

Geo-Environmental Study

- 4.1 This section provides a summary of key geoenvironmental conditions across the AAP Study Area, detailing site constraints and subsequently informing options development. A detailed study has been attached at Appendix 2 and includes an Envirocheck Report.
- 4.2 Given the size of the site and the differences in land use, ownership status, geographical setting, infrastructure and history, the site has been divided into the following zones (as illustrated on Plan 4.2 below, and Plans 4.3 and 4.4, to the rear of this section, showing the site and constraints in more detail).
- Zone One: Comprises the area of land in the west of the site up to the lagoons in Zone Two. The Zone is known to have been a tip and is owned by Saint-Gobain Pipelines;
- 4.4 Zone Two: Comprises the former pipe works in the western-central area of the site and includes a tip and lagoons. It is separated from Zone Four to the northeast and Zone Three to the southeast by Works Lane, which runs roughly north-south along the eastern border of the Zone;
- Zone Three: Comprises a wedge of land along the southern border in the east of the site, and is bound to the north by the River Rother, to the east by Staveley, to the west by Works Road and

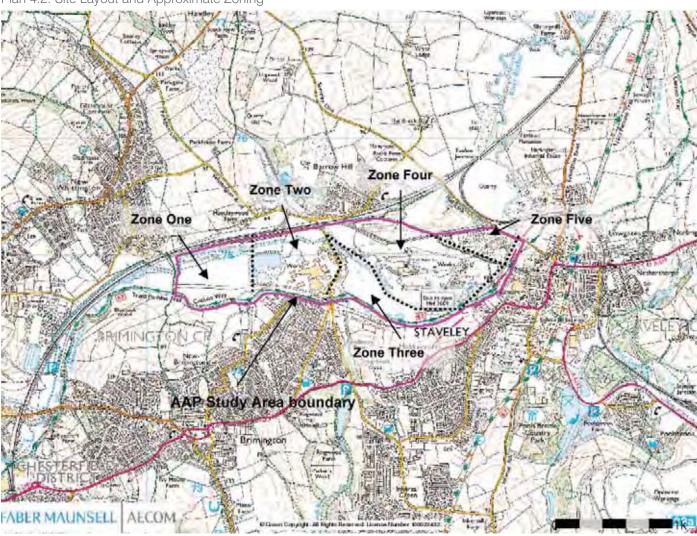
- to the south by Chesterfield Canal. This Zone has been subject to opencast coal mining. The Clocktower Business Centre and Devonshire Business Centre are located in the west of the
- eastern area of the site and comprised a large chemical works (Rhodia Eco Services) until recently, largely concerned with the manufacture of sulphuric acid. A large iron and chemical works were once located in this area. The Zone is bound to the south by the River Rother, to the north by a railway, to the west by Works Road, Zone Six to the northeast and to the east by Zone Five:
- Zone Five: Comprises the Mallinckrodt Chemical Works (now Covidien) who are primarily associated with the production of pharmaceuticals. The Zone is bound to the northwest by Zone six, to the northeast by Hall Lane, to the east by the town of Staveley, to the west by Zone Four and to the south by Zone Three:
- 4.8 Comprises a landfill which no longer accepts waste and in capped in the south of the Zone. Some of the Zone is known to have been subject to opencast mining. The Zone is bound to the northwest by a railway line, to the northeast by Hall Lane, and south by Zones Four and Five.

Following a review of the Landmark Envirocheck report, site walkover and interviews with key stakeholders across the site:

Zone One:

The Zone is bound to the north by a railway, to the south by the Chesterfield Canal, to the west by a tip (constructed in the same way as the one within the Zone), and to the east by the lagoons in Zone Two:

Plan 4.2: Site Layout and Approximate Zoning



- The River Rother (which has been diverted through the Zone at various times in the last hundred years) runs in a west-east direction through the north of the Zone; through the north of the Zone;
- The Zone has been subject to opencast mining to 64m bgl, and filled to 13m bgl with colliery spoil, after which the Zone was filled and domed with foundry sand;
- Anecdotal evidence suggests that in the 1990's, a gas odour was noted in the south of the Zone near the Canal. After an investigation, it was found to be "marsh gas".

Zone Two:

- The Zone is bound to the north by a railway, to the west by Zone One, to the south by the Chesterfield Canal and to the east by Works Road;
- By the late 1800's, the Zone was shown to be part of an iron works. Until recently, the Zone operated as a pipe manufacturers. There are still rail tracks around the Zone from its previous industrial use;
- There is a large lagoon in the west of the Zone.
 Originally intended to be a clay-lined landfill cell, it is now filled with water and might be subject to intrusion from leachate from the surrounding landfills;

- There is an open landfill to the immediate southeast of the lagoon which appears to be filled mostly with foundry iron slag material;
- The buildings are currently being demolished to slab level, which was due for completion in April 2009.

