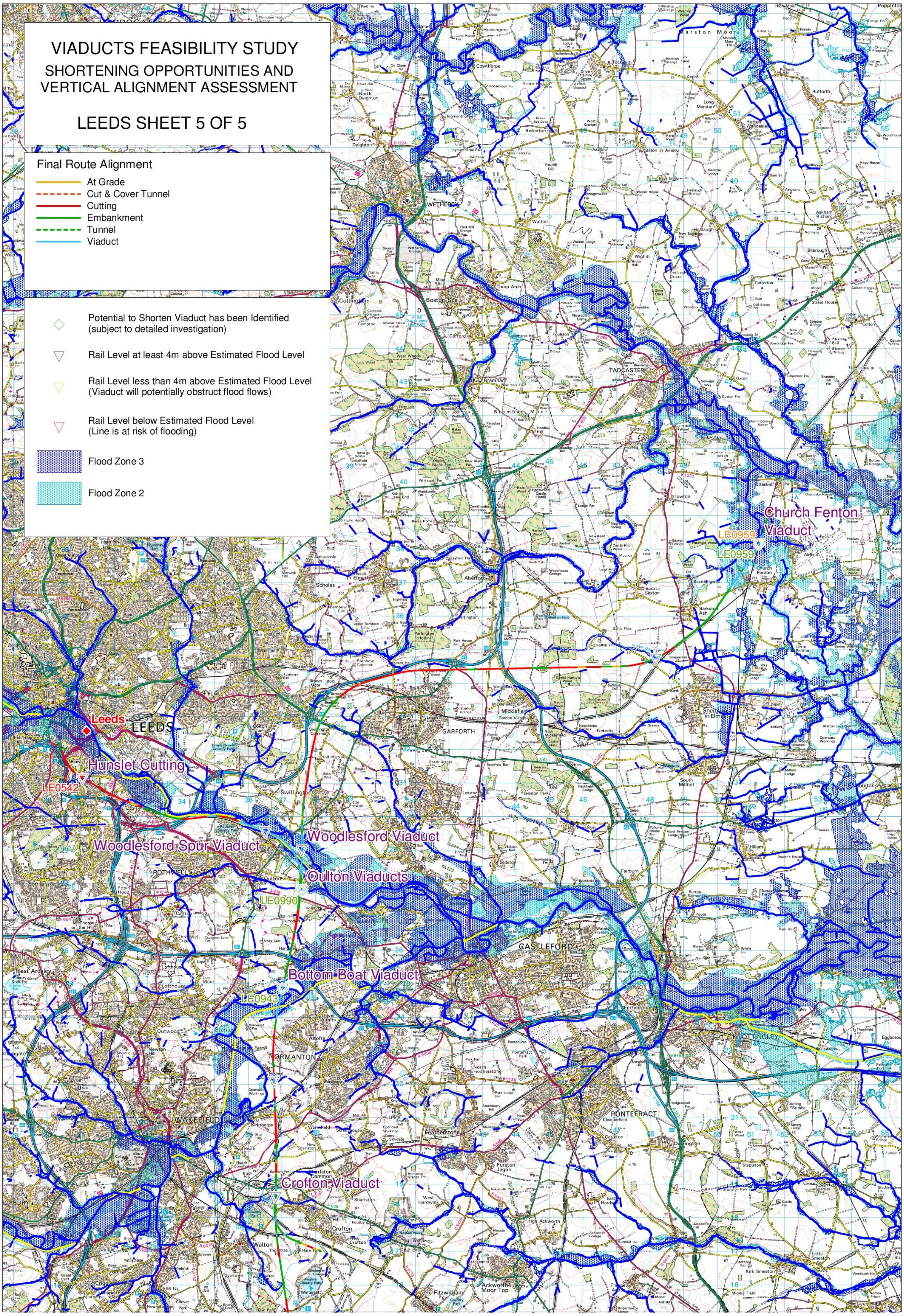

VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
MANCHESTER SHEET 4 OF 4
Final Route Alignment
At Grade
Bored Tunnel
Cutting
Embankment
Green Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood LEvel (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood LEvel (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
MD0304
MD0261
Partington Viaducts
Partington Viaducts
MD0256
Warrington
Lymm Viaduct
MD0621
MD0619
Rostherne Viaducts
MD0600
MD0601
MD0882
Pickmere Viaduct
MD0881
Lach Dennis Viaduct

