MEMO

TO	Andy Palmer	**FROM**	Sophie Collins, Daniela Codeglia
DATE	**08 June 2018**	**CONFIDENTIALITY**	**Confidential**
SUBJECT	**70045931 Northampton NWRR: Technical Note on Preliminary Ground Investigation**		

1. OVERVIEW

This document summarises the ground investigation findings and geotechnical risks likely to impact and influence the choice of design options for the Northampton Northwest Relief Road scheme. The design options currently being considered are: an overbridge option (A) and an underpass option (B). Option A comprises an embankment of maximum 17m in height to approach a bridge over the existing railway line. Option B comprises a cutting approximately 10m deep to approach an underbridge (cut and cover) or jack box under the existing railway line, with 2m from rail level to soffit of the structure.

The purpose of this document is to aid the option selection from a geotechnical perspective to progress the scheme to planning.

2. GROUND INVESTIGATION

A Preliminary Ground Investigation (GI) was undertaken in May 2018. Eight windowless sample boreholes (WS101 to WS108) were formed in the alluvial plain to depths ranging from 4.0 to 6.0m below existing ground level (begl). One rotary borehole (BH101) was drilled to a depth of 10.2m begl to the north of the railway line; a standpipe for the monitoring of groundwater level was installed in this borehole. A location map and borehole logs are included in the attached Preliminary Ground Investigation Factual Report. Draft geological cross-sections are also attached.

The GI confirms the presence of Alluvium in the flood plain to depths ranging 2.5 to 5.3m begl, and weathered Whitby Mudstone beneath the Alluvium. The thickest Alluvium was recorded in boreholes WS101, WS106, WS107 adjacent to the River Nene. The alluvium generally comprises soft sand/gravelly clay or sandy gravel. A 0.2m thick layer of peat was encountered in borehole WS103. Peat was not encountered in other locations; therefore, is likely to be present only in local lenses. No widespread highly compressible material (i.e. peat) is expected. Atterberg laboratory tests were carried out on three samples; on average the Liquid Limit resulted 69%, the Plastic Limit 27% and the Plasticity Index resulted 42%. The alluvium is classified as clay of high to very high plasticity.

Whitby Mudstone was recovered in BH101 near the railway line (no alluvium); a polished shear surface inclined at 45° was observed in the recovered core between 8.00-8.10m begl.

Groundwater strikes were measured between 0.60 to 1.20m begl within the windowless samples in the flood plain. The water level within BH101 was measured on 30/05/2018 and recorded at 0.69m begl. Seasonal variations of the groundwater level may occur, however consistently high groundwater levels are expected.

3. ENGINEERING ASSESSMENT

Expected settlements under a 17m high embankment are estimated to be in the order of 500mm to 800mm. The time to reach a consolidation settlement of 90% is estimated at approximately 2.5 years. This time can be decreased by using techniques such as staged construction, surcharge and vertical drains to speed up the consolidation process.

Whitby Mudstone Formation can be used as embankment fill. Typical side slope gradients for embankments made of this material are in the order of 1(v):3(h). This can be considered appropriate for embankments founded on competent soils, however, this needs to be confirmed by specific stability analysis. The presence of the soft compressible

deposits (i.e. alluvium, peat) may mean that a strategy of staged construction is required, or adoption of shallower slopes, e.g. 1(v):5(h). As an alternative, ground improvement techniques may be undertaken.

4. FACTORS LIKELY TO HAVE AN IMPACT ON OPTION A – EMBANKMENT AND OVERBRIDGE

Factor	Impact on Option A	Mitigation	Remarks
Soft and compressible ground	High differential and total settlements beneath proposed embankment and structures (bridge, culvert units) are likely to occur. Organic soils such as peat have not been recorded widespread across the site.	Dig out and replace Alluvium with granular material. Undertake ground improvement techniques, such as surcharge with vertical drains, Controlled Modulus Columns (CMC), Vibro Concrete Columns, Lime Columns or strengthening of the formation surface using a geogrid. Decrease the embankment load by using lightweight fill material.	
Shallow Groundwater Depth	Groundwater flooding can cause washout of embankments. Ingress of water into excavations	Suitable drainage to be formed under embankments. Detailed design to consider potential for uplift of culverts.	
Flooding	Damage to structures, foundations and earthworks, including erosion of embankment slopes.	Appropriate temporary and permanent drainage and erosion protection measures. Use of balancing ponds to take up lost floodplain storage capacity and other run off caused by loss of permeable surface area.	Maintenance liability.
Shrinking / Swelling of high plasticity clays	Within the Whitby Mudstone Formation. May be caused by changes in groundwater conditions causing excessive movement of bridge foundations. Laboratory test results confirm presence of high and very high plasticity clays.	Piled foundations to be constructed deeper than the zone of influence of the shrinking / swelling zone of influence, into stable ground.	Not a problem under embankment.
Relict shear zones	Within Whitby Mudstone Formation. Increased load due to construction of embankment may reactivate shear surfaces and cause shallow mass movement.	Construct contiguous piles wall at the toe of slope to intercept potential slip surfaces.	
Aggressive ground conditions	Whitby Mudstone Formation has the potential of high water-soluble sulphate / pH conditions which can cause long term breakdown of buried concrete.	Material testing to assess potential. Increase specification of concrete to higher class.	
Earthworks materials	Significant import required.	Agree supply with local development: phase works to suit supply.	

