Project:	Lincoln Southern Bypass	**Date:**	12/12/2017
		TN Ref:	0001
Subject:	Option for River Witham South Bridge (Dual Carriageway)		
Author:	Shunde Qin	**Project Ref:**	738233-WSP-SBR-XX-RP-S-0004
Reviewed:	Gauravkumar Panchal	**Date:**	12/12/2017
Approved:	Mark Northing	**Date:**	12/12/2017

1. Introduction

A new route to the south of the city of Lincoln linking the A15 at Waddington to the A46 at South Hykeham has been proposed which is known at Lincoln Southern Bypass (LSB). The proposed scheme is required to alleviate the current congestion and journey reliability issues associated with the south of the city of Lincoln which will also complete the ring road around the city. There are three bridge structures identified to form the LSB. This document outlines the design criteria and procedures to be adopted for the design of the River Witham Bridge.

The purpose of this desk study is:

- To identify the location of the structure;
- To review the known constraints;
- To identify the unknown constraints;
- To propose initial sizing of the structure;
- To prepare the viable solutions for the bridge structure;
- To provide the comparison between the possible solutions and recommendations;
- To identify the possible risks and hazards of the recommended solutions.

The ground condition at structure location appeared to be poor. The history of the flood data suggest that the structure will be located in the Flood Zone 3. Various options for bridge widening or replacement have been reviewed and evaluated. Table 2 summarising and comparing various structural types, and other factors including design, constructability, aesthetics, future maintenance and environmental impacts.

From the available data various forms of the structure were considered such as single or multi-span arch, truss bridge and high profile suspension bridge. However three-span bridge steel concrete composite or prestressed concrete beam options appears to be the best viable options for the bridge structure. These two proposed forms of structures also blends well with similar structures designed over Lincoln Eastern Bypass.