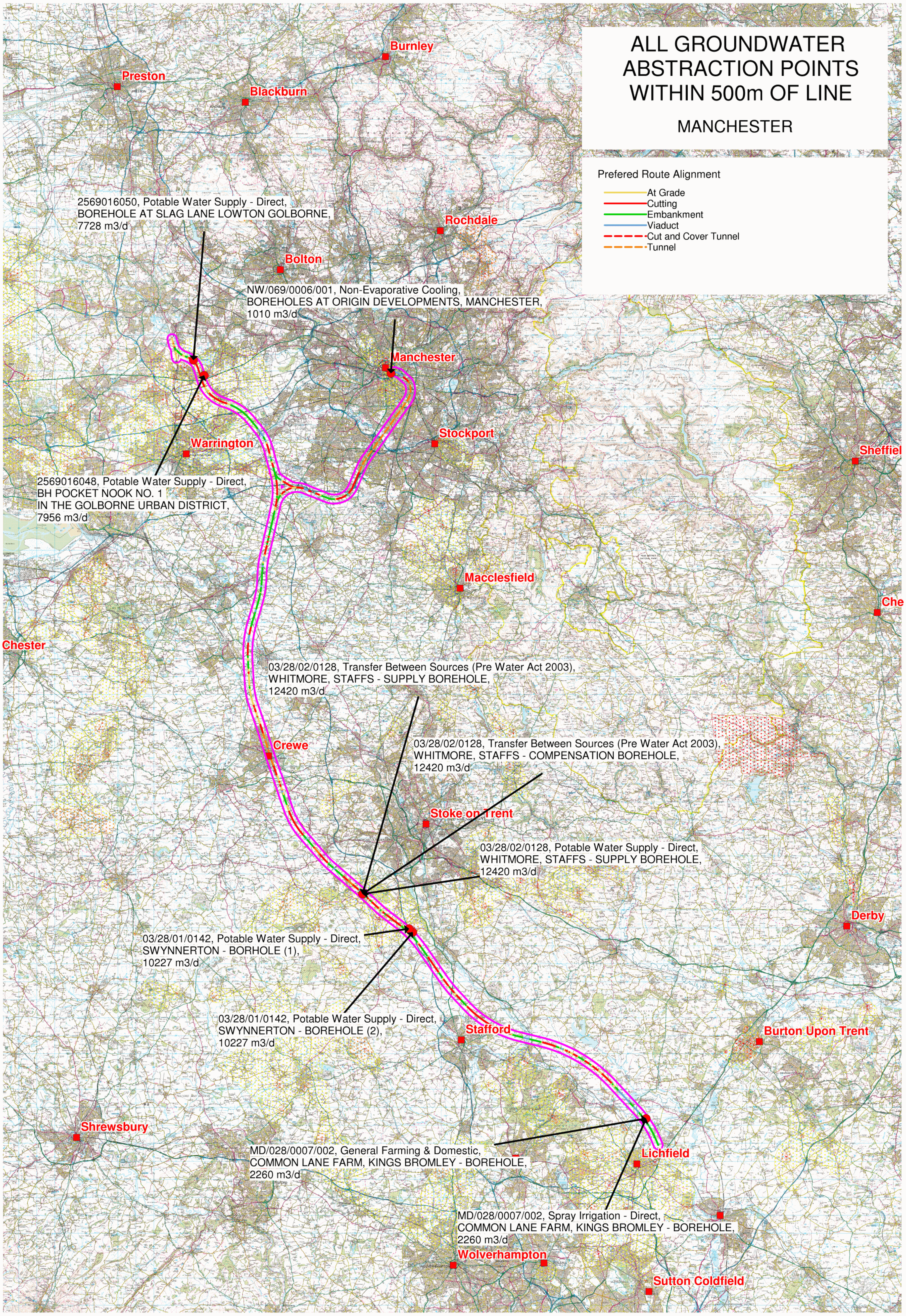

VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
LEEDS SHEET 1 OF 5
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail Level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood Level (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood Level (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Packington Viaduct
LE0626
Measham Viaduct
LE0625
Austrey Viaduct
LE0010
Polesworth Viaduct
LE0008
LE0009
Kingsbury North Viaduct
LE0005
Kingsbury Viaduct
Burton Upon Trent
Tamworth
Nuneaton
SWADLINCOTE
COALVILLE
HINCKLEY
NUNEATON

