Assessment of the Constraints on Sustainable Urban Drainage Systems Due to Rising Mine Water and Mine Water Management

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Abstract

Many urban areas of the UK have underground mine workings, which were dewatered during mining. Cessation of pumping and resultant rising mine water changes the natural and post mining hydrogeological properties of the subsurface. Sustainable drainages systems are the promoted common approach to manage surface water. Groundwater changes can either be influenced by these systems or their presence can influence effectiveness; leading to an increased flooding risk and contrary to the aims of sustainable drainage. This paper describes a trial screening tool developed to help assess the suitability and site specific design of sustainable drainage now and in the future.

Keywords: Rising Mine Water, Water Management, Sustainable Drainage, Constraints

Introduction – sustainable drainage and planning policies

Within England, the National Planning Policy Framework 2018 requires:

- Local authorities to ensure the flood risk is not increased elsewhere when determining any planning application for major development and where appropriate, application should be supported by a site-specific flood-risk assessment.
- All major developments incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should take in to account advice from the lead local flood authority (typically councils), and have maintenance arrangements in place for the lifetime of the development (typically in excess of 20 years).

Government policy (25 year plan) – aims to reduce the risks of harm from environmental hazards – people, environment and economy relating to flooding, drought and erosion. This policy includes making sure that decisions on land use including development reflect the level of current and future flood risk.

Introduction – the groundwater problem

The trial of the screening tool was undertaken in the northeast of England, where issues of groundwater flooding have been occurring (Coal Authority, 2018). Here groundwater flooding has been seen in areas where infiltration has been increased due to changes in rainfall patterns, human activity, or where mine water and groundwater levels have recovered.

Large areas of Northeast England (similar to other areas in the UK) have been undermined by coal workings. During mine operation, pumping artificially lowered the groundwater and in many cases, it resulted in significant and long duration changes to natural pathways, through use of mine drainage pathways. Following cessation of pumping mine water and groundwater levels rose and recovered, are still rising or are controlled and managed by pumping to prevent environmental and aquifer pollution. Due to the age of the mine workings in the area (for instance, some started more than 300 years ago), much of the current urbanisation has developed above mine workings, and also developed when mine water and groundwater levels where artificially lowered by pumping. Fig. 1 shows the area of Newcastle-upon-Tyne and Gateshead and how the urban areas grow along with the extent of underground mine workings.

In some areas, with specific geological, mining and hydrogeological conditions, infiltration based sustainable drainage (SuDS) (or SuDS with an infiltration component or a retention component) may not work at present, or in the future. This could result in groundwater and or surface water flooding risks, in some instances such issues may not occur immediately and develop at a later time.

Where there are mine workings below an area with SuDS, infiltration could be in to the mine workings. Some of these areas have mine water management or controls in place to prevent pollution to surface water courses and the wider environment. Increases or changes in infiltration patterns (due to changes in rainfall patterns) could have adverse impacts on the environment, and potentially on the mine workings.

In many parts of the UK, groundwater flooding often appears to have been overlooked, and has sometimes not been considered an issue. This status is even more pronounced when in areas with ongoing mine water management or mine water rebound. Often, it is assumed the groundwater and infiltration regimes will not change in the future. Fig 3 shows the mine water blocks in the northeast of England and also highlights the areas where mine water level could change in the future (rising mine water or pumping controlled blocks).

Due to the potential risks from changing mine water, the Coal Authority and the Environment Agency undertook a joint project to assess potential risks and develop a

