South East of Scotland Transport Partnership (SEStran)

Edinburgh Orbital Bus Rapid Transit (EOBRT) Project

Traffic Engineering and Preliminary Design

Final Draft Report

Scott Wilson Ltd

July 2010

Revision Schedule

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1.0 INTRODUCTION

1.1 Background

1.1.1 SEStran (South East of Scotland Transport Partnership) appointed Scott Wilson to prepare a Pre-Feasibility and STAG Part 2 Report on potential options for an orbital bus system in Edinburgh. This would link a number of key employment, retail and Park-and-Ride (P&R) sites located within the vicinity of the A720 Edinburgh City Bypass.

1.1.2 Known as the Edinburgh Orbital Bus Rapid Transit (EOBRT) Project, a preferred alignment was produced following the STAG Part 2 Appraisal which links Edinburgh Airport with Millerhill P&R and has different segments running on and off the Bypass.

1.1.3 Following on from this, Scott Wilson developed an outline programme for the implementation of the scheme, which sub-divided the proposed route into 7 segments[1]:

- Section A – Edinburgh Airport to Gogar (South Gyle Access);
- Section B – South Gyle Access / Bankhead Drive to B701 (Wester Hailes Road) / A71 (Calder Road);
- Section C – A71 (Calder Road) / Water of Leith at the A720 Edinburgh City Bypass to Lothianburn P&R site;
- Section D – Lothianburn P&R site to Straiton P&R site;
- Section E – Straiton P&R site / A720 to Lasswade P&R site;
- Section F – Lasswade P&R site / Lasswade Road to Gilmerton Road / Sheriffhall P&R site; and
- Section G – Sheriffhall P&R site / A6106 to B6415 Old Craighall Road / Millerhill P&R site.

1.1.4 The outline programme suggested that the full EOBRT route could be implemented as a phased approach, with combinations of the above sections, rather than constructing the whole route at once. Subsequent assessment of current levels of congestion along the various sections of the proposed route have suggested there is a need to undertake more detailed design of two of the above sections, namely Sections B and D.

1.1.5 Consequently, SEStran appointed Scott Wilson to further develop the possibilities for the implementation of the project focusing on the transportation and engineering aspects of implementing Sections B and D. This report sets out the findings of the study.

1.2 Structure of this Report

1.2.1 The overall structure of this report is as follows:

Chapter 2 – discusses the options for a new link between Lothianburn and Straiton P&R sites and sets out the highway engineering preliminary design and associated costs;

Chapter 3 – examines the traffic engineering and junction amendments required for the two Sections of the EOBRT route examined in this study; and

Chapter 4 – outlines the conclusions and recommendations.

[1] Outline Implementation Programme and Updated Business Case Analysis, Scott Wilson, November 2009

2.0 NEW LINK BETWEEN LOTHIANBURN AND STRAITON PARK-AND-RIDE SITES

2.1 Study Tasks

2.1.1 SEStran issued Scott Wilson with a Study Brief on Monday 8th February 2010 requesting various tasks to be completed for developing the preliminary design for a new off-road link connecting the proposed Lothianburn Park-and-Ride (P&R) site to Straiton P&R site[2]. This Brief is included in Appendix A. A meeting was held with SEStran on Wednesday 10 February 2010 to discuss their needs and agree a suitable methodology. The Brief identified the following outcomes for the study:

- undertake desktop research to establish available information with respect to ground conditions, topography, drainage, public utilities, land ownership and other information relevant to the provision of a new bus link between the two P&R sites;
- identify the best alignment taking into account the information collected, ground conditions, and the likely land-use severance/land access requirements; and
- for the preferred route alignment, develop the key highway and junction interventions and prepare preliminary design drawings and capital cost estimates.

2.1.2 These tasks formed the basis of the work carried out for this section of the EOBRT route and the emerging findings are described in the rest of this chapter.

2.2 Route Alignment Optioneering

Overview

2.2.1 A project Inception Meeting was held on 18th February 2010, which was attended by representatives from the following:

- SEStran;
- City of Edinburgh Council;
- Midlothian Council; and
- Scott Wilson.

2.2.2 The intention was to discuss potential route alignment options between the two P&R sites, with a view to identifying a short list of possible options to take forward to more detailed analysis.

2.2.3 Following the discussions, Scott Wilson identified various alignment options to provide a new off road link to connect the P&R sites. The optioneering involved identifying outline alignment routes for the new off road BRT link based on a high-level engineering analysis of the corridor.

2.2.4 A total of three route options were identified and considered:

[2] EOBRT Brief for Preliminary Design Work for Bus Link between Lothianburn and Straiton P&R, SEStran, 8 February 2010

- Option A – following an alignment to the south of and as close as practicable to the A720 City bypass;
- Option B – following a more southerly route adjacent to the field boundaries; and
- Option C – using the existing Pentland Road with dedicated links to and from both P&R sites.

2.2.5 Appendix B contains a CAD plan (Drawing Number S105976/P/101) of the identified routes and their alignments. Each of the options were considered against a series of design criteria such as design speed, maximum/minimum gradient and stopping sight distance, etc as would be required for the new link. The conclusions for each link option are summarised below.

Route A

2.2.6 The central section has 720m radii with 510m radii on approaches to both P&R sites. The route follows the alignment immediately south of the A720 whilst allowing for a 50m buffer zone adjacent to the existing watercourse which also follows the boundary. A high proportion of this route is non-arable rough ground.

2.2.7 The route links into the entry road at the Lothianburn P&R site so no internal changes would be required other than entry barriers possibly being moved closer to the parking site. At the Straiton P&R site the route will need to cross the car park internal circulatory road to reach the bus stop area. 'Bus only' signs will be required on the link road.

2.2.8 There are a couple of variations to the alignment, referred to as Options A2 and A3. Option A2 links into the Lothianburn P&R site from the south so that it will need to cross the car park internal circulatory road to reach the bus stop area. Again, 'bus only' signs will be required on the link road. Option A3 follows the A720 more closely but requires the radius to drop to 360m and impacts more on the buffer zone adjacent to the water courses.

2.2.9 For options A1 and A2, the total length is approximately 2030 m, while the length for option A3 is circa 2100 m.

2.2.10 The alignment of Route A would have the shortest journey time in terms of linking to the other segments of the EOBRT project. In addition, variation Option A2 with the link into the Lothianburn P&R site from the south provides a direct circuit through the P&R site. Feedback from Midlothian Council has suggested this would also be welcome by Lothian Buses who have requested a second exit point south of the proposed junction access into the P&R site.

2.2.11 However, there are potential ground issues with the alignment due to mining works and made ground. This was confirmed following outline ground investigations which suggests there could be an issue with this alignment.

Route B

2.2.12 This option uses a radii of 360m to allow it to follow the existing field boundaries and water courses, and to follow a more central route between the A720 and Pentland Road.

2.2.13 At both P&R sites, the route will need to cross the car park internal circulatory road to reach the bus stop area. 'Bus only' signs will be required on the link roads. The length of the alignment is approximately 2060 m, which is only slightly longer than Route A.

2.2.14 There could be more cut and fill required with this alignment than Route A, which is likely to have an impact on the capital cost. The alignment has been identified as it follows existing

boundaries between plots of land. However, it does segregate the total land area more than the other two options.

2.2.15 In terms of transport planning issues, the route is slightly longer than Route A which is likely to increase the journey time of bus operations. Other impacts are the same as for Route A.

2.2.16 In terms of potential ground issues, outline ground investigations have suggested that this route has fewer ground issues than Route A.

Route C

2.2.17 Pentland Road is an unclassified road, rural in nature but with an appreciable number of properties having direct access. It is in the Midlothian Council area. The design speed for this road between the A703 junction and the A701 Straiton Road is estimated to be 85kph based on plans only.

2.2.18 The link at the west end from the Lothianburn P&R site, although mainly 510m radius, will require a tight sub-standard bend on the approach to the junction with Pentland Road. Because Pentland Road is poorly aligned, large visibility splays and/or local road improvements would be required.

2.2.19 The link at the east end to Straiton P&R is along the line once planned for the A701 Straiton Bypass. It is not known if this route is reserved, but if the scheme went ahead the link works could be incorporated at minimal expense. The location of a replacement link could then be looked at in light of the bypass construction. The junction with Pentland Road would again require sizeable visibility splays.

2.2.20 The length of the route is approximately 1460 m (580 m for the west link and 880 m for the east link). Route C is likely to have the lowest capital cost of all the options, due to the fact it uses the existing Pentland Road.

2.2.21 However, Route C has the longest journey time of all the options. In addition, the maximum theoretical speed limit of Pentland Road is 85kph which is lower than the other options.

Shortlisted Options for Detailed Design

2.2.22 Following the above outline engineering analysis, a further meeting was held with SEStran on 11 March 2010 to discuss the findings. The meeting concluded the following:

- Route A was discounted due to ground conditions. The route passes through substantial areas of made ground where old reservoir serving workings existed;
- Route B was accepted as being better than Route A due to the lower levels of ground issues, while still allowing a high running speed for EOBRT services. Hence, this was taken forward for more detailed analysis; and
- A variation of Route C was also considered a worthwhile option to take forward towards more detailed analysis. The proposed variation (shown in Drawing S105976/P/101 in Appendix B) would be a hybrid between Routes B and C and would allow for a phased implementation. Phase 1 would link the Lothianburn P&R site to a new junction with Pentland Road, from which it would follow the existing highway to the A701 Straiton Road after which it would travel north to the Straiton P&R site. Phase 2 would take off from Phase 1 to get back onto Route B to complete the 'full' off-road BRT link between the two sites. The initial link to Pentland Road could continue to be used by 'ordinary' buses as a separate route.

2.2.23 The three shortlisted route options (renamed as Route B and Routes C1 and C2) were taken forward for more detailed analysis, including an examination of the geology and ground conditions which is described in the following section.

2.3 Geological Analysis

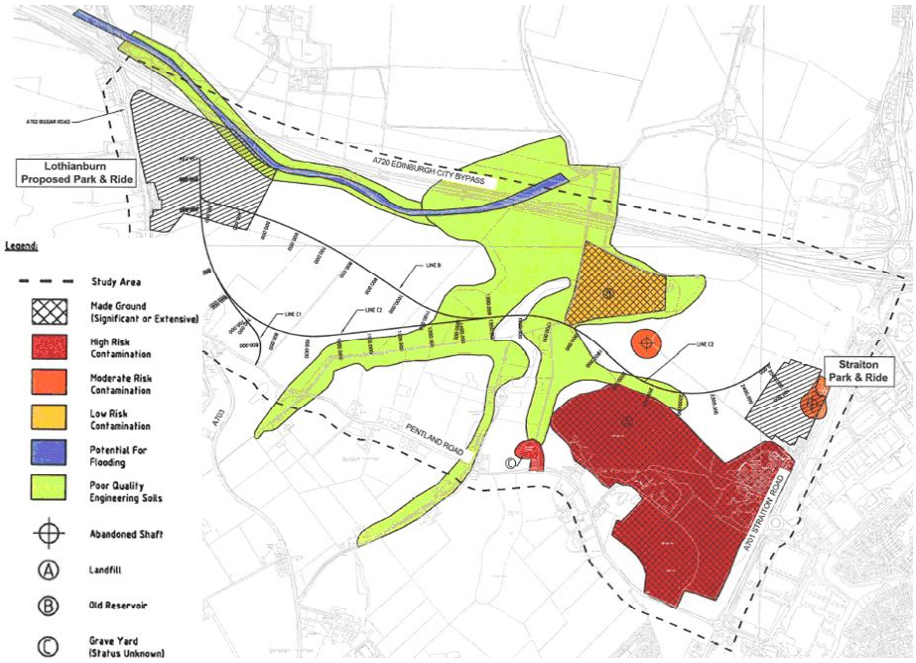
Overview

2.3.1 The geology of the corridor was also considered in a preliminary desk study. A copy of the Geotechnical Analysis Report is included in Appendix C. In summary the following Geotechnical problems were identified along the corridor:

- Cutting Stability (associated with flood plain alluvium deposits);
- Embankment Stability (associated with flood plain alluvium deposits);
- Embankment Settlements (associated with flood plain alluvium deposits);
- Made Ground (associated with contaminated land);
- Ground Subsidence (associated with potential shallow underground mine workings); and
- Contaminated Ground Water (associated mine water discharge).

2.3.2 A Geotechnical Constraints Plan was produced which depicts the areas with geotechnical issues. The Geotechnical Constraints Plan is contained in Appendix C and is reproduced in Figure 2.1 below.

Figure 2.1 – Geotechnical Constraints



2.3.3 The areas highlighted in green in Figure 2.1 show locations of the site which are underlain by poor quality soils.

2.3.4 Route B is underlain by poor quality soils between Ch 1125 and 1250 m. Route C1 is not underlain by any poor quality soils but Route C2 is underlain by poor quality soils between

Ch 1300 to 1550 and Ch 1625 to 1800 m and is also potentially underlain by shallow underground mine workings between Ch 1500 and 2825 m approximately.

2.3.5 These investigations reinforce those of the initial route options discussions and point towards Route B as the preferred option from an engineering perspective.

Recommendations

2.3.6 Given the findings set out above, a series of recommendations have been identified for future geotechnical route assessment. These include the following:

- collate and review solid and drift geology maps and associated memoir(s);
- undertake a detailed review of mine abandonment plans specific to the preferred alignment;
- purchase and review of historic borehole records specific to the preferred alignment;
- review historic ground investigation reports specific to the preferred alignment;
- review data specific to contaminated land hotspots present along or adjacent to the preferred alignment;
- undertake a site walkover and ground investigation surveys to identify important geotechnical issues; and
- collate the findings from the above into a Ground Investigation Plan for use in refining the engineering design as the project progresses through the development stages.

2.3.7 In the absence of the above information, the rest of the preliminary engineering design work has used the data obtained from the desktop Geotechnical Analysis Report, included in Appendix C.

2.4 Land Use Considerations

Overview

2.4.1 The impacts of the proposed bus route on the land use in the area were investigated as part of the earlier STAG 2 study[3], the findings from which are included in this section and an accompanying land use plan is provided in Appendix D.

Green Belt and Open Space

2.4.2 Land south of this section of the A720 Bypass is largely included in the Councils' Green Belt and is thus protected as an area of restraint in both the FECLP 2007 and FMLP 2006. This includes land categorised under a number of local and national environmental designations.

Residential

2.4.3 Along the edges of the corridor, residential housing is predominantly low density, mainly in the form of single farmhouses and rural village clusters. However, higher densities are achieved further towards the eastern end of the section where suburban development has occurred. A pocket of land near the Straiton Junction on the northern extremity of Loanhead is allocated in the FMLP 2006 (Policy HOUS1, Proposal H11) to produce 200 houses towards the authority's strategic housing supply.