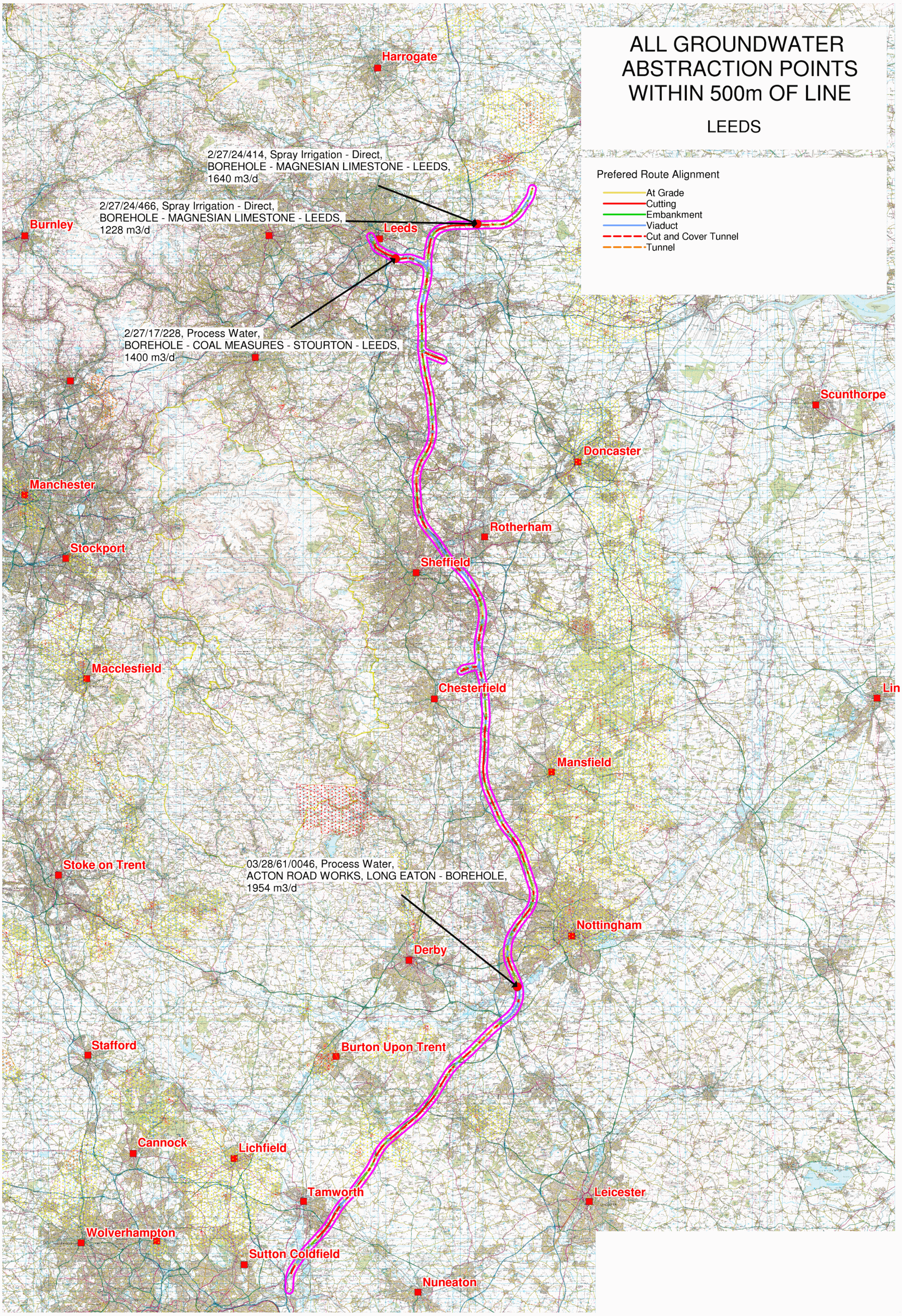

VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
LEEDS SHEET 2 OF 5
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail Level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood Level (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood Level (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Mansfield
Pinxton Viaduct
NOTTINGHAM
Nottingham
Stanton Viaduct
LE0993
Sandiacre Viaduct
LE0689
LE0037
LE0932
Long Eaton Viaduct
LE0930
Ratcliffe on Soar Viaduct
LE0928
Derby


VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
LEEDS SHEET 3 OF 5
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail Level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood Level (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood Level (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Meadowhall Viaduct
Meadowhall Station
Meadowhall Station
Rotherham
Sheffield
SHEFFIELD
LE0381
Staveley North Viaduct
Staveley South Viaduct
LE1024
Poolsbrook Viaduct
LE1020
Chesterfield
LE1013
DRONFIELD
BOLSOVER
MANSFIELD
Mansf


VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
LEEDS SHEET 4 OF 5
Leeds
Hunslet Cutting
LE0542
Woodlesford Spur Viaduct
Woodlesford Viaduct
Oulton Viaducts
LE0948
LE0990
Bottom Boat Viaduct
LE0943
Crofton Viaduct
Wintersett Viaduct
Cudworth Viaduct
LE0797
Barnsley Viaduct
LEEDS
MORLEY
BATLEY
DEWSBURY
WAKEFIELD
NORMANTON
CASTLEFORD
GARFORTH
ROYSTON
HEMSWORTH
WORSBROUGH
HOYLAND
THURNSCOE
WATH UPON DEARNE
SWINTON
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail Level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood Level (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood Level (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2


