St Ambrose

Ground Contamination Detailed Quantitative Risk Assessment

For

Balfour Beatty

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Revision History

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1A	February 2010	Final	5311 E DQRA 1A	Final
1B	February 2010	Final	5311 E DQRA 1B	Final following consultation with North Lanarkshire Council CLO

[redacted]

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1 INTRODUCTION

Ramboll UK Ltd (RUK) has been commissioned by Balfour Beatty to undertake a detailed quantitative assessment to assess the risks to human health from benzo(a)pyrene, benzo(a)anthracene and nickel contamination identified at the proposed St Ambrose school site.

This work follows on from a recommendation made in the ground contamination Generic Quantitative Risk Assessment report completed by RUK (Ref. Ground Contamination Risk Assessment, February 2010), and should be read in conjunction with this report.

1.1 Background

The proposed site for St. Ambrose High School, Coatbridge has previously been used as Townhead Landfill site which was operational from 1945-1972. At present the site lies north of Drumpellier Country Park and is used as community playing fields.

In order to progress the proposed development the site needs to be established as suitable for use as a school considering the potential contaminative impacts present on site associated with its historical use as a landfill site.

Ramboll UK understand 1No. desk study (Phase I) and 2No. intrusive site investigations (Phase II) have been undertaken within the site boundary since 2005; available reports and investigations for the site are outlined below:

- *St. Ambrose High Desk Study (URS, 2005);*
- *Preliminary Ground Investigation Report, St. Ambrose High School, Coatbridge (URS, 2006);*
- *Proposed St. Ambrose High School, Ground Investigation Report (URS, 2008); and*
- *Proposed St. Ambrose High School, Additional Gas Monitoring (URS, 2009)*

A review of these reports was undertaken by WSP (2009) on behalf of North Lanarkshire Council's Environmental Department and is detailed in the letters outlined below and provided in Appendix B:

- *Report Review – Proposed St. Ambrose High School, WSP 17th November 2008;*
- *Proposed St. Ambrose, Townhead Report Review Summary and Recommendations, Environmental Services 18th November 2008 (incl. URS response to comments); and*
- *Report Review Follow Up – St. Ambrose High School, WSP 31st August 2009.*

Additional investigation works supervised by Ramboll were undertaken by Geotechnics Ltd. in 2009 to supplement the existing site data and provide additional information across the site. This data was then used to provide a robust ground contamination risk assessment for the proposed St. Ambrose School, addressing the concerns raised by WSP (2009). This additional work is detailed in the following report:

- *Ground Contamination Risk Assessment Report (RUK, 2010)*

This Generic Quantitative Risk Assessment (RUK, 2010) concluded that the site is suitable for redevelopment with regards to Human Health as long as the following recommendations are adhered to:

1. Limited remediation (e.g. excavation and disposal of localised areas of elevated contaminants should further validation testing prove these materials are unsuitable for reuse) and further detailed quantitative risk assessment;

2. Incorporation of specific design measures (e.g. gas protection measures to mitigate risks posed by ground gases); and
3. Risk management during development (e.g. development of an environmental specification and a watching brief during development to validate conformance to the environmental specification).

This report addresses the requirement for further detailed risk assessment identified in point one above.

1.2 Aims and Scope of Works

The aim of this report is to assess further the potential risks to human health from benzo-a-pyrene, benzo-a-anthracene and nickel identified as potential contaminants of concern and to provide recommendations regarding the suitability of the site for the proposed school development with respect to these three contaminants. In addition recommendations will be provided regarding the suitability of material to be reused on site during site re-profiling works.

The works to be completed to achieve these aims are:

- Develop site specific conceptual model for the proposed school;
- Complete detailed risk assessment modelling for risks to human health from contaminants identified in the GQRA report and provide site specific assessment criteria for the contaminants of concern;
- Review site data using the site specific assessment criteria to determine suitability of material for proposed site development; and
- Provide recommendations regarding suitability of the site for its proposed use and recommendations for material management during site works.

1.3 Constraints and Limitations

This report has been prepared for the exclusive use of Balfour Beatty for the purpose of assisting site evaluation in the context of the proposed redevelopment at the time of writing. This report should not be used in whole or in part by any third parties without the express permission of Ramboll UK Ltd. in writing.

Ramboll has endeavoured to assess all information provided to them during this appraisal. This report summarises information provided from a number of external sources and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon.

2 SITE DETAILS

The site of the proposed St. Ambrose High School is located in Coatbridge, Lanarkshire. A site location plan is presented as Figure 2.1 in Appendix A.

2.1 Site Location

The site is located off Townhead Road and is bordered by Townhead Road to the north, a community centre, pavilion and residential properties to the east, Drumpellier Park to the south and a Golf Course to the west.

The site is located at the approximate National Grid Reference (NGR) 271546, 665970.

2.2 Site Description

The site is described in detail within the Ground Contamination Risk Assessment Report (RUK, 2010) and summarised below.

The site covers an area of approximately 13.5Ha. Currently the site is occupied by numerous sports pitches and is in use by the general public as a recreational area. An area of car parking and an access road is present in the northeast of the site.

A current site layout plan indicating current topographic levels is included in Appendix A as Drawing 5311/E/003.

2.3 Proposed Development

The proposed development at Townhead Road, Coatbridge, will comprise the construction of St. Ambrose High School including a two-storey school building with associated school pitches, car parking, play areas and soft landscaping.

A plan showing the proposed development layout is presented as Drawing No. 5311/E/002 in Appendix A.

Proposed areas of cut and fill at the time of writing are shown on Drawing No. NLC-STA-DRG-C-316 in Appendix A.

3 CONCEPTUAL MODEL

Previous site investigations and assessment provided in RUK 2010 have identified elevated concentrations of contaminants which may pose an unacceptable risk to human health at the site based on the proposed development.

For a risk of pollution or environmental harm to occur as a result of ground contamination, all of the following elements must be present:

- A source, i.e. a substance that is capable of causing pollution or harm;
- A receptor (or target), i.e. something which could be adversely affected by the contaminant; and
- A pathway, i.e. a route by which the contaminant can reach the receptor.

If one of these elements is missing there can be no significant risk. If all are present then the magnitude of the risk is a function of the magnitude and mobility of the source, the sensitivity of the receptor and the nature of the migration pathway.

A detailed conceptual model of the St Ambrose site is developed in this section to identify sources, pathways and receptors and thus identify plausible pollutant linkages. The conceptual model has been developed considering the proposed cut and fill works and concentrations of contaminants reported are considered to be representative of material that will be within the top 1m following re-profiling across the site.

This assessment is being completed to address potential risks to human health from benzo(a)pyrene, benzo(a)anthracene and nickel only, for risks to other potential receptors from other contaminants refer to RUK Ground Contamination Risk Assessment Report (2010).

3.1 Sources

The contaminants identified at elevated concentrations in the GQRA (RUK, 2010) which may present a risk to human health are summarised in Table 3.1 below, (taken from Table 5.2 and Table 5.3 from RUK 2010).

