GeoSmart Information

Environmental Thinking

GeoSmart GW5

GeoSmart Groundwater Flood Risk Map User guide

Notes to accompany GW5 version 2.3

GeoSmart offer groundwater flood risk maps at a range of scales and risk resolutions to meet client requirements. For further details visit our web site www.geosmartinfo.co.uk.

What is groundwater flooding?

Groundwater flooding occurs when sub-surface water emerges from the ground at the surface or into Made Ground and structures. This may be as a result of persistent rainfall that recharges aquifers until they are full; or may be as a result of high river levels, or tides, driving water through near-surface deposits. Groundwater flooding is characterised by:

Water flows to the surface or into basements, services ducts and other subsurface infrastructure rising up through floors or directly from the ground. This may be seen as diffuse seepage from the ground, as emergence of new springs or as an increase in spring flows.

Flooding may last a long time compared to surface water flooding, from weeks to months. Hence the amount of damage that is caused to property may be substantially higher. Likewise closures of access routes, roads, railways etc. may be prolonged.

Flooding may occur with a delay following periods of high rainfall rather than immediately during storms.

Emergent groundwater tends to be clear and relatively clean compared to muddy fluvial flood waters, but potential contamination by sewers and brownfield sites poses additional hazards.

Groundwater flooding or a shallow water table prevents rainfall infiltration and increases the risk of surface water flooding. This means that many surface floods are actually driven by groundwater conditions. But consideration of surface water in isolation and lack of evidence for groundwater conditions leads to incorrect analysis of overall causes.

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Whilst groundwater flooding is generally less hazardous to human health than surface flooding, it is more hazardous to property for a given flood depth, producing 2 to 4 times the damage to building fabric and greater disruption to economic activity due to the longer duration of flood events. Also, the impact may be less about surface water depths or velocities and more about the extended saturation of the shallow subsurface with the following consequences:

1. Damage to basements and other structures below ground
2. Damage to infrastructure such as buried services and ducts
3. Sewer flooding
4. Water damage to property, cultural heritage, crops or sensitive habitats due to saturated conditions
5. Leaching of contamination from brownfield sites and other sources of contamination
6. Slope stability issues
7. Increased likelihood, intensity and duration of surface water flooding due to saturated ground conditions and failure of infiltration drainage systems
8. Increased cost of construction projects, which will need to incorporate preventive groundwater control measures to prevent what, would otherwise cause harm.

Map description

GeoSmart's national groundwater flood risk model takes advantage of all the available data and provides a preliminary indication of groundwater flood risk on a 5m grid for the selected area of coverage on the GW5 map. Our approach is consistent with latest best practice for such assessments and based on authoritative science and quality assured methods.

The map is a general purpose indicative screening tool, and is intended to provide a useful initial view for a wide variety of applications. However, it does not provide an alternative to a proper site-specific assessment, and a detailed risk assessment should be used for any site where the impact of groundwater flooding would have significant adverse consequences.

Mapped classes combine our understanding of likelihood, model and data uncertainty and possible severity. Likelihood is ranked according to whether we expect a chance of groundwater flooding greater than 1% annual probability of occurrence at a site due to extreme elevated groundwater levels. Severity relates to our expectations of the amount of property damage or other harm that groundwater flooding at that location might cause. Uncertainty relates to our confidence that the map accurately represents locations where groundwater may emerge and cause flooding.

The map classification shows on a national mapping scale the areas within which property may be at risk, but this should not be mistaken to mean that groundwater floods will occur

across the whole of the High Risk area. Mapping limitations and a number of local factors may reduce groundwater flood risk to land and property even where it lies within mapped groundwater flood risk zones. Overall risk is presented on the map showing areas with a >1% annual probability of groundwater flooding within the following classes.

CLASS 4: NEGLIGIBLE RISK: There is a negligible risk of groundwater flooding in this area and any groundwater flooding incidence has a chance of less than 1% annual probability of occurrence.