[3] Edinburgh Orbital Bus Project - STAG Part 2 Appraisal Report, Scott Wilson, July 2009

Commercial

2.4.4 The ELSP identifies the A701 corridor (at the eastern end of the corridor) as a Core Development Area. This is a result of emerging development in the field of biotechnology which has taken place at the Bush Estate and Roslin Institutes (Policy ECON2); both of which form part of the region's emerging Science Triangle. These sites are well connected to the Straiton P&R and form a major driver of employment in Midlothian.

2.4.5 Adjacent to the Straiton P&R, is Straiton Retail Park. Aside from the earlier developments of Costco and Ikea, expansion at Straiton has been limited to the development of the Lower Straiton Retail Park and the approval of a small extension close to the A701, on the west side of the Park. Midlothian Council however considers it desirable to support the continued success of Straiton by allowing a small southward expansion of the Park. This is identified in the FMLP 2006 (Policy SHOP4).

2.4.6 Land on the northern edge of Loanhead in the north of the A701 corridor near to the Straiton Retail Park has also been allocated in the FMLP 2006 for strategic economic development (Policy ECON1, Proposal E6). A 10-hectare site has been identified in conjunction with the housing allocation outlined above and is considered suitable for Class Uses 4, 5 and 6. The Local Plan outlines that, if the development is successful, there will be scope for further expansion of the site northwards towards the City Bypass.

Transport

2.4.7 The Straiton P&R facility was opened in September 2008 and provides links with bus routes into Edinburgh city centre. The FMLP 2006 has identified the potential for a road improvement scheme on this section of the A701 between Straiton and Milton Bridge (Policy TRAN4). At this time, the Council is seeking to implement a series of measures to ease congestion in this corridor by giving more priority to buses and cycling on this route. Planning permission has been received for a road scheme to improve the A701 which will continue to be safeguarded as a consented road line.

Assessment (Potential Impacts)

2.4.8 The introduction of a bus route between the P&R facilities at Lothianburn and Straiton presents the opportunity to better link land uses and transport nodes located around the fringe of Edinburgh's urban area.

2.4.9 There are no conflicting land uses along the route although pursuit of this high segregated scheme would mean the provision of a new transport route through protected Green Belt land. Future provision of housing and economic land in the Straiton area would also benefit from their proximity to the EOBRT and the enhanced public transport links which would ensure that different travel options are available and would help existing systems to cope with future/rising travel demand.

2.5 Environmental Issues

Overview

2.5.1 The environmental issues associated with the introduction of the proposed bus route were investigated as part of the earlier STAG 2 study[4], the findings from which are included in this section and an accompanying environmental constraints plan is provided in Appendix D.

Water Quality, Drainage and Flood Defence

2.5.2 The impacts of construction and operation on the hydrological resource are likely to be low providing that the necessary mitigation measures are put in place to avoid pollution of watercourses. The hydraulic capacity of the Burdiehouse Burn must be maintained, to minimise any impacts on upstream flooding. In particular, the design of any additional infrastructure required for the preferred option must preserve the hydraulic capacity of the Burdiehouse Burn and the respective floodplains.

Geology, Agriculture and Soils

2.5.3 No designated sites have been identified at this stage. The predicted effects are likely to be no impacts/negative minor impact but further investigation will be required at the detailed Environmental Statement (ES) stage.

2.5.4 The route options would require the construction of new off-road infrastructure resulting in moderate adverse impacts during construction associated with groundbreaking work and the potential removal of spoil. However, this impact would be temporary.

2.5.5 The predicted impacts are expected to be local but if mitigation measures in the form of best practice construction methods are utilised the significance of any potential impact will be reduced.

Biodiversity

2.5.6 The most likely impacts on the ecological and nature conservation resources along the route are:

- the loss of areas of scrub and grassland habitat which have developed on site or adjacent to the site and will require clearing as part of the development works;
- the loss of bat roosts within trees and structures to be demolished;
- the potential for pollutants entering sensitive and protected watercourses during both construction and operation stages; and
- the potential spread of invasive plant species.

2.5.7 There is potential for significant impacts on protected species, such as bats and to a lesser extent badgers, otters and water voles, and legal implications pertaining to invasive plant species for each route. However, the likelihood and significance of impacts will not be known until detailed ecological field surveys are carried out on site. Surveys of protected species, including detailed inspection of any structures and trees to be demolished should be conducted at an appropriate time.

[4] Edinburgh Orbital Bus Project - STAG Part 2 Appraisal Report, Scott Wilson, July 2009

Visual Amenity

2.5.8 Construction effects are likely to be temporary except for the potential removal of mature vegetation from the site. Small changes to the vegetation pattern are unlikely to significantly affect visual amenity.

Cultural Heritage

2.5.9 The cultural heritage assessment examines those cultural and archaeological resources within a 200m envelope of the EOBRT corridor. There are no SAMs or Listed Buildings present within the study corridor, although part of Morton Conservation Area is located within this corridor.

2.5.10 The possibility of uncharted archaeological remains should be accepted given the nature of the study corridor and the need for further study at the next stage. However, construction effects are considered to have a low impact on any cultural heritage and archaeological resources within the study corridor.

Landscape

2.5.11 The removal of vegetation would be a potential effect but it is unlikely that this will permanently affect the landscape character. Much of the potential vegetation that may be removed is relatively recently planted.

2.6 Emerging Designs

Layout Design

2.6.1 From the above information and discussions with SEStran a series of alignment designs were developed as shown in Drawing S105976/P/102 in Appendix E. This shows the designed alignments for Routes B, C1 and C2. In the short term, Phase 1 of the EOBRT route will be stopping at the Straiton P&R site without continuing eastwards to the Millerhill P&R site, which is Phase 2 of the proposed full EOBRT route. Therefore, Section E-F is not required at the present time, however to future proof the emerging designs in order that they can accommodate Phase 2 of the full EOBRT route designs for this section have been developed as part of the drawings shown in Appendices E and I. The cross-section elevation plans showing the levels of cut-and-fill for the options in Drawings S105976/P/103 to S105976/P/105 are also included in Appendix E.

2.6.2 The route options considered have been designed using the following standards and assumptions:

Design Standards

- Design Manual for Roads and Bridges (DMRB) – Volume 6;
- DMRB design type – Main Distributor Road, Type S2;
- design speed of 100kph;
- carriageway width of 7.3 metres;
- gradient between 6.0% (maximum) and 0.8% (minimum);
- minimum horizontal curvature of R = 360 metres (two steps below desirable minimum);

- minimum vertical curvature of K = 55 for crest curves (one step below desirable minimum) and K = 26 for sag curves (absolute minimum);
- minimum stopping sight distance of 160 metres (one step below desirable minimum); and
- verge width of 2.0 metres.

Assumptions

- kerbing is not required;
- drainage designs will be provided at the detailed design stage;
- design standards have been relaxed in approach to the Park-and-Rides with suitable bus terminus design standards applied;
- lower speed limits will be applied in approach to the P&R sites;
- 50m riparian buffers to all water courses would be required;
- Pentland Road is suitable for bus traffic and can be used as part of Route C1;
- improvements to Pentland Road could be made to satisfy visibility and stopping site distance requirements at the proposed junction of Route C1 with Pentland Road;
- the preferred option cut / fill volumes would be optimised after detailed ground investigation and topographic survey information was received; and
- the options have been designed to an outline stage, further design refinements will be required.

2.6.3 There is also the possibility to link the EOBRT with other ongoing projects in the study area. This could include the A701 Study examining upgrades to junctions with the A702 and Pentland Road. In respect of linking Section B – C with the A703 (phase 1a) to cater for bus services to the Bush Estate and beyond, this could be achieved by linking the A703 with Pentland Road further east. This could form part of another wider study being undertaken by Midlothian Council which will examine improvements to the A702/A703/Pentland Road junction and measures required to accommodate new land-use developments.

2.6.4 There was also some discussion with SEStran about providing a link between section B-C and the A703, however this was found to be unfeasible due to the ground levels. Hence, this short link was not progressed.

Construction Cost Estimates

2.6.5 Appendix F includes a detailed cost analysis of the various sections of the route options.

2.6.6 It should be noted that Route B involves a tight turn to/from the Lothianburn P&R site which would result in slowing down the progress of the bus when negociating this turn. This would therefore reduce the business case benefits.

2.6.7 Adding these sections together gives the total costs for the various route alignments. Table 2.1 overleaf summarises the costs for the various route options.

Table 2.1 – Cost Estimates for Route Options

Option	Sections	Section Length (m)	Cost per Section	Route Base Cost	Optimism Bias	Total Cost
Route B	Section A-D	1,050	£1.11m	£2.39m	£1.05m	£3.44m
	Section D-E	1,020	£1.28m			
Route C1	Section A-B	345	£0.34m	£0.67m	£0.29m	£0.96m
	Section B-C	240	£0.33m			
Route C2	Section A-B	345	£0.34m	£2.49m	£1.10m	£3.59m
	Section B-D	880	£0.87m			
	Section D-E	1,020	£1.28m			
Route C1 + C2	-	-	-	£2.82m	£1.24m	£4.06m

Notes:
- the values above have been rounded to the nearest £0.01m
- cost estimates are in Q4 2009 prices
- Route C1 + C2 refers to the phased implementation described in Section 2.2.22

2.6.8 The cost estimates in Table 2.1 are the highway engineering infrastructure works for constructing the new off-road link between the Lothianburn and Straiton P&R sites, and do not include any on-street traffic engineering costs (which are discussed in Chapter 3).

2.6.9 Forward construction inflation has not been applied. In addition, the cost estimates do not include any allowances for risk and uncertainty. However, contingency at 15% is included. Optimism Bias is also shown separately at 44%.

2.7 Running Speeds and Potential Business Case Impacts

2.7.1 Table 2.2 shows the estimated journey times for all three routes between Lothianburn and Straiton Park-and-Ride sites. When calculating the journey times, the running speed has been based on speed restrictions along existing road sections and design standards for the proposed new segments. The figures below can be compared to the construction cost estimates shown in Table 2.1 earlier. In addition, there is a link between the journey times and operating costs of the BRT service which can also be inferred from the above table. This allows for a consideration of the options and their potential value-for-money.

Table 2.2 – Journey Times for Route Options

Route	Section	Length (km)	Speed (kph)	Time (min)	Total Time (min)
B	A-D	1.05	100	0.63	**1.24**
	D-E	1.02	100	0.61	
C1	A-B	0.35	60	0.35	**3.07**
	B-C	0.24	60	0.24	
	Pentland Rd	1.80	60	1.80	
	A701	0.80	70	0.69	
C2	A-B	0.35	60	0.35	**1.49**
	B-D	0.88	100	0.53	
	D-E	1.02	100	0.61	

2.7.2 As can be seen from Table 2.2, Route B is the fastest option with a total route length of 2.07 km. This is likely to also have the lowest operating cost of all the options. While route B is the fastest option, it has the second highest construction costs.

2.7.3 The second fastest option is Route C2 with a total route length of 2.25 km, and which is marginally higher than Route B. This is likely to have a similar operating cost to Route B, but has the highest capital costs partly due to the length and hence volumes of cut-and-fill involved in its construction.

2.7.4 Route C1 uses a mixture of existing and new road sections. Because of the long route length (total of 3.19 km) it has more than double the running time of all the options. However, the advantage of C1 is the low construction costs of the new road sections, which at less than £1m is less than a third of the other options.

2.7.5 From the above findings, Route C1 would appear to be advantageous in terms of value-for-money, however it is less attractive to the overall journey time of the new BRT service. In addition to operating costs, this could also influence patronage demand levels although clearly this can only be confirmed with some additional transport modelling. Nonetheless, given the current economic climate, Route C1 would provide a workable solution at a significantly lower construction cost, although the higher annual operating cost would discount any savings gained from the lower capital cost if it was operating for a longer period. Since the high operating costs would make it significantly more expensive to run a BRT service over the alignment of Route C1 than any of the other options this suggests Route C1 should be considered as a short-term measure.

2.7.6 Consequently, bearing in mind the benefit of a BRT system is the high quality and fast service it provides passengers, it is possible to implement C1 in the short term and then construct the rest of C2 when further funding is forthcoming. This would reduce running times, optimise operating costs and increase the level of attractiveness to users. This phased implementation, as described in section 2.2.22, would lead to a total capital cost of £2.82m (£4.06m including optimism bias at 44%).

2.7.7 This possible way forward is worth further consideration, and can be confirmed with a suitable business case analysis to quantify the benefits versus the costs (both capital and operating). We would therefore recommend such an analysis be carried out as the project progresses to the next stage.

3.0 BUS PRIORITY MEASURES AND TRAFFIC ENGINEERING PROPOSALS

3.1 Study Tasks

3.1.1 In addition to the preliminary design works for the new off-road link described in Chapter 2, SEStran also issued Scott Wilson with a Study Brief requesting various tasks to be completed for developing traffic engineering plans. This would look at providing better connections for the proposed EOBRT to the Lothianburn park-and-ride site, as well as bus priority improvements to the existing highway infrastructure along the A71 (Calder Road) / B701 (Wester Hailes Road) to Bankhead Drive / South Gyle Access route[5]. A meeting was held with SEStran on 10 February 2010 to discuss and agree a suitable methodology. The Brief identified the following outcomes for the study:

- assess the current performance of key junctions to/from the Lothianburn P&R site and identify whether there is a need for proposals to safeguard the proposed EOBRT from congestion;
- similarly, examine the performance of key junctions along the A71 (Calder Road) / B701 (Wester Hailes Road) to Bankhead Drive / South Gyle Access route and establish the requirement for bus priority measures on the link to safeguard the proposed EOBRT from congestion;
- Identify improvements to the operational characteristics of the existing junctions to facilitate the EOBRT without significant impacts on the overall local network performance and without significant alterations to the junction layouts; and
- design relevant junction and link alterations, and estimate construction costs.

3.1.2 The findings from the above analysis are presented in this Chapter.

3.2 Traffic Modelling and Analysis

3.2.1 In order to test the impacts on the existing and proposed highway network, Scott Wilson developed a series of traffic models using the following computer programs, developed by the Transport Research Laboratory (TRL):

- ARCADY version 6.2 for roundabouts;
- OSCADY version 5.1 for signalised junctions; and
- TRANSYT version 12.1 for more complex signalised junctions (e.g. signalised roundabout).

3.2.2 These programs require traffic data to be input (including flows and percentage of HGVs) as well as junction geometry details such as lane widths, layouts of roundabouts, entry widths, turning radii, flare lengths, signal control data, etc to be specified.

3.2.3 The geometry of the junctions was measured from Ordnance Survey mapping and aerial photos at each location. Regarding traffic signals, phasing and staging were determined based on the junction configuration and traffic flows. In all cases, default intergreen times and minimum green settings were selected in the software packages. In addition, the software was run so that it calculated the optimal signal timings and cycle times based on the traffic flows through the relevant junction.

3.2.4 Traffic flows were obtained from the data collected as part of the Traffic Surveys and Data Report[6], and supplemented with additional surveys in February 2010.