Table 3.1: Summary of Identified Site-Wide Impacts (Human Health)

Determinand	Generic Assessment Criteria GAC (mg/kg)	Maximum concentration (mg/kg)	95^{th} %UCL (excluding outliers) (mg/kg)	Statistical Outliers
Topsoil				
Benzo(a)pyrene	1	7.8	5.43	None
Benzo(a)anthracene	6.2	14	8.61	None
Landfill Material				
Benzo(a)pyrene	1	9.4	2.31	None
Nickel	130	660	97.7	660mg/kg

3.2 Receptors

The site is being developed primarily as a secondary school for children of ages 11-18years. It is understood that the south-eastern part of the school building and the sports pitches will also be used as a community sports facility during weekends. It is assumed that this weekend use would be for children and adults of all ages. In addition, there is a public right of way through the centre of the site which is considered likely to be used on a daily basis by dog walkers for example.

The human health receptors at this site based on the proposed site use are therefore:

- School students who will attend the school on a regular basis.

- Teachers who will attend the school on a regular basis.
- Groundskeeper/caretaker assumed to attend the school during standard working hours and also to provide access at weekends.
- Dog walkers assumed to use the right of way through the centre of the site on a daily basis.
- Children and adults of all ages using the playing fields and south-eastern part of the school building as a community sports facility at weekends.

3.3 Pathways

Pathways are the means by which a contaminant can reach a receptor. Active pathways are dependent on the physical characteristics of the source compounds, the site and surrounding area between the source and receptor.

The nature of the site surface affects the potential for direct contact between site users and the impacted soils. The proposed development layout in Drawing 5311/E/002 indicates areas of soft landscaping and sports pitches where site users may come into direct contact with the soils. Material will be brought onto site as a make-up for all the sports pitches, however, as a worst case for this assessment; it is considered that site soils will be used for the sports pitches. Direct contact pathways will not be active in areas beneath the building footprint and hardstanding.

There is a potential for volatilisation and migration of contaminants which may pose a risks in particular in indoor spaces. Although the source contaminants are not considered highly volatile, volatilisation and inhalation are considered as active pathways.

The following pathways will therefore potentially be active with regards to human health:

- Ingestion of soil /dusts;
- Dermal contact with soil; and
- Volatilisation, vapour migration and inhalation.

3.4 Summary

The pollutant linkages identified as potential significant are shown in Table 3.5 below.

Table 3.2: Potentially significant pollutant linkages

Source	Pathway	Receptors
Benzo(a)pyrene Benzo(a)anthracene Nickel	Ingestion of soils/dusts Dermal contact with soils Inhalation of vapours	11-18 year old student Adult teacher Groundskeeper /caretaker Dog walkers Weekend users of community facilities

Further site specific human health risk assessment modelling has therefore been undertaken to provide a more site specific assessment of the significance of the identified pollutant linkages.

An updated Site Conceptual Model is provided as Drawing 5311/E/004, Appendix A.

4 HUMAN HEALTH ASSESSMENT MODELLING

The generic assessment undertaken by RUK (2010), assessed the site in relation to generic criteria for a residential end use without home-grown produce. As demonstrated in the conceptual model developed in Section 3, the site is highly unlikely to be used in a manner similar to the standard residential scenario, therefore the initial assessment is considered to be highly conservative.

The aim of this detailed quantitative modelling is reduce uncertainty and to modify conservative assumptions made at the GQRA stage to provide a more site specific assessment of risks to future site users under conditions most likely to be encountered during the use of the site following the proposed development.

4.1 Methodology

RUK has carried out detailed human health risk assessment using CLEA v1.06 (EA, 2009) to generate Site Specific Assessment Criteria (SSAC) for the compounds of concern.

A number of contaminant specific and site specific input parameters are required to define the environmental conditions and nature of the receptors at the site, and thus quantify the site conceptual model. These are discussed in the sections below.

Due to the uncertainty in the receptor exposure models, a detailed sensitivity analysis has been undertaken to assess the significance of the input parameters for the different models completed and thus identify the critical receptors.

4.2 Source Characteristics

The source impacts considered within this study are:

- Benzo(a)pyrene
- Benzo(a)anthracene
- Nickel

Toxicity and chemical characteristics

For each compound, toxicological health criteria values are required to define minimal risk levels and various chemical properties are required to define likely contaminant partitioning and transport. These values have been sourced for each compound in accordance with the UK guidance on the hierarchy of authoritative data sources detailed in SR2 (EA 2009). All input values are presented in Appendix C with references.

Bioavailability

Bioavailability is defined as the fraction of the chemical that can be absorbed by the body.

As no site specific data is available for the site, a worst case estimate of 100% bioavailability is used within the base model assessment, however this is likely to be conservative for the source compounds identified.

4.3 Pathway Characteristics

The following pathways are potentially active with regards to human health:

- Ingestion of soil /dusts.
- Dermal contact with soil.
- Volatilisation, vapour migration and inhalation.

The ingestion, dermal contact and inhalation elements of these pathways are defined through the receptor exposure characteristics (detailed in Section 4.4).

However in order to estimate a concentration of the contaminants in air, fate and transport modelling is required to determine volatilisation and migration through the unsaturated zone into a building or outdoor air space.

Parameters must therefore be defined to quantify the unsaturated zone through which contaminants will migrate and also the indoor and outdoor airspaces in which vapours may build up.

Unsaturated zone characteristics

The unsaturated zone predominantly comprises Made Ground; including sandy silt topsoil and slightly clayey sandy gravel and gravelly sand strata.

For simplicity of modelling and assessment and to allow for potential variability of Made Ground in each locality, a single 'typical' shallow Made Ground material has been quantified as a typical sandy silt loam to reflect the topsoil which is the most heavily impacted source material.

Table 4.1 below details the unsaturated zone input parameters used and reference for each.

Table 4.1: Unsaturated zone input parameters

Parameter	Value used in model	Reference
Soil type	Sandy silt loam	Default parameters within CLEA model used for soil type.
Soil Organic Matter	15%	Average of site values for shallow soils
pH	7.8	Average of site values for shallow soils

Building parameters

Building parameters are required to assess potential vapour intrusion and accumulation within the proposed buildings. These parameters determine vapour concentrations in the indoor air space and thus the receptor point exposure concentration indoors.

The building parameters are estimated based on the proposed layout at the time of writing. In the absence of site specific data, parameters are generally selected based on the CLEA typical commercial office building as it is considered that this will be the most similar generic building type to the proposed school building. Table 4.2 below details the input parameters used and justification for each.

Table 4.2: Building parameters

Parameter	Value used in model	Units	Reference
Building footprint	10,000	m^2	Approximate area of proposed school building
Living space air exchange rate	1	hr^{-1}	Typical estimate for office and warehouse buildings. (SR3 EA 2009).

Parameter	Value used in model	Units	Reference
Living space height above ground	3.0	m	Estimate for school building
Living space height below ground	0	m	No basements proposed
Pressure difference	5.1	Pa	Assumed similar to standard commercial office building (SR3 EA 2009).
Foundation thickness	0.275	m	Proposed slab thickness
Floor crack area	1980	cm^2	Assumed similar to standard commercial office building (SR3 EA 2009).
Dust loading factor	100	$\mu g\ m^3$	Assumed similar to standard commercial office building (SR3 EA 2009).
Default soil gas ingress rate	150	$cm^3\ s^{-1}$	Assumed similar to standard commercial office building (SR3 EA 2009).

