Appendix B

Correspondence with North Lanarkshire Council / WSP

Your ref: TBD
Our ref: [redacted]

17th November 2008

[redacted]

[redacted]

Report Review – Proposed St. Ambrose High School

Further to our review of the ground investigation report relating to the proposed St. Ambrose High School site located at the Townhead Road football pitches in Coatbridge, North Lanarkshire, WSP Environmental Ltd (WSPE) is pleased to provide the following comments.

The following report was provided for review:

- Proposed St. Ambrose High School – Ground Investigation Report. URS Corporation Limited (URS), October 2008 (Ref #: 49339729)

The investigation report was prepared for the purposes of assessing the contamination, ground gas, and mineral stability at the site to determine any risks to proposed redevelopment of a high school, as well as providing geotechnical information to inform foundation design. URS notes that the report is not intended to cover all aspects required for detailed design of the development.

Detailed development plans were not included in the report, as it is understood development plans are still in progress.

Comments on the report are provided below, followed by overall conclusions and recommendations. It should be noted that, for this review, WSPE has concentrated solely on the environmental aspects of the report. The geotechnical content (including mineral stability sections) of this report will be reviewed and commented on under a separate review letter to be provided in the future.

Ground Investigation

Summary of Report

Previous Reports

URS completed a Desk Study Report for the site in 2005 and a Preliminary Ground Investigation in 2006. URS indicates these previous reports were reviewed to provide background information for the current investigation.

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Site Information

- The site is located to the northwest of Coatbridge and is bounded by Townhead Road to the north, a community centre and pavilion to the east, Drumpellier Park to the south and a golf course to the west.
- URS reports that the site, as investigated, occupies approximately 13.5 ha in area. They note the area of the current investigation differs from that of the preliminary investigation undertaken in 2006.

Desk Study Information

- Through historical map review, URS reports that the site was historically associated with coal mining, until after the 1930s, when the site was utilised as a landfill. The establishment of sports pitches on the site occurred in the 1970s.
- NLC records indicate that the Townhead Landfill started in 1945 and closed in 1972. During the period of operation an estimated half million tonnes of domestic refuse from Coatbridge was deposited at the site. In addition to this, 77,000 gallons of wet sewage and unspecified residue from Gartsherrie Steel Works were disposed of annually for an indeterminate period.
- Anticipated ground conditions were based on the 2006 investigation, including topsoil overlying made ground, over peat, over Lower Lacustrine deposits, over glacial till, over bedrock.
- The site was reported to be underlain by coal seams at shallow depths, with areas of recorded workings in multiple seams beneath the site. These have been considered potential mineral instability issues by URS. URS reviewed mine abandonment plans and commented on the general coal stratigraphy. One historical mine shaft was identified as being in the northeast of the site, with an additional historical entry adjacent to the site boundary, approximately 20m off-site to the southeast. URS considered that the presence of unrecorded entries on site could not be discounted.
- URS's review of the Groundwater Vulnerability Map of Scotland (1995) indicates that the bedrock strata beneath the site is moderately permeable fractured or potential fractured rocks that do not have a high primary permeability, or other formations of variable permeability.
- With regards to hydrology, URS identified several drains located to the southwest of the site, Lochend Loch ~500m to the west of the site, and Woodend Loch ~800m to the northwest of the site, and Monklands Canal ~350m to the south of the site. URS does not reference water quality ratings of these water features in this report.
- URS's preliminary CSM identifies contaminated materials associated with historical landfill and mining operations, unknown fill materials, and peat as potential on-site sources; existing and historical railway lines, mineral railway, and a hospital as potential off-site sources; dermal contact, ingestion, inhalation, leaching to surface/ground water, migration of contaminants in surface/groundwater, generation of ground gasses, root uptake, and uptake by aquatic fauna as pathways; and human health, shallow groundwater in superficial deposits, deeper groundwater in bedrock, nearby surface waters, ecological receptors, construction materials, and nearby building structures as potential receptors.

Site Investigation and Sampling Strategy

- Works were carried out between June and August 2008 and included 105 trial pits, 26 cable percussive boreholes, and 10 rotary (open-hole) boreholes. Additionally, 21 cone penetration tests were carried out primarily for geotechnical purposes.
- Groundwater/ground gas monitoring standpipes were installed in 26 boreholes.
- URS reports that a total of 27 made ground and 19 natural soil samples were submitted for laboratory analysis, comprising a suite of heavy/phytotoxic metals, sulphide, sulphur, pH, speciated PAHs, total phenols, TPHCWG, and VOCs. Ten groundwater samples were retained from site and were analysed for the above parameters, as well as ammonical nitrogen, nitrate/nitrite, chloride, manganese, and dissolved organic carbon. WSPE has reviewed the analytical results in the appendices and approximates actual sampling delivery as follows:
  - Soils: 57 samples submitted to laboratory, with 41 analysed for metals/inorganics, 36 for TPH, 41 for PAHs, and 3 for VOCs.
  - Leachates: 17 soil samples analysed for leachable metals/inorganics and PAHs, 15 analysed for TPH.
  - Groundwater: 10 samples all analysed for metals/inorganics, PAHs, and TPH.
- Asbestos sampling was carried out on 13 made ground samples.
- URS states non-targeted sampling was applied in selecting analytical testing as final development layout has not been determined.

Site Investigation Findings

- The investigation identified ground conditions similar to those identified in 2006. Made ground was found at surface or underlying topsoil, and noted thickness was between 0.45m and 8.3m. Made ground comprised clayey gravelly sand with ash and various debris. Peat was found underlying the made ground in primarily the central portion of the site, between 0.3m and 5.5m thick where noted, and considered very fibrous with little decomposition noted. Natural materials noted at site underlying the made ground/peat included Lower Lacustrine deposits (sandy gravelly silt) and glacial till (stiff sandy gravelly clay). Bedrock was located between 7.4 and 14.7m bgl and noted to comprise sandstone, mudstone and coal with evidence of worked horizons.
- Groundwater strikes were noted while advancing boreholes between 2.9m and 14.2m bgl in 13 boreholes, and between 1.9m to 4.0m in 44 trial pits. Standing water levels in boreholes, where noted, ranged between 2.2 and 8.1m bgl.

Mineral Stability Assessment

- URS's mineral stability assessment will be reviewed and commented on by WSPE under separate letter report.