[5] EOBRT Brief for Traffic Engineering Work for Bus Link between Calder Road to South Gyle, SEStran, 8 February 2010
[6] EOBRT Traffic Surveys and Data Report, Scott Wilson, January 2010

3.3 Lothianburn P&R Site Access Proposals

Overview

3.3.1 Using the traffic models developed, bus priority measures to address access to/from the Lothianburn P&R site were identified with the intention of safeguarding the EOBRT services from existing and future congestion.

3.3.2 The identified proposals are shown on Drawing S105976/P/1201 in Appendix G, and briefly described below.

Proposals

3.3.3 Table 3.1 documents the nature of the problems in the area before describing the proposed measures to address each problem and the overall impacts these will have on the operation of the EOBRT services.

Table 3.1 – Current Traffic Issues and Proposed Measures

Problem	Proposed Measure	Outcome
Minor congestion to general traffic could delay new EOBRT services.	Eastbound (off-ramp) bus lane into Lothianburn junction.	EOBRT services can bypass any potential pinch-points.
Delays to junction impact new EOBRT services.	Traffic signal / bus gate.	EOBRT services can avoid excessive queuing.
	Northbound bus lane, Lothianburn junction.	

3.3.4 The proposals would involve modifying the eastbound off-ramp to incorporate a bus only lane, giving priority to buses approaching the roundabout.

3.3.5 In order to allow the buses to quickly traverse the south roundabout on their way to the westbound A720 bypass on-ramp, a new bus lane would be constructed bypassing the south roundabout. The new bus lane would be off-road from the existing carriageway and therefore would not reduce the available capacity for existing (general) traffic. A bus gate would be installed to the north of this roundabout to allow the EOBRT to merge back on to the main road. The bus gate could be activated by the bus on approach and the other traffic stopped at signals to allow the bus out.

3.3.6 The entrance / exit to the park-and-ride site at Lothianburn has not been examined as part of this study. However, the road may require modification to cope with the increased traffic when the park-and-ride is implemented. SEStran have advised that the basic assumption in this study is that the signal junction access to the park-and-ride will be designed to appropriate standards and efficiently operated. The exact design of the access should be addressed during the detailed design works of the park-and-ride[7].

[7] Meeting with SEStran officials on 18th June 2010

Network Impacts Tests

3.3.7 The proposals were tested using the junction traffic models developed as described in Section 3.2.

3.3.8 To keep the presentation of the modelling results consistent with those presented for the current traffic conditions in the Capacity Analysis Study[8], the numbering and nomenclature of the junctions was kept the same. Hence, for this section of the EOBRT route, the junctions which are affected are numbered Junctions 12 and 13. Similarly, the same opening year (2013) for the project and traffic growth scenarios were used as in the Capacity Analysis Study.

3.3.9 The junction modelling of the future traffic flows with the existing highway layout are presented in Table 3.2 overleaf. This is followed by Table 3.3, which shows the results of the analysis of the new highway changes on future traffic flows plus the EOBRT services. Comparing the two sets of results shows that the measures introduced retain the existing capacity of the network for general traffic and also accommodate the EOBRT services by introducing additional flares/lanes or re-programming the settings of signal controlled junctions.

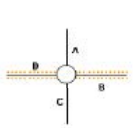
3.3.10 The results of the assessment have shown the proposals to accommodate the EOBRT do not impact significantly upon other road users at the opening year of the project.

[8] Capacity Analysis Study – Interim Report, Scott Wilson, March 2010

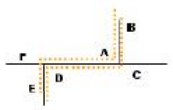
Table 3.2 – Junction Capacity Analysis (Existing Highway Layouts)

2013 Existing Highway Layout (ATC and TMfS Growth Rates)

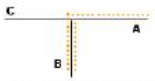
			Junction 4		Junction 5				Junction 6				Junction 7		Junction 12		Junction 13		Junction 14		Junction 15	
Year	Time	Arm	Max RFC	Max Queue	Max RFC		Max Queue		Max RFC		Max Queue		Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue
2013 (ATC Growth Rates) Existing Highway Layout	AM	A	26%	0	L: 68%	S: 82%	L: 7	S: 7	-		-		47%	1	88%	9	66%	1	47%	1	60%	1
		B	44%	0	L: 96%	R: 39%	L: 16	R: 2	L: 76%	R: 91%	L: 3	R: 7	89%	2	54%	0	31%	0	62%	1	60%	1
		C	9%	0	S: 58%	R: 93%	S: 7	R: 6	14%		-		68%	1	81%	2	75%	2	-	-	78%	8
		D	111%	77	L: 64%	S: 24%	L: 4	S: 1					00%	3					51%	1	75%	5
		E			L: 2%	R: 62%	L: 0	R: 4											51%	0	57%	1
		F			S: 55%	R: 3%	S: 4	R: 0														
	PM	A	36%	0	L: 26%	S: 109%	L: 2	S: 41	-		-		80%	7	117%	53	76%	2	92%	5	70%	2
		B	60%	1	L: 115%	R: 48%	L: 81	R: 4	L: 22%	R: 69%	L: 1	R: 3	67%	1	35%	0	38%	1	19%	0	68%	1
		C	20%	0	S: 65%	R: 101%	S: 11	R: 7	25%		-		44%	0	59%	1	51%	1	-	-	89%	11
		D	20%	0	L: 60%	S: 51%	L: 4	S: 4					81%	1					52%	1	88%	5
		E			L: 3%	R: 67%	L: 1	R: 6											45%	0	72%	3
		F			S: 44%	R: 7%	S: 4	R: 1														
2013 (TMfS Growth Rates) Existing Highway Layout	AM	A	25%	0	L: 65%	S: 78%	L: 6	S: 7	-		-		42%	1	92%	5	63%	1	44%	1	57%	1
		B	42%	0	L: 92%	R: 37%	L: 12	R: 2	L: 49%	R: 85%	L: 1	R: 5	84%	2	52%	0	29%	0	57%	1	57%	1
		C	9%	0	S: 56%	R: 88%	S: 7	R: 5	13%		-		63%	1	75%	1	71%	2	-	-	75%	7
		D	106%	45	L: 63%	S: 24%	L: 4	S: 2					85%	2					49%	1	72%	4
		E			L: 2%	R: 60%	L: 1	R: 5											48%	0	54%	1
		F			S: 53%	R: 3%	S: 5	R: 1														
	PM	A	37%	0	L: 27%	S: 112%	L: 3	S: 49	-		-		95%	12	122%	67	78%	2	96%	7	71%	2
		B	62%	1	L: 119%	R: 49%	L: 96	R: 4	L: 24%	R: 71%	L: 1	R: 3	70%	1	36%	0	40%	1	21%	0	69%	1
		C	21%	0	S: 68%	R: 104%	S: 11	R: 8	26%		-		48%	0	61%	1	53%	1	-	-	91%	13
		D	20%	0	L: 62%	S: 53%	L: 4	S: 4					83%	2					53%	1	89%	6
		E			L: 3%	R: 66%	L: 1	R: 6											47%	0	75%	4
		F			S: 45%	R: 8%	S: 4	R: 1														



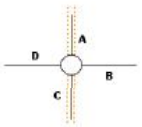
Junction 4 - South Gyle



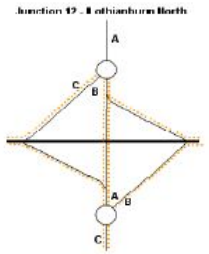
Junction 5 - Bankhead



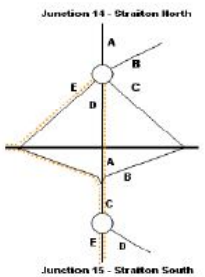
Junction 6 - Bankhead Avenue



Junction 7 - Sighthill



Junction 13 - Lothianburn South



Junction 15 - Straiton South

Maximum Queue Lengths are shown in vehicle per lane.

For Signalised Junctions, lane movements are indicated as follows:

- L: Left turn - S: Straight - R: Right turn

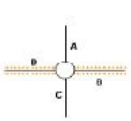
RFC numbers in red show arms that are over 85% (90% for traffic signal).

RFC numbers in bold red show arms that are over 100%

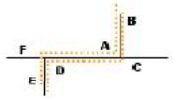
Table 3.3 – Junction Capacity Analysis (with the EOBRT Services and the New Proposed Highway Changes)

2013 EOBRT (ATC and TMfS Growth Rates)

			Junction 4		Junction 5				Junction 6		Junction 7		Junction 12		Junction 13		Junction 14		Junction 15	
Year	Time	Arm	Max RFC	Max Queue	Max RFC		Max Queue		Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue	Max RFC	Max Queue
2013 (ATC Growth Rates) with EOBRT	AM	A	26%	0	L: 68%	S: 92%	L: 18	S: 12	26%	0	47%	1	95%	19	73%	5	41%	0	50%	18
		B	44%	0	L: 79%	R: 35%	L: 10	R: 6	27%	0	89%	7	46%	0	35%	2	43%	0	49%	2
		C	9%	0	S: 60%	R: 82%	S: 12	R: 13	10%	0	60%	2	67%	6	67%	7	-	-	65%	19
		D	111%	77	L: 43%	S: 13%	L: 2	S: 2			90%	9					72%	13	59%	7
		E			L: 1%	R: 45%	L: 0	R: 7									40%	4	52%	11
		F			S: 45%	R: 5%	S: 9	R: 0												
	PM	A	36%	0	L: 32%	S: 135%	L: 6	S: 94	10%	0	80%	7	105%	55	91%	0	94%	11	84%	15
		B	60%	1	L: 140%	R: 58%	L: 85	R: 11	21%	0	67%	2	31%	0	36%	1	13%	0	63%	8
		C	20%	0	S: 59%	R: 48%	S: 9	R: 5	14%	0	44%	1	63%	5	59%	2	-	-	77%	21
		D	20%	0	L: 42%	S: 38%	L: 2	S: 6			81%	4					71%	13	62%	6
		E			L: 1%	R: 43%	L: 0	R: 6									46%	5	58%	13
		F			S: 43%	R: 8%	S: 8	R: 1												
2013 (TMfS Growth Rates) with EOBRT	AM	A	25%	0	L: 53%	S: 88%	L: 10	S: 10	25%	0	42%	1	89%	13	69%	4	39%	0	47%	17
		B	42%	0	L: 76%	R: 25%	L: 8	R: 5	25%	0	84%	5	43%	0	32%	1	40%	0	47%	2
		C	0%	0	S: 62%	R: 97%	S: 11	R: 20	13%	0	63%	2	61%	6	82%	10			62%	18
		D	106%	45	L: 41%	S: 13%	L: 2	S: 2			85%	6					68%	13	56%	6
		E			L: 1%	R: 43%	L: 0	R: 6									37%	3	50%	10
		F			S: 43%	R: 5%	S: 9	R: 0												
	PM	A	37%	0	L: 28%	S: 139%	L: 4	S: 94	41%	0	95%	12	119%	93	77%	7	90%	13	88%	15
		B	62%	1	L: 144%	R: 48%	L: 90	R: 10	21%	0	70%	2	31%	0	37%	1	14%	0	65%	8
		C	21%	0	S: 47%	R: 49%	S: 10	R: 6	14%	0	46%	1	65%	5	60%	2	-	-	79%	24
		D	20%	0	L: 44%	S: 37%	L: 2	S: 6			83%	5					73%	14	64%	6
		E			L: 1%	R: 44%	L: 0	R: 6									47%	5	59%	13
		F			S: 44%	R: 8%	S: 8	R: 1												

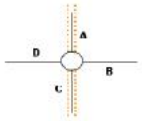


Junction 4 - South Cyle

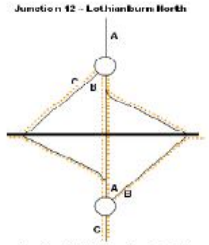


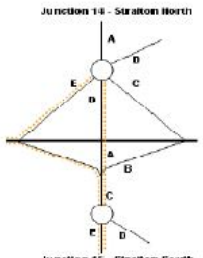
Junction 5 - Bankhead

Junction 6 - Bankhead Avenue



Junction 7 - Sighthill





Maximum Queue Lengths are shown in vehicle per lane.

For Signalised Junctions, lane movements are indicated as follows:

- L: Left turn - S: Straight - R: Right turn

RFC numbers in red show arms that are over 85% (90% for traffic signal).

RFC numbers in bold red show arms that are over 100%

Cost Estimates of the Proposals

3.3.11 The costs of the proposed modifications to the highway accesses at the Lothianburn P&R site were estimated based on rates from recent similar projects. Table 3.4 below shows a summary of the estimated costs involved in the implementation of the proposals described above.

Table 3.4 – Costs of Bus Priority Measures and Highway Modifications at the Lothianburn P&R Site

Cost Component	Estimate
Road Alterations	£178,200
Other Costs (e.g. management, site supervision, contingencies etc.)	£144,900
Sub-Total	£323,100
Optimism Bias (44%)	£142,100
Grand Total	**£465,200**

Notes:
- figures have been rounded to the nearest £100
- values are in Q4 2009 prices

3.3.12 The proposed modifications to the roundabouts and new bus priority measures would cost circa £465,200 at 2009 prices. A full breakdown of the costs is included in Appendix H.

3.3.13 At the request of SEStran, the total costs of the options were then split down to each individual proposal using a simple pro-rata method based on the proportions of works proposed for each measure and our own judgement. This crude disaggregation of costs allows for an indication of the costs of each proposal. Clearly splitting the costs in this way does not take into account the effects of the loss of economies of scale if all the measures were let in one construction contract as opposed to separate contracts. Table 3.5 shows the estimates which include infrastructure and other costs as well as Optimism Bias uplifts.

Table 3.5 – Costs by Measure

Proposed Measure	Cost
Eastbound (off-ramp) bus lane into Lothianburn junction.	£103,900
Traffic signal / bus gate.	£245,700
Northbound bus lane, Lothianburn junction.	£115,700

Notes:
- figures have been rounded to the nearest £100
- values are in Q4 2009 prices

3.4 South Gyle Access / Bankhead Drive to A71 (Calder Road) / B701 (Wester Hailes Road)

Overview

3.4.1 The junction modelling around the Bankhead Drive area had shown capacity issues at South Gyle roundabout, the junctions around Bankhead Avenue and also Sighthill roundabout. Consequently, various proposals to improve travel conditions for the new EOBRT services were identified. These are shown on Drawings S105976/P/1204, S105976/P/1205 and S105976/P/1206 in Appendix G, and briefly described below.

Proposals

3.4.2 Table 3.6 outlines the nature of the problems in the area before describing the proposed measures to address each problem and the overall impacts these will have on the operation of the EOBRT services.