4.4 Receptor Exposure Characteristics

5No. main potential human receptor groups have been identified for the proposed St Ambrose school site: students, teachers, groundskeepers, dog walkers and users of the community facilities.

In order to complete the detailed modelling assessment, the critical receptor needs to be identified, i.e. the user of the site most likely to be affected by the impacts identified. This will depend mainly on the age of the receptor, frequency of the site use and activities on site. The 5 main receptors are discussed in brief below:

1. The 11-18year old student is considered likely to be more susceptible than adults working at the school but only over a maximum period of 7 years at school.
2. The adult teachers will be less susceptible to impacts than the younger students but are potentially at risk for a much longer duration assuming a worst case full working lifetime.
3. The activity patterns of typical adult groundskeepers/caretakers is uncertain, however given the use of the facility at weekends as well as during the school week there is a potential that an adult may frequent the site on a daily basis through the week for security and maintenance of school and grounds and also briefly at weekends to allow access to the appropriate facilities.
4. Dog walkers using the right of way through the site are considered most likely to use the path daily but only to walk through and not spend a significant amount of time on the site. The right of way runs adjacent to the school building and as such will mostly be across hardstanding areas where contact with the site soil will be minimal. It is therefore considered very unlikely that this user group will be a critical receptor. Dog walkers will therefore not be considered further within this assessment.
5. Users of the community sports facilities are assumed to be children and adults of all ages, using the facility for community sports club training and matches and interschool sports matches.

It is unclear at this stage which user group will be the critical receptor at this site therefore 4 different exposures models are defined.

Parameters quantifying the receptor and exposure pathways must be defined for each of the receptor models. These are discussed for each receptor group in the following sections. These parameters are used for the reasonable worst case base assessment models on which to perform the sensitivity analysis.

4.4.1 11-18yr old student

It is assumed that a student will be at the school for 7 years from age 11 to 18 years old. However, CLEA defines age classes at yearly intervals up to the age of 16 then a single age class for 16-65 year olds. In order to provide a conservative model for the school students therefore, only the 11-16 year old age classes are modelled.

Table 4.3 below details the input parameters used and justification for each.

Table 4.3: Land Use and receptor Data - School Student

Parameter	Value	Reference
Exposure Frequency (days/year)	190	Standard school year.
Occupancy Period Indoors (hours)	7	Estimate based on 5 hours per day indoors and 2 hours per day outdoors through the basic school day (ECETOC 2001). An additional 2 hours indoors per day has been included for extracurricular activities and/or after school club assumed as a worst case for the minority of students.
Occupancy Period Outdoors (hours)	2	

No ingestion rates or soil-skin adherence factors specific to school pupils could be sourced. These parameters are therefore defined for each age class based on data from CLEA v. 1.06.

The air dispersion factors and the fraction of the site with hard or vegetative cover are based on a standard commercial building as this is considered the closest in size to the proposed school building and site area.

4.4.2 Adult Teacher

It is assumed that an adult teacher will attend the school on a standard term time basis for a worst case full working lifetime.

Table 4.4 below details the input parameters used and justification for each.

Table 4.4: Land Use and receptor Data - School Teacher

Parameter	Value	Reference
Exposure Frequency (days/year)	195	Standard school year, including standard 5 teacher days in addition to the 190 days the students attend.
Occupancy Period Indoors (hours)	7	Estimate based on 5 hours per day indoors and 2 hours per day outdoors through the basic school day (ECETOC 2001). An additional 2 hours indoors per day has been included for supervision of extracurricular activities and/or after school meetings as a worst case for the minority of teachers.
Occupancy Period Outdoors (hours)	2	

No ingestion rates or soil-skin adherence factors specific to teachers could be sourced. These parameters are therefore defined for the age class based on the standard commercial worker model data from CLEA v. 1.06.

The air dispersion factors and the fraction of the site with hard or vegetative cover are based on a standard commercial building as this is considered the closest in size to the proposed school building and site area.

4.4.3 Groundskeeper/caretaker

The activity patterns of typical adult groundskeepers/caretakers are uncertain, however given the use of the facility at weekends there is a potential that an adult may frequent the site on a daily basis through the week for security and maintenance of school and grounds and also briefly at weekends to allow access to the appropriate facilities.

Table 4.5 below details the input parameters used and justification for each.

Table 4.5: Land Use and receptor Data – Groundskeeper/caretaker

Parameter	Value	Reference
Exposure Frequency (days/year)	230	Assuming a standard working year at full time assuming daily exposure to outdoor pathways (SR3, EA 2009). An allowance for additional weekend visits has not been included as these are most likely to be short and thus cannot be modelled within the same model as the full time working hours.
Occupancy Period Indoors (hours)	4.5	Standard working day for a commercial worker as per SR3, EA 2009 assuming a 45hour working week.
Occupancy Period Outdoors (hours)	4.5	

The values in the table above do not provide an ideal model of likely exposure frequency/duration but will be considered further within the sensitivity analysis.

No ingestion rates specific to groundskeepers/ caretakers could be sourced. However, the soil-skin adherence factors defined for a standard commercial worker are based on a groundskeeper (SR3, EA 2009) therefore these parameters are defined for the age class as per a standard commercial scenario, based on data from SR3 (EA, 2009).

The air dispersion factors and the fraction of the site with hard or vegetative cover are based on a standard commercial building as this is considered the closest in size to the proposed school building and site area.

4.4.4 Users of community facilities

Users of the community sports facilities are assumed to be children and adults of all ages, using the facility for community sports club training and matches and interschool sports matches. The critical users within this group are again unclear prior to modelling. Two scenarios have been modelled, one assuming very young children of primary school age (4-11 year olds) attending weekly sports clubs and a second scenario assuming secondary school children attending sports clubs twice a week.

Table 4.6 below details the input parameters used and justification for each.

Table 4.6: Land Use and receptor Data – Community Use

Parameter	Value	Reference
a. 4-11 year old		
Exposure Frequency (days/year)	39	Assuming 1 occasion per week during term time (39 weeks).
Soil-skin adherence factor outdoor (mg cm^{-2} day^{-1})	1	Residential scenario used as worst case.
Occupancy Period Indoors (hours)	0.5	Estimate based on: Indoor time assumed 0.5 hour for changing/washing etc. Outdoor assumed to include either warm-up and match or training. A review of after-school sports clubs has been undertaken and typically, training sessions for children aged 4-11yrs are 1hr long (see list of school links in references)
Occupancy Period Outdoors (hours)	1	
b. 11-16 year old		
Exposure Frequency (days/year)	78	Assuming 2 occasions per week during term time (39 weeks).
Soil-skin adherence factor outdoor (mg cm^{-2} day^{-1})	0.6	Estimate based on rugby player (USEPA 2004).
Occupancy Period Indoors (hours)	0.5	Estimate based on: Indoor time assumed 0.5 hour for changing/washing etc. Outdoor assumed to include either warm-up and match or training. A review of after-school sports clubs has been undertaken and typically, training sessions for children aged 11-16yrs are 1-2hr long (see list of school links in references)
Occupancy Period Outdoors (hours)	2	

No ingestion rates or indoor soil-skin adherence factors specific to sports fields could be sourced. These parameters are therefore defined for the age class based on data from SR3 EA2009.

