Shallow coal mining has been undertaken historically in many urban areas throughout the UK, and it remains a threat to construction. Masked by interim development the risks are often poorly appreciated. Their age, and often unrecorded nature means that they are difficult to characterise or predict. This paper, explores the diversity of coal mining related geohazards and their effect on urban construction. To prevent inappropriate site development the Coal Authority has developed a robust permissions process to regulate activities which affect its property. The need for this regulatory control is explained along with its objective to protect public safety, the environment, and, by the promotion of current best practice, limit future liability. By reference to recent urban examples the risks are explored, including the action or inactions leading to claims, damages, or delays, all resulting in financial loss. An insight is given as to how the Authority, by using its GIS database develop site specific conceptual models to assess applicants proposals against the known mining-related risks. Finally, some of the remaining geotechnical challenges are discussed, which if overcome, will further assist all involved, and the regulatory process.

**PERMISSIONS HISTORY**

The Coal Authority was established by the Coal Industry Act upon privatisation in 1994. As a result of the duties vested in it by the state, the Authority must manage the liabilities arising from disturbance or interference of its property from development. This function is carried out by the Authority’s Permissions Department. When satisfied with an applicants proposals a permit to ‘Enter or disturb the Coal Authority’s mining interests’ is issued acknowledging agreement for work to proceed.

Provided the postcode of a site is known it is possible to search the Coal Authority’s online Gazetteer at www.coal.gov.uk/services/property search/gazetteer/index.cfm to determine if it lies within a coal mining area and a ‘Mining Report’ is required. Examination of the latter with the relevant published geological mapping will enable an assessment of whether the Authority’s property is likely to be entered or disturbed, given a clients proposals. Although there are exceptions, the Authority owns all former coal mine entries and workings and all coal seams whether intact or worked. Typical works requiring permission include site investigation boreholes (including those for geothermal installations and water abstraction), piling operations or excavations penetrating coal, drilling and grouting of mine workings, and investigations to locate mine entries (including probing and trenching).

**Why Is Regulation Necessary?**

Throughout the UK over 2 million buildings are affected by shallow coal mine workings, (approximately 8%), and of these 130,000 are known to lie within 20m of 1 or more shafts. Surprisingly less than 50% of all property owners have obtained a coal mining report for their property and as a result many owners will be unaware of the risks. Although proportionally small, on average 15 shaft collapses occur each year.

Mining related geohazards encompass a multitude of problems, they include;

- Subsidence and collapse of mine entries and shallow mine workings
- Unrecorded entries, soughs (mine water drainage tunnels) and workings
- Emission of noxious or asphyxiating mine gases, driven by natural or human/construction induced conditions.
- Spontaneous combustion of coal by exposure to atmospheric conditions.
- Impoundment, unconsented discharge or uncontrolled release of mine water.
- Minewater recovery and rise.
- Pollution incidents resulting from mine water and contaminated shaft fill.
- Settlement associated with opencast mine backfill.
- Failure of slopes and tips comprising colliery spoil or waste
- Mining related fissure and fault reactivation.
The majority of these hazards have the potential to seriously threaten public safety especially in urban locations. They are more likely however to have a detrimental impact on the design, cost and delivery of a project. Affected developments may be left with a residual liability or alter the potential risks to others. An earlier summary of the related geohazards associated with abandoned mines in the urban environment is provided by Culshaw et al. (2000).

THE EXISTING FRAMEWORK

The present Permissions process is complimentary to the precedence set by Planning Policy Guidance 14 (PPG14) ‘Development on Unstable Land’ (1990) in which the responsibility for assessing the suitability of a site for any purpose rests with the developer, as does the responsibility and subsequent liability for its safe development and secure occupancy. Under the Permissions process the developer and/or landowner is required to indemnify the Authority against any claim. PPG 14 refers developers to the need for consultation with the Authority, as the successor to British Coal, with respect to foundation measures taken to protect new developments in affected areas.

The issue of mine gases and public safety has been highlighted in 2006 following a fatal incident in Bell Road, Dudley, West Midlands. Subsequent to this the Health and Safety Executive (2007) published a position statement regarding the threat of producing and/or moving carbon monoxide when drilling into coal measure strata. The document recommends that ‘Water flushing should be the primary flushing method for work of this kind in the vicinity of coal measures and a risk of creating and/or moving carbon monoxide has been identified’. Only where this is not reasonably practicable will other control measures be considered. As a result in the urban setting where occupied buildings exist in the close proximity to drilling operations, water flush operations should generally be considered mandatory.

The permissions process is recognised in general geotechnical practise throughout the construction industry and the Highways Agency Manual of Contract Documents for Highways, MCHW (1997) Ground Investigation Procedure provides some guidance to what is required from consultants and contractors alike, although the current version is in need of revision.