Zone Three:

- The Zone is bound to the north by the River Rother, to the south by the Chesterfield Canal, to the west by Works Road, and to the east by the town of Staveley;
- The Zone currently comprises the Clocktower Business Centre and the Devonshire Buildings Business Centre in the west of the Zone, both of which have commercial and industrial units;
- In 2000, the central-western parts of the Zone are shown as opencast workings, which are not indicated on the 2008 map of the Zone. Anecdotal evidence from Site Operatives in Zone Four suggests these workings were up to 30m deep;
- Japanese Knotweed has been noted in the east of the Zone by Site Operatives from Zone Four.

Zone Four:

- The Zone is bound to the north by a railway and Zone Six, to the east by the chemical works in Zone Five, and to the south by the River Rother with Zone Three beyond;
- In the late 1700's, a mill, a large mill pond and a foundry are shown in the north of the Zone. Staveley Iron Works and Hollingwood Colliery are shown in the Zone in the late 1880's. By the 1960's, a chemical and pipe works are shown to exist in near the centre of the Zone. Anecdotal evidence from Site Operatives suggests there was a PVC warehouse also located near the centre of the Zone;
- The Zone was most recently identified as a chemical works (Rhodia Eco Services) which was largely concerned with the production of sulphuric acid. This is classified as a COMAH site, but given that all the buildings associated with the production of sulphuric acid have been demolished, it is assumed that the COMAH status is no longer active;
- There is a biological effluent treatment plant and a generator located in the east of the Zone;
- The buildings associated with the chemical works have been demolished to slab level in the last two years;
- A weir originally ran through the southern-central part of the Zone to the mill in the northwest, but became disused and formed a series of goytes, which now form a potential refuge for brown trout;
- Anecdotal evidence from the Site Operatives suggests Japanese Knotweed, Himalayan Balsam and Giant Hogweed were all noted in the east of the Zone near the canal;
- The Zone is split over three levels which was to achieve a hydraulic gradient when the Zone operated as a chemical works;
- The River Rother has been re-routed, particularly in the east of the Zone.

Zone Five:

- The Zone is bound to the north by Zone Six, to the east by Hall Lane, and to the south and west by Zones Three and Four;
- The Zone is currently used as a chemical works concerned with the manufacture of medical/ pharmaceutical products, which is a designated COMAH site. The site currently has a 2km hazard zone, although the HSE will be contacted to enquire whether this can be reduced to 500m as operations at the works are less significant and provide less of a hazard to the wider area;
- The buildings in the south of the Zone have been demolished to slab level in the last two years;

- Anecdotal evidence from a Site Operative in Zone Four suggested that the Zone was built upon approximately 10m of iron slag from the former iron works;
- A subway is located on the western border with Zone Four and runs from the southwest to the northwest of the Zone;
- The Zone slopes steeply down to the River Rother in the south of the Zone.

Zone Six:

- The Zone is bound to the northwest by a railway line, to the northeast by Hall Lane, and south by Zones Four and Five;
- Some of the Zone has been subject to opencast workings;
- Filling of the landfill ceased in November 2007.
 The south has been capped and topsoiled and restoration works are proceeding in the north for an end use as grassland, forest and footpaths;
- The site is gassing which is being used by a gas to energy plant;
- There are at least five surface water features in the Zone, mostly concentrated in the south and east.
- 4.9 The ground conditions and previous activities on site have resulted in a number of geotechnical constraints as listed below.
- 4.10 Made Ground is present across the site and is unlikely to be a suitable founding material for shallow foundations for the proposed structures and buildings.
- 4.11 The areas of open cast backfill in Zones One, Three and Six and landfills (in Zones One, Two and Six) will have a significant thicknesses of uncompacted Made Ground (30m – 60m), which can result in significant voids and therefore long term unpredictable settlement.
- 4.12 The iron slag, which is thought to have been placed around the site (depending on the processes used) can expand on contact with water leading to unpredictable swelling, which can damage foundations and infrastructure.
- 4.13 Several buildings in Zones Two, Four and Five are currently, or have already been demolished to slab level. Buried foundations and basements are likely to represent an obstruction to the development and will need to be investigated prior to commencement of the construction works.