Chemical Testing Results and Assessment

- Chemical analysis results for human health risk assessment have been compared to Generic Screening Criteria (GAC) values reflecting a residential without plant uptake end-use. URS notes this is conservative in relation to the proposed end-use as a school, as less exposure would be expected compared to residential use.
- No statistical assessment of sample results was undertaken (such as calculating the upper 95th percentile of contaminant populations in line with CLR7) due to URS considering the made ground materials heterogeneous and not expected to follow standard distribution.
- URS's soil GACs appear to be based on published Soil Guideline Values (SGVs) where available; however, no information is provided about the methodology, modelling software, and input parameters used to derive GACs.
- Leachate and groundwater results are screened against firstly against UK Environmental Quality Standards (EQS) for freshwater, with UK Drinking Water Standards used where EQS values are not available. URS notes that multiple screening levels of EQS have been applied based on hardness and sensitivity of aquatic life.
- Made ground and natural material populations are assessed separately. Historical samples (from the 2006 investigation) do not appear to be included in the assessment.
- Exceedances of arsenic, lead, nickel, total cyanide, benzo(a)pyrene, and dibenzo(ah)anthracene were noted in made ground soil samples in multiple locations.
- A smaller number of exceedances were noted for arsenic, chromium, lead, nickel, TPH aromatics EC21-EC35, and TCE in natural soils.
- No asbestos detections were noted in those made ground samples submitted for analysis.
- Leachate exceedances included cadmium (1 location), sulphate (1 location), and phenols (6 locations) out of 16 leachate samples. Groundwater exceedances included manganese (10 locations), nitrite (2 locations), ammonical nitrogen (9 locations), TPH (2 locations), fluoranthrene (3 locations), benzo(a)anthracene (3 locations) and benzo(a)pyrene (6 locations) out of 10 groundwater samples.
- In assessing risks to human health, URS considered that the majority of the soil exceedances occurred at depths greater than 1m in depth and were thus too deep to allow direct contact/ingestion and not a risk for the final development. For those exceedances noted within 1m of surface (arsenic, lead, nickel, and benzo(a)pyrene), URS reported that these were marginal exceedances, and note that the screening values used (representing residential end-use) are most likely over-conservative for school use. URS reports that all exceedances of residential screening values are less than screening values representing a commercial/industrial end-use. Direct contact from groundwater is not expected due to recorded depths.

- URS recommends standard PPE for construction workers and considers overall risks to human health low.
- In assessing risks to the water environment, URS considers the following:
  - That cadmium, sulphate and phenol are the only completed pollutant linkages on site (soil leachable contaminants mobilising to the groundwater).
  - Ammonium and manganese are generated by the breakdown of organic components of landfill waste, and are expected to diminish over time due through capillary action due to lack of lining and with consideration that the landfill was closed in the 1970s, indicating a diminishing source. Due to the distance to sensitive receptors (350m and greater), URS considers that the manganese and ammonium would not negatively impact these receptors due to attenuation and dilution over this distance and the landfill materials being a limited, diminishing source.
  - The remaining exceedances (nitrite, fluoranthene, benz(a)anthracene, benzo(a)pyrene and TPH fractions) are considered localised, and are expected to be retained in the perched waters on-site due to the underlying cohesive silt and clay deposits, which URS believes will prevent migration to the underlying bedrock aquifer.
  - Further, these cohesive deposits are expected to diminish lateral movement of contaminants, and infiltration is expected to reduce with the placement of hardstanding and foundations on site following development plans.
- Contaminant concentrations were compared to Water Regulations Advisory Scheme (WRAS) guidance. Due to concentrations of multiple contaminants exceeding screening values, URS recommends wrapped iron pipe upgrades for water supply pipes. In areas of site considered above the water table, URS considers that over-excavated, double width trenches backfilled with inert fill would allow standard HDPE pipes. URS notes placing pipes in soils contaminated with arsenic is considered unacceptable without remediation of the soils, such as soil removal.
- Based on sulphate and pH concentrations in the soil compared to BRE guidance, URS recommends DS-3, AC-4 design class for concrete at the site.
- With regards to cut and fill for development purposes, URS recommends that areas of higher contaminant leachability noted in the report should be avoided unless being placed on top of already contaminated soils; and further recommends that a scope for assessment of materials intended for re-use be agreed with NLC.

Ground Gas Assessment

- Ground gas monitoring was carried out on four occasions over a 3-week period. A total of 26 boreholes were monitored.
- Monitoring was carried out by Raeburn Drilling.
- Methane was detected at concentrations up to 68.7% v/v and carbon dioxide up to 30.2% v/v. Depleted oxygen was recorded in several boreholes.

- URS queries the flow rates provided by Raeburn (all 0.0 L/hr on all occasions) due to the nature of the made ground/peat materials, varying atmospheric pressures, and flow rates of up to 2.7 L/hr being recorded in URS's previous 2006 investigation.
- URS has assessed the gas data based on worst-case conditions following the Wilson and Card methodology (CIRIA C665), using the maximum methane recorded in recent monitoring and historical gas flow rates, and considers Characteristic Situation 4 representative of the gas regime, with recommended protection measures including proprietary gas resistant membranes and positively pressurised underfloor sub-space with monitoring facilities. URS suggests this be used for worst-case preliminary design, with 12 no. monitoring visits carried out over six months to allow a more robust assessment, following the recommended number of monitoring events in CIRIA C665.

Conclusions and Recommendations

- URS concludes/recommends that:
  - Overall risks to human health for the development are low;
  - A worst-case scenario of ground gas Characteristic Situation 4 should be assumed, with 6 more months of monitoring carried out. Also the potential need for passive gas-venting trench at the north boundary of the site should be evaluated after subsequent assessment;
  - Risks to closest water receptors are low due to distance and source concentrations, and that cohesive deposits underlying the site would limit contaminant migration, though they recommend that control measures be implemented during development to prevent creating new pathways,
- URS also provides conclusions for the continued site use as playing fields, including:
  - Risks to human health and the water environment from contaminants considered low;
  - That ground gas risks be further assessed to determine risks to adjacent properties;

WSPE Comment

Desk Study

- WSPE considers the coverage and conclusions of the desk study information included and the initial conceptual site model generally reasonable.

Methodology, Investigation, Chemical Testing, and Risk Assessment

- The spatial distribution of exploratory holes has been compared with best practice as outlined in BS 10175:2001. On a 13.5 hectare site, a total of 143 exploratory holes indicates that an average grid spacing of ~30m has been delivered in assessing ground conditions.