Table 3.6 – Current Traffic Issues and Proposed Measures

Problem	Proposed Measure	Outcome
Congestion to general traffic could delay new EOBRT services.	Modification of the Eastbound approach to Gyle roundabout.	EOBRT services can bypass any potential pinch-points.
Delays to junction impact new EOBRT services.	Modification to signals at South Gyle Access/Bankhead Drive/Bankhead Avenue junction.	EOBRT services can avoid excessive queuing.
On-street parking along Bankhead Avenue slowing traffic flow.	Traffic regulation along Bankhead Avenue.	Speed up EOBRT services running time.
On street parking along Bankhead Avenue restricting bus movements.	Bus Boarders on Bankhead Avenue.	Priority given to EOBRT vehicles.
Removal of on-street parking.	Creation of off-street car parking.	Vehicles displaced with TROs along Bankhead provided with alternative parking.

3.4.3 To address the identified capacity issues some junction modifications are proposed. Firstly, the South Gyle roundabout should be modified to cater for three lanes on the approach from the west, allowing the addition of a dedicated bus lane to bypass the queuing traffic in the AM peak.

3.4.4 Secondly, the traffic signals at the South Gyle Access / Bankhead Drive / Bankhead Avenue junction should be optimised to ensure the signal timings are managing the traffic effectively. The junction signals should operate under a vehicle-actuated arrangement which adapts the green and cycle times to the different traffic flows throughout the day.

3.4.5 To remove parking along the length of Bankhead Avenue a new Traffic Regulation Order (TRO) with associated double yellow lines is required. The bus stops along the road should be amended with bus boarder facilities to help control the general traffic and allocate priority

to the bus services. Site observations also showed there is difficulty with enforcing prohibited parking at existing bus stops, with some vehicles observed to be parking on the kerb. Hence, the bus boarders will also help with the enforcement of the TRO.

3.4.6 The removal of these parking spaces would have to be accommodated elsewhere, in line with City of Edinburgh Council policy on the replacement of on-street parking with off-street spaces. Therefore, a new car parking facility is proposed on grassland situated on the north side of Bankhead Drive. The new car parking facility would accommodate 155 spaces and would also involve the relocation of an existing cycle track which would be moved to the opposite side of the car parking.

Network Impacts Tests

3.4.7 The proposals were tested using the junction traffic models described in Section 3.2 to assess their effect on the road network in the area. The results are shown in Tables 3.2 and 3.3 presented previously.

3.4.8 To keep the presentation of the modelling results consistent with those presented for the current traffic conditions in the Capacity Analysis Study[9], the numbering and nomenclature of the junctions was kept the same. Hence, for this section of the EOBRT route, the junctions which are affected are numbered Junctions 4 to 7. Similarly, the same opening year (2013) for the project and traffic growth scenarios were used as in the Capacity Analysis Study.

3.4.9 Due to the nature of this section, the proposals were found to have minimal implications and are not expected to impact directly on general traffic in the area.

Cost Estimates of the Proposals

3.4.10 The costs of the proposed modifications were estimated based on rates from recent similar projects. Table 3.7 below shows a summary of the estimated costs involved in the implementation of the proposals described above.

Table 3.7 – Costs of the Bus Priority Measures and Parking / Highway Modifications

Cost Component	Estimate
Road Alterations	£100,600
Car Park	£187,300
Other Costs (e.g. management, site supervision, contingencies etc.)	£208,300
Total	£496,200
Optimism Bias (44%)	£218,300
Grand Total	***£714,500***

Notes:
- figures have been rounded to the nearest £100
- values are in Q4 2009 prices

3.4.11 The proposed modifications are estimated to cost circa £714,500 at 2009 prices with the highest value of the works attributable to the construction of the new car park. A full breakdown of the costs is included in Appendix H.

[9] Capacity Analysis Study – Interim Report, Scott Wilson, March 2010

3.4.12 At the request of SEStran, the total costs of the options were then split down to each individual proposal using a simple pro-rata method based on the proportions of works proposed for each measure and our own judgement. This crude disaggregation of costs allows for an indication of the costs of each proposal. Clearly splitting the costs in this way does not take into account the effects of the loss of economies of scale if all the measures were let in one construction contract as opposed to separate contracts. Table 3.8 shows the estimates which include infrastructure and other costs as well as Optimism Bias uplifts.

Table 3.8 – Costs by Measure

Proposed Measure	Cost
Modification of the Eastbound approach to Gyle roundabout	£164,200
Modification to signals at South Gyle Access/Bankhead Drive/Bankhead Avenue junction	£106,300
Traffic regulation along Bankhead Avenue	£36,900
Bus Boarders on Bankhead Avenue	£21,700
Creation of off-street car parking	£385,300

Notes:

- figures have been rounded to the nearest £100
- values are in Q4 2009 prices

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Introduction

4.1.1 From the previous congestion analysis and modelling it was determined Phase 1 of the EOBRT should run from Edinburgh Airport to Straiton Park-and-Ride site. This report examined the engineering requirements and possible capital costs involved in implementing this Phase, considering two sections namely Section B – South Gyle Access / Bankhead Drive to B701 (Wester Hailes Road) / A71 (Calder Road) and Section D – Lothianburn P&R site to Straiton P&R site.

4.2 Engineering

New Link between Lothianburn and Straiton Park-and-Ride Sites

4.2.1 Initially Scott Wilson identified various alignment options to provide a new off road link to connect the P&R sites between Lothianburn and Straiton. The optioneering involved identifying outline alignment routes for the new off road BRT link based on a high-level engineering analysis of the corridor. From this three shortlisted route options (renamed as Route B and Routes C1 and C2) were taken forward for more detailed analysis, including an examination of the geology and ground conditions.

4.2.2 The total capital costs for the routes, excluding forward construction inflation and risk and uncertainty are summarised in Table 4.1.

Table 4.1 – Cost Estimates for New Link Options

Option	Route Cost	Optimism Bias	Total Cost
Route B	£2.39m	£1.05m	£3.44m
Route C1	£0.67m	£0.29m	£0.96m
Route C2	£2.49m	£1.10m	£3.59m
Route C1 + C2	£2.82m	£1.24m	£4.06m

Notes:
- values are in Q4 2009 prices
- Route C1 + C2 refers to the phased implementation detailed in section 2.2.22

4.3 Traffic Analysis

Lothianburn P&R Site Access

4.3.1 A series of traffic models were then developed to test the impacts of bus priority measures to address access to/from the Lothianburn P&R site. These measures were identified with the intention of safeguarding the EOBRT services from existing and future congestion.

4.3.2 The proposals would involve modifying the eastbound off-ramp to incorporate a bus only lane, giving priority to buses approaching the roundabout.

4.3.3 In order to allow the buses to quickly traverse the south roundabout on their way to the westbound A720 bypass on-ramp, a new bus lane would be constructed bypassing the south roundabout. The new bus lane would be off-road from the existing carriageway and therefore would not reduce the available capacity for existing (general) traffic. A bus gate would be installed to the north of this roundabout to allow the EOBRT to merge back on to

the main road. The bus gate could be activated by the bus on approach and the other traffic stopped at signals to allow the bus out.

4.3.4 The entrance / exit to the park-and-ride site at Lothianburn has not been examined as part of this study. However, the road may require modification to cope with the increased traffic when the park-and-ride is implemented. SEStran have advised that the basic assumption in this study is that the signal junction access to the park-and-ride will be designed to appropriate standards and efficiently operated. The exact design of the access should be addressed during the detailed design works of the park-and-ride[10].

4.3.5 The results of the assessment have shown the proposals to accommodate the EOBRT do not impact significantly upon other road users at the opening year of the project.

4.3.6 The costs of the proposed modifications to the highway accesses at the Lothianburn P&R site were estimated as circa £465,200 at 2009 prices.

South Gyle Access / Bankhead Drive to A71 (Calder Road) / B701 (Wester Hailes Road)

4.3.7 The junction modelling around the Bankhead Drive area had shown capacity issues at South Gyle roundabout, the junctions around Bankhead Avenue and also Sighthill roundabout.

4.3.8 To address the identified capacity issues a number of junction modifications are proposed. Firstly, the South Gyle roundabout should be modified to cater for three lanes on the approach from the west, allowing the addition of a dedicated bus lane to bypass the queuing traffic in the AM peak.

4.3.9 At the South Gyle Access / Bankhead Drive / Bankhead Avenue junction, the traffic signals should be optimised to ensure the signal timings are managing the traffic effectively.

4.3.10 Along Bankhead Avenue a new Traffic Regulation Order (TRO) along with double yellow lines is required to remove parking along the length of the road.

4.3.11 The removal of these parking spaces would have to be accommodated elsewhere, in line with City of Edinburgh Council policy on the replacement of on-street parking with off-street spaces. Therefore, a new car parking facility is proposed on grassland situated on the north side of Bankhead Drive. The new car parking facility would accommodate 155 spaces.

4.3.12 Due to the nature of this section, the proposals were found to have minimal implications and are not expected to impact directly on general traffic in the area.

4.3.13 The proposed modifications are estimated to cost circa £714,500 at 2009 prices with the highest value of the works attributable to the construction of the new car park.

4.4 Recommendations

4.4.1 The above conclusions highlighted that none of the three proposed routes between Lothianburn and Straiton P&R sites (Routes B, C1 and C2) can be discounted based on the engineering analysis or journey times comparisons alone, and that the main factors are therefore their respective capital and operating costs. Hence, we recommend a Business Case Analysis be carried out to assess the three routes in light of their associated economic costs and benefits.

[10] Meeting with SEStran officials on 18th June 2010

4.4.2 A more detailed Business Case should also be carried out for Sections A and C of the EOBRT route (respectively from the Airport to Gogar and from the Calder Road/ B701 junction to the Lothianburn P&R site). There are some uncertainties about Section A due to the works at Gogar Roundabout associated with the Edinburgh Tram and the new rail station. However it is possible to undertake a light update of the costs from the Pre-Feasibility Study and prepare a Business Case Analysis for the whole of Phase 1 of the EOBRT route.

4.4.3 Furthermore, only a limited ground investigation was carried out for this analysis and a series of recommendations have been identified for future geotechnical route assessment. These include the following:

- collate and review solid and drift geology maps and associated memoir(s);
- undertake a detailed review of mine abandonment plans specific to the preferred alignment;
- purchase and review of historic borehole records specific to the preferred alignment;
- review historic ground investigation reports specific to the preferred alignment;
- review data specific to contaminated land hotspots present along or adjacent to the preferred alignment;
- undertake a site walkover and ground investigation surveys to identify important geotechnical issues; and
- collate the findings from the above into a Ground Investigation Plan for use in refining the engineering design as the project progresses through the development stages.

4.4.4 Finally, we recommend detailed research be carried out for Phase 2 of the EOBRT route from the Straiton P&R site to the Millerhill P&R site.

Appendix A

Study Brief

First Floor, Hopetoun Gate, 8b McDonald Road, Edinburgh, EH7 4LZ, Tel: 0131 524 5150

Chairman: Cllr Russell Imrie Partnership Director: Alex Macaulay

8 Feb 2010

Edinburgh Orbital BRT Project

Brief for Framework Consultant

to undertake Preliminary Junction and Link design work for section between

south/west of junction A71 (Calder Rd) / B701 (Wester Hailes Rd) to north of junction Bankhead Drive / South Gyle Access

Background

This work follows the previous studies on the EOBRT project undertaken by Scott Wilson.

This work is based on the premise that this section of the Orbital BRT is already seriously congested in the a.m. and p.m. peaks and that improvements are required to ensure attractive public transport journey times.

Brief

1. Undertake relevant research/investigation to assess current performance of the three junctions (including the Bankhead Ave / Bankhead Crossway North junction) and the links.

2. Establish current transport proposals for the area, including those in relation to the nearby educational establishments and in relation to Tram works. Also establish land ownership beyond the existing highway boundary should future land-take be necessary.

3. Establish if further information not readily available is required and discuss with Client.

4. Identify what improvements can be made to the operational characteristics of the existing junctions to facilitate the orbital BRT

services without significantly worsening the overall performance of the junctions and without significantly altering the junction layouts.

5. Establish if changes to junction layout/type will offer significant improvement in performance.

6. Establish the requirement of bus priority measures on the link and on the approaches to the junctions and, if relevant, establish if this (and any change in junction layout) can be contained within existing highway boundaries.

7. Undertake design of relevant junction and link alterations. Plans should be prepared to at least 1:200 scale for junctions and 1:500 for the links.

8. Establish implementation costs of the preferred option. Costs should include land costs (if relevant), drainage, public utilities, traffic management works, landscaping, detailed design etc.

9. Prepare a project report to enable the client to take the project forward with relevant parties, including Transport Scotland, City of Edinburgh Council and Bus operators.

10. The consultant should liaise fully with the local authority in the execution of the above work.

11. Work should be completed by 31 March 2010.

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Chairman: Cllr Russell Imrie Partnership Director: Alex Macaulay

8 Feb 2010

Edinburgh Orbital BRT Project

Brief for Framework Consultant

to undertake Preliminary Design work for Bus Link between Lothianburn and Straiton P&R sites

Background

This work follows the previous studies on the EOBRT project undertaken by Scott Wilson.

This work is based on the premise that the section of the Edinburgh Bypass between Lothianburn and Straiton is already seriously congested in the a.m. peak and that it is most unlikely that Transport Scotland will provide hard shoulders on this section of the bypass (that could potentially be used by an Orbital BRT).

The link is therefore required so that an orbital BRT service can serve both P&R sites without buses getting held up in serious congestion.

Brief

1. Undertake desktop research (in particular liaise with Midlothian and City of Edinburgh Councils) to establish available information in respect of ground conditions (including the existence of mine works), topography, drainage, public utilities, land ownership and other information relevant to the provision of a bus link.

2. Establish if further information not readily available is required and discuss with Client.

3. Identify the best alignment taking full account of the information obtained from 1. and the likely implementation cost. This must also take into account any land use severance/land access requirement, environmental issues and any risk of flooding.

4. The design should be based on a design speed of 100 kph but this may be relaxed on the approaches to the P&R sites.

5. Vertical and horizontal design drawings should be prepared to at least 1:500 scale and must include the tie in with and any necessary alterations to existing / proposed Park & Ride sites.

6. The work should also include suitable bus priority measures on the A702 (northbound) between the access to Lothianburn Park&Ride to the junction with A720 Edinburgh Bypass.

7. Design and Costs should include all relevant costs, including land costs, ground works, drainage, fencing, landscaping, detailed design etc.

8. Prepare a project report to enable the client to take the project forward with relevant parties, including Transport Scotland, Midlothian and City of Edinburgh Councils and Bus operators.