The air dispersion factors and the fraction of the site with hard or vegetative cover are based on a standard commercial building as this is considered the closest in size to the proposed school building and site area, taking into account the height of the receptor.

4.5 Results from initial base models

Table 4.7 below summarises the site specific assessment criteria (SSAC) derived for each compound for each of the receptor groups.

Table 4.7: Summary of receptor target values for the base models

Compound	Site Specific Assessment Criteria (mg/kg)				
	School student	Adult Teacher	Adult Groundskeeper	4-11 yr old community user	11-16yr old community user
Benzo(a)pyrene	12	16	14	23	38
Benzo(a)anthracene	82	110	95	160	260
Nickel	2,500	3,000	3,600	17,000	36,000

There are a number of uncertain parameters involved in the derivation of these SSAC in particular for the groundskeepers and community use. A sensitivity analysis has been completed below to assess the significance of this uncertainty and allow a reasonable final model to be selected as the critical receptor and final SSAC for the site.

4.6 Sensitivity Analysis

A sensitivity analysis has been undertaken for each receptor group, detailed in the sections below. The sensitivity analysis has been completed using benzo(a)pyrene as the most critical contaminant identified on site.

The age classes for each receptor group have been defined based on the critical users within the group. Parameters for each age class are defined within the CLEA software and science reports. No alterations to these standard UK parameters have been made.

For each receptor group (with the exception of the community use outdoor scenario), no specific ingestion rates or soil-skin adherence factors could be sourced. These parameters were all therefore defined for each age class based on data within CLEA v. 1.06. These parameters are not included within the sensitivity analysis as they are defined from the most appropriate UK guidance available.

The air dispersion factors and the fraction of the site with hard or vegetative cover are based on a standard commercial building as this is considered the closest in size to the proposed school building and site area. These parameters are not included within the sensitivity analysis as they are defined from the most appropriate UK guidance available.

Uncertain parameters are discussed and reasonable final model inputs selected.

4.6.1 School student and teacher

The only uncertain and variable parameters within these models are the occupancy times and exposure frequency. Although the exposure frequency is set at 190 days/year for pupils and 195 days/year for teachers as the standard UK school year, the pitches are proposed to be used by the community outside school hours. Therefore it is likely that a student who attends the school may return at weekends for sports activities.

The attendance on site during weekends is likely to be of limited duration perhaps only a maximum of 3hrs per weekend for a training session and sports match. This additional site time is difficult to model within the CLEA model as the number of hours per day is set the same for each day attending site. To try and allow for this extra time on site, an estimate of total hours per year on site has been made assuming the standard school year along with an additional allowance for short weekend visits. This has then been adapted into 2 models, one adding the extra site time onto the standard school days (i.e. 190 days/per year at an extended occupancy period) and a second model assuming reasonable maximum number of days attendance with the total hours on site divided by this extended exposure frequency.

The student model is more conservative than the teacher model as the occupancy period is the same variable for both models, only the student model has therefore been considered further within the sensitivity analysis.

A summary of the analysis for the school student receptor is provided in Table 4.8 below detailing the range of input parameters and the effect of altering each on the resultant SSAC. The Base Model SSAC was 12mg/kg.

Table 4.8: Sensitivity Analysis – School Student

Parameter	Base model	Range	Resultant SSAC for range (mg/kg)	Reference
Occupancy Period (hours/day)	7 hrs indoors, 2hrs outdoors	5hrs indoors, 2hrs outdoors	13	Base model: 5 hours per day indoors and 2 hours per day outdoors through the basic school day (ECETOC 2001) plus an additional 2 hours indoors per day for after school clubs. Range: 5hrs indoors, 2hrs outdoors - ECETOC 2001 guidance with no after school allowance; 5hrs indoors, 4hrs outdoors – ECETOC 2001 guidance plus an additional 2hrs outdoors 9 hours indoors as worst case.
		9hrs indoors	11	
		5hrs indoors, 4hrs outdoors	13	
Exposure Frequency (days/year) and Occupancy Period (hours/day)	190 days/yr with 7hrs indoors, 2hrs outdoors	190 days/yr with 7.3hrs indoors and 2.5hrs outdoors*	12	Base model: Assuming the standard UK school year Range: Assuming additional weekend visits of 3hrs (2hrs outdoors, 1hr indoors) once a week throughout the year. Total hours/yr = 190daysx9hrs +52daysx3hrs = 1866 hours/yr (assuming 1382hrs/yr indoors, 484hrs/yr outdoors). A. 190 days at 9.8hours/day (1866hrs/yr divided by 190 days) - including 7.3hrs/day indoors, 2.5hrs/day outdoors. B. 242days at 7.7hours/day (1866hrs/yr divided by 242 days) – including 5.7hrs/day indoors, 2hrs/day outdoors.
		242 days/yr with 5.7hrs indoors and 2hrs outdoors*	10	

**assuming 7hrs indoors and 2hrs outdoors during a school day and 1hr indoors, 2hrs outdoors during a weekend visit as an assumed worst case*

The occupancy period alone makes limited difference to the SSAC.

The variations in exposure frequency and occupancy period based on the potential for a student at the school to attend a weekend leisure visit have slightly reduced the SSAC when considering the maximum number of days attendance. The base model of 9hrs per day over the standard term time of 190days is considered reasonable for the student receptor. However, it is possible that a high proportion of children who attend the school and live in the local community will attend weekly sports classes during term times and holidays. Therefore it is considered more appropriate for the final model to consider the school student who also attends a sports class once every weekend throughout the year to add a degree of conservatism. The more conservative of the two scenarios modelled will be adopted as the final model.

4.6.2 Groundskeeper/Caretaker

No specific time activity data has been identified for school groundskeepers and as such the nature and duration of activities are highly uncertain.

It is assumed that as a minimum a groundskeeper/caretaker will be employed for a standard working year of 230 days/year, 9 hours per day as defined for a standard UK commercial worker (SR3 EA, 2009). It is considered highly unlikely that a groundskeeper would be working longer hours than this thus 9 hours is considered a conservative maximum for the length of the working day.

Given that the site is to be used at weekends as well as during the working week, it is possible that a groundskeeper may also have responsibility for attending site to provide access to facilities for club use at the weekend. This attendance on site is likely to be of limited duration perhaps only a maximum of half an hour each day. This additional site time is difficult to model within the CLEA model as the number of hours per day is set the same for each day attending site. To try and allow for this extra time on site, an estimate of total hours per year on site has been made assuming the standard working year along with an additional allowance for short weekend visits. This has then be adapted into 2 models, one adding the extra site time onto the standard working days (i.e. 230 days/per year at an extended occupancy period) and a second model assuming reasonable maximum number of days attendance with the total hours on site divided by this extended exposure frequency.

A summary of the analysis is provided in Table 4.9 below detailing the range of input parameters and the effect of altering each on the resultant SSAC. The Base Model SSAC was 14mg/kg.