Modifications to the present planning system have been proposed by Pennell & Banton (2008) and trials initiated to ensure that when needed all developers give due consideration to mining related risks, safety and stability of the ground in consultation with the Coal Authority when submitting Planning Applications. A flow diagram of the process where a Coal Mining Risk Assessment (CMRA) is required can be found at www.coal.gov.uk/services/planning/referral.cfm. The Authority itself is currently unduly exposed to liability claims from new construction activity because;

- it remains a statutory consultee only under the (General Permitted Development) Order, GDPO (1995),
- planning authorities do not owe a duty of care to a landowner when granting planning permission, and is not liable to neighbouring landowners by doing so
- site investigations and some other ground stabilisation operations, all of which require Authority permission, do not necessarily require planning consent.
- the Coal Authority does not have the same powers as a Local Authority to undertake corrective action under the Environmental Protection Act 1990 and Local Government (Miscellaneous Provisions) Act 1976.
- planning permission may be granted in some cases without attached conditions addressing the actual mining risks and subsequently Building Control Officers operate within the scope of the Building Regulations and are powerless to correct the situation.

Large scale development initiatives have requirements for investigation, reporting and planning set by Planning Policy Statement Nos. 23, 25 and Part IIA of the Environmental Protection Act 1990. Many smaller schemes do not, but may have the same associated risk or liability.

The report by Forster and Freeborough (2006) contains one of the few commentaries regarding the implementation of PPG 14 by Planning Authorities describing it as being ‘successful in getting geohazards included in some local plans but their inclusion had not been universal in areas where it was needed’ and ‘examination of draft planning documents, the outcomes of planning applications and… informal discussions indicated that the uptake was patchy’. To highlight this, to our knowledge, Castle Morpeth Borough Council is the only Local Authority which has produced and issued specific advice to the public regarding the threat of mine gas entering properties.

Who and What are the benefits?
The Permissions process which is non-profit making, facilitates the exchange of information necessary to enable developers to make
appropriate informed decisions regarding the impact of mining on their site through, planning, design and construction. A schemes risk register can be populated accordingly so any impact on design, operational, programme and costs identified. The further a project progresses, the more difficult and costly any necessary change will be. Permissions can be granted without contractors and specialist sub-contractors being notified provided the agreed methodology is carried though usually by incorporation into the tender process. So as not to stifle innovation the process allows consideration of revised methodologies thereafter. It is important that applicants state as comprehensively as possible what the development intentions are. The Authority requires that site inspections are carried out as a routine function of the process. Complete guidance to the permissions process is now available online at www.coal.gov.uk/services/permissions/.

**Common Misconceptions**

The Authority will not fund or undertake remedial work to aid or facilitate a developer on a site. In a limited number of cases the Authority will have to act to protect public safety, fulfil its statutory duties or qualify and manage its own future liability. If corrective action is required from the Authority as a result of negligence or omission on the part of an Indemnifier, the Indemnifier is then likely to face a claim for costs incurred under a breach of contract. The Authority is not required in any way to contribute to treatment or stabilisation costs for an indemnified site and no equivalent funding route to English Partnerships ‘Land Stabilisation Programme’ for non-coal workings exists currently.

A retrospective application process does exist but is reserved for exceptional ‘unforeseeable’ circumstances this is generally only acceptable where a desk study would not have anticipated that the entry or disturbance of the Authority’s property was possible. The process exists to capture work undertaken which otherwise would not be reported and will assist with nearby assessments in the future.

**Concerning Industry Trends**

Egan (2008) presented the findings of the Federation of Piling Specialists Survey which evaluated the usefulness of ground investigation information provided to its members. The results rather alarmingly highlight an industry plagued by insufficient or inadequate site investigations producing poor quality data. At sites potentially affected by mining hazards this only introduces ambiguity in quantifying the risks. It is often the case that site investigation contracts are awarded on price rather than value, consequently for clients any saving is frequently short lived. Engineers provide final logs often from their interpretation of drillers notes introducing the scope for further error. Gaining an engineering appreciation of urban brownfield sites is more reliant on multi-disciplinary techniques and the figure that nearly three quarters of geophysical investigations in the survey were considered to be of little use would seem a reasonable estimate given recent experience from those targeting shallow mining. As all sites are individual it is very difficult to set meaningful minimum requirements for an investigation. However, if concerns exist regarding possible inadequacy of an investigation, the applicant and client are likely to be challenged.

Of the 1000 annual applications typically received, 50% fail to provide satisfactory completion information and the trend continues for factual reports to be received, unaccompanied by recommendations or a declaration statement. A similar number of sites are expected to undertake work without permission which is neither in the interests of the contractor or the client and could result in court action and the intervention of the HSE. Proving that a feature such as a mine entry is not present is equally as important as providing the as-built treatment details.

**PROMOTING IMPROVED PRACTICE**

The Authority is committed to working with organisations such as the HSE, British Drilling Association (BDA), and CIRIA on practical low-cost solutions which consider the residual risk. All information supplied is treated as confidential to protect the commercial interests of the applicant. The Coal Authority is presently collaborating with the aforementioned to produce a Code of Practise for Safe Drilling into the Coal Measures to provide more comprehensive guidance anticipated from the aforementioned HSE position statement. Its aims are threefold:

1. Promote safe practice
2. Provide a standard approach stating the minimum expected useful to clients particularly for the purposes of tendering or specification of work, and
3. Better define acceptable methodologies to assist the planning of investigation and treatment work.