9. The consultant should liaise fully with the two local authorities in the execution of the above work.

10. Work should be completed by 31 March 2010.

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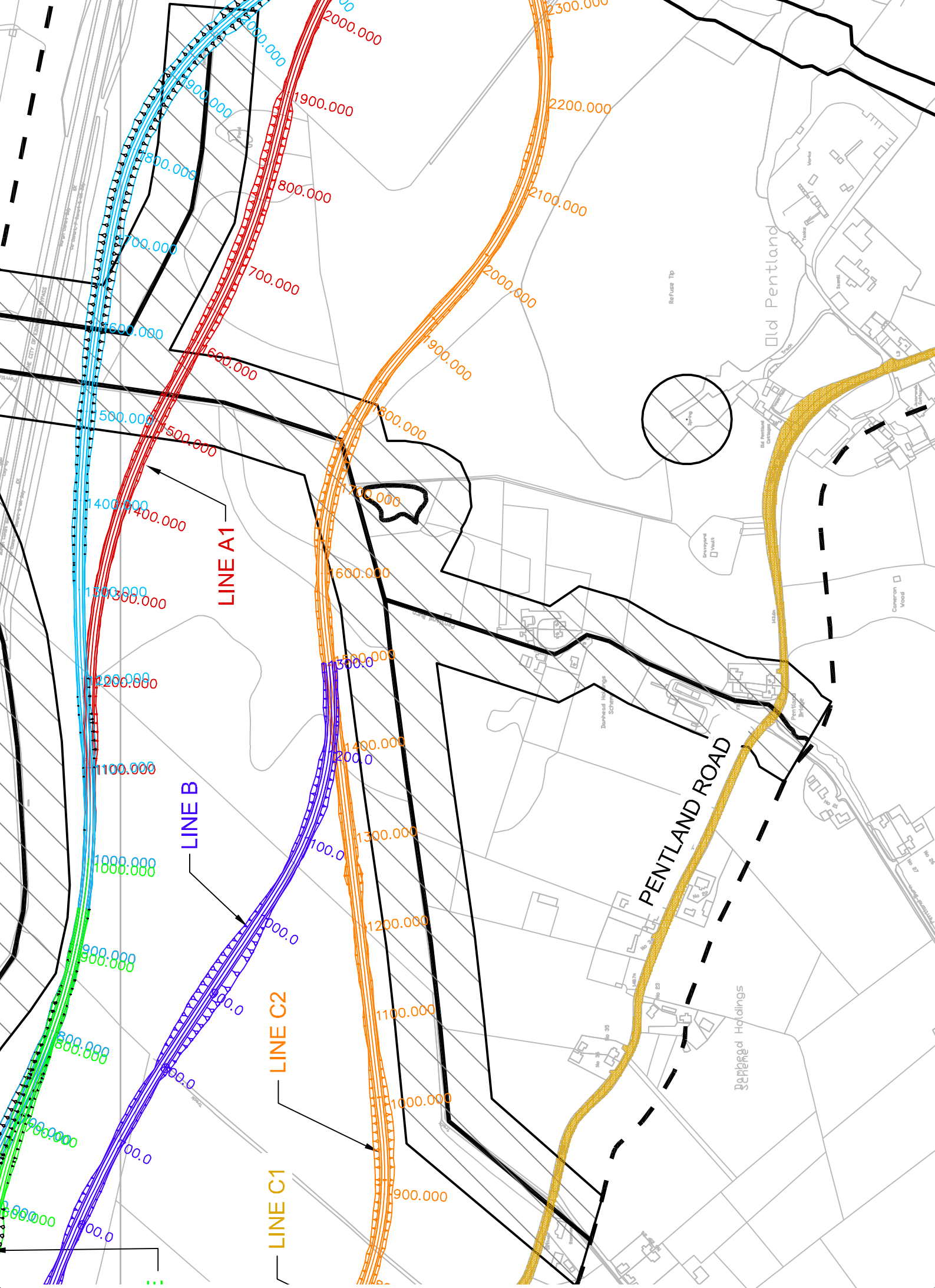
Appendix B

Initial Alignment Options Drawing



Appendix C

Geotechnical Desk Study

Edinburgh Orbital Bus Project

Preliminary Desk Study for Lothianburn to Straiton Route Selection

March 2010

Prepared for

Revision Schedule

Preliminary Desk Study for Route Selection
March 2010

Rev	Date	Details	Prepared by	Reviewed by	Approved by
01	March 2010	First Issue	**Katerina Braun** Chartered Geologist	**Ali Bastekin** Associate	**Ali Bastekin** Associate

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Table of Contents

1 Introduction

Scott Wilson Ltd (SWL) was appointed by South East of Scotland Transport Partnership (SEStran) to undertake a route appraisal exercise for a proposed orbital bus route between Straiton Park and Ride and a second proposed Park and Ride Car Park at Lothianburn.

Three possible route alignments were developed, which are referred to as A, B and C. SEStran reviewed the proposed route alignments and instructed SWL to progress with B, C1 and C2 only. Refer to the Proposed Rote Options Drawing (Ref: S105976/P/102) for a plan of the study area and proposed route alignments B and C. The majority of alignment C1 utilises the existing Pentland Road. This section of alignment C1 is excluded from discussion within this report.

Scott Wilson Ltd was asked to prepare a preliminary desk study of the study area to identify potential geotechnical constraints relative to each proposed route alignment.

The following information was reviewed during preparation of this report:

- Pre-war Ordnance Survey Maps (www.old-maps.co.uk)
- Satellite images of the study area on www.google.co.uk/maps
- British Geological Survey Solid and Drift Geological Maps, 1:50,000 scale
- British Geological Survey 'Hydrogeology Map of Scotland, 1:625,000 scale
- British Geological Survey, Mine Abandonment Plans (for non- coal mineral workings only
- SEPA Website - Flood Map & Interactive Map on www.sepa.org.uk
- www.snh.org.uk

A detailed geotechnical desk study specific to the preferred route alignment should be undertaken once the preferred alignment has been agreed. This detailed desk study should include an alignment specific walkover, review of historic borehole records and ground investigation reports and review of large scale solid and drift geological maps.

2 Site History

2.1 Pre-Second World War (1945)

A selection of historic ordnance survey maps was reviewed to ascertain the site history within the study area. The old maps were reviewed online at www.old-maps.co.uk.

2.1.1 1854-1855 Ordnance Survey Map, 1:10,560 & 1:2,500 scale

This map shows the land use within the study area to consist predominantly of fields. Several dwellings are situated within the study area immediately north of Pentland Road at Pentland village.

Burn 1, labelled as 'Swanston Burn', meanders to the north of the study area at or just south of the northern boundary along an east-northeast west-southwest alignment. This burn is also referred to as Lothian Burn on later maps.

Burn 2 'Pentland Burn', flows towards the north within the study area in a north south alignment. The burn doglegs in the centre of the study area to the east for about 200 metres. To the south of the study area, this stream flows towards the northeast.

Burn 3 is un-named and is situated to the west of Pentland Burn and Pentland Bridge, flowing towards the east-northeast merging with Pentland Burn in the centre of the study area.

Burn 4 is un-named and flows in a north-westerly direction towards Pentland Burn. This burn is situated approximately 400 metres northeast of the road bend at Pentland and some 900 metres north-northeast of the cross road at New Pentland at the south western corner of the study area.

Burn 5 is un-named and flows towards the northeast and Swanston Burn (also referred to as Lothian Burn) to the south of Lothianburn village at Goldburn.

A Grave Yard is labelled on the map within the study area immediately north of Pentland Road, approximately 150 metres west of the road bend at Pentland.

No mineral workings are shown within the study area.

2.1.2 1894 Ordnance Survey Map, 1:2,500

An 'old shaft' is labelled on the map at the corner of a field boundary 275 metres to the east of the Pentland Burn dogleg. A spoil mound is shown adjacent to the old shaft. The shaft pumping engine is also labelled and is situated about 150 metres north of the old shaft. As this shaft is referred to as an 'old shaft' on the 1894 map and is absent from the 1854-55 map, workings within this mine must therefore commenced not long after 1855 and ceased sometime before 1894.

The land to the north of the old shaft and east of Pentland Burn is now labelled as a reservoir with bog and marsh symbols. The reservoir may have been used to store groundwater extracted from the mine during its operation.

Pentland Oil Works first appears in the 1894 OS map; hence oil shale extraction must have commenced somewhere between 1855 and 1894. Extraction took place by opencast means

and covered approximately 2km^2 to the north of Pentland Road and to the northeast and east of Pentland Village. As a result of these activities, the Burn 4 has been cut into two. It is not known if the burn was culverted or diverted during the extraction works.

A spring appeared in 1894 to the east of the Grave Yard at the eastern boundary of the extraction site. Reservoirs are also labelled within the south-eastern area of the extraction pit.

2.1.3 1907-1908 Ordnance Survey Map, 1:10,560 & 1:2,500 scale

Pentland village is now referred to as Old Pentland.

Pentland Oil Works is labelled as disused; hence it must have closed down somewhere between 1894 and 1907.

The old shaft and pumping station are still shown. The reservoir to the north of the old shaft and east of Pentland Burn is now labelled as 'Old Reservoir'.

'Quarries' and 'Air Shafts' are labelled about 1000 metres south of Straiton Village to the east of the road between Straiton and New Pentland villages. Extraction of mineral seams must have therefore commenced between 1894 and 1907-8 within this area.

No other significant changes were noted in the study area.

2.1.4 1915 Ordnance Survey Map, 1:10,560 scale

Pentland Oil Works is no longer labelled on the map.

An old sand pit is labelled immediately west of the A701 about 700 metres south of Straiton Village.

'Air Shafts' are labelled immediately west of the A701 about 400 metres to the south of Straiton village and 200 m south of Mid Straiton Cottages. The 'Quarries' labelled about 1000 metres south of Straiton Village are now referred to as 'Old Quarries'.

No other significant changes were noted in the study area.

2.1.5 1931 Ordnance Survey Map, 1:10,2560 scale

A 'Brick Works' is now labelled at the former Pentland Oil Works site. The pumping station and 'Old Reservoir' are no longer shown.

Several buildings have been erected 500 m to the north of Pentland Bridge adjacent to Pentland Burn. Numerous buildings have also been erected either side of Pentland Road to the west of Pentland Bridge.

No other significant changes were noted in the study area.

2.2 Post-Second World War (1945)

A caravan park has been set up immediately north of the former site of Pentland Oil Works and immediately west of the A701. A car park has been constructed to the north of the Caravan Park, immediately west of the A701. This is referred to as 'Straiton Park and Ride', which is to be the easterly terminus for the new orbital bus route between Lothianburn and Straiton.

The extraction pit has been infilled at the former site of the Pentland Oil Works, and is now labelled as a disused refuse tip and has been landscaped.

Several more dwellings have been constructed within the study area to the west of Old Pentland and north of Pentland Road.

The A720 bypass has been constructed along the northern boundary of the study area since the 1931 map.

3 Surrounding Environment

3.1 Topography

Ground level at the site varies between 125 and 160 m Above Ordnance Datum (AOD). The ground surface typically falls towards the north and the A720.

In the western part of the study area the land falls gently towards the east-northeast steepening towards the west. In the middle part of the study area, the land falls towards the north and is relatively flat. In the eastern part of the study area, the land falls gently towards the northwest. The land rises steeply to the west of the study area within the Pentland Hills Regional Park.

Ground level along the proposed alignments is hummocky and relatively flat. No engineering complications are envisaged in relation to sidelong ground.

3.2 Drainage

3.2.1 Surface Drainage

Drainage at the site reflects the ground surface gradient. Consequently, burns and surface water run off will flow in the following directions depending upon where burns are situated within the study area:

- Towards the east and northeast within the western part of study area
- Towards the north within the middle part of the study area
- Towards the northwest within the eastern part of the site.

3.2.2 Watercourses

There are currently four burns present within the study area, as follows:

- Burn 1: Swanston / Lothian Burn situated along the northern boundary of the study area, aligned east-southeast west-northwest.
- Burn 2: Pentland Burn situated in the middle part of the study area, aligned north south approximately.
- Burn 3: Un-named burn west of Pentland Burn aligned northeast southwest.
- Burn 4: Un-named burn east of Pentland Burn

Historically, there was a fifth burn (referred to as Burn 5 in Section 2), that flowed within the eastern part of the study area to the east of Pentland Burn in a northwest southeast alignment. This burn was diverted or obstructed during mineral extraction operations at Pentland Oil Works in the mid to late 1800s.

There is a spring labelled on recent and historic OS maps between Pentland and Clippen's Landfill Site. This may have developed in response to the blockage of Burn 5 discussed above.

There are no rivers present within the study area.

3.2.3 Potential for Flooding

Scottish Environment Protection Agency (SEPA)'s interactive coastal and river flooding map was reviewed to identify areas at risk of flooding. This map is available on SEPA's website at www.sepa.org.uk.

A narrow strip of land adjacent to Swanston Burn has been identified as an area at risk of river flooding between the western site boundary and approximately halfway along the northern boundary.

3.3 Sensitive Land Uses

3.3.1 Protected Areas

Scottish Natural Heritage's (SNH) Interactive Map available on www.snh.org.uk/snhi/map was reviewed to establish whether any protected areas are present within the study area.

The following protected areas were checked:

- Sites of Special Scientific Interest (SSSI)
- Special Areas of Conservation (SAC)
- Special Protection Areas (SPA)
- RAMSAR
- National Scenic Areas (NSA)

None of the above sites were identified within the study area.

One SSSI was indentified to the south if the study area and south of Loanhead. This site is referred to as Bilston Burn SSSI and is more than 500 metres from the site. Any construction activities within the study area are unlikely to impact this SSSI.

3.3.2 Nature Reserves and Parks

Scottish Natural Heritage's (SNH) Interactive Map available on www.snh.org.uk/snhi/map was reviewed to establish whether or not there are any parks or nature reserves present within the study area.

The following sites were checked:

- Local Nature Reserve (LNR)
- National Nature Reserve (NNR)
- National Park (NP)
- Country Park (CP)

- Regional Park (RP)

None of the above sites were identified within the study area.

Two LNR sites are present within a kilometre of the study area. The first site referred to as 'Straiton Pond' is situated immediately east of Straiton and the A701 and south of the A720. This site includes a pond (former mineral excavation pit) and kilometre long section of a disused railway.

The second LNR site is referred to as 'Burdiehouse Burn Valley Park', which is situated to the northeast of the study area, north of the A720 and east of the A701. This site covers a 3km section of Burdiehouse Burn between Burdiehouse Mains and Liberton Golf Club.

One regional park was observed immediately west of the study areas, which is referred to as 'Pentland Hills Country Park'.

One country park was noted immediately west the study area in the vicinity of Hillend (Hillend Country Park). This park is relatively small, covering an area a little less than $1km^2$.

Construction activities are unlikely to impact the country park, regional park or Straiton Pond LNR given the topography and drainage regime at the site.

All of the burns at the site are tributaries to the Burdiehouse Burn. Consequently, construction activities within the study area could impact the Burdiehouse Burn if surface water contaminated with construction waste or chemicals was to flow into the burns present within the study area. Careful drainage control measures will need to be adhered to during construction to prevent surface water runoff transporting construction waste into the tributaries of Burdiehouse Burn.