Table 4.9: Sensitivity Analysis – Groundskeeper/Caretaker

Parameter	Base model	Range	Resultant SSAC for range (mg/kg)	Reference
Occupancy Period (hours/day)	4.5hrs indoors, 4.5hrs outdoors	6hrs indoors, 3hrs outdoors	14	Base model: Standard 9 hour working day (EA 2009) with estimated split of 50%indoor, 50%outdoor.
		3hrs indoors, 6hrs outdoors	15	Range: indoor/outdoor time varied to 1/3indoors, 2/3outdoors and 2/3 indoors, 1/3outdoors

Parameter	Base model	Range	Resultant SSAC for range (mg/kg)	Reference
Exposure Frequency (days/year) and Occupancy Period (hours/day)	230 with 4.5hrs indoors, 4.5hrs outdoors	269d/yr with 7.8hours/ day	13	Base model: Standard working year at full time, assuming daily exposure to outdoor pathways and standard 9 hour day, estimated split of 50%indoor, 50%outdoor. Range: Assuming additional term time weekend visits of 0.5hr once a week. Total hours/yr = 230daysx9hrs +39daysx0.5hrs = 2090 hours/yr. A. 269 days at 7.8hours/day (2090hrs/yr divided by 269 days). B. 230days at 9.1hours/day (2090hrs/yr divided by 230 days).
		230d/yr with 9.1hours/ day	14	

Occupancy period and exposure frequency makes only a minor difference to the SSAC. Although the increased exposure frequency is likely to represent a worst-case estimate of exposure for this receptor group, this is considered to be an overly-conservative estimation of exposure time.

The base model is considered to have a reasonable degree of conservatism built in through the long working day assumed. The base model inputs will therefore be maintained for the final SSAC model.

4.6.3 Users of community facilities

The critical users within this group and activity patterns are unclear and as such, two scenarios were modelled, one assuming primary school age children (4-11 year olds) attending weekly sports clubs and a second scenario assuming secondary school children attending sports clubs twice a week.

The main variables for these models are the exposure frequency (e.g. No of training session/matches per week), occupancy period (how much time is spent on site indoors and outdoors during each visit) and the outdoor soil-skin adherence factor.

A summary of the analysis is provided in Table 4.10 below detailing the range of input parameters and the effect of altering each on the resultant SSAC.

Table 4.10: Sensitivity Analysis – Community Sports Field User

Parameter	Base model	Range	Resultant SSAC for range (mg/kg)	Reference
4-11 yr old (Base Model SSAC = 23mg/kg)				
Exposure Frequency (days/year)	39	52	17	Base model: assumed once a week during term time. Range: 52 – once per week throughout the year; 78 –twice per week during term time; 104 – twice per week throughout the year.
		78	12	
		104	8.7	

Parameter	Base model	Range	Resultant SSAC for range (mg/kg)	Reference
Soil-skin adherence factor outdoor (mg cm^{-2} day^{-1})	1	0.6	27	Base model: Residential scenario used as worst case. Range: 0.6 - rugby player (USEPA 2004); 0.3 - soccer player (USEPA 2004).
		0.3	31	
Occupancy Period (hours/day)	0.5hr indoors, 1hr outdoors	0.5hr indoors, 2hr outdoors	22	Base model: based on typical lengths of after-school sports activities following a review of UK Primary School sports programmes. Range: 2hr outdoor considered maximum likely for training or sports match for this age group.
11-16 yr old (Base Model SSAC = 38mg/kg)				
Exposure Frequency (days/year)	78	39	76	Base model: assumed twice a week during term time. Range: based on typical practises per week of after-school sports activities following a review of UK Secondary School sports programmes 39 - once a week during term time; 52 – once a week throughout the year; 104 – twice per week throughout the year; 117 – three times per week during term time.
		52	57	
		104	28	
		117	25	
Soil-skin adherence factor outdoor (mg cm^{-2} day^{-1})	0.6	1 for age class 12, 0.3 for age classes 13-16	43	Base model: rugby player (USEPA 2004). Range: 1 and 0.3 - standard residential values for age classes (SR3 EA2009); 0.3 - soccer player (USEPA 2004).
		0.3	48	
Occupancy Period (hours/day)	0.5hr indoors, 2hr outdoors	0.5hr indoors, 3hr outdoor	38	Base model: estimate for this age group. Range: 3hr outdoor considered maximum likely for training plus a sports match.

In completing the sensitivity analysis process it is clear that the 4-11 year receptor group is the more sensitive of the two age groups modelled. The 11-16 year will therefore not be discussed further.

Occupancy period makes only a minor difference to the SSAC. The base model input is considered a reasonable exposure assumption for the age group and as such will be retained in the final model.

The soil to skin adherence factor makes a significant difference to the model. The base model input is considered over conservative for the proposed use of the site, however in the absence of any other age and activity specific guidance, the conservative end of the range will be retained for the final models.

The main influence on the model output is the exposure frequency. The base model of 1 visit per week during term time is considered reasonable for the 4-11yr old receptor as at this age it is considered unlikely that more frequent off-site trips (away from their own primary school) will be made for organised activities. It is possible that children may also visit the site during holidays however, thus a frequency of once a week throughout the year may be more appropriate and will be used for the final models to add a degree of conservatism.

4.6.4 Summary of Sensitivity Analysis

The sensitivity analysis has shown the most uncertain and sensitive parameter for most models to be the exposure frequency. This is reasonably well defined for the basic student and teacher models but is harder to define within the CLEA model for possible short duration additional weekend exposure.

Minor amendments are considered appropriate to the previously defined base models to provide an estimate of reasonable maximum exposure for each receptor. These changes are detailed in 4.6.1-4.6.3 above and the SSAC derived using the final models for each receptor are summarised in Table 4.11 below. The final model output sheets from CLEA v1.06 are provided in Appendix D.

Table 4.11: Summary of receptor target values for the revised base models

Compound	Site Specific Assessment Criteria (mg/kg)			
	School student	Adult Teacher	Adult Groundskeeper	4-11 yr old community user
Benzo(a)pyrene	10	16	14	17
Benzo(a)anthracene	69	110	95	120
Nickel	2,400	3,000	3,600	13,000

The school student has been identified as the most conservative of the receptor groups.

The sensitivity analysis was completed for benzo(a)pyrene only. In order to confirm that this analysis is appropriate for the other contaminants of concern, the %contribution to the SSAC from each pathway has been assessed. The sensitivity analysis can be assumed appropriate for all contaminants with similar pathway contributions. Table 4.12 below compares the pathways for each of the contaminants of concern for the school student model.

Table 4.12: Contaminant Pathways

Pathway (%)	Benzo(a)anthracene	Benzo(a)pyrene	Nickel
Soil ingestion	58.3	58.3	48.5
Dermal indoor	3.89	3.89	0.12
Dermal outdoor	37.7	37.7	1.20

Pathway (%)	Benzo(a)anthracene	Benzo(a)pyrene	Nickel
Inhalation of dust (indoor and outdoor)	0.15	0.15	0.12
Inhalation of vapour (indoor and outdoor)	0.00	0.00	0.00
Oral Background	0.00	0.00	49.9
Inhalation Background	0.00	0.00	0.03

Soil ingestion is the dominant pathway for both benzo(a)pyrene and benzo(a)anthracene with oral background being the dominant pathway for nickel. With the exception of background levels the dominant pathway for nickel is also soil ingestion, therefore the relative sensitivity of parameters identified for benzo(a)pyrene will be the same as that identified for benzo(a)anthracene and nickel.