5. FACTORS LIKELY TO HAVE AN IMPACT ON OPTION B – CUTTINGS AND UNDERBRIDGE

Factor	Impact on Option B	Mitigation	Remarks
Network Rail asset protection	Extended program, temporary works, extensive monitoring, Settlement of railway is likely to be induced by groundwater lowering (temporary and/or permanent)	-	-
Soft ground within alluvium (i.e. clay)	Risk of instability of side slopes in soft ground in cutting excavations during construction.	Support of sides of excavation will be required at all times. Limit length of excavations open at any one time by forming bays.	Increased costs.
Shallow Groundwater depth	Can reduce effective stresses leading to slope instability. Can also severely impede construction and flooding of excavations and structures below groundwater level.	The groundwater level will need to be lowered at least to depth of excavation by pumping and maintained constantly at this level during and after construction (permanent dewatering). Might need temporary works measures (i.e. water tight structure such as sheet piles or cofferdam) to keep water out of excavation.	Increased costs for construction and long-term maintenance costs. Settlement of railway is likely to be induced by groundwater lowering (temporary and/or permanent)
Relict shear zones	Within Whitby Mudstone Formation. Have the potential to be reactivated during excavations causing instability.	Support of sides of excavation will be required during construction and permanently (e.g. retaining walls). Limit length of excavations open at any one time by forming bays.	Higher risk than for embankments
Flooding	Cuttings / tunnel have the potential to be flooded impeding usability. Also, high risk for workers / end users.	Permanent flood mitigation measures would be required to protect the excavation from the exposure to flooding, such as flood berms or permanent pumping. Flood berms would be required to protect the excavation from the exposure to flooding.	High risk for workers / end users. Increased cost.
Shrinking / Swelling of high plasticity clays	May be caused by changes in groundwater conditions within the Whitby Mudstone Formation causing excessive movement of underground structures.	Appropriate testing to determine potential. Treatment with hydrated lime / cement, however this is dependent on sulphate concentration and organic content. Alternative stabilisers available.	Increased cost.
Aggressive ground conditions	Whitby Mudstone Formation has the potential of high water-soluble sulphate / pH conditions which can cause long term breakdown of buried concrete.	Appropriate testing to determine potential. Increase specification of concrete to higher class.	
Brampton Brook	Excavation of approach cuttings is likely to intercept Brampton Brook.	Diversion of the brook is necessary.	Increased cost.
Material disposal	Alluvium is unlikely to be suitable for re-use as engineered material.	Could be reused as landscaping material	High cost of disposal.

6. GEOTECHNICAL RISK REGISTER

The Geotechnical Risk Register is attached. Environmental risks (e.g. contamination, etc.) are not included in this reduced version of the risk register.

7. DALLINGTON GRANGE BORROW PITS

The proposed location of borrow pits is shown on the Dallington Grange Masterplan (attached). The preliminary GI did not investigate the area where the borrow pits are proposed to be located. An Interim Geotechnical and Geo-Environmental Report prepared for the housing development by Rolton Group (2007) reports some information on the ground conditions (although not exhaustive as testing on the material is limited). The report includes trial pit logs undertaken in the area. The area of interest is partly underlain by the Whitby Mudstone Formation and partly by the Northampton Sand Formation.

Both the Northampton Sand Formation and the Whitby Mudstone Formation are likely to be suitable for re-use as embankment fill; however, further laboratory testing is needed to assess the suitability of the material.

8. CONCLUSION

From a geotechnical perspective there are fewer risks associated with an overbridge and embankment solution (Option A) compared to an underbridge solution (Option B). Material excavated in the Dallington Grange development is likely to be suitable for re-use as embankment fill thus cutting costs associated with material import.