- Chemical testing sample distribution is lower. A total of 46 samples analysed from this site would indicate a sample has been analysed on an average grid spacing of ~54m, which would be considered reasonable following the definition of an "exploratory investigation" in BS10175.
- However, URS has indicated that for their evaluation of risks to human health, the made ground materials are considered heterogeneous (not following a normal distribution) and all chemical results are evaluated individually. In assessing risks to human health, those contaminants exceeding residential GAC but located greater than 1m bgl are considered by URS to not present a risk as no pathway is believed present. While URS acknowledges shallow exceedances are present, the contamination assessment (presented in Appendix J) of 24 made ground samples shows that only 7 samples were retained and analysed from a depth less than 1.0m, meaning that near-surface made ground samples have only been retained and analysed on an average grid spacing of ~140m. As near-surface contamination is considered the primary risk to human health, this spacing is not considered sufficient to provide confidence that a robust assessment of risks to human health has been carried out for near-surface contamination.
- Further, the omission of consideration of contamination at depth in assessing risks to human health contradicts that potential cut and fill may occur on-site for development.
- The residential GAC screening values presented by URS appear reasonable; however, supporting information of those derived values should be submitted.
- While the use of GAC based on residential end-use is a reasonable first tier of screening (and likely over-conservative for the proposed end use), URS's conclusion that contaminants pose a low risk to human health are based those noted exceedances being only "marginal" over residential GACs and less than commercial/industrial end use. However, neither of the exposure assumptions used to generate residential and commercial/industrial GACs would be applicable to the proposed end use, and considering risks low based exceedances only being "marginal" lacks quantified, supporting evidence. WSPE considers that undertaking DQRA for the generation of GAC screening values reflecting the proposed end use (with supporting information documentation of input parameters and assumptions) would be necessary to robustly assess risks to human health. It would be reasonable to carry this out only for those contaminants noted to exceed residential screening values.
- The evaluation of risks to nearby surface water features is queried. While it is reasonable to assume that the nearest surface water body (350m from site) is unlikely to be significantly affected by mobile contaminants travelling through the underlying geology, drains have been indicated as being present on the adjacent site to the southwest. No evaluation has been carried out of the ability of mobile contaminants to reach these drains and then potentially travel through these drains as a preferential pathway.
- While URS offers that the site-wide manganese and ammonia concentrations are expected to diminish over time due to dispersal, they then offer that migration of mobile contaminants would be limited laterally and downward due to the cohesive deposits noted on-site. It is not clear how dispersal and retention of mobile contaminants would occur simultaneously.
- URS's consideration that low permeability cohesive deposits would limit downward migration of contaminants to the bedrock aquifer is queried as:

  - WSPE considers that a known mine entry on site and shallow workings could allow a preferential pathway of downward migration.
  - Borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. For example, borehole log 110 indicates only 0.4m of glacial till overlying the bedrock, and log S311 indicates 0.7m.
- URS has not indicated if any potable water wells were identified in the vicinity of the site which may present a risk to human health through ingestion of contaminated groundwater.
- The use of double-width / over-excavated trenches would need to be confirmed as acceptable to Scottish Water to allow use of standard plastic water pipes on-site.
- The current ground gas risk assessment and recommendations are considered reasonable based on information available at present, and WSPE concurs additional monitoring and assessment should be carried out as recommended by URS.
- URS's recommendation that spatial consideration of leachable contamination be considered prior to re-use of materials on a cut/fill basis is not considered practical as only 18 leachate samples have been analysed from site, and URS has noted that the made ground materials are heterogeneous in nature. As such, a spatial understanding of material leachability is not well-defined at present. As such, the secondary recommendation that an agreed scope/frequency of sampling for determining re-usability is considered more reasonable in this scenario.

Recommendations

WSPE recommends the querying the issues identified above as follows:

- Justification that risks to human health from near-surface contamination have been sufficiently assessed spatially when it appears that only 7 near-surface samples (less than 1.0m deep) were retained and analysed over a 13.5 hectare site.
- Comment on potential risks to human health if of soils greater than 1.0m are exposed/relocated on site in cut and fill groundworks.
- While the use of GAC values based on residential end-use are considered a reasonable, albeit over-conservative, initial screen, concluding that risks to human health are low for the proposed development based on exceedances only being "marginal" lacks quantified supporting evidence. Further, the use of commercial/industrial GACs as a secondary screen is considered potentially under-conservative. As such, the derivation of appropriate screening values reflecting the proposed end use would be necessary to support the conclusion that risks to human health are low for the development. It would be reasonable to only carry this out for those contaminants which have been identified as exceeding residential-use GACs.

- Further information should be provided on the models, input parameters, and assumptions used to derive the generic assessment criteria values presented in the report, as well as any DQRA-based screening values derived following the above comment.
- Comment on the perceived ability of mobile contaminants to reach the drains noted on the adjacent site and whether or not these drains are considered a preferential pathway for reaching nearby surface water features.
- Comment on the ability for manganese and ammonia (with the former present 2 orders of magnitude above the presented GAC) to diminish over time when URS suggests that horizontal and lateral migration would be limited by underlying the cohesive deposits.
- Further consideration of the ability of the cohesive deposits to limit downward migration of contaminants to the bedrock aquifer if a known mine entry on site exists, and when borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. For example, borehole log 110 indicates only 0.4m of glacial till overlying the bedrock, and log S311 indicates 0.7m.
- Indicating if any potable water wells have been identified in the vicinity of the site which may present a risk to human health through ingestion of contaminated groundwater.
- The use of double-width / over-excavated trenches would need to be confirmed as acceptable to Scottish Water to allow use of standard plastic water pipes on-site.

I trust that the above meets your requirements. However, please do not hesitate to contact me if you should have any queries or comments.

Yours sincerely

[redacted]

[redacted]
Senior Consultant

cc [redacted]

Suggested Text for Response Letter

Dear Sirs,

We have reviewed the following report for the proposed St Ambrose High School Site:

- Proposed St. Ambrose High School – Ground Investigation Report. URS Corporation Limited (URS), October 2008 (Ref #: 49339729)

Following the review, we request comment/clarification on the following issues:

1) Justification that risks to human health from near-surface contamination have been sufficiently assessed spatially when it appears that only 7 near-surface samples (less than 1.0m deep) were retained and analysed over a 13.5 hectare site.
2) Comment on potential risks to human health if of soils greater than 1.0m are exposed/relocated on site in cut and fill groundworks.
3) While the use of GAC values based on residential end-use are considered a reasonable, albeit over-conservative, initial screen, concluding that risks to human health are low for the proposed development based on exceedances only being “marginal” lacks quantified supporting evidence. Further, the use of commercial/industrial GACs as a secondary screen is considered potentially under-conservative. As such, the derivation of appropriate screening values reflecting the proposed end use would be necessary to support the conclusion that risks to human health are low for the development. It would be reasonable to only carry this out for those contaminants which have been identified as exceeding residential-use GACs.
4) Further information should be provided on the models, input parameters, and assumptions used to derive the generic assessment criteria values presented in the report, as well as any DQRA-based screening values derived following the above comment.
5) Comment on the perceived ability of mobile contaminants to reach the drains noted on the adjacent site and whether or not these drains are considered a preferential pathway for reaching nearby surface water features.
6) Comment on the ability for manganese and ammonia (with the former present 2 orders of magnitude above the presented GAC) to diminish over time when URS suggests that horizontal and lateral migration would be limited by underlying the cohesive deposits.
7) Further consideration of the ability of the cohesive deposits to limit downward migration of contaminants to the bedrock aquifer if a known mine entry on site exists, and when borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. For example, borehole log 110 indicates only 0.4m of glacial till overlying the bedrock, and log S311 indicates 0.7m.
8) Indicating if any potable water wells have been identified in the vicinity of the site which may present a risk to human health through ingestion of contaminated groundwater.

9) The use of double-width / over-excavated trenches would need to be confirmed as acceptable to Scottish Water to allow use of standard plastic water pipes on-site.

Should you require further assistance please do not hesitate to contact the officers dealing with your application.

Regards,

Checklist for Phase I (Minimum Requirements)			
Area of Information	Info Included (Y/N)	Satis-factory (Y/N)	Comments
Preliminary Risk Assessment/Desk study	Y	Y	
Purpose & Aims of the study (A statement is required explaining the reason for the report)	Y	Y	
Site Location Plan and current layout plans (appropriately scaled and annotated with north point, National Grid Reference (minimum 6 figures) and site area in hectares	Y	Y	
Environmental Setting including the interpretation and implications of: • the geology, hydrogeology and hydrology of the area; • information from the Environment Agency on abstractions, pollution incidents, water quality classification, landfill sites within 250 metres and flood risk; and • whether there are any archaeological or ecological considerations	Y	Y	No archaeological
Conceptual Site Model (CSM), showing all potential source/pathway/receptor linkages	Y	Y	
Site History, including former industrial uses on and adjacent to the site from historical maps	Y	Y	Historical maps not provided but history summarised from a previous report
Interpretation of CSM, including Qualitative Risk Assessment	Y	Y	
Identification of potential contaminants of concern and source areas	Y	Y	
Identification of information gaps and uncertainties, recommendations for intrusive contamination investigations (if necessary) to include the identification and justification of target areas for more detailed investigation	Y	Y	
Conclusions and Recommendations	N	Y	Conclusions/recommendations made following intrusive investigations

Checklist for Phase II (Minimum Requirements)			
Area of Information	Info Included (Y/N)	Satis-factory (Y/N)	Comments
Purpose & Aims of the study (A statement is required explaining the reason for the report)	Y	Y	
Site Location Plan and current layout plans (appropriately scaled and annotated with north point, National Grid Reference (minimum 6 figures) and site area in hectares	Y	Y	
Review and summary of any previous reports with references	Y	Y	
Revised Conceptual Site Model (CSM), showing all potential source/pathway/ receptor linkages	Y	Y	
Sampling Strategy (Refer to BS10175 for methodology, justification and location plan)	Y	N	Though exploratory hole coverage is reasonable, number of samples retained and analysed from top 1.0m do not appear sufficient following URS's exposure scenario.
Borehole and Trial Pit Logs	Y	Y	
Gas and Vapour Monitoring, including atmospheric conditions and flow rates as per CIRIA C665	Y	Y	More monitoring recommended in report.
Site Specific Risk Assessment for both Health and Environmental Receptors. To include: • Objectives and details of proposed site use • Details of the models selected and justification of choice for the site • Justification for input parameters, with source reference for literature values and additional calculations for field derived parameters, assumptions, safety factors • Any model printouts that have been generated (e.g. CLEA Model and P20, the data worksheets should be included) • Compliance with UK policy where non-UK models are used	Y	N	Residential GACs are acceptable as an initial screen but derived GACs for school end-use have not been provided to support the assessment. No methodology/supporting info for the GACs used in the report has been provided.

Checklist for Phase II (Minimum Requirements)			
Area of Information	Info Included (Y/N)	Satis-factory (Y/N)	Comments
Interpretation of Results including: • Description of ground conditions (made ground and ground water) • Discussion of the nature and extent of contamination • Meaningful comparison of the analytical results to appropriate standards, with full justification of the standards chosen • To include consideration of ground gas and the presence of asbestos	Y	N	Risks of exposure from deeper soils from developmental cut/fill not explored. The ability of cohesive deposits to protect the groundwater aquifer is queried based on borehole records. Drains and potable water wells not assessed as potential pathways/receptors. High levels of groundwater contamination are reported as expected to diminish over time, but supporting evidence for this assumption is queried.
Evaluation of Site Investigation results against Conceptual Model	Y	N	See issues above.
Conclusions and Recommendations. This should include remediation proposals and further monitoring when required.	Y	N	See issues above.

PROPOSED ST. AMBROSE HIGH SCHOOL, TOWNHEAD
REPORT REVIEW
SUMMARY AND RECOMMENDATIONS

Summary

The Council`s appointed Technical Advisors for contaminated land, WSP, were tasked with reviewing the intrusive site investigation report that was produced by URS on behalf of the Council. The investigation report was prepared for the purposes of assessing the contamination, ground gas, and mineral stability at the site to determine any risks to proposed redevelopment of a high school, as well as providing geotechnical information to inform foundation design.

Environmental Services have carried out a preliminary assessment of the reports produced, prepared a summary of salient issues and make the following conclusions and recommendations:

Conclusions and Recommendations

- With the initial information presented it is considered that contamination issues on the site are manageable and that the gas issues should also be manageable, but this is unclear with the data presented. **The report represents an initial exploratory SI and risk appraisal and is not designed as a detailed remedial management strategy report. Further, comprehensive SI is anticipated which would allow a remediation strategy/management plan to be accurately defined.** However, remediation costs are liable to be significant. **At this stage the most significant remedial costs, which will be required to facilitate development, are considered to be associated with ground gas. There is currently an ongoing programme of gas monitoring being undertaken at the site, which will help to define specific remedial requirements. However, as for other requirements in relation to remediation, URS cannot comment on the significance of costs at this stage.**
- The methodology used to quantify and evaluate the levels of contaminants found on the site requires to be justified, particularly since the current best practice guidance has recently been withdrawn and is in the process of being updated. **In the absence of replacement SGVs it is considered acceptable to use the withdrawn ones at this time. GACs don't infer unacceptable risks to health and given that the awaited newly derived SGVs will be the same or higher than the current criteria, it is considered that the current withdrawn SGVs and adopted approach are appropriately health protective in the context of human health risk assessment.**
- The suitability of foundation design that will not provide any new pathways for gas or contaminants to impact on human health post-build. i.e. Pile Foundations could cause a pollution problem if not properly mitigated for during design and build. **Agree. These pathways were included in the CSM and will be considered during the detailed design stage and mitigated against appropriately.**
- A minimum of six months of further gas monitoring to fully characterise the gassing situation on site. **Agree. As discussed above a fortnightly programme has been initiated at the site, and will run for a period of 6 months.**
- Due to the high concentrations of gases found on site there would have to be high levels of mitigation measures required for the school. These mitigation measures may comprise of alarm systems, active gas extraction system, passive gas venting, gas management procedures, evacuation procedures, and emergency procedures. Extensions or building works that were to occur at the school would have to take cognisance of any gas mitigation measures installed. The gas preclusion measures would require validation and maintenance and this will have cost implications. Further information on gas site issues requires to be produced, in order that an informed assessment of the risks can be made and advice provided accordingly. **Agree. Further information, assessment and design requirements will be provided on-completion of the 6 monthly gas monitoring.**

- As part of the review process clarification on several points will be required from URS on issues that are not clear in the report.
- Further justification is required that risks to human health from near-surface contamination have been sufficiently assessed spatially when it appears that only 7 near-surface samples (less than 1.0m deep) were retained and analysed over a 13.5 hectare site. Further intrusive testing could be required. **As detailed in the site investigation report, a non-targeted spatial sampling strategy was adopted for chemical testing. A total of 24 No. soil samples of made ground (landfill waste) where analysed and although only 7 were recorded in the top metre all 24 were used for materials classification and assessment purposes.**
- The potential for excavated materials to be used for groundworks on other parts of the site as part of development process are currently unclear. As such, costs may arise through the disposal of excavated materials, which are deemed unsuitable for use elsewhere on the site. Other costs may include importing of clean, inert fill required as part of the groundworks for the site. **Agree.**
- Further consideration by URS is required of the ability of the cohesive deposits to limit downward migration of contaminants to the bedrock aquifer if a known mine entry on site exists, and when borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. **Borehole logs generally indicate that there is a sufficient thickness of low-permeability cohesive materials including Glacial Clays underlying Peat and Lower Lacustrine deposits, which will limit downward migration of contaminants and provide significant potential for attenuation of contaminants. The precise location of the mineshafts is not currently known however these are anticipated to be at a distance from the likely development area.**
- It is recommended that SEPA are engaged quickly and asked to comment on the proposals to build this new school on land used as a former landfill, as they are statutory consultees with respect to issues relating to the water environment. **Agree. However to further clarify the conclusions presented, it is considered that once the site has been developed the risks to the water environment will be low provided appropriate design control measures are adopted during the construction phase of the school to limit the creation of new pathways.**

Issues

WSP, the Council`s appointed Technical Advisors for contaminated land were tasked with reviewing the intrusive site investigation report that was produced by URS on behalf of the council. The investigation report was prepared for the purposes of assessing the contamination, ground gas, and mineral stability at the site to determine any risks to proposed redevelopment of a high school, as well as providing geotechnical information to inform foundation design. **The information provided in the site investigation report was intended to assist in the planning process and cost budgeting. It was not intended to cover all aspects required for detailed design of the development and it is anticipated that further detailed investigation, assessment and definition of development specific remedial measures will be required prior to commencement of the design stage.**

Basic Desk Study information

NLC records indicate that the Townhead Landfill started in 1945 and closed in 1972. During the period of operation an estimated half million tonnes of domestic refuse from Coatbridge was deposited at the site. In addition to this, 77,000 gallons of wet sewage and unspecified residue from Gartsherrie Steel Works were disposed of annually for an indeterminate period. Multiple coal seams beneath the site are shown to have been worked in the past and the presence of unrecorded mine entries cannot be discounted. **Agree.**

Site Investigation Findings

- Made ground was found at surface or underlying topsoil, and noted thickness was between 0.45m and 8.3m
- Peat was found underlying the made ground in primarily the central portion of the site, between 0.3m and 5.5m thick
- Natural materials noted at site underlying the made ground/peat
- Bedrock was located between 7.4 and 14.7m below ground level.

No comments.

The mineral stability assessment will be reviewed and reported separately.

Chemical Testing and Assessment

In assessing risks to human health, URS considered that the majority of the soil exceedances occurred at depths greater than 1m in depth and were thus too deep to allow direct contact/ingestion and not a risk for the final development. For those exceedances noted within 1m of surface (arsenic, lead, nickel, and benzo(a)pyrene), URS reported that these were marginal exceedances, and note that the screening values used (representing residential end-use) are most likely over-conservative for school use. URS reports that all exceedances of residential screening values are less than screening values representing a commercial/industrial end-use. Direct contact from groundwater is not expected due to recorded depths. **Agree.**

Risks to the Water Environment

URS considers that cadmium, sulphate and phenol are the only completed pollutant linkages on site (soil leachable contaminants mobilising to the groundwater).

Ammonium and manganese are generated by the breakdown of organic components of landfill waste, and are expected to diminish over time due through capillary action due to lack of lining and with consideration that the landfill was closed in the 1970s, indicating a diminishing source. Due to the distance to sensitive receptors (350m and greater), URS considers that the manganese and ammonium would not negatively impact these receptors due to attenuation and dilution over this distance and the landfill materials being a limited, diminishing source. **Agree.**

The remaining exceedances (nitrite, fluoranthene, benz(a)anthracene, benzo(a)pyrene and TPH fractions) are considered localised, and are expected to be retained in the perched waters on-site due to the underlying cohesive silt and clay deposits, which URS believes will prevent migration to the underlying bedrock aquifer. **Agree.**

With regards to cut and fill for development purposes, URS recommends that areas of higher contaminant leachability noted in the report should be avoided unless being placed on top of already contaminated soils; and further recommends that a scope for assessment of materials intended for re-use be agreed with NLC. **Agree.**

Contaminant concentrations were compared to Water Regulations Advisory Scheme (WRAS) guidance. Due to concentrations of multiple contaminants exceeding screening values, URS recommends wrapped iron pipe upgrades for water supply pipes. In areas of site considered above the water table, URS considers that over-excavated, double width trenches backfilled with inert fill would allow standard HDPE pipes. URS notes placing pipes in soils contaminated with arsenic is considered unacceptable without remediation of the soils, such as soil removal. **Agree.**

Ground Gas Assessment

Methane was detected at concentrations up to 68.7% v/v and carbon dioxide up to 30.2% v/v. Depleted oxygen was recorded in several boreholes.
URS has assessed the gas data based on worst-case conditions following the Wilson and Card methodology (CIRIA C665), using the maximum methane recorded in recent monitoring and historical gas flow rates, and considers protection measures including proprietary gas resistant membranes and positively pressurised underfloor sub-space with monitoring facilities. URS suggests this be used for worst-case preliminary design, with 12 no. monitoring visits carried out over six months to allow a more robust assessment, following the recommended number of monitoring events in CIRIA C665. **Agree and discussed in detail above.**

URS: Conclusions and Recommendations

Overall risks to human health for the development are low.