VIADUCTS FEASIBILITY STUDY
SHORTENING OPPORTUNITIES AND VERTICAL ALIGNMENT ASSESSMENT
LEEDS SHEET 5 OF 5
Final Route Alignment
At Grade
Cut & Cover Tunnel
Cutting
Embankment
Tunnel
Viaduct
Potential to Shorten Viaduct has been Identified (subject to detailed investigation)
Rail Level at least 4m above Estimated Flood Level
Rail Level less than 4m above Estimated Flood Level (Viaduct will potentially obstruct flood flows)
Rail Level below Estimated Flood Level (Line is at risk of flooding)
Flood Zone 3
Flood Zone 2
Church Fenton Viaduct
LE0959
LE0959
Leeds
LEEDS
Hunslet Cutting
LE0542
Woodlesford Viaduct
Woodlesford Spur Viaduct
Oulton Viaducts
LE0990
Bottom Boat Viaduct
LE0943
Crofton Viaduct
WETHERBY
TADCASTER
GARFORTH
CASTLEFORD
NORMANTON
WAKEFIELD
PONTEFRACT
ROTHWELL


ALL GROUNDWATER ABSTRACTION POINTS WITHIN 500m OF LINE
MANCHESTER
Prefered Route Alignment
At Grade
Cutting
Embankment
Viaduct
Cut and Cover Tunnel
Tunnel
Burnley
Preston
Blackburn
Rochdale
Bolton
Manchester
Stockport
Warrington
Sheffiel
Macclesfield
Che
Chester
Crewe
Stoke on Trent
Derby
Stafford
Burton Upon Trent
Shrewsbury
Lichfield
Wolverhampton
Sutton Coldfield
2569016050, Potable Water Supply - Direct, BOREHOLE AT SLAG LANE LOWTON GOLBORNE, 7728 m3/d
NW/069/0006/001, Non-Evaporative Cooling, BOREHOLES AT ORIGIN DEVELOPMENTS, MANCHESTER, 1010 m3/d
2569016048, Potable Water Supply - Direct, BH POCKET NOOK NO. 1 IN THE GOLBORNE URBAN DISTRICT, 7956 m3/d
03/28/02/0128, Transfer Between Sources (Pre Water Act 2003), WHITMORE, STAFFS - SUPPLY BOREHOLE, 12420 m3/d
03/28/02/0128, Transfer Between Sources (Pre Water Act 2003), WHITMORE, STAFFS - COMPENSATION BOREHOLE, 12420 m3/d
03/28/02/0128, Potable Water Supply - Direct, WHITMORE, STAFFS - SUPPLY BOREHOLE, 12420 m3/d
03/28/01/0142, Potable Water Supply - Direct, SWYNNERTON - BOREHOLE (1), 10227 m3/d
03/28/01/0142, Potable Water Supply - Direct, SWYNNERTON - BOREHOLE (2), 10227 m3/d
MD/028/0007/002, General Farming & Domestic, COMMON LANE FARM, KINGS BROMLEY - BOREHOLE, 2260 m3/d
MD/028/0007/002, Spray Irrigation - Direct, COMMON LANE FARM, KINGS BROMLEY - BOREHOLE, 2260 m3/d


ALL GROUNDWATER ABSTRACTION POINTS WITHIN 500m OF LINE
LEEDS
Prefered Route Alignment
At Grade
Cutting
Embankment
Viaduct
Cut and Cover Tunnel
Tunnel
2/27/24/414, Spray Irrigation - Direct, BOREHOLE - MAGNESIAN LIMESTONE - LEEDS, 1640 m3/d
2/27/24/466, Spray Irrigation - Direct, BOREHOLE - MAGNESIAN LIMESTONE - LEEDS, 1228 m3/d
2/27/17/228, Process Water, BOREHOLE - COAL MEASURES - STOURTON - LEEDS, 1400 m3/d
03/28/61/0046, Process Water, ACTON ROAD WORKS, LONG EATON - BOREHOLE, 1954 m3/d
Harrogate
Burnley
Leeds
Scunthorpe
Doncaster
Manchester
Rotherham
Stockport
Sheffield
Macclesfield
Chesterfield
Lin
Mansfield
Stoke on Trent
Nottingham
Derby
Stafford
Burton Upon Trent
Cannock
Lichfield
Tamworth
Leicester
Wolverhampton
Sutton Coldfield
Nuneaton