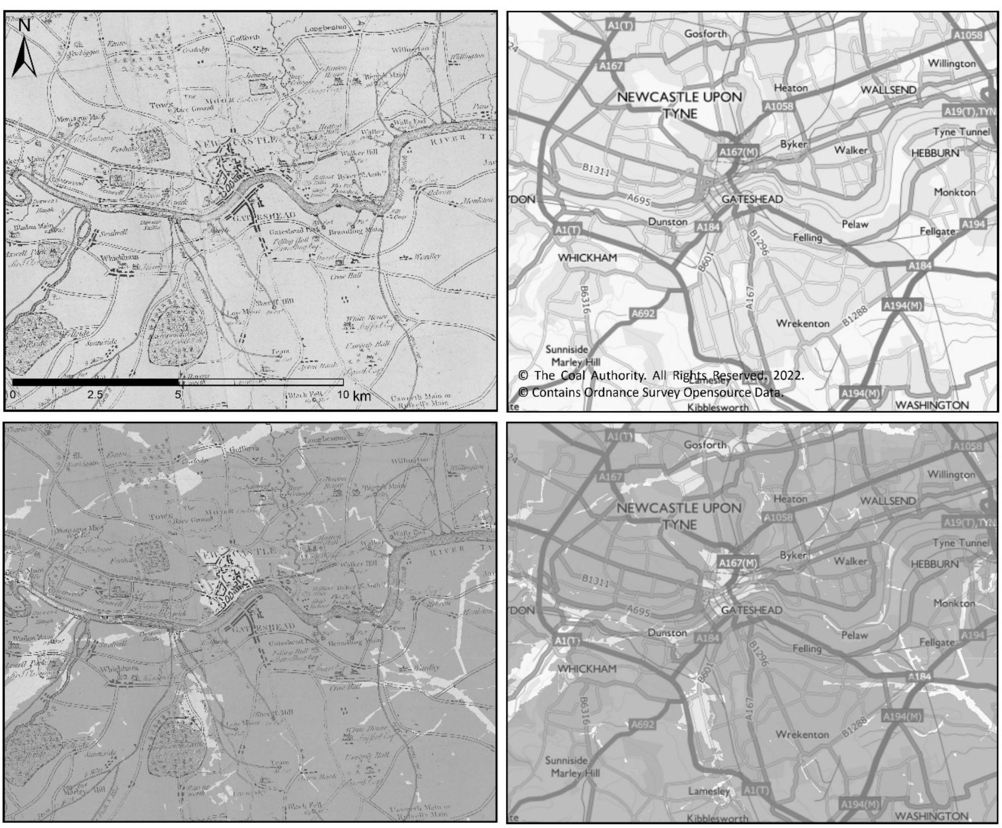

Figure 1 maps showing urban development between and coal mine workings (top left: map dated 1788; top right map dated 2020; shaded areas on bottom maps are mine workings).

Figure 2 *groundwater flooding caused by an unplanned reduction in mine water pumping (the pumping station is 7 km from the groundwater issue). Images Coal Authority© and Environment Agency©.*

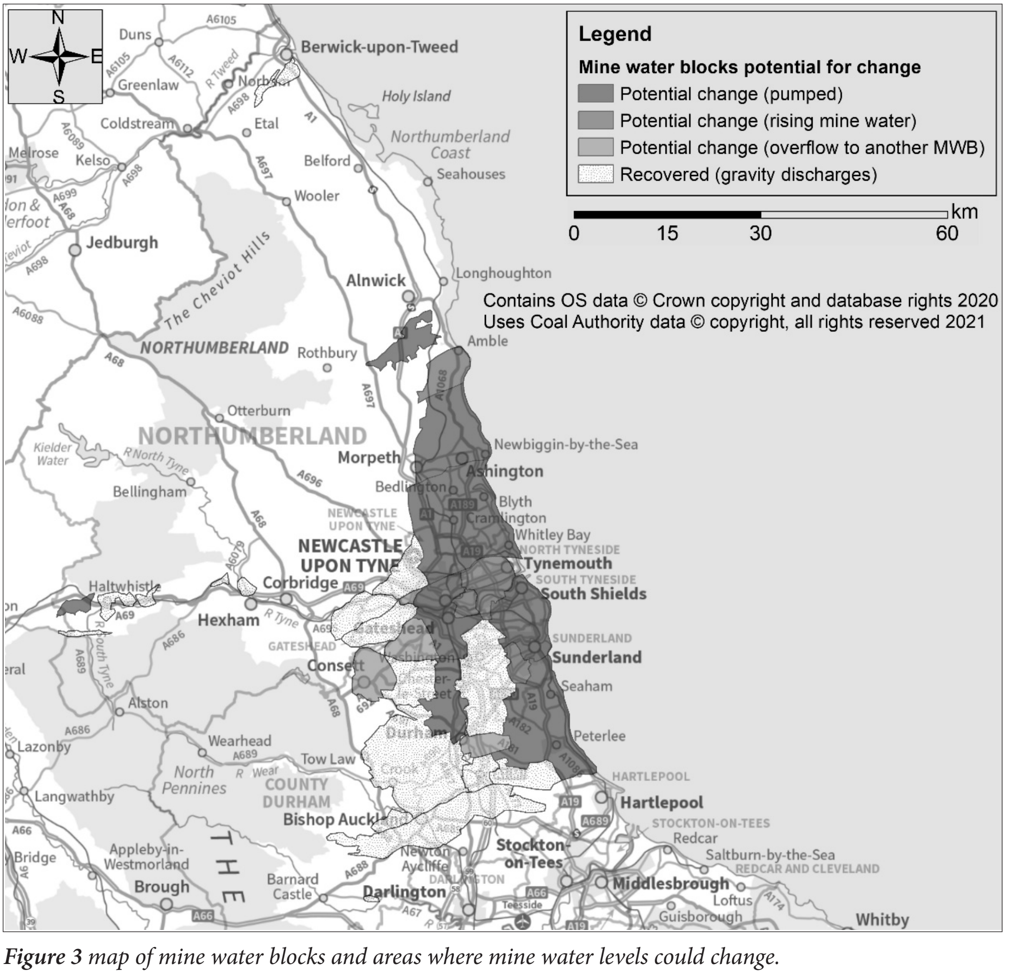

Figure 3 *map of mine water blocks and areas where mine water levels could change.*

screening tool to be used by lead local flood authorities, developers, and consultants.