ATTACHMENTS

- Risk Register
- Preliminary Ground Investigation Factual Report (Ref. 70045931-F10 - June 2018)
- Cross-section
- Dallington Grange Masterplan

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GEOTECHNICAL RISK REGISTER (08/06/2018)

No	Hazard	Consequence	Phase of project affected	Risk Management Measures	Comments or further recommended actions	Risk
1	Soft and compressible ground	High differential and total settlements. Increased costs to dig out and replace Alluvium or undertake ground improvement techniques.	Foundations, construction, design life	Appropriate ground improvement methods may be adopted (e.g. excavate and replace, surcharge, etc.). Foundation design to be carried out according to tolerable settlement limits and appropriate Factor of Safety.	Compressible strata may arise from Alluvium or weathered bedrock. The deposits may provide low bearing capacity and detailed consideration of foundation types may be required.	Very high
2	Flooding	Increased construction costs. Damage to structures, foundations and earthworks, including erosion of embankment slopes. Maintenance liability.	Excavations, earthworks, design life	Design will consider flood levels and fluctuations, including rapid drawdown. Ensure adequate temporary and permanent drainage for earthworks and structures. Permanent pumping might be needed.	The majority of the site is at high risk of flooding. The southern-most region of the site, in the vicinity of Grange Farm, is at a very low risk of flooding.	High
4	Aggressive ground conditions	Long term degradation of concrete components leading to reduced design life and increased maintenance costs.	Design life	Laboratory tests to determine aggressiveness of the ground. Design sulphate classifications for buried concrete to be assessed. Depending on sulphate concentration, avoid calcium-based additives to treat soils (i.e. lime, cement) or blend in non plastic soils. Increase specification of concrete to higher class.	The presence of the Whitby Mudstone Formation indicates that there is the potential for high water-soluble sulphate / pH conditions to be present on site.	Medium
5	Shrinking / Swelling Potential	Changes in groundwater conditions as a result of the construction may cause shrinking or swelling of any high plasticity clays which may result in excessive movement of structures.	Foundations, excavations, earthworks	Geotechnical sampling and testing to assess plasticity of the strata below the site. Treatment with hydrated lime / cement, however this is dependant on sulphate concentration.	Whitby Mudstone Formation is present beneath the site and has the potential to be a high plasticity clay. High plasticity clay has been confirmed within the Alluvium.	Very low

No	Hazard	Consequence	Phase of project affected	Risk Management Measures	Comments or further recommended actions	Risk
6	Relict shear surfaces within the Whitby Mudstone Formation	Relict shear zones have the potential to be reactivated during construction works causing instability / landslides to occur.	Excavations, foundations, earthworks	GI to be undertaken to investigate the presence of relict shear surfaces within the Whitby Mudstone Formation. Undertaking geomorphological mapping to identify areas at higher risk of ground movements. Construct contiguous piles wall at the toe of slope to intercept potential slip surfaces.	The geological map indicates the site to be in an area where the Whitby Mudstone Formation is present. This stratum has the potential to contain relict shear zones.	Medium
7	Valley cambering and associated gulls	Mistaken geology: gulls or cambered blocks can easily be missed in routine investigation. Can lead to use wrong material parameters. Cambered blocks can become unstable during excavation.	Ground Investigation, Excavation, Design, Design life	Increased number and closer-spaced GI in areas where Northampton Sand is expected to be found. Excavation may need support.	Valley cambering may be present in the area adjacent to Grange Farm.	Low
8	Unexpected Ground Conditions (including variable strata thicknesses)	Unsuitable earthwork proposals if parameters assumed in the design are worse than that encountered on site during construction.	Design and construction works	Adequate GI to be undertaken to assess the spatial and compositional nature of the different strata beneath the site.		High
10	Instability of existing slopes on or adjacent to the proposed scheme	Failure of existing slopes and proposed embankment during construction.	Earthworks	Geotechnical slope survey with analysis of existing slopes to assess the geotechnical properties of slope material. Ground investigation to assess the geotechnical properties of slope material. Unstable slope faces may need additional stabilisation works.		High
13	Hard ground or obstructions	Delay site works, Increased construction costs.	Excavations, foundations	GI to assess the spatial and compositional nature of the strata beneath the site. Min 5m coring into competent rock to prove bedrock.	Obstructions may be associated with Made Ground, natural superficial and solid geology.	Medium