The second aim will hopefully eliminate those contractors who win work on the back of quotations that ignore current guidance, irrespective of whether it is later readdressed.
A recent drilling incident has highlighted the dangers associated with drilling into Coal Measures, and worked horizons in particular. In July 2009 at Kirkcaldy, Scotland a spontaneous combustion incident, believed to have been caused by rotary air flush drilling whilst coring, resulted in a heating event within shallow unrecorded workings, down dip of nearby residential housing. Following the recovery of a smouldering core sample carbon monoxide concentrations up to 500ppm, (the long-term exposure limit being only 30ppm), were recorded from 3 monitoring boreholes. At the time of writing the heating is believed to have been contained to a localised area by the sealing of boreholes with a cementitious grout on advice of the Authority. Whilst monitoring continues it is hoped that the need for costly grouting works and the evacuation of local residents will be avoided. A permit had not been obtained to undertake the drilling operations and the incident was reported to the HSE in accordance with agreed procedures set out in the current Memorandum of Understanding established between the Authority and HSE.

This and other recent incidents have highlighted concerns that drilling is being undertaken without the necessary materials and equipment present to deal with instances such as uncontrolled minewater discharge, release of mine gases under pressure and spontaneous combustion. The risks to construction workers on mining affected sites are serious. All parties should now be aware that individuals with responsibility can be held personally accountable for omissions, deficiencies or poor practice in protecting their workforce under the Corporate Manslaughter Act (2007).

**Sources of information**

In addition to historic Ordinance Survey maps, geological maps produced by the BGS and the mine abandonment plans held by the Mining Records Centre in Mansfield a number of other information sources exist. The series of Applied Geological maps summarised by Smith and Ellison (1999) are especially targeted to urban sites. Although, (Royce 2009) has highlighted that one of their main shortcomings is the ability to portray superficial materials, particularly where complex assemblages exist. Despite this they provide useful information which should not be ignored.

The Engineering Group of the Geological Society of London now provides several informative internet pages devoted to mining geohazards which have been produced by the Working Party on Geohazards, at www.ukgeohazards.info/. The BRE Environmental Code of Practice (2006) includes an example specification for drilling and grouting works, although the revision of this document has been recommended recently by the Environment Agency.

The ground often gives rise to ‘unforeseen circumstances’; if this occurs whilst construction is underway the Conditions of Contract will normally deal with this under specific clauses. Whilst conditions may be unforeseen the question as to whether they were unforeseeable arises. This would not be the case, if for example, an omission had been made in viewing records which could have predicted the circumstance during the deskstudy phase. It is always recommended that a consultant view the relevant Mine Abandonment Plans.

Those providing advice from information contained in Mining Reports, must be aware of the limitations of the data and the conditions under which it is provided; those in doubt should refer to the Law Society and Coal Authority (2006) Directory and Guidance. Since developers will require the non-residential service they should be aware that the usual accompanying insurance extends only to residential dwellings. Increasingly client’s advisors are relying on outdated mining reports, the recommendation by the Law Society is that any report greater than 90 days old should not be relied upon. Where an entry or entries are shown to affect a development it is recommended that a follow on Interpretative Report is obtained.

Whilst this paper is concerned with coal mining related geohazards information relating to naturally occurring ground stability hazards is now offered by the Ground Stability Report, available for on and off coalfield areas, details of which can be found at www.groundstability.com. These reports are in-part compiled for the British Geological Survey’s Geosure Database and indicate the potential for the occurrence of shrinkable clay, running sand, compressible and collapsible deposits, landslides and soluble rocks. Although currently restricted to these 6 types of natural hazard further information can be obtained for the BGS Georeports Service at www.bgs.ac.uk/GeoReports and by contacting their enquiry team who can offer enhanced site specific reporting. In respect to non-coal mining hazards, the former Department of the Environment in the early 1990’s commissioned a series of national land instability reports, one of these resulted in the creation of the Natural and Mining Cavities Database which still maintained and updated under licence from DEFRA by Peter Brett Associates.
Geotechnical considerations
Ancillary or enabling works often occur before the mining related risk is properly established and frequently it is these operations which result in surface collapse and or place construction workers in danger. The trafficking of plant and equipment and haulage of earthworks materials are common instigators of near surface crown-hole collapse, see Figure 1. These, and activities like vibro-stone columns and dynamic compaction, impart vibration energy into the ground with the potential to cause instability. Shafts are particularly under threat, and where treatment details are unknown, they should be regarded as potential voids.

Clients need to be aware of what the certifying consultant engineer’s specification is providing. Comments such as ‘The stabilisation process shall involve the infilling of open voids to eliminate, as far as is reasonably practicable, the risk of a mine working collapse having an influence on the completed structure. The process will not improve the bearing or consolidation properties of the ground…’ may be reasonable. It is important that designers are made aware of the limitations of treatment works to avoid inappropriate assumptions. In cases where stabilisation occurs before proposals are finalised the consultant should ensure that any subsequent alterations, particularly in layout, have been suitably catered for.