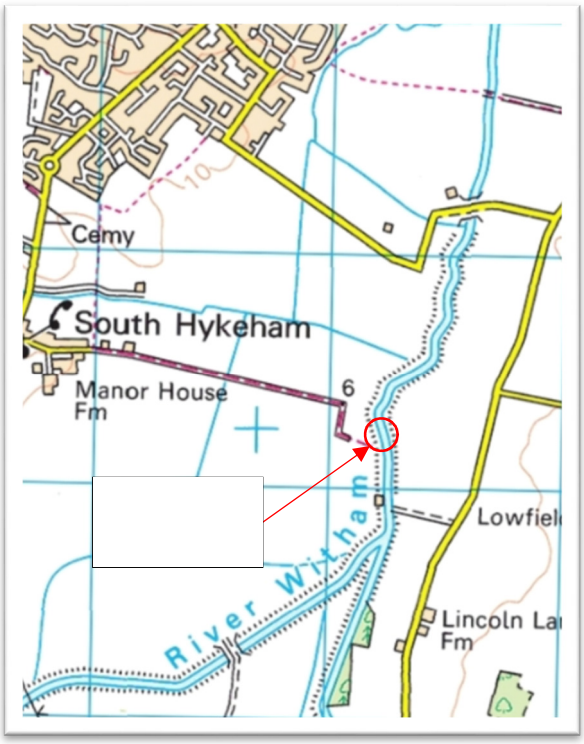
2. The Site

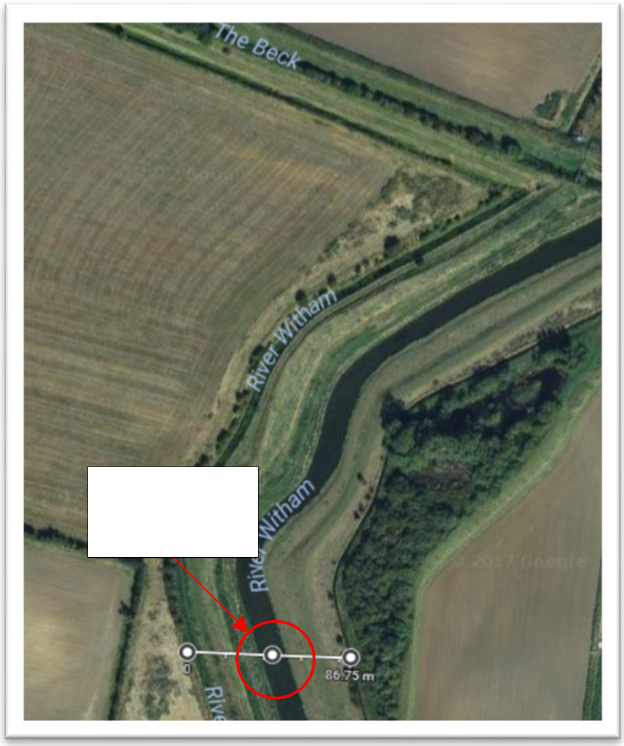
2.1. Description

The scheme located to the south of the city of Lincoln joining the A15 at Waddington to the A46 at South Hykeham. The route will run south-west from the A15 at Bracebridge Heath, passing through fields to the north of RAF Waddington, crossing the A607 Grantham Road before heading sharply down the slope and across Station Road, Waddington. After this, the route passes flat lying fields up to the junction of Brant Road and Somerton Gate Lane before heading further west across the River Witham and to the south of the village of South Hykeham. The route turns north-west past the town, crossing Boundary Lane and further fields before joining the existing A46 Hykeham roundabout. At Waddington, the site level is around 70m Above Ordnance Datum (AOD) to the top of the Lincoln Edge where the level drops sharply to about 40m AOD at the toe of the scarp. The ground then gently falls to about 10m AOD in the Witham valley and remains around this level to the A46 roundabout.

The structure will be located at the south of the city of Lincoln over the River Witham approximately 810m to the south of the Meadow Lane.

2.2. Location Plan





3. Site Constraints

The site constraints can be grouped into the following categories:

- Headroom (including flooding information);
- Statutory undertakers;
- Archaeological constraints;
- Environmental constraints;
- Third party land ownership; and,
- Geotechnical information.

3.1. Headroom

It has been confirmed that River Witham is not a navigation channel at the structure location. Hence, the minimum vertical clearance will be based on the highest flood level in the region. The data collected from the government website for flood information service shows that the highest water level recorded in this area is 2.43m since the station was opened. The flooding is possible over 2.11m. Hence, the minimum headroom clearance of 3.00m is suggested between the soffit of the bridge and the existing ground level at the bridge location. This assumption will also reduce the risk of any damage during the construction stage.

3.2. Statutory undertakers

The information of statutory undertakers will be updated once it is available. Reference should be made to correspond drawings. Information should include gas, water, electricity and telecommunications plant cross the bridge. Trial holes should be carried out to confirm the presence of services during preliminary design stage.

Table 1 Statutory Summary

Authority	Service	Details	Location
Network Rail	Hazards	Not present	

3.3. Archaeological constraints

There is no archaeological survey data available. The information may potentially affect the location of the foundations/substructures. The archaeological information will be updated once it is available.

3.4. Environmental constraints

There are no data available suggest the presence of green belt to the east of the River Witham. This should be confirmed by environmental survey. If green belt presents in this area, a design option that reduced the impact on the green belt should be taken into consideration.

3.5. Third party land ownership

Land ownership details have currently not been requested from HM Land Registry. It should be noted that the proposed locations are surrounded by farm lands. It is thought unlikely that this will have a significant bearing upon proposals, however, it is recommended that land ownership details should be obtained during this stage to confirm the assumptions.

3.6. Geotechnical information

The geotechnical information will be updated once it is available. It should be noted that the geotechnical information should include an asbestos survey to clarify the risk of asbestos in the proposed area. It should also include any other information of ground conditions that may affect the design proposals.

4. Design Requirements

The outline design of the bridge has been progressed using the following criteria:-

Geometric dimensions:-

South footway:	2.00 m
South hardstrip:	1.125 m
Westbound dual carriageway:	7.35 m
Centre reserve and hardstrip:	4.50 m
Eastbound dual carriageway:	7.35 m
North hardstrip:	1.125 m
North cycleway:	3.00 m
North footway:	2.00 m
Others (Parapet Plinth etc):	1.60 m
Total width of proposed structure:	30.05 m

The minimum headroom clearance between the soffit of the bridge and the existing ground level is 3.00m (as previously suggested). It should be noted that the dimensions may vary at preliminary design stage.

5. Proposed Options

According to Figure 1 from Conceptual Design of Bridges (2013), there are two forms of structure options considered for the conceptual design stage. The proposed Option-1 comprises a three-span continuous, non-integral, steel beams composite with reinforced concrete deck, supported by reinforced concrete abutment and piers. The similar form type of structure has been designed over River Witham for Lincoln Eastern Bypass. The proposed Option-2 comprises a three-span continuous precast prestressed concrete W-beams made composite with an insitu reinforced concrete top slab. The beams span into integral piers with insitu reinforced concrete diaphragms which span transversely between the supports. The beams are supported by free elastomeric bearings at each abutment.