A worst-case scenario of ground gas Characteristic Situation 4 should be assumed, with 6 more months of monitoring carried out. Also the potential need for passive gas-venting trench at the north boundary of the site should be evaluated after subsequent assessment.

Risks to closest water receptors are low due to distance and source concentrations, and that cohesive deposits underlying the site would limit contaminant migration, though they recommend that control measures be implemented during development to prevent creating new pathways.

URS also provides conclusions for the continued site use as playing fields, including, risks to human health and the water environment from contaminants considered low, and that ground gas risks be further assessed to determine risks to adjacent properties.

Agree to all above.

Pollution Control (WSP) Comment

Spatial distribution of exploratory holes and chemical testing distribution is as recommended in best practice guidance. But near surface sampling was considered too low especially as near-surface contamination is the primary risk to human health, this spacing is not considered sufficient to provide confidence that a robust assessment of risks to human health has been carried out for near-surface contamination. Justification for the limited number of samples in the top metre is provided above. **Taking into account that this investigation was intended to provide preliminary information to support planning and not detailed design the approach of mass spatial characterisation was undertaken. It is considered that there**

may be an opportunity to obtain further near surface samples during any future detailed investigations.

Further, the omission of consideration of contamination at depth in assessing risks to human health contradicts that potential cut and fill may occur on-site. **The site investigation report provides advice to take account of the spatial distribution of contaminants recorded in the made ground to limit cutting operations in areas of the site where fill materials may not be suitable for reuse. In the same regard, any cut platforms intended to form open/landscaped areas where direct contact will be an issue should be taken into account during the design phase. However, if design does require final levels to introduce pollutant linkages via contact with contaminants currently at depth, further sampling and assessment may need to be undertaken and mitigation measures designed accordingly.**

No evaluation has been carried out of the ability of mobile contaminants to reach drains that were found on site and then potentially travel through these drains as a preferential pathway.

No drains were found on site. It is assumed that reference to several drains located to the southwest of the site in Drumpellier Country Park on Page 10 has generated this comment. Future drainage will be designed taking into account the potential for contaminants to travel through them via groundwater as preferential pathways. However, taking into account monitoring data, which has proven a relatively deep groundwater table >2mbgl, it is unlikely that a complete pollutant linkage will exist. If services are laid in areas of 'cut' consideration may be given to sealed trenches.

URS's consideration that low permeability cohesive deposits would limit downward migration of contaminants to the bedrock aquifer is queried as WSPE considers that a known mine entry on site and shallow workings could allow a preferential pathway of downward migration.

URS considered the introduction of piled foundations could create potential pathways, which might allow the downward migration of dissolved contaminants to deep groundwater resources. If un-grouted and uncapped, shafts can be considered in the same way. At this stage the current location of shafts is not currently known and further assessment is planned to be undertaken. The current risk assessment will be updated to consider these as pathways if future investigation demonstrates the need to do so.

The current ground gas risk assessment and recommendations are considered reasonable based on information available at present, and WSPE concurs additional monitoring and assessment should be carried out as recommended by URS. **Agree, see above.**

URS's recommendation that spatial consideration of leachable contaminants be considered prior to re-use of materials on a cut/fill basis is not considered practical as only 18 leachate samples have been analysed from site, and URS has noted that the made ground materials are heterogeneous in nature. As such, a spatial understanding of material leachability is not well-defined at present. As such, the secondary recommendation that an agreed scope/frequency of sampling for determining re-usability is considered more reasonable in this scenario. **URS have no issues with this further recommendation.**

Recommendations

It is recommended that the issues identified above are queried as:

- The methodology used to quantify and evaluate the levels of contaminants found on the site requires to be justified, particularly since the current best practice guidance has recently been withdrawn and is in the process of being updated. **See above.**
- The suitability of foundation design that will not provide any new pathways for gas or contaminants to impact on human health post-build. i.e. Pile Foundations could cause a pollution problem if not properly mitigated for during design and build. **Agree. The main**

issue is considered to be the potential for upward migration of hazardous ground gas, which is being considered further as discussed above.

- A minimum of six months of further gas monitoring to fully characterise the gassing situation on site. **Agreed.**
- Due to the high concentrations of explosive and asphyxiant gases found on site there would have to be high levels of mitigation measures required for the school. These mitigation measures may comprise of alarm systems, active gas extraction system, passive gas venting, gas management procedures, evacuation procedures, emergency procedures. Extensions or building works that were to occur at the school would have to take cognisance of any gas mitigation measures installed. The gas preclusion measures would require validation and maintenance and this will have cost implications. Further information on gas site issues requires to be produced, in order that an informed assessment of the risks can be made and advice provided accordingly. **Agreed, further information provided above.**
- As part of the review process clarification on several points will be required from URS on issues that are not clear in the report.
- Further justification is required that risks to human health from near-surface contamination have been sufficiently assessed spatially when it appears that only 7 near-surface samples (less than 1.0m deep) were retained and analysed over a 13.5 hectare site. Further intrusive testing could be required. **See above for further information.**
- The potential for excavated materials to be used for groundworks on other parts of the site as part of development process are currently unclear. As such, costs may arise through the disposal of excavated materials which are deemed unsuitable for use elsewhere on the site. Other costs may include importing of clean, inert fill required as part of the groundworks for the site. **See above for further information.**
- Further consideration by URS is required of the ability of the cohesive deposits to limit downward migration of contaminants to the bedrock aquifer if a known mine entry on site exists, and when borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. **See above for further information.**
- With the initial information presented it is considered that contamination issues on the site are manageable and that the gas issues should also be manageable, but this is unclear with the data presented. However, remediation costs are liable to be significant. **To reiterate, at this stage the most significant remedial costs, which will be required to facilitate development, are considered to be associated with ground gas. There is currently an ongoing programme of gas monitoring being undertaken at the site, which will help to define specific remedial requirements. However, as for other requirements in relation to remediation, URS cannot comment on the significance of costs at this stage.**
- It is recommended that SEPA are engaged quickly and asked to comment on the proposals to build this new school on land used as a former landfill, as they are statutory consultees with respect to issues relating to the water environment. **Agree.**