- 4.14 The site is situated on Alluvium which is likely to be variable in terms of thickness and nature. The suitability as a founding material for shallow foundations and possibly for piled foundations for more heavily loaded structures will need to be assessed based on the results from intrusive ground investigations.
- 4.15 Fifty three shafts and adits were noted in Zones One, Two and Three; the treatment details for some are unknown. A large cluster of shafts in Zone Two may actually be a series of bell pits suggesting that shallow workings may exist below the Zone. There is therefore the potential for voids from the coal seams and ironstone horizons which are known to have been worked (some extensively) on the site. Even when the shafts have been treated there is likely to be an exclusion zone around each one in which built development will not be permitted.
- 4.16 Groundwater levels may be high with perched water tables within any Made Ground. This is likely to pose a hazard if particularly deep pads or footings are required. A ground investigation will be required to confirm ground water levels and any variability in ground conditions.
- 4.17 Further investigation is recommended to determine the extent of the potential contamination on site. It is likely that certain areas of the site will encounter relatively high soil concentrations of contaminants associated with previous contaminative land uses. If development occurs on land containing soil concentrations which exceed the appropriate assessment criteria, there may be a requirement for some form of remediation/mitigation of the ground.
- 4.18 Based on the information above, the following recommendations are suggested to further assess the site::
- Obtain and review recent ground gas monitoring information to assess the ground gas regime at the site in accordance with BS8485 (2007) Code of practice for the treatment of soil gas in Brownfield sites. Carry out further gas monitoring if the existing information is insufficient;
- Obtain and review restoration information of the opencast works in order to assess the nature of backfill and contamination status of the site;
- Undertake a mining desk study, and obtain and review recent intrusive ground investigation information to assess the potential presence of shallow mine workings;
- Confirm with the HSE that the active COMAH status in Zone Four is no longer applicable and should be revoked;

- Obtain and review the PPC application and Site Condition Report to determine the contamination status of the site;
- Undertake an assessment of the nature and presence of Japanese Knotweed across the site;

4.19 Potential Constraints and Recommendations

The table below summarises the potential constraints and recommendations identified in the site from the information above.

Potential	Details	Identified Constraints	Recommendations	Potential Mitigation
Zone Specific				1
Contamination	Zones One and Two	Zone One		
Constraints Zone Specific			Following review of the existing information provide input into any remediation undertaken by the tenants (Saint-Gobain Pipelines).	If the ground investigation undertaken by the tenant, and the proposed remediation are suitable for the proposed end use no further mitigation is likely to be required. However, if the ground investigation and/ or remediation are not suitable for the proposed end use then further ground investigation or remediation may be required.
	across the Zone, which could pose a risk to human health, Controlled Waters and other statutory receptors. Unknown fill material with unknown lining and capping specification presents significant contamination issues. Could also have differential settlement of buildings and attack of inground structures from contaminants. Geotechnical constraints from swelling iron slag. Lagoon (Constraint): Could be subject to leachate intrusion from surrounding landfills.			

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
		Former Settling Ponds (Constraint): Could be subject to leachate intrusion from surrounding landfills.		
		Former Pipe Works Storage Area (Constraint): Potential contamination from spills/poor storage.		
		Former Pipe and Iron Works (Constraint): Potential contamination from former processes. Geotechnical constraints from swelling iron slag.		
		Dismantled Railway (Constraint): Obstructions to development.		
		Former buildings (Constraint): Obstructions to development from buried structures.		
		End use: could potentially be used for residential/employment and recreation.		
	Zone Three			
	The contamination status of the Zone is unknown.	Former Opencast Coal Workings (Significant	Obtain and review restoration information	If the ground investigation and
	Reference to the historical plans included in the Landmark Envirocheck Report indicates that in Zone Three, a flour (and later a corn mill and iron foundry), an iron works, Hollingwood Colliery, rail	Constraint): Collapse potential of backfill material and potential contaminative issues from operational days. Former Hollingwood Colliery (Constraint): Potential mineshafts, worked ground	of the opencast works in order to assess the contamination status of the site.	restoration works undertaken during the closure of the opencast workings are suitable for the proposed end use no further mitigation is likely to be required.
	tracks, opencast workings, sewage tanks, pipe works and current industrial practices have been located in the Zone at various points in time. It is likely that tipped material comprised primarily of that associated with the former iron works and spoil	and spoil. Japanese Knotweed (Constraint): Can potentially grow through concrete/ buildings. Former Corn/Flour/Iron		However, if the ground investigation and/ or remediation are not suitable for the proposed end use then further ground investigation or remediation may be
	from the opencast coal workings. Therefore, there is the potential for encountering heavy metals, organic and inorganic compounds	Foundry (Constraint): Contamination from former industry. Former Pond (Constraint):		required.