4 Ground Conditions

4.1 Drift Geology

4.1.1 General

The drift edition of British Geological Survey Sheet 32 'Edinburgh' (1:50,000 scale) details the drift geology within the study area. Recent and historic ordnance survey maps and aerial photography were also used to identify areas of Made Ground.

A Drift Geology Plan was prepared using the above geological map. Please refer to Drawing S105976/P/601.

The following drift lithologies are present within the site boundary:

- Made Ground
- Flood Plain Alluvium
- Glacial and Glacio-fluvial Granular Deposits
- Glacial Till

Made Ground has been identified at discrete locations within the study area. Refer to Section 6 for further details.

Flood Plain Alluvium covers about a quarter of the site, generally the central portion of the study area. Flood plain alluvium deposits typically consist of very loose to loose interbedded SILT, very loose to loose fine SAND and soft or very soft CLAY.

There are three discrete bodies of granular glacial deposits present within the study area and a larger body, situated within the middle to eastern portion of the study area. These deposits are of glacial and glacio-fluvial origin. Based upon engineering experience in Midland Valley glacial lithologies, these deposits are typically medium dense, dense or very dense well graded SAND and GRAVEL, sandy GRAVEL or gravelly SAND with limited clay content.

Glacial Till is exposed at ground surface across the majority of the site, except where underlain by glacio-fluvial and glacial granular deposits or flood plain alluvium or where bedrock is exposed at ground surface. Based upon engineering experience in Midland Valley of Scotland, this deposit is typically a firm to stiff becoming stiff and very stiff at depth, sandy gravelly CLAY with varying cobble and boulder content.

Drift deposits are absent at two locations to the north and south of Lothianburn along the western boundary of the study area.

It is not possible to ascertain the thickness of each drift deposit or the combined thickness using available data. Historic borehole records are available within the study area and these should be purchased and reviewed during preparation of detailed desk study specific to the preferred alignment once agreed.

4.1.2 Route B Drift Geology

Table 4.1 below summarises the drift deposits that are likely to be encountered along the proposed alignment B. Chainages are measured from the west, i.e. the proposed position of Lothianburn Park and Ride.

Table 4.1 Table summarising drift deposits likely to be encountered along Route B alignment

Chainage From (m)	Chainage To (m)	Deposit Type
0	200	Cohesive Glacial Deposits (NB: shallow bedrock envisaged)
200	550	Cohesive Glacial Deposits
550	625	Granular Glacial Deposits
625	1125	Cohesive Glacial Deposits
1125	End (1250)	Flood Plain Alluvium

About 85% of the alignment is underlain by Cohesive Glacial Deposits. Flood Plain Alluvium and Granular Glacial Deposits underlie about 10% and 5% of the alignment respectively.

4.1.3 Route C Drift Geology

Table 4.2 below summarises the drift deposits that are likely to be encountered along the proposed route C. Chainages are measured from the west, i.e. the proposed position of Lothianburn Park and Ride.

Table 4.2 Table summarising drift deposits likely to be encountered along Route C alignment

Route Reference	Chainage From (m)	Chainage To (m)	Deposit Type
C1	Start (275)	800	Cohesive Glacial Deposits
	800	End (850)	Cohesive Glacial Deposits (NB: shallow bedrock envisaged)
C2	Start (275)	1275	Cohesive Glacial Deposits
	1275	1550	Flood Plain Alluvium
	1550	1625	Granular Glacial Deposits
	1625	1800	Flood Plain Alluvium
	1800	2025	Cohesive Glacial Deposits
	2025	2225	Flood Plain Alluvium
	2225	2425	Cohesive Glacial Deposits
	2425	2675	Granular Glacial Deposits
	2675	End (2850)	Cohesive Glacial Deposits

The entire alignment of C1 is underlain by Cohesive Glacial Deposits.

About 65% of the C2 alignment is underlain by Cohesive Glacial Deposits. Flood Plain Alluvium and Granular Glacial Deposits underlie about 20% and 15% of the route respectively.

4.2 Solid Geology

4.2.1 General

The solid edition of British Geological Survey Sheet 32 'Edinburgh' (1:50,000 scale) details the solid geology within the study area.

A Solid Geology Plan was prepared using the above geological map. Please refer to Drawing S105976/P/602.

Table 4.3 summarises the lithological groups, formations and members that either outcrop or subcrop within the study area.

Table 4.3 Table summarising lithological groups, formations and members within study area

Member Name	Formation Name	Group Name	Mineral Seams	Age
Fairmilehead Volcanic Member	Pentland Hills Volcanic Formation	Lanark Group	N/A	Silurian-Devonian
Carnethy Hill Volcanic Member		Lanark Group	N/A	Silurian-Devonian
Hopetoun Member	West Lothian Oil Shale Formation	Strathclyde Group	Houston Coal Fells Oil Shale Broxburn Oil Shale Pentland Oil Shale Burdiehouse Limestone	Early Carboniferous
Calders Member	West Lothian Oil Shale Formation	Strathclyde Group	N/A for site	Early Carboniferous
N/A	Gullane Formation	Strathclyde Group	N/A for site	Early Carboniferous
N/A	Kinnesswood Formation	Inverclyde Group	N/A	Early Carboniferous

4.2.2 Lanark Group

The Pentland Hills Formation belongs to the Lanark Group, which is of Late Silurian to Early Devonian age. This group was deposited somewhere between 400 and 440 Million Years Ago (Ma) approximately.

The Fairmilehead and Carnethy Hill Volcanic Members are of Late Silurian to Lower Devonian age and include intrusive and extrusive igneous rocks of Basalt, Andesite and Trachyte type within the study area. These units belong to the Pentland Hills Volcanic Formation, which underlies the western half of the study area to the east of the Pentland Fault.

Bedrock is exposed at ground surface at two locations within the study area to the north and south of Lothianburn village. Bedrock is overlain by drift litholigies across the remainder of the study area.

4.2.3 Strathclyde Group

The West Lothian Oil Shale Formation and the Gullane Formation both belong to the Strathclyde Group, which is of early Carboniferous age. The Strathclyde Group was deposited between 325 and 345 Million Years Ago (Ma) approximately and is the youngest group of rocks

present within the study area. The West Lothian Oil Shale Formation is younger than the Gullane Formation.

The West Lothian Oil Shale Formation includes five mineral seams, three oil shale seams, a coal seam and a limestone. The lithology consists of OIL SHALE set in cyclical sequences of pale coloured SANDSTONE interbedded with grey SILTSTONE and grey MUDSTONE with subordinate coal, limestone and ironstone.

The Gullane Formation consists of cyclical sequences of pale coloured fine to medium grained SANDSTONE interbedded with grey MUDSTONE and SILSTONE, with subordinate coal, seatrock, limestone and ironstone.

4.2.4 Inverclyde Group

The Kinnesswood Formation belongs to the Inverclyde Group, which is also of early Carboniferous age but is older than the Strathclyde Group discussed above. This group was deposited between 340 and 360 Ma approximately.

The lithology of the Kinnesswood Formation predominantly consists of purple-red, yellow, white and grey-purple, fine to coarse grained cross bedded SANDSTONE that fine upwards. These sandstones are interbedded with planar, poorly bedded SANDSTONE, red MUDSTONE and nodules or thin beds of CONCRETIONARY CARBONATE.

4.2.5 Faulting

There are two main fault trends within the Edinburgh area, those that are aligned NNE-SSW and those that are aligned ENE-WSW.

A major fault referred to as the Pentland Fault transects the centre of the study area. This fault is aligned north-northeast south-southwest and has downthrown strata to the east, i.e. younger rocks of Carboniferous age are now juxtaposed against older rocks of late Silurian to early Devonian age. A second fault is present within the study area which is aligned ENE WSW. This fault has downthrown strata to the north, such that younger lithologies of the Fairmilehead Volcanic Member are juxtaposed against older rocks of the Carnethy Hill Volcanic Member. This fault is only present to the west of the Pentland Fault where it terminates.

4.2.6 Folding

The bedrock to the east of the Pentland fault has been folded into a series of anticlines and synclines. One syncline and one anticline are situated within the study area. The axial trace of the syncline is marked on the solid geology plan and is situated approximately 200 metres to the east of the Pentland Fault. The axial trace of the anticline is marked 450 metres to the east of the Pentland Fault. The axial traces of these anticlines and synclines share the same orientation as the Pentland Fault.

4.2.7 Dip and Dip Direction

Dip and dip direction markers included on the BGS solid geology show the sedimentary strata to vary in dip magnitude and direction. To the west of the syncline axial trace, the sedimentary strata dip 75 degrees to the southeast. To the east of the syncline axial trace and to the west of the anticline axial trace, the sedimentary strata dip 60 degrees to the north east. Dip and dip direction markers further to the west, show the sedimentary strata to the east of the anticline axial trace to dip between 45 and 50 degrees towards the southeast. There are no dip and dip

direction markers provided on the BGS solid geology map to the west of the Pentland Fault within the study area.

4.2.8 Route B Solid Geology

Table 4.4 below summarises the bedrock lithologies likely to underlie proposed route B. Chainages are measured from the west, i.e. the proposed position of Lothianburn Park and Ride.

Table 4.4 Table summarising bedrock lithologies likely to underlie Route B alignment

Chainage From (m)	Chainage To (m)	Deposit Type
0	1225	Basalt, Andesite or Trachyte
1225	1225	Pentland Fault
1225	1500	Cyclical sequences of pale coloured fine to medium grained SANDSTONE interbedded with grey MUDSTONE and SILSTONE, with subordinate coal, seatrock, limestone and ironstone.

The route is not underlain by shallow (<30 m below rockhead) workable mineral seams. Bedrock may have been historically quarried locally throughout the site where bedrock outcrops or subcrops near the ground surface.

4.2.9 Route C Solid Geology

Table 4.5 below summarises the bedrock lithologies that are likely to underlie proposed route C. Chainages are measured from the west, i.e. the proposed position of Lothianburn Park and Ride.

Table 4.5 Table summarising bedrock lithologies likely to underlie Route C alignment

Route Reference	Chainage From (m)	Chainage To (m)	Deposit Type
C1	Start (275)	End (850)	Basalt, Andesite or Trachyte
C2	Start (275)	End (1475)	Basalt, Andesite or Trachyte
	1425	1425	Pentland Fault
	1425	1500	Cyclical sequences of pale coloured fine to medium grained SANDSTONE interbedded with grey MUDSTONE and SILSTONE, with subordinate coal, seatrock, limestone and ironstone.
	1500	1525	Burdiehouse Limestone
	1525	2050	Cyclical sequence of OIL SHALE, pale coloured SANDSTONE interbedded with grey SILTSTONE and grey MUDSTONE with subordinate coal, limestone and ironstone
	2050	2050	Pentland Oil Shale
	2050	2175	Cyclical sequence of OIL SHALE, pale coloured SANDSTONE interbedded with grey SILTSTONE and grey MUDSTONE with subordinate coal, limestone and ironstone
	2175	2200	Burdiehouse Limestone
	2200	End (2850)	Cyclical sequence of pale coloured SANDSTONE interbedded with grey SILTSTONE and grey MUDSTONE with subordinate coal, limestone and ironstone

The route is underlain by shallow (<30 m below rockhead) workable mineral seams between Ch 1500 and 2200 m. Bedrock may have been historically quarried locally throughout the site where bedrock outcrops or subcrops near the ground surface.

4.3 Hydrogeology & Groundwater

4.3.1 General

The 'Hydrogeology Map of Scotland' prepared by the BGS was reviewed to establish the hydrogeological significance of each of the soil and rock types expected at the site.

4.3.2 Groundwater

At this stage, there is insufficient information available to determine likely ground water levels.

Ground water is likely to be near to ground surface within the central and northern parts of the study area where alluvium is present and in vicinity of the burns.

Mine water may be issuing at the site, particularly where the spring is labelled on current and historic ordnance survey maps between the grave yard and Clippen's landfill site. A site walkover was not carried out as part of this preliminary desk study to verify whether or not water issuing from this spring constitutes mine water. A site walkover should be implemented during preparation of the detailed desk study specific to the preferred alignment. During this walkover, the spring referred to above and all water courses present along or near to the preferred alignment should be inspected to ascertain the presence of mine water at the site.

4.3.3 Drift Deposits

The permeability of the Flood Plain Alluvium deposits will vary depending upon the particle size distribution. This deposit is likely to comprise a mix of interbedded fine sands, silts and clay/silt laminations. The coefficient of permeability is therefore likely to range between 10^{-4} and 10^{-7}m/s (Table 2.1 in Craig's 'Soil Mechanics'). These deposits tend to be horizontally layered. Consequently, ground water will preferentially flow along the more permeable sandier horizons. The lateral permeability of this deposit will therefore be higher than its vertical permeability. Perched water tables are likely, where groundwater is trapped within the sandier material or unable to percolate down through the less permeable clay rich layers. The BGS describes this deposit as a concealed aquifer with limited or local potential.

Granular glacial and Glacio-fluvial deposits tend to be well graded and slightly clayey to very clayey. The permeability of these deposits is therefore likely to be in the region of 10^{-3} to 10^{-4} m/s (Table 2.1 in Craig's 'Soil Mechanics'). The BGS describe these deposits as a locally important aquifer where intergranular flow is significant. The groundwater potential will vary depending upon the thickness of any saturated material. As groundwater contained within these deposits is shallow, groundwater bodies contained within these deposit are at risk of diffuse and point source pollution.

Glacial Till in the Central Belt of Scotland is typically a sandy gravelly CLAY and is therefore impermeable with a coefficient of permeability in the order of 10^{-7} m/s or less where unfissured. Pockets of sand and gravel are common within the deposit, which often contain perched water. This deposit is therefore an aquiclude due to its negligible to low permeability.

4.3.4 Bedrock

Bedrock permeability will vary across the site. Andesite, Basalt and Trachyte (Pentland Hills Volcanic Formation) are impermeable due to their crystalline nature. The BGS describe these rock types as impermeable to weakly permeable concealed aquifers of limited potential. Actual permeability will depend upon fracture/discontinuity geometry and intensity.

The sedimentary strata at the site consist of a mixture of impermeable aquicludes (mudstone, seatearth, oil shale, limestone) and permeable aquifers (sandstone and siltstone) strata. The vertical and lateral permeability of this deposit will therefore depend upon the dip and dip direction of the strata. The BGS describe the sedimentary strata at the site as moderately permeable highly productive and locally important aquifers in which flow is dominantly through fissures and other discontinuities.

5 Mineral Stability

5.1 General

The site is situated at the western edge of the Midlothian Coalfiled. The western half of the study area is underlain by volcanic rocks of late Silurian to early Devonian age; hence there is no risk of mine working related subsidence within this area.

Mine abandonment plans relevant to the study area are held by the British Geological Survey at their Edinburgh office. These were reviewed to ascertain the presence and extent of shallow underground and opencast mineral workings at the site.

There are known workings within the study area, which extracted the Pentland Oil Shale and the Burdiehouse Limestone.