Environmental Services
18 November 2008
[redacted]

Your ref: TBD
Our ref: [redacted]

31st August 2009

[redacted]
North Lanarkshire Council
Central Area Office
453 Main Street
Coatbridge
ML5 3RS

Dear [redacted]

Report Review Follow up – St Ambrose High School

WSPE previously carried out a review of reports relating to the above-referenced site and identified issues requiring clarification/further comment. Our review history is summarised as follows:

Item(s) Reviewed	WSPE Response	Summary of Issues Queried
• Proposed St. Ambrose High School – Ground Investigation Report. URS Corporation Limited (URS), October 2008 (Ref #: 49339729)	Letter dated 17th November 2008, ref: 12151574/001/70/MB	• Limited number of near-surface samples • Screening values potentially under/over conservative • No information on source / derivation of screening values • Potential for drains to be preferential pathways • Assumptions of diminishing concentrations of groundwater exceedances • Consideration of thin clays and mine entries in downward contaminant migration. • If potable water wells were potential receptors

Further to our previous review and comments, WSPE has received the following supplementary information for review:

Item(s) Reviewed
• Document titled "Proposed St. Ambrose High School, Townhead – Report Review – Summary and Recommendations." This appears to be URS comments inserted into Environmental Service's review letter dated 18th November 2008, reference CM/CP/FM/RW.

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WSP Group plc
Offices worldwide

The recommendations from WSPE's most recent review letter are reproduced below, together with comments on the additional information provided, and any outstanding issues/concerns. It was recommended that clarification / explanation be sought on the following issues:

1) Justification that risks to human health from near-surface contamination have been sufficiently assessed spatially when it appears that only 7 near-surface samples (less than 1.0m deep) were retained and analysed over a 13.5 hectare site.

   URS has characterised the previous assessment as an initial exploratory SI and risk appraisal and that further comprehensive SI is anticipated to define an appropriate remedial strategy.

   WSPE considers additional investigation and assessment as the best way forward.

2) Comment on potential risks to human health if of soils greater than 1.0m are exposed/relocated on site in cut and fill groundworks.

   URS comments that "the SI report provides advice to take account of the spatial distribution of contaminants recorded in the made ground to limit cutting operations in areas of the site where fill materials may not be suitable for reuse. In the same regard, any cut platforms intended to form open/landscaped areas where direct contact will be an issue should be taken into account during the design phase. However, if design does require final levels to introduce pollutant linkages via contact with contaminants currently at depth, further sampling and assessment may need to be undertaken and mitigation measures designed accordingly."

   WSPE considers this approach reasonable and will await forthcoming works and assessment, as proposed by URS, to determine if the proposed strategy is suitable with regards to the final cut and fill.

3) While the use of GAC values based on residential end-use are considered a reasonable, albeit over-conservative, initial screen, concluding that risks to human health are low for the proposed development based on exceedances only being "marginal" lacks quantified supporting evidence. Further, the use of commercial/industrial GACs as a secondary screen is considered potentially under-conservative. As such, the derivation of appropriate screening values reflecting the proposed end use would be necessary to support the conclusion that risks to human health are low for the development. It would be reasonable to only carry this out for those contaminants which have been identified as exceeding residential-use GACs.

   URS has not commented on this directly but has comments on the recent withdrawal of previously-published SGVs, and considered it useful to use the previous values until new ones are published. As URS has proposed additional works and assessment, WSPE assumes future assessment will reference more applicable, recent SGV and GAC screening values.

4) Further information should be provided on the models, input parameters, and assumptions used to derive the generic assessment criteria values presented in the report, as well as any DQRA-based screening values derived following the above comment.

No further information provided other than discussed in Comment #3, above.

5) Comment on the perceived ability of mobile contaminants to reach the drains noted on the adjacent site and whether or not these drains are considered a preferential pathway for reaching nearby surface water features.

URS comments "No drains were found on site. It is assumed that reference to several drains located to the southwest of the site in Drumpellier Country Park on Page 10 has generated this comment. Future drainage will be designed taking into account the potential for contaminants to travel through them via groundwater as preferential pathways. However, taking into account monitoring data, which has proven a relatively deep groundwater table >2 mbgl, it is unlikely that a complete pollutant linkage will exist. If services are laid in areas of 'cut' consideration may be given to sealed trenches."

If future drainage design will include consideration of preferential pathway, WSPE considers this issue can be further reviewed once additional information is provided.

6) Comment on the ability for manganese and ammonia (with the former present 2 orders of magnitude above the presented GAC) to diminish over time when URS suggests that horizontal and lateral migration would be limited by underlying the cohesive deposits.

No direct response has been provided by URS to this issue, but URS has proposed a re-assessment of pollutant linkages with regards to the final design.

7) Further consideration of the ability of the cohesive deposits to limit downward migration of contaminants to the bedrock aquifer if a known mine entry on site exists, and when borehole logs indicate cohesive deposits are not significantly thick on a site-wide basis. For example, borehole log 110 indicates only 0.4m of glacial till overlying the bedrock, and log S311 indicates 0.7m.

URS states: "borehole logs generally indicate that there is a sufficient thickness of low-permeability cohesive materials including Glacial Clays underlying peat and Lower Lacustrine deposits, which will limit downward migration of contaminants and provide significant potential for attenuation of contaminants. The precise location of the mineshafts is not currently known however these are anticipated to be at distance from the likely development area." Later in the letter they further state "URS considered the introduction of piled foundations could create potential pathways, which might allow the downward migration of dissolved contaminants to deep groundwater resource. If un-grouted and uncapped, shafts can be considered in the same way. At this stage the current location of shafts is not currently know and further assessment is planned to be undertaken. The current risk

assessment will be updated to consider these as pathways if future investigation demonstrates the need to do so."

WSPE considers this approach reasonable.

Recommendations

URS has clarified in their response letter that the original reviewed site investigation report was considered preliminary for costing purposes, and that further site investigation and assessment are proposed to form a detailed remedial strategy. As such, WSPE has no comments at present and await the proposed supplementary reporting by URS.

I trust that the above meets your requirements. However, please do not hesitate to contact me if you should have any queries or comments.