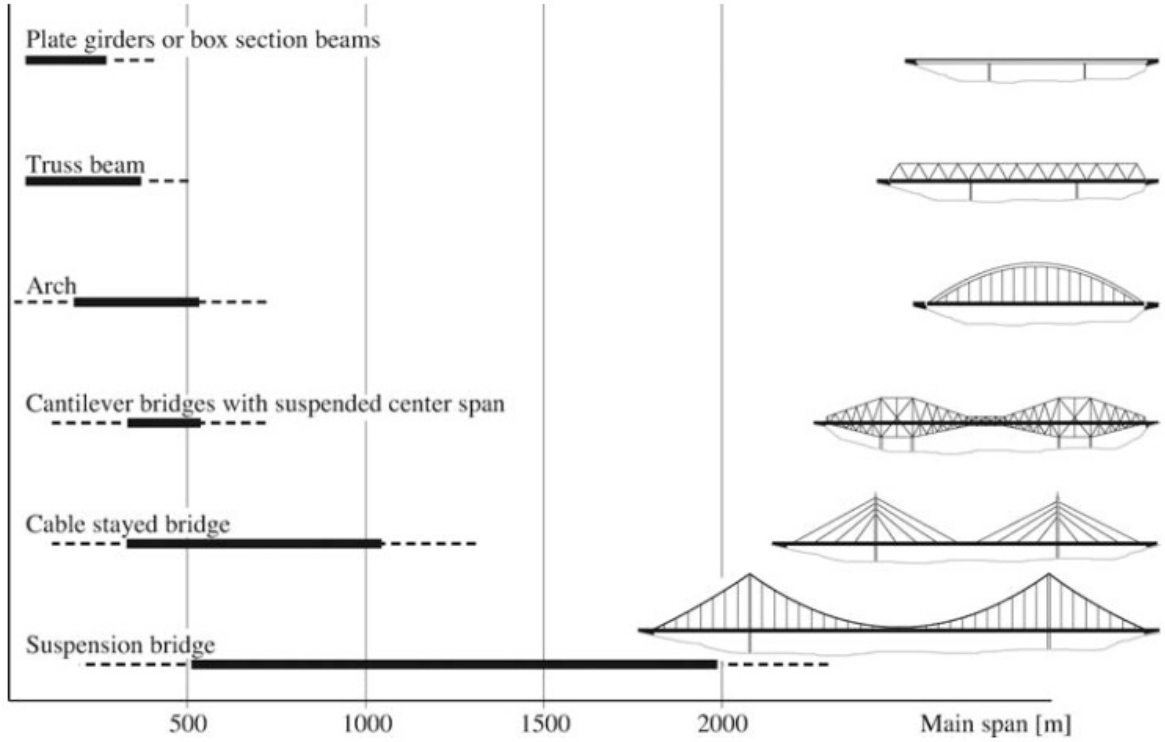


Figure 1: Main types of longitudinal structural form and corresponding main span ranges

5.1. Option 1 – Weathering Steel I Beams and In-situ Deck

This section is to be read in conjunction with drawing 738233-WSP-SBR-XX-DR-C-0007 contained in Appendix A.

The bridge will be three-span structure with one 47m long centre spans and two 36m long side spans giving total span length of approximately 119m. The actual length of each span may vary based on the archaeological and geotechnical investigation at a later stage. It should be noted that eastbound and westbound structure can be designed as two separate structures. However, the two separated structures will increase the cost for construction and maintenance.

The superstructure shall comprise of 10 No. weathering steel plate girders acting compositely with an in-situ reinforced concrete deck. The soffit of the plate girders will be curved in profile with deeper sections at pier locations and shallower sections at mid span and abutments.

The parapets will be supported by a discontinuous in-situ reinforced concrete edge beam. The deck cantilever soffit angles will vary to provide a constant depth of edge beam along the structure. High containment H4a parapets will be provided on south end of the bridge and the approach ramps. 1.8m high N1 W2 equestrian parapets and parapets will be provided on the north end of the bridge and the approach ramps.

The end supports will comprise of reinforced earth skeletal abutments on a reinforced concrete piled foundation. The approaches will be retained by reinforced earth wing walls parallel to the carriageway supported by Load Transfer Platform and Control Modulus Columns. The inspection galleries will be provided at each abutment. The reinforced earth wall will be reinforced using polymer or steel straps and faced with concrete blocks. The intermediate supports will comprise of reinforced concrete vertical cantilever intermediate piers supported on a reinforced concrete pile foundation.

Construction method:-

- Provision of temporary access to the site.
- Construct pile foundations and pile caps for abutments and piers.
- Construct abutment and pier columns.
- Construct the MSE walls and backfill up to the bearing shelf level.
- Construct abutment bank-seats and Install reinforced earth behind abutment bankseats.
- Lift the beams in to their positions and place the permanent formwork. Install bracing members.
- Fix the reinforcement and cast the deck slab. It should be noted that the deck will be casted at different stages. Detail of the casting stages will be studied in a later design stage.
- Pour parapet plinths. Construct the bridge parapets.
- Install bridge verges, apply deck surfacing and install movement joints.
- Install bridge furniture.