The use of geogrids as solutions to cover grouted shafts has become increasingly popular for areas left intentionally undeveloped because of the risks posed to buildings and infrastructure. It is important to remember the design life of such applications, and the fact that they may act to disguise future settlement.

Empirical rules of thumb like the 10x seam thickness rule often cited and referred to in CIRIA SP32, Healy and Head (1984), are open to misinterpretation and abuse. There are various scenarios in which the rule should be used with caution. In steeply inclined seams a bulking ratio determined from physical and mechanical properties of the ground may, because of lateral migration of material, significantly underestimate the actual collapse potential.

The known susceptibility of some opencast backfill to collapse settlement remains of concern. Recent pipeline projects, which by their construction are sensitive to differential movements have successfully crossed backfilled areas but required additional monitoring to ensure the risk is properly assessed and suitably mitigated.

Figure 1 Induced collapse of near-surface roadway by earthworks traffic, Commercial Development, Stoke-on-Trent.

A major concern when undertaking grouting works is the potential to damage third party property. This may occur some time in the future, and result in a costly claim or difficult remedial work. In the urban environment where properties may border the treatment area, sufficient controls must be in place to prevent trespass and party wall disputes. Grouting has the potential to interfere with services, result in ground heave, and alter the local transmissivity of near surface with respect to mine water and mine gases. Such events may require the evacuation of the public, affect property values, release contamination or result in disruption to businesses.
The difficulties associated with stabilisation works in ground comprising running sands in the presence of a high water table were highlighted in December 2006 when the Authority responded to a shaft collapse at a site near Bolton. The void created consumed outbuildings and affected a road which was later diverted during the engineering works. The permanent solution comprised a 22m x 12m reinforced cap supported on 18m long rock socketed CFA piles forming a contiguous retaining wall around the shaft perimeter. Added to this, the 8m of superficial fill over the site was found to contain hazardous waste. The total cost of the remediation was £0.5 Million, a significant amount considering the shaft was only 3.0m in diameter, albeit void. It is important to note that the sands were contained within made ground as running sands are commonly considered a natural ground hazard.

The use of contaminated material as shaft infill or intentional disposal of waste into shafts is widespread. Whilst the Authority’s interpretative reports give some information, much activity is likely to be unrecorded. As a result ‘it should be assumed that all materials encountered in boreholes... are potentially contaminated.’ BRE (2006). Contractors should recognise the increased potential for contingency measures and the client the unforeseen costs and liability.

As might be expected a strict adherence of shaft cap treatment to that recommended in CIRIA SP32 exists, and advice to structural engineers in overcoming mining related problems continues to reinforce this in the absence of updated guidance. With sustainability, new standards and site handling issues in mind it is recommended that designers depart from the practice of using an ‘off the shelf’ solution but individually design caps as structural elements, to meet the specified serviceability requirements, and in the process reduce structural redundancy.

CONCEPTUAL MODELLING OF MINING GEOHAZARDS

All permission applications are assessed on a site specific basis following a dual assessment process. This considers the ground engineering (stability) risk and secondly the geoenvironmental risk. The latter include mine water and mine gases which are accessed using the source-pathway-receptor methodology. The need for conceptualisation of sites is a well accepted industry best practice, and supported from the geotechnical viewpoint in the AGS Good Practice Guidance Document (2007) which recommends that a conceptual model should be developed for all sites. For gas, BS8485 (2008), makes the conceptual model a requirement, and BRE R488 (2006) recommends the approach for the protection of groundwater from leachates in PFA.

The Authority’s attributed geospatial database is used in the Permission assessment process to develop site specific conceptual models that can identify the existing risk from mining related geohazards. At the end point a residual risk is derived which takes into consideration the likely interaction and effect of an applicants proposals. The database is updated on a daily basis and internationally unrivalled in its comprehensive national coverage. Because of this, and the targeted purpose of the model produced it is perhaps closer to realising the future application of GIS systems in which site investigations today are testing the pre-existing spatial models developed using real data.

The visualisation of possible emission pathways is particularly beneficial because of their complexity, interaction and variety. The possible pathways typically available can be classified as follows;

1. **Discrete man-made emission points**
   - Mine entries shafts and adits
   - Un-reinstated, poorly sealed or open boreholes and excavations

2. **Diffuse Natural Pathways**
   - Permeable strata, particularly jointed sandstone.
   - Geological faults

3. **Diffuse man-made emission points**
   - Shallow mine workings, including those from outcrop
   - Surface disturbance including made or backfilled porous ground
   - Service ducts & trenches
   - Mining induced fractures.

It is important to consider that temporary migration pathways can be created during construction, gases may be under pressure as a result of minewater recovery and that the release of mine gas is strongly influenced by the prevailing atmospheric (barometric) pressure at the surface. Basements, buried structures and confined rooms; and those with poor ventilation, are at an increased risk. All excavation boreholes need to be effectively sealed from the atmosphere to ensure they do not later become migration pathways, especially where they are located within the footprint of proposed buildings.