The most sensitive receptor exposure scenario identified is the Student Model 2. CLEA v. 1.06 models used in this assessment are included in Appendix D.

4.7 Final Model

Based on the sensitivity analysis and model runs described above, the most sensitive, realistic exposure scenario is considered to be the student receptor who also visits the site every weekend to attend a sports class. This model has been selected as the final model for specification of site specific assessment criteria for the material at St. Ambrose.

Table 4.13 below details the final model exposure parameters used for the most sensitive receptor at the site.

Table 4.13: School Student (11-16yrs)

Parameter	Value used in Model	Units	Reference
Exposure frequency	242	events/ year	Assuming school student and user of the sports facilities for 1 visit per week.
Occupancy Period	5.7 indoors 2 outdoors	hours	Standard school day (ECETOC, 2001) with an additional 2hrs per day indoors to allow for extracurricular activities.
Soil ingestion rates	0.1 (AC 12) 0.05 (AC 13-16)	g/day	SR3, EA 2009
Adherence of soil to skin (outdoor)	1 (AC 12) 0.3 (AC 13-16)	$mg/cm^2 day^{-1}$	SR3, EA 2009
Adherence of soil to skin (indoor)	0.06	$mg/cm^2 day^{-1}$	SR3, EA 2009

Table 4.14 below shows the site specific assessment criteria (SSAC) derived using the final model parameters in comparison to the representative site concentrations

(95th percentile from each stratum) for each contaminant of concern at St. Ambrose. The CLEA model output sheets are provided in Appendix D.

Table 4.14: Final model SSAC

Compound	SSAC (mg/kg)	Representative site concentrations (mg/kg)		Identified hotspot concentrations
		Topsoil	Landfill Materials	Landfill Materials*
Benzo(a)pyrene	10	5.4	2.3	NA
Benzo(a)anthracene	69	8.6	2.6	NA
Nickel	2,400	NA	98	660

**No hotspots of benzo(a)pyrene, benzo(a)anthracene or nickel were identified in topsoil material*

None of the representative site concentrations or identified hotspot concentrations exceed the SSAC. Based on the available data it is therefore considered unlikely that the material at the St. Ambrose site will pose a significant risk to human health if the site is developed as a school as per current proposals.

5 SUMMARY AND RECOMMENDATIONS

Impacts were identified during the GQRA (RUK 2010) which were considered to pose a possible risk to human health based on the proposed development of the site as a high school with associated sports pitches, soft landscaping and car parking. Elevated concentrations of benzo(a)pyrene were identified in the topsoil and landfill material across the site, elevated concentrations of benzo(a)anthracene were identified in the topsoil material and a hotspot of nickel was identified in the landfill material.

5.1 Detailed Human Health Risk Assessment

A detailed human health exposure assessment has been carried out to assess the potential significance of these elevated compounds in soil in relation to the proposed use of the St. Ambrose site.

Not only will the site be used as a school for students aged 11-18yrs, the sports pitches will also be available for organised community use and there will be a right of way through the school grounds for the general public. Therefore, there are uncertainties in the likely user exposure at this site. Variability of exposure has been considered within a detailed sensitivity analysis for different receptor groups and different exposure scenarios for each group.

The assessment and sensitivity analysis indicates that a school student, who also attends a sports class each week, is likely to be the critical receptor. This frequent exposure model was identified as the most conservative of the estimated exposure models. This model is considered to present a reasonable maximum exposure scenario for likely user exposure to impacted soils at the site; this includes for, *inter alia,* teachers, community site users and groundskeepers.

5.2 Conclusions

The reasonable worst case exposure model has calculated site specific assessment criteria (SSAC) as detailed in Table 4.14

None of the representative site concentrations of benzo(a)pyrene, benzo(a)anthracene or hotspot concentrations of nickel from the St. Ambrose site exceed these SSAC. This suggests that, based on the assumptions made in the development of the conceptual site model and existing chemical data reported; the St. Ambrose site would be suitable for use as a school with community facilities to be used by the general public within the context of the scenarios modelled. The SSAC developed are considered suitable for all uses and areas of the site thus there will be no specific material management precautions required with regards to benzo(a)pyrene, benzo(a)anthracene or nickel.

However, the recommendations made in the Generic Quantitative Risk Assessment (RUK, 2010) should also be adhered to in order to ensure any residual risks to Human Health are mitigated. These recommendations include:

1. Limited remediation (e.g. excavation and disposal of localised areas of elevated inorganic contaminants should further validation testing prove these materials are unsuitable for reuse);
2. Incorporation of specific design measures (e.g. gas protection measures to mitigate risks posed by ground gases); and
3. Risk management during development (e.g. development of an environmental specification and a watching brief during development to validate conformance to the environmental specification).

6 REFERENCES

BRE 2004. *Cover Systems For Land Regeneration*.

DEFRA and the Environment Agency, 2002 TOX2 *Contaminants in soil: updated collation of toxicological data and intake values for humans. Benzo(a)pyrene* SC050021/TOX1 (April, 2002)

ECETOC 2001 *Exposure Factors Sourcebook for European Populations (with focus on UK Data)* Technical Report No. 79

Environment Agency, 2009a SR2 *Human Health toxicological assessment of contaminants in soil* SC050021/SR2 (January 2009)

Environment Agency, 2009b SR3 *Updated technical background to the CLEA model* SC050021/SR3 (January 2009)

Environment Agency, 2009c SR4 *CLEA Software (Version 1.05) Handbook* SC050021/SR4 (September 2009)

Environment Agency, 2009d *CLEA Software (Version 1.06)* (September 2009)

Environment Agency, 2009e *Soil Guideline Values for Nickel in Soils: SC050021 / Nickel SGV* (March 2009)

Environment Agency, 2009f TOX 8 *Contaminants in soil: Updated collation of toxicological data and intake values for humans, Nickel: SC050021/Tox 8* (May 2009)

USEPA, 2004a *Additional and current dermal absorption fraction values for soil (ABSd)* (Supplementing Exhibit 3-4 of Part E) [online]
Available from www.epa.gov/oswer/riskassessment/ragse/index.htm

USEPA, 2004b *Risk Assessment Guidance For Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance For Dermal Risk Assessment).* Interim Review Draft For Public Comment, EPA/540/R/99/005.

School Links:

A review of various after-school sports programmes for children of Primary School (4-11yrs) and High School (11-16yrs) ages was undertaken to establish the typical frequency and duration of after-school sports activities. This list is not exhaustive.