Advantages:-

- The use of weathering steel beams would require lower maintenance when compared to conventional mild steel beams.

- The structure would be easy to construct compare to in-situ construction method as no casting of concrete are required. The steel fabrication work would be done relevantly easy offsite and lift into place.
- The lifting weight for steel beams would be lower when compared to precast concrete beams. A relatively lighter crane would be required to place the beams into the position. Lighter construction also reduces the substructure cost.
- It should be noted that a similar characteristic of the bridge has been agreed in principle for the Lincoln Eastern Bypass – River Witham Bridge. Hence, manufacture and fabrication of the same type bridge may simple comparing to the precast reinforced concrete beam option.
- The span length would result in a beam height of approximately 1.8m at mid-span. This would produce a lower road profile than when compared to using pre-cast concrete beams.

Disadvantages:-

- The cost of construction using steel beams would be higher than the cost of using precast concrete beams.
- There may be disruption to traffic during future maintenance work.
- The option also involves the casting of insitu reinforced concrete elements such as abutments, piers and deck slab which will cause the traffic disruptions.
- Although primarily constructed of weathering steel, routine inspection and maintenance would still be required.

5.2. Option 2 – Pre-cast Reinforced Concrete Beams and In-situ Deck

This section is to be read in conjunction with drawing 738233-WSP-SBR-XX-DR-C-0008 contained in Appendix A.

The bridge will be three-span structure with one 47m long centre spans and two 36m long side spans giving total span length of approximately 119m. The actual length of each span may vary based on the archaeological and geotechnical investigation at a later stage. It should be noted that two structures could be constructed for eastbound and westbound carriageways separately. The two separated structures will reduce the effect of the traffic from one direction to the other direction structures. However, the two separated structures will increase the cost for construction and maintenance.

The superstructure shall comprise of 9 No. pre-stressed concrete 'W' beams. The type of precast beams may change at the preliminary design stage. The beams would be made composite with an in-situ reinforced concrete deck slab. The beams span into integral insitu reinforced concrete diaphragms spanning transversely between the supports at the piers. Mechanical bearings will be provided at the abutments and these will be positioned in line with the pier supports. At each abutment, all of these bearings will be free to move and rotate. Inspection galleries would be provided at each abutment.

The parapets will be supported by a discontinuous in-situ reinforced concrete edge beam. The deck cantilever soffit angles will vary to provide a constant depth of edge beam along the structure. High containment H4a parapets will be provided on south end of the bridge and the approach ramps. 1.8m high N1 W2 equestrian parapets and parapets will be provided on the north end of the bridge and the approach ramps.

The end supports will comprise of reinforced earth skeletal abutments on a reinforced concrete piled foundation. The approaches will be retained by reinforced earth wing walls parallel to the carriageway supported by Load Transfer Platform and Control Modulus Columns. The inspection galleries will be provided at each abutment. The reinforced earth wall will be reinforced using polymer or steel straps and faced with concrete blocks. The intermediate supports will comprise of reinforced concrete vertical cantilever intermediate piers supported on a reinforced concrete pile foundation.

Construction method:-

- Provision of temporary access to the site.
- Construct pile foundations and pile caps for abutments and piers.
- Construct abutment and pier columns.
- Construct the MSE walls and backfill up to the bearing shelf level.
- Construct abutment bankseats and Install reinforced earth behind abutment bankseats.
- Erect falsework for abutment and pier diaphragms and temporary supports for precast beams.
- Lift the beams in to their positions and place the permanent formwork.
- Fix the reinforcement and cast the deck slab. It should be noted that the deck will be casted at different stages. Detail of the casting stages will be studied in a later design stage.

- Decommissioning of temporary supports for precast beams after the concrete has attained its designated strength.
- Pour parapet plinths. Construct the bridge parapets.
- Install bridge verges, apply deck surfacing and install movement joints.
- Install bridge furniture.

Advantages:-

- The bridge would be easy to construct compared to the conventional cast-in-situ construction. The precast concrete beams can be cast offsite and lifted on their position.
- Low future maintenance cost as the structure would be integral at the piers and semi-integral at the abutments.
- The precast and reinforced concrete bridge elements will require fairly low maintenance costs compared to steel beam option.
- This option may have less environmental impacts due to less future maintenance requirements.

Disadvantages:-

- There may be disruption to traffic during future maintenance work.
- The prestressed concrete beams are heavier compared to steel beams and require substantially larger substructure hence higher construction cost.
- The option involves the lifting of heavy construction elements including the precast concrete beams.
- The option also involves the casting of in-situ reinforced concrete elements such as abutments, piers and deck slab.
- The span length requires a beam height of up to 2m which could result in a more elevated road profile.