Screening tool development methodology

The section below describes how different parts of the tool were developed. Essentially, the screening tool was developed using the following key stages.

Stage 1 – assess and appraise potential risks and constraints of SuDS and mine water.

- Set up of an early project group between the Coal Authority, Environment Agency, and 2 of the lead local flood authorities in northeast England.
- Initial ideas were for risk based maps, however, due to the complexity of the potential surface and groundwater interaction, a preferred constraints tool was chosen.
- Standard approach of "source-pathway-receptor" used throughout the development of the tool.

Stage 2 – determine or delineate mine water blocks (hydraulically connected workings) for the northeast of England coalfield.

- Historically the coalfield was divided in to areas, mainly for management during mining, but in some instances these management areas are connected underground.
- Coal Authority mining information and former coalfield reports used along with mine water level data to determine mine water blocks.

Stage 3 – develop a decision process (flowchart) for SuDS constraints category assessment (simplified version in fig. 4).

- Key criteria chosen (with a Yes or No answer) to use for the assessment, following liaison with the project group, these were: major development defined by the Town & Country Planning Act, shallow mine water (<10 m below surface); shallow mine workings (<30 m below surface); and controlling outflow (gravity discharge or pumping station) nearby (<1 km from site).

Stage 4 – produce mine water contours based on 2018 water levels.

- Mine water contours were drawn in ArcMap™ using various contouring techniques such as spline-tension, and spline regularized at different grid spacing settings, these were compared to hand drawn contours, as a reality check. In some instances to help with the automated contouring, dummy points were created.

Stage 5 – determine standard contouring methods to be used for future prediction.

- The methods used for drawing 2018 contours within ArcMap™ for different mine water management scenarios were used to draw future (fully recovered) contours.
- Each block was assessed to determine potential or actual controlling outflow point such as unfilled mine shaft.

Stage 6 – produce predicted mine water contours in a fully recovered situation.

- If the mine water block was fully recovered then the future and current contours were the same.
- In mine water blocks that are pumped or rising, potential controlling outflow points (such as unfilled mine shafts) were identified and determined, based on their surface elevation. Steep conservative mine water gradients of up to 0.002 (1 in 500) and the potential controlling outflow points were used to produce possible future mine water levels.

Stage 7 – write up factsheets for each mine water block.

- Documents for each mine water block (34 in total) were produced that gave a brief summary of the mine water block, its boundaries, the data used for the assessment, and the methodology used for contouring.

Stage 8 – Spatially map the constraints for the full combined extent of the mining blocks.

- The different key criteria layers were mapped in a GIS and analysed using the decision tree, this resulted in a single layer on constraints for use.