Gospel Oak Primary School, London
http://www.gospeloak.camden.sch.uk/parents/clubs/clubs.htm

Woodlands Community College, Derby
http://www.woodlands.southampton.sch.uk/school/extracurricular_students.html

Harefield Primary School, Southampton
http://www.harefield-pri.southampton.sch.uk/school/index/htm

Bitterne Manor Primary School, Southampton
http://www.bitternmanor.southampton.scho.uk/school/clubs/htm

Regents Park Community College, Hampshire
http://www.regentsparkcollege.org.uk/folders/curriculum/physical_education_amp_dance/extra_curricular_timetable/

Redbridge Community High School
http://www.school-portal.co.uk/GroupHomepage.asp?GroupID=52681

Appendix A

Drawings and Figures

Notes

Rev	Description	Date	By Chk	App

INFORMATION

ST AMBROSE

RAMBOLL

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www.ramboll.co.uk

PROPOSED SITE LAYOUT PLAN

Scale:	Date:	Drawn:	Checked:
1:1000 @ A1	NOV 2009	JH	ZM

Drawing No.:	Rev:
5311/E/002	I01

Notes

Rev	Description	Date	By / Chk	App

INFORMATION

ST AMBROSE

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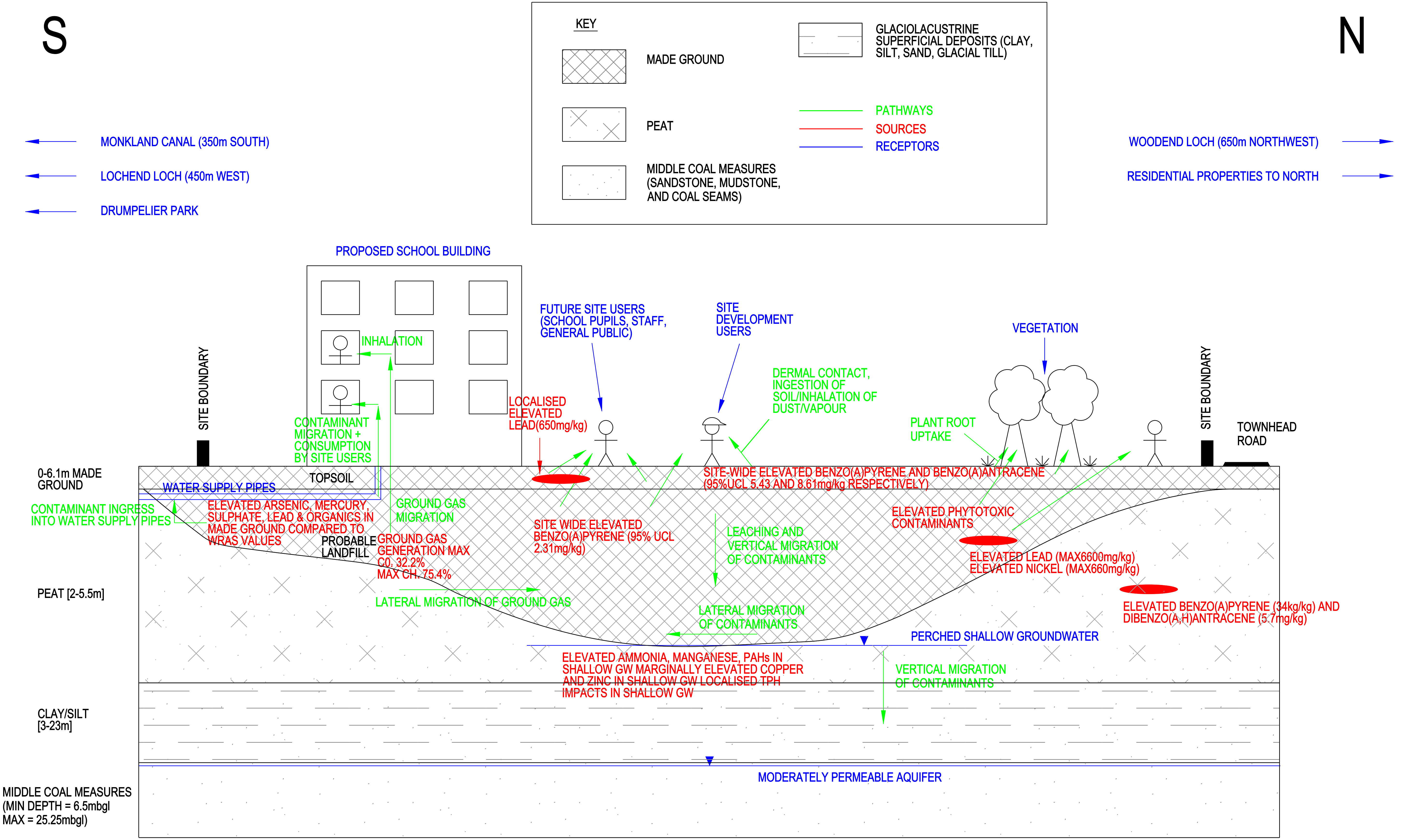
CURRENT SITE LAYOUT
(EXISTING SITE LEVELS)

Scale:	Date:	Drawn:	Checked:
1:1000 @ A1	NOV 2009	JH	ZM

Drawing No.:	Rev:
5311/E/003	I01



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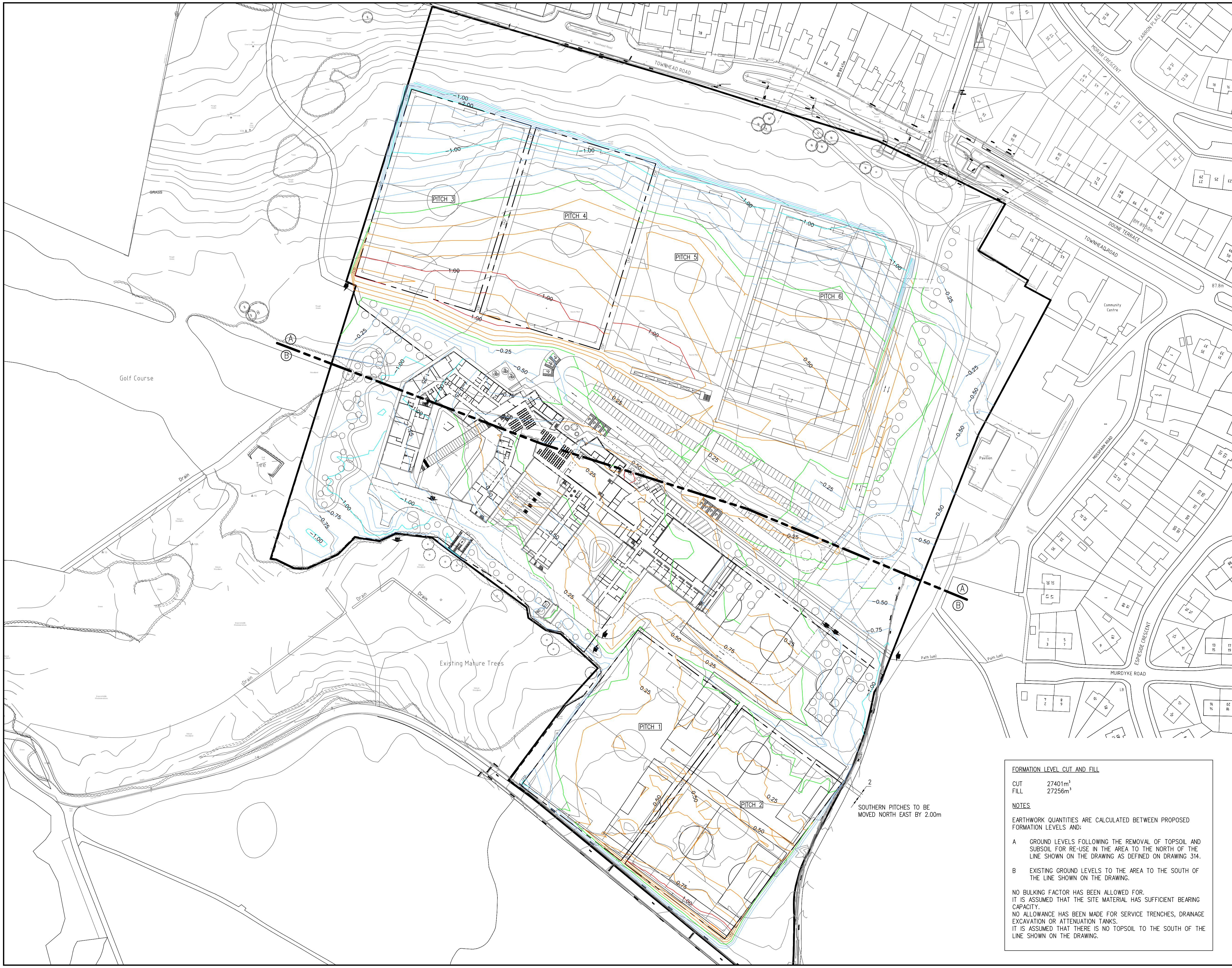
ST AMBROSE