Yours sincerely

[redacted]

[redacted]
Senior Consultant

cc [redacted]

Appendix C

CLEA Model Input Parameters

CLEA Model chemical input parameters

Parameter		Benzo[a]pyrene	Benz[a]anthracene
Chemical type		organic	organic
oral HCV	Type	ID	ID
	$\mu g\ kg^{-1}\ BW\ day^{-1}$	2.00E-02	1.38E-01
	Notes	LQM/CIEH 2009	LQM/CIEH 2009
inhal HCV	Type	ID	ID
	$\mu g\ kg^{-1}\ BW\ day^{-1}$	7.00E-05	4.80E-04
	Notes	LQM/CIEH 2009	LQM/CIEH 2009
Oral MDI for adults	$\mu g\ day^{-1}$	nr	nr
	Notes		
Inhalation MDI for adults	$\mu g\ day^{-1}$	nr	nr
	Notes		
Air-water partition coefficient (K_{aw})	$cm^3\ cm^{-3}$	1.76E-06	3.16E-05
	Notes (measured or calculated at 283K unless stated)	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Diffusion coefficient in air	$m^2\ s^{-1}$	4.38E-06	4.60E-06
	Notes (measured or calculated at 283K unless stated)	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Diffusion coefficient in water	$m^2\ s^{-1}$	3.67E-10	3.80E-10
	Notes (measured or calculated at 283K unless stated)	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Relative molecular mass	$g\ mol^{-1}$	252.31	228.29
	Notes	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Vapour pressure	Pa	2.00E-08	1.24E-06
	Notes (measured or calculated at 283K and standard pressure unless stated)	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Water solubility	$mg\ L^{-1}$	3.80E-03	3.80E-03
	Notes (measured or calculated at 283K unless stated)	At 25°C. Science Report – SC050021/SR7	Science Report – SC050021/SR7
Organic carbon - water partition coefficient (K_{oc})	Log ($cm^3\ g^{-1}$)	5.11E+00	4.89E+00
	Notes	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Octanol - water partition coefficient (K_{ow})	Log (dimensionless)	6.18E+00	5.91E+00
	Notes	Science Report – SC050021/SR7	Science Report – SC050021/SR7
Soil-water partition coefficient (K_d)	$cm^3\ g^{-1}$	NR	NR
	Notes		
Dermal absorption fraction	dimensionless	1.30E-01	1.30E-01
	Notes	SR3, EA 2009	SR3, EA 2009
Soil-to-dust transport factor ($g\ g^{-1}$ DW)		0.5	0.5
Subsurface soil to indoor air correction factor (dimensionless)		1	1

Appendix D

CLEA Model Outputs

STEP 5: RESULTS

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		Ratio of ADE to relevant Health Criteria Value			Soil Assessment Criteria			Soil Saturation Limit	Pathway Contributions (%)										
		oral HCV	inhal HCV	Combined	oral HCV	inhal HCV	Combined		direct soil ingestion	sum of consumption of homegrown produce and attached soil	dermal contact (indoor)	dermal contact (outdoor)	inhalation of dust (indoor)	inhalation of dust (outdoor)	inhalation of vapour (indoor)	inhalation of vapour (outdoor)	oral background	inhalation background	Total
Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.70	0.30	1.00	1.42E+01	3.33E+01	9.98E+00	1.37E+01	58.31	0.00	3.89	37.65	0.15	0.00	0.00	0.00	0.00	0.00	100.00
2	Benz[a]anthracene	0.70	0.30	1.00	9.82E+01	2.28E+02	6.87E+01	2.57E+01	58.31	0.00	3.89	37.65	0.15	0.00	0.00	0.00	0.00	0.00	100.00
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Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.58	0.42	1.00	2.70E+01	3.72E+01	1.56E+01	1.37E+01	51.36	0.00	18.35	30.03	0.22	0.01	0.00	0.02	0.00	0.00	100.00
2	Benz[a]anthracene	0.57	0.43	1.00	1.86E+02	2.48E+02	1.06E+02	2.57E+01	51.36	0.00	18.35	30.03	0.22	0.01	0.00	0.03	0.00	0.00	100.00
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Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.62	0.38	1.00	2.29E+01	3.74E+01	1.42E+01	1.37E+01	51.38	0.00	18.36	30.05	0.14	0.02	0.00	0.05	0.00	0.00	100.00
2	Benz[a]anthracene	0.60	0.40	1.00	1.58E+02	2.38E+02	9.49E+01	2.57E+01	51.37	0.00	18.36	30.04	0.14	0.02	0.00	0.07	0.00	0.00	100.00
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Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.90	0.10	1.00	1.92E+01	1.80E+02	1.73E+01	1.37E+01	56.80	0.00	1.72	41.44	0.01	0.00	0.00	0.02	0.00	0.00	100.00
2	Benz[a]anthracene	0.89	0.11	1.00	1.32E+02	1.02E+03	1.17E+02	2.57E+01	56.80	0.00	1.72	41.44	0.01	0.00	0.00	0.03	0.00	0.00	100.00
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Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.97	0.03	1.00	3.92E+01	1.18E+03	3.79E+01	1.37E+01	51.79	0.00	3.45	44.74	0.01	0.00	0.00	0.00	0.00	0.00	100.00
2	Benz[a]anthracene	0.97	0.03	1.00	2.70E+02	8.07E+03	2.62E+02	2.57E+01	51.79	0.00	3.45	44.74	0.01	0.00	0.00	0.00	0.00	0.00	100.00
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		Ratio of ADE to relevant Health Criteria Value			Soil Assessment Criteria			Soil Saturation Limit	Pathway Contributions (%)										
		oral HCV	inhal HCV	Combined	oral HCV	inhal HCV	Combined		direct soil ingestion	sum of consumption of homegrown produce and attached soil	dermal contact (indoor)	dermal contact (outdoor)	inhalation of dust (indoor)	inhalation of dust (outdoor)	inhalation of vapour (indoor)	inhalation of vapour (outdoor)	oral background	inhalation background	Total
Number	Chemical	(dimensionless)	(dimensionless)	(dimensionless)	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%	%	%	%	%	%
1	Benzo[a]pyrene	0.70	0.30	1.00	1.42E+01	3.33E+01	9.98E+00	1.37E+01	58.31	0.00	3.89	37.65	0.15	0.00	0.00	0.00	0.00	0.00	100.00
2	Benz[a]anthracene	0.70	0.30	1.00	9.82E+01	2.28E+02	6.87E+01	2.57E+01	58.31	0.00	3.89	37.65	0.15	0.00	0.00	0.00	0.00	0.00	100.00
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