5.3. Options Summary

Table 2 Structures Options Summary

Option Ref	Relative Ease of construction	Specialist site preparation	Extensive temporary works Required?	Complex construction methodology	Design life / Extension	Maintenance costs	Aesthetics	Environmental Impact
Option 1 (Pre-fabricated weathering steel beams with in-situ concrete deck)	Simple	Require temporary site/access	Moderate – but vast majority of steel fabrication will be cast offsite, and crane-lifted into the position	No	120 yrs	Normal	Standard	Normal
Option 2 (Precast concrete beams with concrete infill)	Simple	Require temporary site/access	Moderate – but vast majority of precast components will be cast offsite, and crane-lifted into the position	No	120 yrs	Low	Standard	Normal

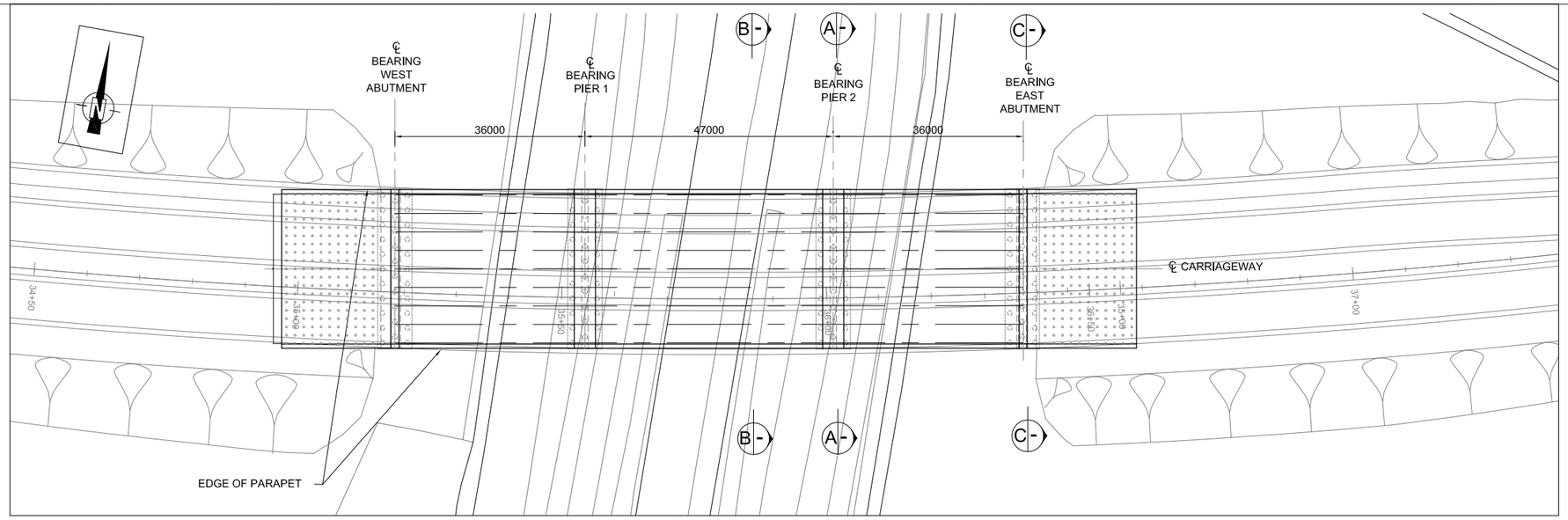
6. Risks and Hazards

The possible risks and hazards have been listed below:

1. Construct of new structures adjacent to the River Witham. Working adjacent to a watercourse.
2. Construction is adjacent to/over watercourse. E.g. foundation, anchorage, tower, pier, deck erection etc. Drowning in watercourse/flooded land. Construction workers.
3. Bridge excavations, e.g. walls and other structures. Falling into excavations, groundwork collapse, slope instability, construction workers.
4. Setting up formworks for piers, foundations and walls during construction. Temporary instability. Instability of cured concrete structures, such as walls, piers and foundations. Instability of temporary works, such as setting up formworks. And Instability of permanent structure during construction. Construction workers.
5. Craning or lifting operations. Failure during lifting due to asymmetric lifting, uncontrolled lifting, Construction workers.
6. Access for maintenance. Exposure to live traffic, working from height etc. for maintenance.
7. Maintenance Operatives.
8. Presence of services (relocating existing STATS during construction/demolition). Electrocution - striking services leading to injury. Construction workers.
9. Hot work carried out for steel composite bridge widening. Welding and cutting - working under hot environment lead to injury and vision damage.
10. Agree software that should be used in preliminary and detail stage.
11. Reduce one span (compare to single carriageway option) will narrow the opening area and increasing the length of MSE wall. This may result an increasing in the flood level at this location. Hence, flooding risk assessment should be carried out to identify the effect of the structure after construction.