Drilling operations other than water flush in the urban environment need to set in place other effective control measures in agreement with the
Authority. Where relied upon barrier superficial deposits or the case of flooded mine workings need to be proven across the site, especially since former construction on brownfield sites may have disturbed or removed the natural superficial cover. Flexibility to switch from air flush to water flush whilst drilling may prove cost effective depending on thickness of superficial cover and the size of investigation. The internal monitoring of receptor properties is generally always preferred rather than use of intervening monitoring points. Figure 2 provides an example conceptual site model of a site where air-flush drilling was undertaken with a requirement for internal gas monitoring. All the aforementioned reinforce the need for detailed, high quality design and reporting of Phase 1 and 2 investigations.

Figure 2 An applicant’s conceptual model of mine gas risk resulting from an air-flush operation, at a site in Rochdale.

It is important the mine gas risk to proposed development is properly considered using CIRIA 665. Recognition is needed however to the expected paucity and unpredictability of potential mine gas release. The variability in monitored gas concentrations is well recorded from the Authority’s liability sites, an example of which is included in Figure 3. Gases are almost always monitored during investigations only for the threat that drilling poses and not to supplement or fulfill the site assessment requirements as defined in Card et al. (2007), CIRIA C665.

Figure 3 Mine gas monitoring records from a liability site, in Rotherham. Spot readings from a sealed drift vent installed in 1994.

The classification of PFA as a waste material remains under review by the Environment Agency (2008). This, and the draft quality protocol covering the re-use of PFA is expected to recognise the valuable use (given certain control measures described therein) of PFA as a reusable and cost effective by-product of the power generation industry and bring present UK guidelines in line with the European Waste Directive. The aforementioned report recommends that the BRE Code of Practise document is revised to take account of updated legislation and terminology and the adoption of a quality protocol using the reports own risk assessment procedure.

With the growth of ground source heat pumps (GSHP’s) and continuing need for new water supply boreholes, the risk of drillers encountering methane is increased by likely interception of deep workings. A fact highlighted in July 2008 on a site in Bradford City Centre, in which a drill rig caught fire during drilling works to reposition a submersible pump following drawdown trials in a new deep water abstraction well.

**CONTRACTUAL RISK AND LIABILITY**

By taking out an indemnity, the indemnifier, which in all cases should be the developer and/or landowner, is entering into a **contract by deed** with the Authority, **the term therefore being a period of 12 years from the effective date**. During this time the indemnifier is bound to the terms and conditions of the permission which include some ‘absolute’ obligations with respect to liabilities arising from the aforementioned mining related geohazards. The developer or landowner is agreeing to indemnify the Authority “against liability for claims, losses or damages, including those made under the Coal Mining Subsidence Act 1991” and those which result from any failure by the Applicant or the Applicant’s contractors to comply with the requirements of the permission, or “as a result of any act, failure, inadequacy, omission, negligence or default by the Applicant or the Applicant’s contractors in designing or carrying out the work”. The AGS Loss Prevention Alert No. 40 (2009) addresses specifically the Authority’s indemnity conditions advising their members that they should not act, and, as is explained, cannot generally fulfil, all the conditions required of the indemnifier.

These clauses exist because of the serious consequences to public safety which potentially
exist and are supportive to Planning Policy Guidance 14 (1990 with Annex 1: 1996) which states that ‘Primary responsibility for assessing the suitability of a site for any purpose rests with the developer’. Failure to involve the Authority when decisions are made concerning mining related risks means developers proceed ‘at their own risk’ and may subsequently incur costly corrective action.

In respect to professional indemnity insurance clients remain at risk because of the potential delay in the manifestation of a problem, which could be several years after contract completion. In this case it is the value of insurance carried at the time of notification of the claim being made that applies and not the amount they were required to have under the contract. Furthermore, clients will need to prove the insured’s legal liability for their loss and there is no guarantee that an insurance company itself will be able to fulfil any subsequent settlement. When appointing a contractor clients should be vigilant of net contribution clauses written into conditions of appointment.

Delays associated with the permissions process often result from a lack of communication, namely who takes ownership of completing, submitting and managing the application. It is recommended that the client as indemnifier should clearly allocate responsibility at the outset.

In a limited number of circumstances the Authority may wish to convey to the developer former entries affecting a site. Clients therefore need to examine this implication for subsequent sale or retained long-term ownership thereafter.

It is essential that Clients appoint a qualified supervisor in accordance with PPG14 which states that those responsible for preparing the Ground Stability Declaration should meet the requirements of a Geotechnical Specialist as defined by the ICE Site Investigations Steering Group. Ownership of any specification should be clearly assigned and any contractor appointed should have BDA audited and qualified drilling staff. Clients should be clear of the implications of warranty conditions set by a contractor especially for undertaking treatment works. The significant benefits of specifying full-time supervision need to be realised. A consultant will take a degree of responsibility and therefore liability for works undertaken under their supervision.

With the economic downturn mothballed sites have increased in number dramatically but clients should not forget their Health and Safety obligations under the Occupier’s Liability Act (1957) and (1984). For sites where a permit remains in effect, they may need to react quickly to maintain the safety and security of a site.