Areas underlain by known shallow (<30 m below rockhead) mineworkings or potentially underlain by shallow (<30 m below ground level) mineworkings are annotated on the 'Shallow Mineworkings Risk Plan' (Drawing Ref: S105976/P/603. Risk levels are defined as follows:

- Negligible Risk – area not underlain by workable mineral seams
- Low Risk – area not underlain by shallow workable seams
- High Risk – area underlain by shallow workable seams with no evidence of workings
- Very High Risk – area underlain by shallow workable seams with evidence of workings

5.2 Burdiehouse Limestone

The Burdiehouse Limestone is present at shallow depth below alignment C2 between Ch 1500 and 2200 m.

The Burdiehouse Limestone was initially extracted by open cast methods at outcrop to the north of Straiton prior to 1855. Workings were subsequently extended underground and southwards from the quarry by stoop and room techniques. These works ceased in 1870. The underground workings were extended southwards towards Pentland Road, i.e. within study area between 1920 and 1961. It is thought that these workings relate to the seam of Burdiehouse Limestone that subcrops between Straiton and Pentland in a northeast southwest alignment. Workings within this seam would have extended down dip, i.e. towards the southeast and away from the site. These workings do not underlie any of the proposed routes.

The seam has been extracted by open cast means at Pentland Oil Works to the south of the alignment between Ch 1850 and 2200 m.

An old shaft observed in the old OS maps in the middle of the study area may have provided access to the Burdiehouse Limestone seam that subcrops within the central portion of the site below alignment C2 between Ch 1500 and 2200 m, as the shaft is situated down dip of the Burdiehouse Limestone subcrop. There are no mine abandonment plans detailing extraction of this seam within this area. Workings within this area occurred somewhere between 1855 and

1894. These workings probably closed in the mid to late 1800s, at a time when preparation of mine abandonment plans was not mandatory.

5.3 Pentland Oil Shale

This is situated 33 metres above the Burdiehouse Limestone, i.e. at a shallower depth. The Pentland Oil Shale underlies alignment C2 between Ch 1600 and 2050 m within the Pentland Syncline. The seam dips towards the northwest between Ch 1875 and 2050 and to the southeast between Ch 1600 and 1875 m. The seam is not shown in the geological plans to the west of the syncline axial trace; however it is possible that the Pentland Oil Shale could also subcrop to the west of the syncline axial trace (shown on the 'Solid Geology Plan, Drawing Ref: S105976/P/602 as a dashed line). An old shaft observed in the old OS maps in the middle of the study area may have provided access to the Pentland Oil Shale seam, since it is situated down dip of the Pentland Oil Shale subcrop. Workings within this area occurred somewhere between 1855 and 1894. These workings probably closed in the mid to late 1800s, at a time when preparation of mine abandonment plans was not mandatory.

The seam has been extracted by open cast means at Pentland Oil Works to the south of the alignment between Ch 1850 and 2200 m.

The Pentland Oil Shale also subcrops in the southeast corner of the study area to the southeast and east of Old Pentland. The seam dips towards the southeast in this area. This seam was worked to 350 m bgl by stoop and room at Pentland Oil Works (run by the Clippens Oil Company). Worked thicknesses ranged between 1.5 and 1.8 m. Workings within this seam were abandoned in 1897.

5.4 Broxburn Oil Shale

This seam is situated about 84 metres above the Pentland Oil Shale and subcrops in the southeastern corner of the study area to the southeast of the Pentland Oil Shale subcrop.

The Broxburn Oil Shale seam may subcrop between the Pentland Oil Shale subcrop and the axial trace of the syncline present in the middle of the site. The subcrop of the Broxburn Oil Shale is labelled at and north of the site boundary and could theoretically extend towards the southwest and within the site boundary. This seam may also subcrop on the opposite limb of the syncline, as discussed regarding the Pentland Oil Shale above.

There are no known workings within this seam situated within the study area. This seam is known to be productive as it has been worked in the Lothians area. Unknown workings may therefore exist at shallow depth in this area in the immediate vicinity of the syncline axial trace or in the southeast corner of the site.

5.5 Shafts and Adits

Two shafts have been identified within the study area.

One shaft is labelled as an old shaft on the 1894 OS map and was therefore active prior to this period. It is not known which seam or seams were accessed from this shaft.

A second shaft, labelled as an air shaft, is shown within the study area to the north of the Straiton Caravan Park and immediately west of the A701. This shaft appeared on the 1915 OS Map. A car park now overlies this area. It is assumed that this shaft was investigated and remediated during construction of the car park. This should be investigated during preparation of the detailed geotechnical desk study once the preferred route alignment has been chosen. This shaft probably was constructed to feed air into the Burdiehouse Limestone

None of the proposed alignments are situated within 100 metres of a known shaft or adit. Once the preferred alignment has been agreed, the Coal Authority should be consulted for an alignment specific assessment. There may be unknown shafts present along alignment C2 between Ch 1500 and 2200 m, which may have been used to access workable mineral seams that underlie the site. A site walkover should be carried out during preparation of the detailed desk study along the preferred alignment to identify any unknown hidden shafts or adits that are present within a 50 metre corridor of the site.

5.6 Subsidence History

Ground subsidence occurred in 1978 along the A701 at Straiton. This is probably related to the collapse of shallow underground workings within the Burdiehouse Limestone, since the geological maps infer this seam to subcrop in the vicinity of the A701 at Straiton.

A subsidence hollow appeared near Straiton Caravan Park in 1986. This feature is probably also attributable to the collapse of shallow underground mineworkings within the Burdiehouse Limestone.

In March 2000, a 14 m diameter 10 m deep crater opened up at the former Clippen's Landfill Site. A crater formed within an area of limestone workings 30 to 40 metres from the western limit of the workings (i.e. close to subcrop) and outside the area of oil shale workings.

There is no correspondence detailing subsidence occurrences along the proposed alignments. A site walkover should be carried out during preparation of the detailed desk study specific to the preferred alignment to identify the presence of any historic mining subsidence related activity.

5.7 Shallow Mineworkings Risk Rating

The Shallow Mineworkings Risk Plan (Drawing Ref: S105976/P/603) defines the risk along alignments B and C1 as 'Negligible' throughout.

The Shallow Mineworkings Risk Plan (Drawing Ref: S105976/P/603) defines the risk along alignment C2 as follows:

- Negligible – Start (Ch 275 m) to 1425 m
- Low – Ch 1425 to 1500 m
- High – Ch 1500 to 2200 m
- Low – Ch 2200 to End (Ch 2850 m)

6 Contaminated Land

6.1 General

Areas of contaminated land identified during preparation of this preliminary desk study are annotated on the 'Geotechnical Constraints Plan' (Drawing Ref: S105976/P/604).

The following contaminated land risk rating system has been used:

- Low risk (yellow) in relation to anticipated construction activities/engineering integrity
- Moderate risk (orange) in relation to anticipated construction activities/engineering integrity
- High risk (red) in relation to anticipated construction activities/engineering integrity

A site walkover has not been carried out. This should be implemented once the preferred road alignment has been agreed during preparation of an alignment specific detailed geotechnical desk study. Areas of contaminated land should be identified and described during the site walkover.

6.2 Indentified Sites

The following sites have been identified as potentially contaminated:

- Site A – Landfill, High Risk
- Site B – Old Reservoir, Moderate Risk
- Site C – Grave Yard, High Risk
- Abandoned Shafts, Moderate Risk

6.3 Contaminated Land Risk Rating

Route B does not cross any areas of identified potentially contaminated land.

Route C1 does not cross any areas of identified potentially contaminated land.

Route C2 does not cross any areas of identified potentially contaminated land.

7 Engineering Discussion

7.1 General

Geotechnical problems were identified as follows:

- Cutting Stability (associated with flood plain alluvium deposits)
- Embankment Stability (associated with flood plain alluvium deposits)
- Embankment Settlements (associated with flood plain alluvium deposits)
- Made Ground (associated with contaminated land)
- Ground Subsidence (associated with potential shallow underground mine workings)
- Contaminated Ground Water (associated mine water discharge)

The 'Geotechnical Constraints Plan' (Drawing Ref: S105976/P/604) has been highlighted in green to show areas of the site is underlain by poor quality soils. Alignment B is underlain by poor quality soils between 1125 and 1250 m. Alignment C1 is not underlain by any poor quality soils. Alignment C2 is underlain by poor quality soils between Ch 1300 to 1550 and Ch 1625 to 1800 m.

The 'Shallow Mine Workings Risk Plan' (Drawing Ref: S105976/P/603) has been highlighted in red to show areas of the site is potentially underlain by shallow underground mine workings. Alignment C2 is potentially underlain by shallow underground mine workings between Ch 1500 and 2825 m approximately.

7.2 Cutting Stability

Flood plain alluvium deposits tend to have a shallow ground water profile as they are often situated close to watercourses and river channels and in low lying areas. The presence of a shallow water table could result in short and long term drainage problems where excavating cuttings. Continual flow of water from a cut slope face will result in erosion and oversteepening of the slope face in the long term, subsequent reduction in the Slope Factor of Safety and ultimately slope failure. Furthermore, flooding of the road could occur in the long term if the water table was to remain high or rise during periods of inclement weather. Provision of adequate slope drainage and erosion control measures would be required in areas of cut excavated through flood plain alluvium.

Flood plain alluvium deposits also may have perched water tables where the deposit consists of interbedded and interlaminated fine sand, silt and clay layers. Seepages may occur where cuts are excavated through this material. These seepages could lead to long term erosion and

oversteepening of the slope face, subsequent reduction in the slope Factor of Safety and ultimately slope failure. These can be mitigated, by provision of a robust drainage system combined with erosion control measures.

7.3 Embankment Stability & Settlements

Where embankments are to be constructed over flood plain alluvium, bearing capacity failure and slope instability may occur as a result of the low shear strength properties. In the long term due to the heterogeneous nature of the deposits and variable thicknesses, differential settlement could occur longitudinally. Furthermore, total settlement magnitudes may be high and unacceptable depending upon the material's consolidation properties. The latter issues can be engineered by excavation of unsuitable material, in-situ treatment of unsuitable material or by structural solutions such as construction of embankments founded on piled footings. Embankments may also be 'floated' or basally reinforced with geocell mattresses, geogrids or sheet geotextiles where differential and total settlement is not a concern.

In order to keep construction costs to a minimum, the length of route underlain by flood plain alluvium should be considered such that the route requiring the least ground treatment is selected.

7.4 Contaminated Land

None of the proposed alignments are underlain by potentially contaminated land; consequently engineering issues related to Made Ground deposits have not been discussed any further. This should be verified during the site walkover that is to be implemented during preparation of the detailed geotechnical desk study specific to the preferred alignment.

7.5 Shallow Underground Mine Workings

A ground investigation will be required to ascertain whether or not identified shallow mineral seams that subcrop below this section of Alignment C have actually been extracted.

A mining investigation would be required, to determine the following:

- Thickness and extent of shallow (<30 m below rockhead) worked seam(s)
- Types of superficial deposits present and their material properties
- Depth to rockhead and thickness of superficial deposits
- Types of bedrock present between lowermost worked seam and rockhead and their material properties

- Groundwater levels including presence of artesian water

If the ground investigation proves that there are indeed shallow underground workings within this area, some form of remedial treatment will be required such as bulk grouting of the voids or utilisation of sheet geotextiles.

The most robust form of treatment consists of injecting grout into the voids and associated areas of collapsed, broken ground thereby eliminating all risk associated with future ground subsidence. This technique is however expensive.

An alternative more economical solution may be to utilise sheet geotextiles placed longitudinally below the road pavement. Should the ground subside in response to the collapse of shallow underground mine workings, the sheet geotextile will protect the road pavement by preventing ultimate limit state failure in the short term. Settlement of the road pavement can not be prevented; hence serviceability limit state failure criteria will not be satisfied. Settlement will usually manifest itself as a circular depression. The development of these features can be used as an alarm, alerting local authorities that ground subsidence has occurred in the area that require treatment.

When these features occur, a geotechnical inspection supplemented by ground investigatory work will be required to determine the extent of ground subsidence. Following the inspection and investigation, remedial works will need to be designed and instigated as a matter of urgency before ultimate limit state failure of the road pavement occurs. The remedial works in this instance would consist of discrete grouting in the vicinity of the subsided ground.

Unfortunately, it is not possible to predict when and where ground subsidence will occur. It is therefore difficult to determine long term maintenance costs associated with discrete emergency remedial works required post ground subsidence. Mine plan data and ground investigation data could be used to determine the likelihood of ground subsidence occurring along the preferred alignment, which could be used to assist with predicting long term maintenance costs associated with discrete emergency remedial works.

7.6 Mine Water Discharge(s)

Mine water may be issuing at site and may be contaminated. A site walkover should be implemented during preparation of an alignment specific geotechnical desk study. The Engineer should investigate all water courses and ponding water to determine the presence of mine water discharge. Where observed, a water sample should be taken for contamination testing.