APPENDIX A

General Arrangement Drawings



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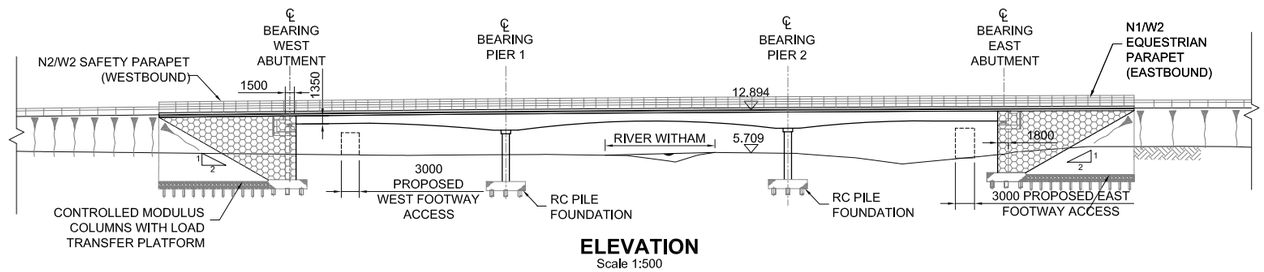

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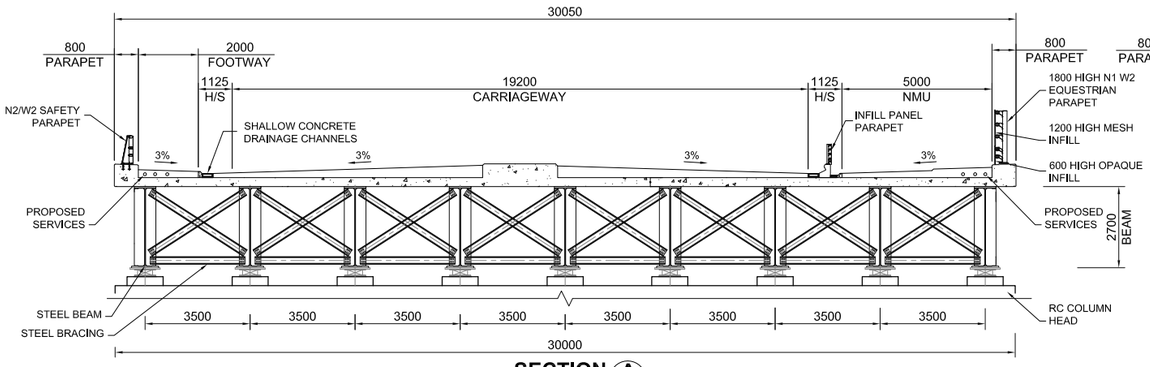

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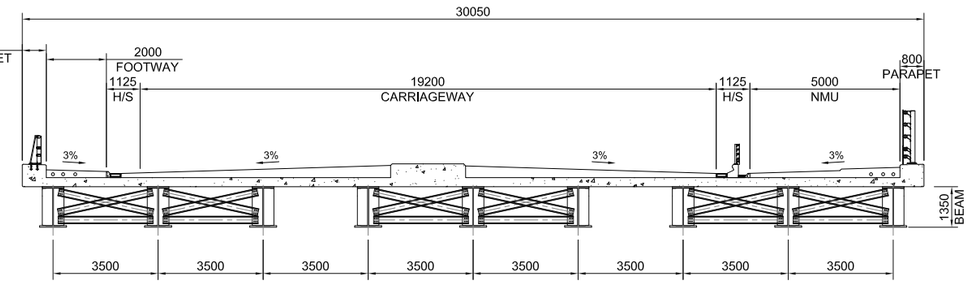

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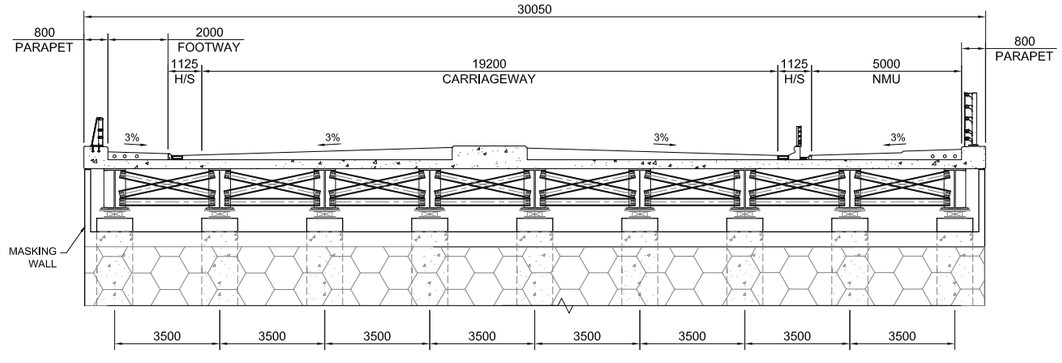

SECTION C
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X-Refs & Blocks used in this Drawing

Notes:

1. Do not scale from this drawing.
2. All dimensions are in millimetres unless otherwise noted.
3. All levels are in meters unless otherwise stated.
4. The structure element dimensions are shown based on conceptual design and subject to change at detailed preliminary design stage.