**FINANCIAL RISK**

Increasingly financial institutions are looking to check that Coal Authority permission has been correctly obtained for all work elements before releasing funds. As a result developers may find substantial funds tied up until such time as conveyances are completed and the necessary documentation is in place. Insurers like the National House Builders Council, (NHBC) check to confirm that the Coal Authority has no outstanding objections to a development and furthermore to confirm that it has been carried out to an agreed standard. The option exists to the Authority, where it believes inappropriate development to have taken place, to record and publish this on all future mining reports covering the affected site.

Many former mining properties have restrictive covenants placed on their deeds that specify what development is permitted in future. In some cases the Authority maintains access and leasehold right and these should be thoroughly checked at the due diligence stage.

Cases are known where development, stabilisation of shallow workings by grouting, have been claimed to have affected adjacent Network Rail Infrastructure. These have resulted in speed restrictions for trains using the line and consequently train operators have filed claims against the developer to compensate for the disruption to services.

Clients and developers should protect themselves in cases where contamination may affect water quality. By commissioning testing of pre-construction ground water samples a benchmark for water quality can be established.

The Authority operates several hundred ‘liability sites’ across the country many of which perform a vital function, whether by monitoring, treating or pumping mine water or actively withdrawing mine gases. Associated with these are discharge consents and other operating licenses which have the potential to be affected by nearby development. There is no reason however, provided development is well planned in consultation with the Authority, for works to be prohibited near these liability sites, particularly in the case of beneficial regeneration. Recently in Sunderland the Authority worked with the local authority and design consultants to install a new public artwork that will enhance the visual
appearance of operational mine vents located next to the Stadium of Light, Figure 4.

Figure 4 ‘Looking in, Looking out’, public artwork at the Stadium of Light, Sunderland, a) foundation construction and b) completed artwork.

RECENT CASE HISTORIES

Three case histories are presented. Although they are all problematical in nature they serve the purpose to demonstrate the consequences of inappropriate development, or in the final case, unforeseen circumstances.

1. Commercial Units, Ashington, Northumberland.

The site is located in the centre of a modern industrial estate. One voided shaft and one partially filled shaft occupy the site, both brick lined and sunk to deep workings at approximately 228m below ground level. These shafts were the former upcast (4.65m diameter) and downcast (2.7m diameter) shafts of a colliery which closed in 1967. The two shafts were separated by a lining to lining distance of only 5.5m. Planning permission had been granted for two steel framed buildings for light industrial usage. Foundations comprising vibro-stone columns to a depth of 5 to 6 metres were being installed through the superficial made ground to within a planned 5m of the voided upcast shaft. Rockhead comprising weathered sandstone was suspected at approximately 10-11m depth but had not been confirmed by earlier investigations which terminated in the glacial deposits.

The issue of poor communication between the site manager, (engaged directly by the landowner), and the main contractor and sub contractors was identified soon after the Authority was approached by a local Building Control Officer. It was apparent that no specialist geotechnical advice was retained on the project following the initial site investigation. The Structural Engineer had been asked to design the building without knowledge of any mining risks being present, the main contractor then proposed the vibro stone column foundations under a similar understanding. It was apparent at this stage that the developer had not planned any remedial works to either shaft and had not proven their location or condition. The site itself had not been securely fenced from public access despite a public car park adjoining the site. As a construction site, plant was trafficking over the area and concern was raised that despite warnings to demarcate an area free from traffic around the plotted locations of the shafts, this was not being observed.

Given the situation of having to make daily visits to the site the Local Authority was sufficiently concerned that the HSE were notified and a visit by one of their regional inspectors followed. The HSE issued a temporary stop notice preventing the continuance of work on site until the notifiable matters were satisfactorily resolved. Work on site was suspended for approximately 1 week. It was considered that the Site Manager had breached the requirements of CDM (2007), the revision of which has partially been to strengthen and ensure effective communication between the involved parties. The Local Authority issued a requirement for contamination testing of soils and a further site investigation to confirm the absence of shallow unrecorded mine workings. The Authority, with the owner now engaged in the permission process, issued a series requirements which were endorsed by the Planning Department and Building Control, these included;

- The building footprint was revised to give an increased standoff from the up cast shaft sufficient to allow the remaining vibro-stone columns to be installed safely with a revised exclusion zone around the shafts.
- Permission was given to fill the shafts with stone locally sourced and crushed on site to an agreed specification and in consultation with the Environment Agency following payment and issue of the appropriate licence. These works were supervised by a specialist sub-contractor with fill levels being increased in unison to avoid a possible collapse of both shafts at depth.
- The Authority’s assessment revealed the presence of a third (counterweight) shaft associated historically with the upcast shaft. Investigation revealed a shaft diameter of 2m containing loose fill and a depth of 14m. This shaft was subsequently located, drilled and grouted but not capped as it was positioned in a landscaped area away from any building.
- A fourth staple shaft was believed to exist beneath the revised building footprint and additional investigation work was required to confirm this did not extend to the surface.
- The upcast and downcast shafts now acceptably filled were capped to a CIRIA SP32 specification with inspection covers to
monitor fill levels. Concerns had arisen when, nearing completion of filling process, the upcast shaft fill slumped suddenly to a depth of 14m.