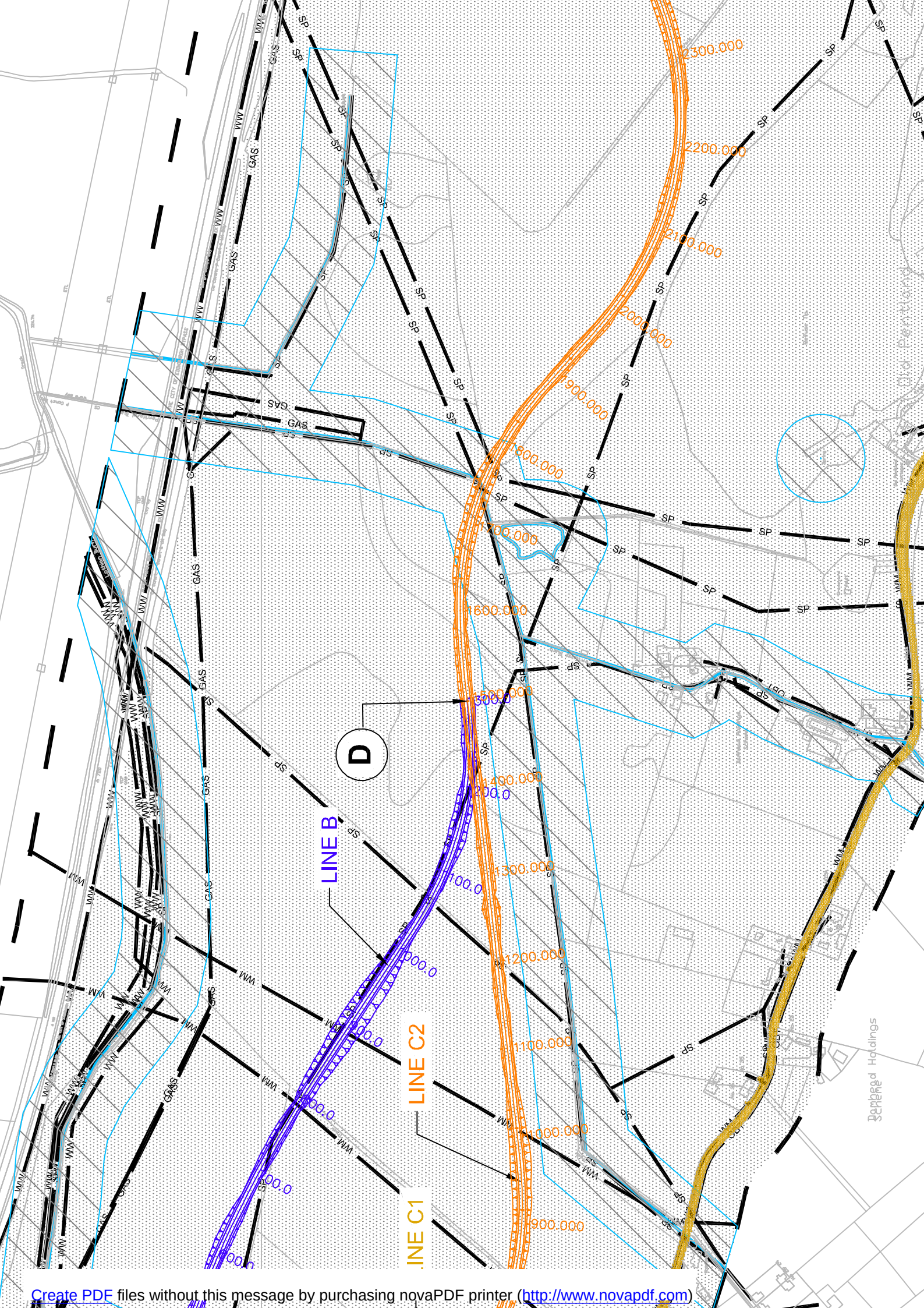
8 Recommendations

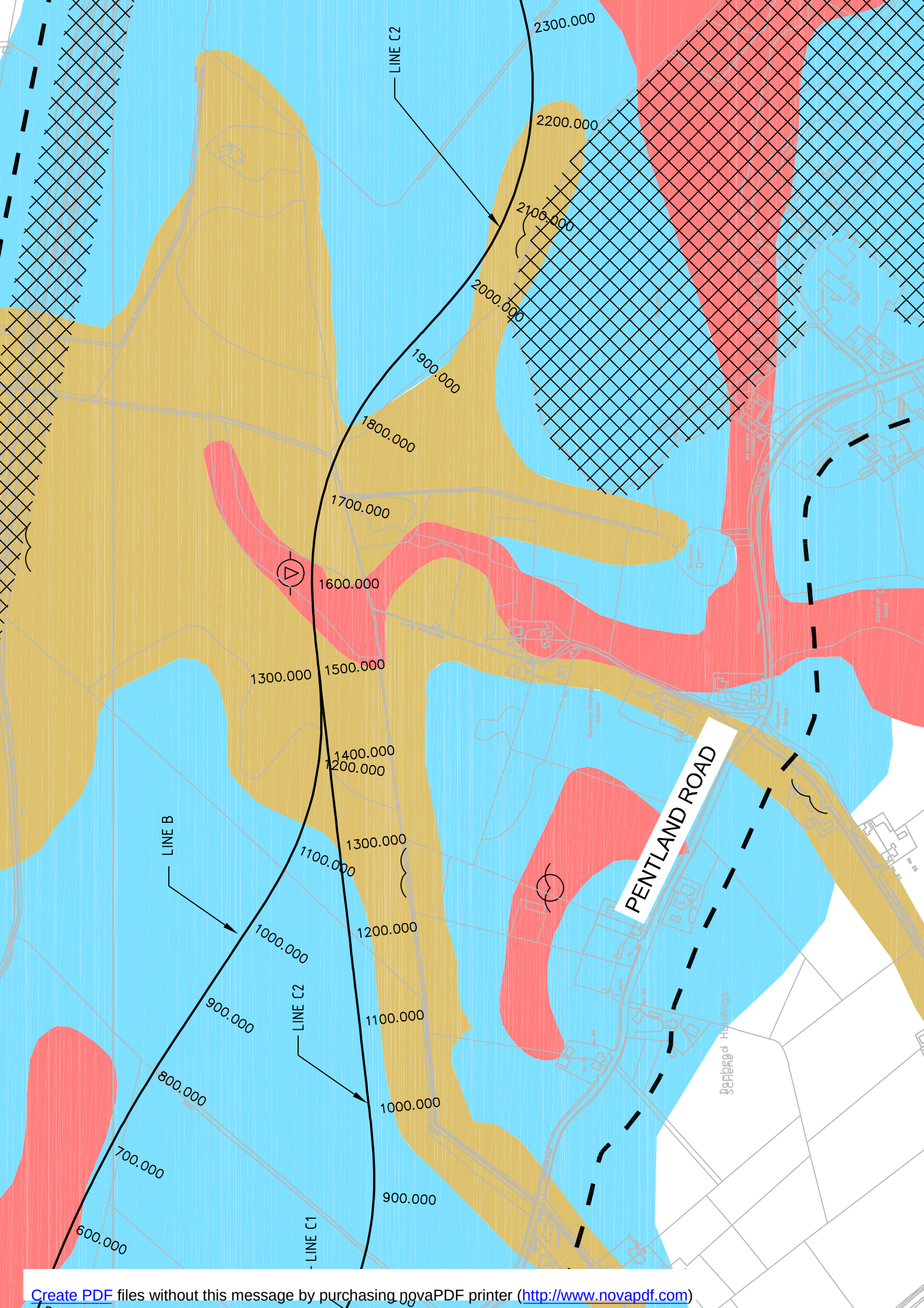
A detailed geotechnical desk study should be prepared specific to the preferred alignment and should include the following:

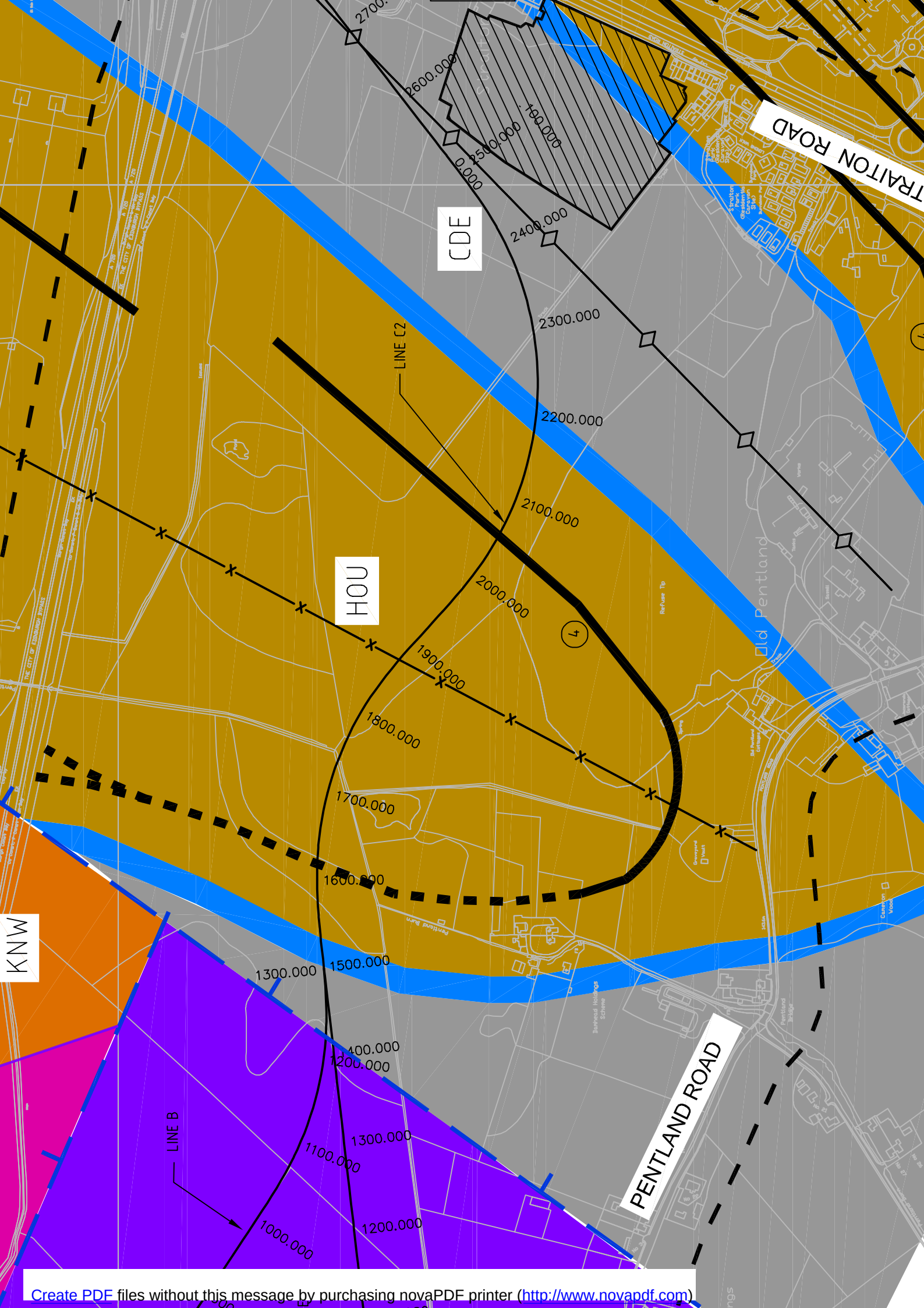
- Review of large scale solid and drift geology maps and associated memoir(s)
- Detailed review of mine abandonment plans specific to the preferred alignment
- Purchase and review of historic borehole records specific to the preferred alignment
- Review of historic ground investigation reports specific to the preferred alignment
- Review of environmental data specific to contaminated land hotspots present along or adjacent to the preferred alignment
- Site walkover to identify the following:
    - Contaminated land
    - Poor quality engineering soils
    - Mining related ground subsidence
    - Hidden, unknown abandoned shafts and adits
    - Old quarries (open and infilled)
    - Mine water discharge
    - Contaminated groundwater
- A ground investigation plan shall be included, which shall be based upon the findings of detailed desk study and enable the following to be investigated and proven:
    - Extent, thickness and material properties of the flood plain alluvium deposits
    - Extent, thickness and material properties of the granular glacial deposits
    - Extent, thickness and material properties of the cohesive glacial deposits
    - Extent, thickness and material properties of any made ground encountered including types and levels of contaminants present
    - Groundwater levels including type and levels of contamination where mine water discharge present
    - Presence, depth, thickness and extent of shallow underground mine workings
    - Presence and extent of any collapsed ground
    - Bedrock types present above the lowermost worked seam and their material properties

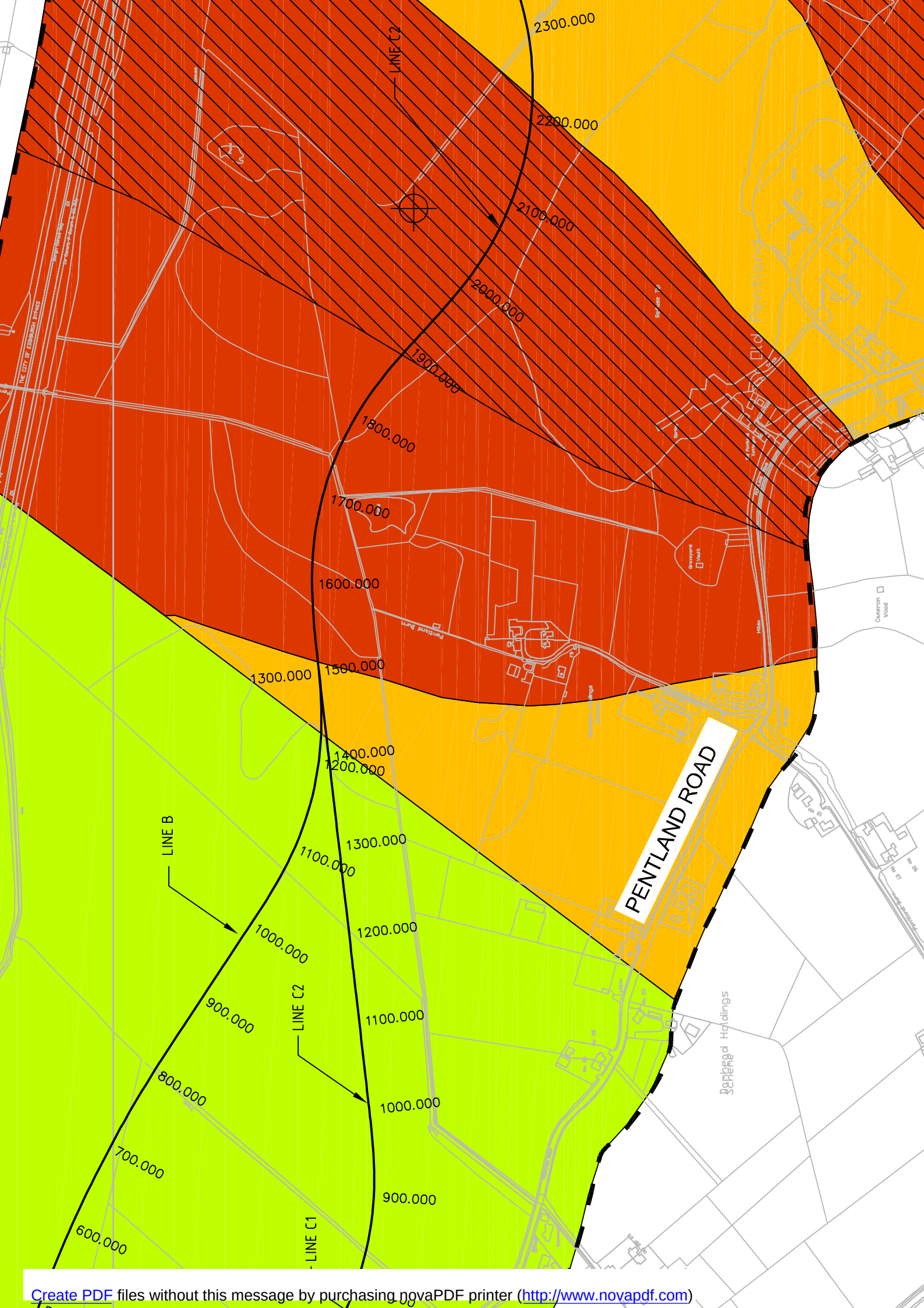
Drawings

S105976/P/102	Plan of Proposed Route Options
S105976/P/601	Drift Geology Plan
S105976/P/602	Solid Geology Plan
S105976/P/603	Shallow Mineworkings Risk Plan
S105976/P/604	Geotechnical Constraints Plan









Appendix D

Land Use & Environmental Constraints Plans