Reinforced Earth Wall Panels

Load Transfer Platform

Lincolnshire Highway Alliance drawing created using base information supplied by external party detailed below:
Base Information Provided By:
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Revision:	Description:	Drawn By:	CAD By:	Approved By:	Approval Date
	Amendment Details				

Drawing 1st Approval
1st Approval by: GP
Date: 12 DEC 2017

Drawn/Designed by: SQ
CAD Drawing Creation — Created By: KT — Date: 12/12/17

Scale:
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Secondary:

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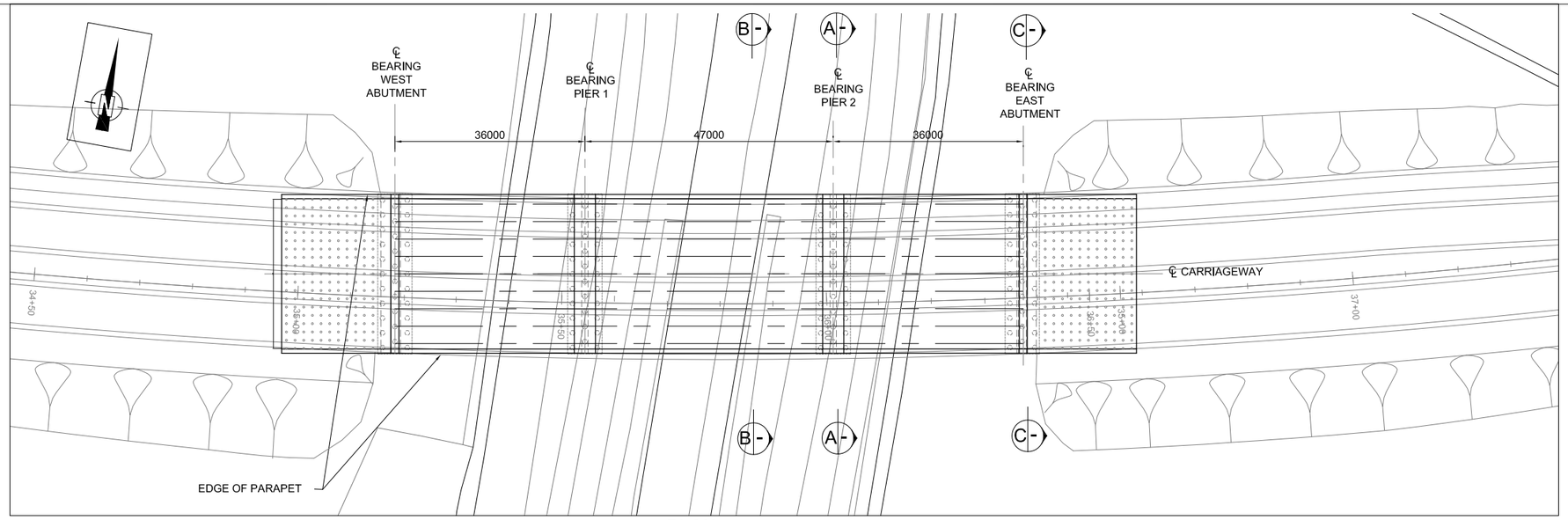
Customer Service Centre : (01522) 782070

BSI Certificate No. FS20705

Scheme Reference	Job Ref.	DFT Series No.	Drawing No.	Revision.
738233-WSP	SBR	XX-DR	C/0007	Rev.A0

Alternative Scheme Code:
Road No:
Parish: LINCOLN
Structure No:
SCN No:
Site Ref:

Description:
LINCOLN SOUTHERN BYPASS
RIVER WITHAM SOUTHERN BRIDGE
GENERAL ARRANGEMENT
DUAL CARRIAGEWAY - OPTION 1



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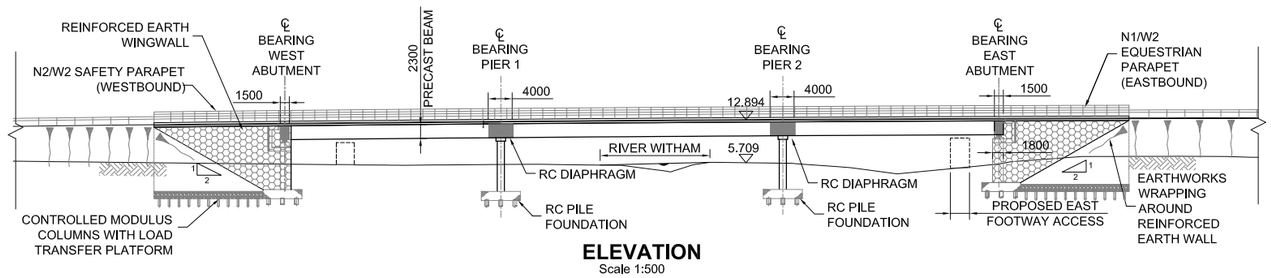

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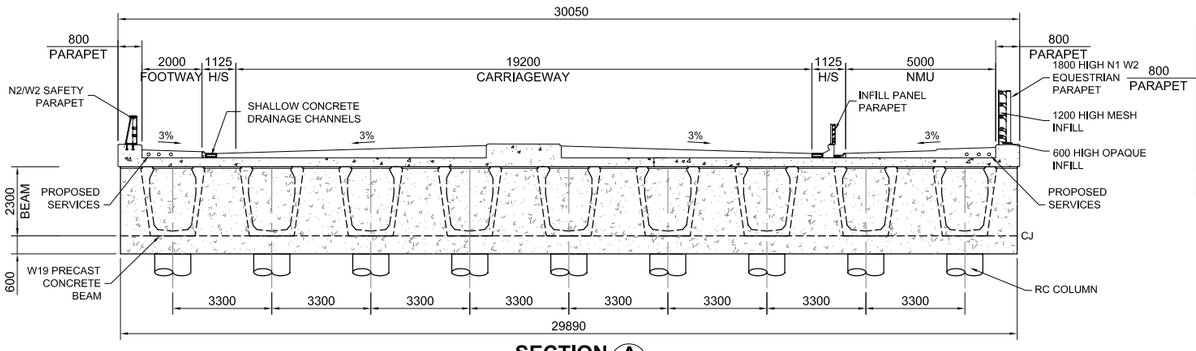

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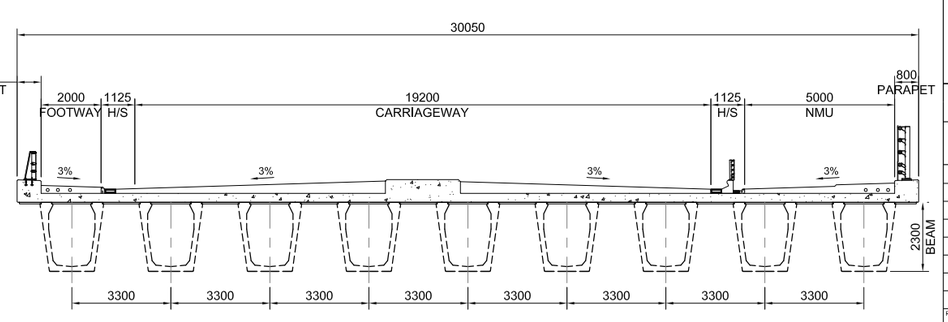

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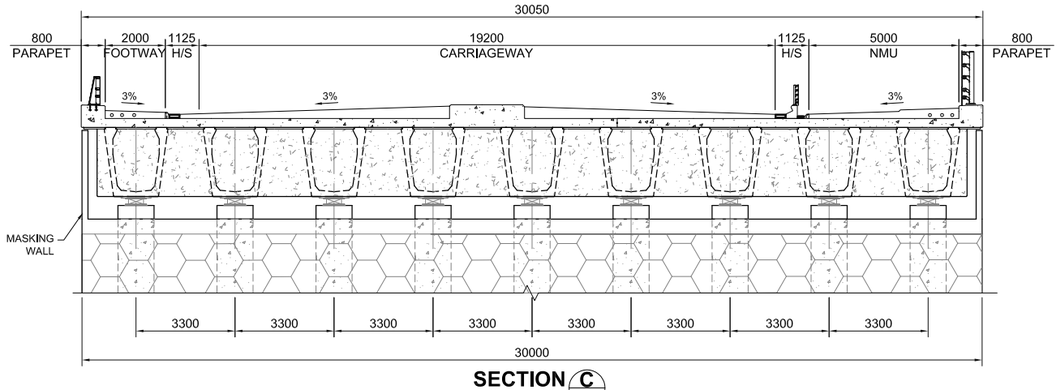

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Parish: LINCOLN
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Description:
LINCOLN SOUTHERN BYPASS
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GENERAL ARRANGEMENT
DUAL CARRIAGEWAY - OPTION 2