- The owner was unaware that the Authority maintained leasehold on an area surrounding the two main shafts and an access route to it through the site. As a result the Authority has retained the right to access the shaft in future to inspect the fill and monitor gas/mine water levels from the installed vent.

Figure 5 Ashington site, a) shafts prepared for capping (inset shaft filling operation) and b) geophysical electromagnetic (EM31) plot showing limited coverage of the site resulting from access constraints.

All property conveyances were withheld until the works were satisfactorily completed and the validation report including declarations was received in March 2009. This delay resulted in financial difficulties for the developer as their lender refused to release further funds. The constructed units could not be handed over to the expectant leaseholders and contractual penalties for the late delivery were due to commence. The overall development costs in overcoming the mining related hazards in this case are expected to have exceeded £150k, an estimated 15% of the total build cost.

2. Housing Development in Oldham, Greater Manchester

A housing developer was constructing a small development (13 units) of 3 storey semi-detached town houses. Geotechnical investigations had been undertaken from 2005 onwards and identified the site as being affected both by shallow workings within 1 seam at approximately 22m below ground level and two recorded mineshafts. Difficulties on the site commenced when a dispute arose between the client and the original specialist stabilisation subcontractor consequently the original subcontractor was dropped. A second company was duly appointed to complete the works with the developer indemnifying the whole site, including all previous treatment works. The original subcontractor contacted the Authority advising us of their concerns that untreated mining features existed and other unrecorded features were suspected.

The reporting of basement obstructions being encountered during surface trenching for the second recorded mineshaft lead to concerns that it could be present, but had not been detected. Records supplied confirmed that the known shaft had been located and its depth proven in October 2007 before any construction commenced. Later work in early 2009 to drill and grout the shaft found that it had been built over, straddling two units one pile penetrating the shaft interior. Without informing the Authority and acting in trespass a spanning structural reinforced concrete beam had been constructed over the shaft requiring the breach of the installed gas protection membrane. The details of the beam had not being agreed with building control and on examination was considered unacceptable by the Authority's Structural Engineers.

Without a successful conclusion it is expected that suitable comments will be placed on the mining records for the shaft which will affect the properties future price and desirability. At the time of writing, the housing developer was faced with the prospect of having to demolish the properties or provide a substantial security fee against future damage claims. The latter would only be permissible on provided it could be satisfactorily demonstrated that any future movement was likely to result only in serviceability issues and not endanger the public or future occupiers.

Figure 6 Coal Authority assimilated GIS data taken from the conceptual model assessment for the Oldham site.

3. Proposed Secondary School Redevelopment, Gateshead

The intention of this PFI project is to redevelop a 1960’s CLASP school site in Gateshead. 1 recorded mineshaft was known to affect the site, coincident with a manhole location a permission application was received to investigate the shaft.
Services and existing school buildings meant that the location of probe holes would be restricted and the use of geophysics difficult because of thick made ground deposits largely comprising colliery spoil. Inspection of the shaft by a team from the Mines Rescue Service found an anti-chamber at 8m depth at the base of the upper rectangular brick lined section beneath the surface manhole. Access was gained from the anti chamber to a lower circular masonry lined shaft which intercepts an unrecorded drainage tunnel or sough at 14m depth. The sough comprises an arched tunnel approximately 1.6m high and 1.5m wide.

A CCTV survey explored the tunnel and located a suspected roof collapse at 12m south and 14m northeast of the shaft base. It was evident from this that water at the base of the shaft, originally considered not to be flowing was indeed actively draining water, in some quantity, from the south towards the existing school and proposed redevelopment to the northeast. Construction with steel arches, now heavily corroded, and timber blocking to the deteriorating mudstone roof appeared coincident with a construction date around the late 19th Century or early 20th Century, shown in Figure 7. No record of the drainage sough has been found from any archive source and an extensive search of the Authority’s abandonment plans and records for the nearby former colliery provides no indication of its existence, even at decommissioning or from the subsequent sale of land to the Local Authority.

Assessments of the stability of cut slopes along the southern boundary of the site made largely in colliery spoil revealed more than one slope to be at or below a factor of safety of 1 as a result of a high water table saturating the underlying Glacial Till. The hydrogeology of the site is further complicated by artesian waters within the coal measure sandstones. The client was informed that if impoundment of the tunnel occurred due to construction related collapse, an unpredictable and uncontrolled mine water discharge could occur at the surface, the stability of the perimeter spoil slopes could be jeopardised as well as the integrity of any structure present at the surface.