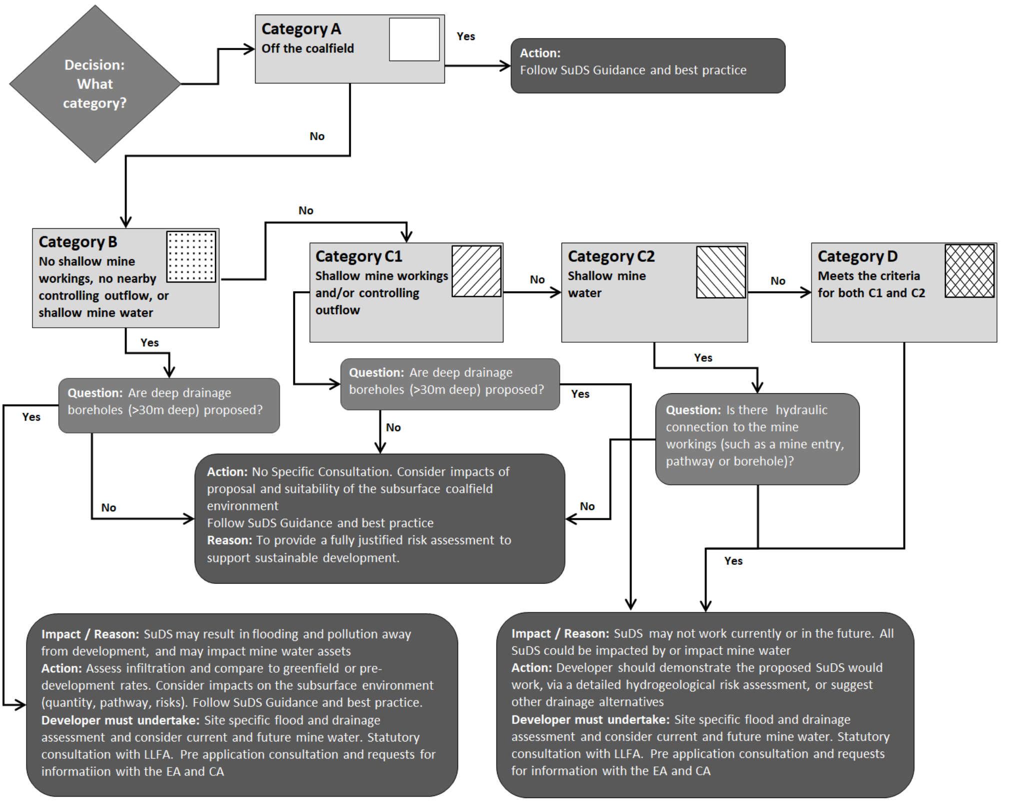

***Figure 4** simplified flow diagram for constraints categories.*

Stage 9 – write the guidance documentation.

Stage 10 – publish the screening tool package and trial for 1 year.

Throughout all the stages, regular stakeholder workshops were held with the key end users of the tool. This was to help make sure that the tool was easy to use, easy to understand, it was beneficial, and it met the needs of the end users.

Screening tool, what is it?

The screening tool incorporates three key components, which include: the 'constraints map', which spatially maps the constraints categories, a guidance document and a supporting document which collates the 34 mine water block factsheets; all of these are EA assets but published and accessed online by the Coal Authority (Coal Authority 2018 and Coal Authority 2021). The reason being because the published constraints map has been developed to be used with other key information which are already available on the Coal Authority Interactive Viewer, such as surface coal mining, mine entries and probable shallow mine workings, and lead local flood authority information. The constraints map available on the Coal Authority Interactive Viewer (fig. 5) has been issued to key end users such as the local planning authorities and the lead local flood authorities.

General comments

Dissemination of the constraints tool on the development of sustainable drainage via the screening has been hugely successful in raising awareness of the associated risks to and from sustainable drainage systems from mine water and groundwater recovery.

Other areas in the UK would benefit from adopting this screening tool approach where the same risks require assessing and mitigating.

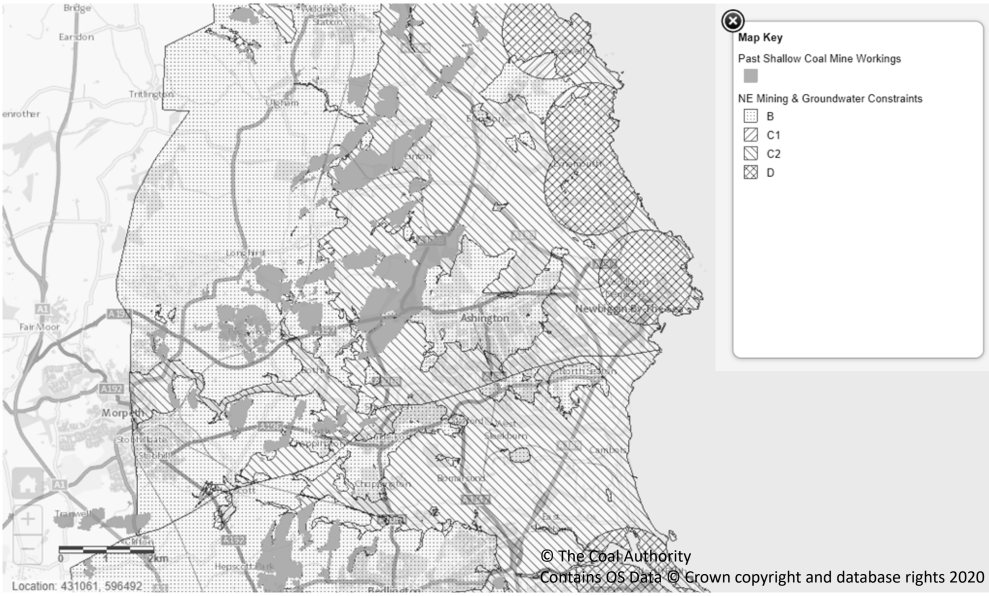

Figure 5 *screenshot of online interactive viewer with the constraints categories and shallow mine workings.*

Use of the screening tool for strategic planning (such as Strategic Flood Risk Assessments, Local Development Frameworks, urban drainage plans); and for assessing development control applications has helped identify the drainage risks and mitigation measures for development. It has also help identify new and additional evidence or data that has both validated and identified where the assessment and screening tool requires improving. This has resulted in updates are planned for 2021-22.

The screening tool has greatly changed and informed the understanding of mine workings hydrogeology. Continuing to use this tool will aim to develop additional supporting assessments and datasets, which can be used to identify critical drainage areas. Expanding partnerships and development of the tool can also be used for the development of fully integrated flood models, planning and management of sustainable urban drainage, and potential development of a predictive and groundwater flood warning system.

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