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
	across the Zone, which could pose a risk to human health, controlled waters and other statutory receptors	Filled with unknown material- contamination potential unknown and potential differential settlement.		
		End use: likely to be restricted to public open space. Development in the eastern part of the Zone subject to COMAH Regulations.		
	Zone Four The contamination status of the Zone is unknown. Reference to the historical plans included in the Landmark Envirocheck Report indicates that in Zone Four, the iron works, unidentified mill, sewage works, iron foundries and works, chemical works (including the effluent treatment plant), pipe works, rail tracks, wagon works, PVC powder warehouse, tips and ponds have been located in the Zone at various points in time. Tipped material may have comprised material associated with the former iron works and foundries, as well as other unknown material before the iron works covered much of the Zone. There is an active COMAH status issued for the Zone for the chemical works, but given that all the buildings associated with the production of sulphuric acid have been demolished, it is assumed the licence has lapsed or been revoked. Therefore, there is the potential for encountering heavy metals, organic and inorganic compounds across the Zone, which could pose a risk to human health, Controlled Waters and other statutory receptors.	Former Iron Foundry (Constraint): Contamination from former industry. Former Mill Pond (Constraint): Filled with unknown material- contamination potential unknown and potential differential settlement. Former Sewage Works (Constraint): Contamination from former industry. Former PVC Warehouse (Constraint): Contamination from former industry. Former Iron and Pipe works (Constraint): Contamination from former industry. Former Weir (Constraint): Filled with unknown material- contamination potential unknown and potential differential settlement. Former River Meander (Constraint): Filled with unknown material- contamination potential unknown and differential settlement. Biological Effluent Treatment Plant and Generator (Constraint): Contamination from former industry. Japanese Knotweed (Constraint): Can potentially	Obtain and review recent intrusive ground investigation information to assess the contamination status of the site. Following review of the existing information provide input into any remediation undertaken by the tenants (Rhodia Eco Services). Confirm with the HSE that the active COMAH status is no longer applicable and should be revoked.	If the ground investigation undertaken by the tenant, and the proposed remediation are suitable for the proposed end use no further mitigation is likely to be required. However, if the ground investigation and/ or remediation are not suitable for the proposed end use then further ground investigation or remediation may be required.

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
		grow through concrete/buildings. Giant Hogweed (Constraint): Irritant. Former buildings (Constraint): Obstructions to development from buried structures. End use: could potentially be used for residential/employment and recreation. Development in the eastern part of the Zone subject to COMAH Regulations.		
	Zone Five The contamination status of the Zone is unknown. Reference to the historical plans included in the Landmark Envirocheck Report indicates that in Zone Five, tips, an unidentified works, rail tracks, and a chemical works have been located in the Zone at various points in time. Tipped material may have comprised material associated with the former iron works, as well as other unknown material before the iron works covered much of the corridor. Therefore, there is the potential for encountering heavy metals, organic and inorganic compounds across the Zone, which could pose a risk to human health, Controlled Waters and other statutory receptors. There is an active COMAH status issued to the chemical works with a hazard zone radius of 2km. The hazard zone is thought to be under review to reduce the radius to 500m.	COMAH Site (Significant Constraint): Cannot build within 500m of site. Iron Slag Material (Constraint): Potential contamination from former processes. Geotechnical constraints from swelling iron slag. Himalayan Balsam (Constraint): Extremely invasive. Former buildings (Constraint): Obstructions to development from buried structures. End use: development subject to COMAH Regulations.	Obtain and review the PPC application and Site Condition Report to determine the contamination status of the site. Confirm with the HSE that the active COMAH hazard zone radius may be reduced to 500m.	Depending on the proposed end use there may be a requirement for ground investigation following the surrender of the PPC licence and the vacation of the site. Remediation of contaminated material if contaminated material if contamination levels exceed the appropriate assessment criteria and pose a risk to human health, Controlled Waters or other statutory receptors.
	The contamination status of the	Capped Landfill (Significant		