Design proposals involve spanning a 6m settlement trough using ‘rafted strips’ running the length of the building. These have been designed to transfer the column and wall loads to the ground. They are also required to support the lateral beams spanning the width of the building which lie parallel to the conjectured alignment of the drainage tunnel. Such a solution would significantly increase the build cost. In places rock cover is expected to decrease to approximately 9m but with a substantial void at this depth and a history of partial roof collapse the risk to any structure above remains high. Grouting of the tunnel is not an option because of the continuing drainage function, and the costs of new pipejacking works to divert the flow currently cost prohibitive. As a result of the mining related problems the project remains several months behind schedule with investigative work continuing to try to determine the course and discharge of the sough. The Authority is considering the option of installing a permanent remote monitoring station within the shaft to gather water level data in the tunnel and give warning of high water levels.

Figure 7 a) Photograph of the unrecorded drainage sough, taken viewing downstream towards the existing school buildings, and b) a location plan showing the proposed redevelopment layout, Gateshead.

FUTURE DEVELOPMENTS

Clearer policy statements regarding acceptable development would be beneficial to all and improved efficiency of processing applications will be necessary in the future. The latter is currently being addressed by recent commitments to update internal operations.

The Authority is currently examining the possibility of some applications being processed automatically. The aim of this new online service will be to both reduce turnaround time and deal with an anticipated increase in application numbers resulting from the issue of new standing advice to, and referral from, local authority planning departments.

An ongoing mine entry inspections programme, is a proactive way in which landowners will made aware of potential hazards whilst ensuring suitable measures are taken to protect public safety.

It is hoped that forthcoming developments external to the Authority will assist clients and their advisors. They include;

1. The release of the British Geological Survey’s national borehole database into public domain.
The availability of this data is significant for the assessment of urban sites because of the concentration of data held and its assistance with clarifying what control measures are necessary, particularly in relation to superficial deposits. It should allow the easier development of meaningful conceptual models.

2. Plans to create a ‘Register of Ground Engineering Professionals’ by the British Geotechnical Association should make the identification and appointment of suitably qualified consultants a more assured proposition for clients.

3. The BGS ‘Derived Products’ team has commenced work on the ‘Underground Asset Management tool’ to help determine what existing infrastructure could be potentially at risk from a variety of hazards; mining included. A by-product again will be a much improved characterisation of superficial deposits.

Collaboration

The Authority is currently in discussions with Network Rail to ratify and implement a working procedure for referral and exchange of information within its infrastructure boundaries. It is expected that Network Rail will update its operating standards and procedures to regularise the agreement.

A much needed rewrite of the CIRIA Special Publication 32 has been agreed between the Authority and CIRIA and although a funding gap currently exists it is hoped this major update will draw on the existing guidance bringing it in line with recent UK and European legislative changes. This document should complement the intended code of practice for drilling into coal measures.

Research

Work needs to be undertaken in the near future to promote the receipt of ‘Ground Stability Declarations’ albeit in an updated format to that currently presented in Appendix 2E of PPG14. Involvement of a ‘Geotechnical’ or ‘Ground Engineering’ Specialist is recommended as mandatory for sites where a Coal Mining Risk Assessment (CMRA) is a planning requirement. Ideally this should subsequently form part of the permission application.

Experience has highlighted that the minimum requirements for site investigation where shallow mine workings are suspected need to be more clearly defined, whilst taking account of the benefits of a phased approach.

A variety of control sites are required for research into how mine gases are moved or displaced as a result of intrusive drilling and stabilisation work, as opposed to or in interaction with, the natural drivers. Although work has commenced in this area many unanswered questions remain and improved methods of predicting both gas concentrations at receptors and influencing distances from drilling operations is needed. The present spontaneous combustion list will need to be improved through research as the data is largely derived from incidents recorded from historic underground mining operations.

A combination of smart technologies and multidisciplinary approach is often required to resolve complexities intrinsic to the urban environment. Monitoring While Drilling (MWD) systems which record various useful parameters digitally would greatly benefit the management and recording of treatment works and rigs with recirculation of drilling fluids are increasingly in demand in the urban locations. The downhole Cavity Autoscanning Laser System CAL-S has applications particularly where open voids remain. Where work may affect on or offsite properties the monitoring of nearby structures should be undertaken. Automation of digitally recorded data is now easier as plant can be fitted with GPS to provide spatially populated mapping across a site. These techniques should not remain the preserve of remedial treatments.

The extension of current AGS data format to capture mine treatment and stabilisation works would be of great benefit but its uptake by the industry, as in the case of piling, Egan (2008), is likely to remain a prohibitive factor. Successful digital 4D representation of, for example, drilling and grouting works is likely to remain the preserve of larger, higher profile projects. Despite this has been demonstrated to be highly beneficial for urban projects where public consultation is essential, Hyder Consulting (2009).

Geophysics should always be used in a complementary manner to other often intrusive investigation techniques forming a combined approach. It appears however that their full potential is not being realised at present and this may be helped by the publishing of summary data and statistics to improve the situation.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Ian Wilson, Director of Mining Projects and Property at the Coal Authority for his kind permission to publish this paper. Bill Denton, Coal Authority Operations Manager is thanked for his review and comments.
on the draft manuscript. The views and opinions contained herein are those of the author, and are not necessarily those of The Coal Authority.

REFERENCES