CONCEPTUAL SITE MODEL

Rev	Description	Date	By / Chk	App

Scale:	Date:	Drawn:	Checked:
NTS	NOV 2009	JH	ZM

Drawing No.:	Rev:
5311/E/004	I01



FORMATION LEVEL CUT AND FILL

CUT 27401m^3
FILL 27256m^3

NOTES

EARTHWORK QUANTITIES ARE CALCULATED BETWEEN PROPOSED FORMATION LEVELS AND;

A GROUND LEVELS FOLLOWING THE REMOVAL OF TOPSOIL AND SUBSOIL FOR RE-USE IN THE AREA TO THE NORTH OF THE LINE SHOWN ON THE DRAWING AS DEFINED ON DRAWING 314.

B EXISTING GROUND LEVELS TO THE AREA TO THE SOUTH OF THE LINE SHOWN ON THE DRAWING.

NO BULKING FACTOR HAS BEEN ALLOWED FOR.
IT IS ASSUMED THAT THE SITE MATERIAL HAS SUFFICIENT BEARING CAPACITY.
NO ALLOWANCE HAS BEEN MADE FOR SERVICE TRENCHES, DRAINAGE EXCAVATION OR ATTENUATION TANKS.
IT IS ASSUMED THAT THERE IS NO TOPSOIL TO THE SOUTH OF THE LINE SHOWN ON THE DRAWING.

Notes

1. THIS DRAWING IS NOT TO BE SCALED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTURAL DRAWINGS, STRUCTURAL AND M&E DRAWINGS.
3. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH RAMBOLL 300 SERIES DRAWINGS.

FORMATION LEVELS BASED ON THE FOLLOWING CONSTRUCTION DEPTHS:

FFL / FORMATION LEVEL	980	BUILDING MAKE-UPS
PROPOSED GROUND LEVEL / FORMATION LEVEL	450	ROAD MAKE-UPS
PROPOSED GROUND LEVEL / FORMATION LEVEL	250	PATH AND YARD MAKE-UPS
PROPOSED GROUND LEVEL / FORMATION LEVEL	600	LANDSCAPING MAKE-UPS
PROPOSED GROUND LEVEL / FORMATION LEVEL	385	SAND PITCH MAKE-UPS PITCH 1
PROPOSED GROUND LEVEL / FORMATION LEVEL	360	SYNTHETIC PITCH MAKE-UPS PITCHES 2,3&4
PROPOSED GROUND LEVEL / FORMATION LEVEL	250	GRASS PITCH MAKE-UPS PITCHES 5&6

KEY

- PRIMARY FILL CONTOUR (1.00m)
- SECONDARY FILL CONTOUR (0.25m)
- ZERO CUT FILL CONTOUR
- PRIMARY CUT CONTOUR (1.00m)
- SECONDARY CUT CONTOUR (0.25m)
- SITE BOUNDARY

Rev	Description	Date	By / Chk	App
P01	FIRST ISSUE	26/11 2009	VCH / LF	RH

PRELIMINARY

ST AMBROSE HIGH SCHOOL & DRUM PARK ASN

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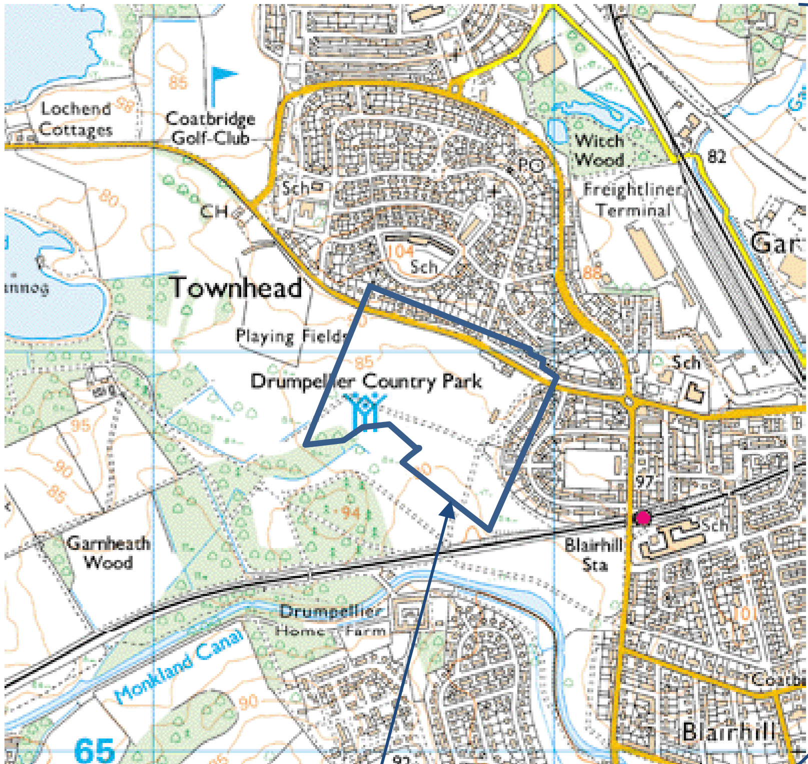
PROPOSED FORMATION LEVEL ISOPACHYTE CONTOURS

Scale:	Date:	Drawn:	Checked:
1:1000@A1	NOV. 2009	VCH	LF

Drawing No.:	Rev:
NLC-STA-DRG-C-316	P01

Figure 2.1
Site Location Plan



Approximate Site Boundary

Site Address:
Site of Proposed St Ambrose High School
Townhead Road
Coatbridge
ML5 2HU

Approx. NGR: 271546, 665970