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
	Zone is unknown.	Constraint):		
	Reference to the historical plans included in the Landmark Envirocheck Report indicates that in Zone Six, allotment gardens, opencast works and a landfill site have been located in the Zone at various points in time. The composition of the tipped material has not been proven. Therefore, there is the potential for encountering heavy metals, organic and inorganic compounds across the Zone, which could pose a risk to human health, Controlled Waters and other statutory receptors.	Unknown fill material with unknown lining and capping specification presents significant contamination issues. Could also have differential settlement of buildings and attack of inground structures from contaminants. Geotechnical constraints from swelling iron slag. End use: likely to be restricted to public open space. Development in the eastern part of the Zone subject to COMAH Regulations.		
General Site				
Ground Gas	There is the potential for ground gas associated with the Made Ground (including infilled ponds and landfills) and Coal Measures present across the site, and the adjacent landfill to the north of the site. The site has also been subject to remedial works, by or on behalf of the Coal Authority, associated with a mine gas investigation. Anecdotal evidence also revealed that in Zone One, a gas odour was detected near the Chesterfield Canal in the 1990's, which after investigation, was found to be "marsh gas".	Potentially asphyxiating/explosive.	Obtain and review recent ground gas monitoring information to assess the ground gas regime at the site in accordance with BS8485 (2007) Code of practice for the treatment of soil gas in Brownfield sites. If the ground gas monitoring information is insufficient undertake further ground gas monitoring across the site.	Incorporation of ground gas protection measures into the development if required.
Mining	The Coal Authority Report indicates that the site is within the likely zone of influence from workings in seven seams of coal at shallow to 390m depth, and last worked in 1987. The property is in the likely zone of influence from workings in two seams of ironstone at shallow depth, and last worked in 1848.Opencast works are also known to have taken place across the site. There	Mineshafts, worked ground and spoil.	Undertake a mining desk study, and obtain and review recent intrusive ground investigation information to assess the potential presence of shallow mine workings. Positively locate the shafts and adits and determine if they have	If the existing information shows that the shallow mine workings do not pose a risk e.g. due to their removal during opencast works then mitigation may not be required. If shallow mine workings are encountered incorporation of grouting or ground improvement

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
	are no known faults or lines of weakness at the surface which would make properties unstable in the site caused by mining however. Additionally, reference to the Mining Report indicates that there are 53 shafts and adits located in Zones One, Two and Three.		been treated and capped.	works may be required. Treatment and capping of mine shafts/ adits may be required.
Ground Conditions	The ground conditions of the majority of the site are unknown. However, as iron slag and potentially other forms of Made Ground have been placed over the majority of the site, there may be compressibility, shrinkage and settlement hazards associated with the Made Ground. Anecdotal evidence also suggests that Zone Five has been raised by approximately 10m by iron slag from the former iron works located at the site. Zone The variable nature and potential significant thickness of Made Ground may present a geotechnical hazard. The nature and thickness of the colliery spoil in Zone Three (up to 30m) and in Zone One colliery spoil (40m thick) beneath the landfill consisting of 13m of spend foundry sand represent a significant geotechnical hazard. Reference to the historical plans included in the Landmark Envirocheck Report (Ref. 1) indicates that there have been numerous structures around the site that have recently been demolished to slab level (specifically in Zones Two, Four and Five). Foundations may also still exist from buildings that were demolished less recently in other areas of the site. Japanese Knotweed was also noted in Zones Three and Four.	Geotechnical constraints from swelling iron slag. Collapse potential of backfilled of opencast mines. Obstructions to development from buried structures. Japanese Knotweed can grow through concrete/buildings.	Obtain and review recent intrusive ground investigation information to the ground conditions of the site including identification and delineation of significant Made Ground and areas where buried foundations may be present. Undertake an assessment of the nature and presence of Japanese Knotweed across the site.	Due to significant thicknesses of Made Ground in Zones One and Three creating ground stability issues it is recommended that development in these zones is restricted to public open space. Foundation and infrastructure design to take into account potentially poor ground conditions. Undertake remedial works to eradicate the site of Japanese Knotweed.

Potential Constraints	Details	Identified Constraints	Recommendations	Potential Mitigation
Groundwater	Actual groundwater levels are unknown, but could exist perched in the Made Ground or Alluvial deposits that are thought to exist across the site. The Carboniferous Coal Measures underlying the site are classified as a Minor Aquifer. There is also the potential for groundwater rebound following the cessation of deep underground coal workings and opencast workings.	If groundwater is shallow, buried structures (e.g. attenuation tanks) may be subject to buoyancy uplift.	Obtain and review recent intrusive ground investigation information, and existing groundwater monitoring data to assess the groundwater regime at the site.	Localised dewatering during construction and surface water attenuation. Implementation of a suitable drainage system for the proposed development.