Comments: No further investigation of risk is deemed necessary unless proposed site use is unusually sensitive. However, data may be lacking in some areas, so assessment as 'negligible risk' on the basis of the map does not rule out local flooding due to features not currently represented in the national datasets used to generate this version of the map.

CLASS 3: LOW RISK: There is a low risk of groundwater flooding in this area with a chance of greater than 1% annual probability of occurrence.

Comments: There will be a remote possibility that incidence of groundwater flooding could lead to damage to property or harm to other sensitive receptors at, or near, this location. For sensitive land uses further consideration of site topography, drainage, and historical information on flooding in the local area should be undertaken by a suitably qualified professional. Should there be any flooding it is likely to be limited to seepages and waterlogged ground, damage to basements and subsurface infrastructure, and should pose no significant risk to life. Surface water flooding, however, may be exacerbated when groundwater levels are high.

CLASS 2: MODERATE: There is a moderate risk of groundwater flooding in this area with a chance of greater than 1% annual probability of occurrence.

Comments: There will be a significant possibility that incidence of groundwater flooding could lead to damage to property or harm to other sensitive receptors at, or near, this location. Where flooding occurs it is likely to be in the form of shallow pools or streams. There may be basement flooding, but road or rail closures should not be needed and flooding should pose no significant risk to life. Surface water flooding and failure of drainage systems may be exacerbated when groundwater levels are high. Further consideration of the local level of risk and mitigation, by a suitably qualified professional, is recommended.

CLASS 1: HIGH: There is a high risk of groundwater flooding in this area with a chance of greater than 1% annual probability of occurrence or more frequent.

Comments: It is likely that incidence of groundwater flooding will occur, which could lead to damage to property or harm to other sensitive receptors at, or near, this location. Flooding may result in damage to property, road or rail closures and, in exceptional cases, may pose a risk to life. Surface water flooding and failure of drainage systems will be exacerbated when groundwater levels are high. Further consideration of the local level of risk and mitigation, by a suitably qualified professional, is recommended.

From an Indicative to a Verified Risk Assessment

It is important to note that in order to provide a consistent national approach and in the light of data deficiencies, there are significant limitations in the assessment of flooding likelihood. For example, groundwater flooding events in one location may correspond to a 1 in 50 year (2%) flood with the same event representing a 1 in 500 year (0.2%) event elsewhere. The 1 in 100 year (1%) return period should therefore be regarded as 'indicative'.

Like other current groundwater flood maps used in the UK, the GeoSmart map shows areas of potential groundwater emergence. Additionally, it is important to understand that the actual extent of above-ground flooding will be less than is indicated because of two mitigating factors:

National groundwater flooding models do not take into account the magnitude of flows emerging from the ground. Therefore, while groundwater heads might be indicative of groundwater emergence, the actual amount of flow might not be sufficient to cause flooding at that location (although the accumulated flows downstream might be).

Even if emergent groundwater was at a rate sufficient to cause local flooding, the nature of the urban man-made subsurface tends to drain water away before it reaches the surface. Sewers, granular fill around utilities and road sub-grade are all highly permeable formations that would be able to drain quite high groundwater flows away. This tends to move the groundwater flooding problem down the catchment.

The GeoSmart Groundwater Flood Risk Map highlights areas where there is sufficient evidence to suggest that flooding could occur.

GeoSmart is a groundwater flooding advisor and also provides specialist reports and services to assist clients in assessing and mitigating groundwater hazards. This experience at the leading edge of UK groundwater science ensures that our model represents best practice in this field at a pragmatic, albeit necessarily preliminary, level. However, given the various limitations of national-scale mapping and the available data which do not represent local, small-scale subsurface features that may control pathways of groundwater flow, the map may represent 'false positives', where it suggests flooding risk which for local reasons or errors will not occur, and 'false negatives', where it suggests that flood risk is negligible when it may for similar reasons be significant. Information on confidence level and ways to improve this can be provided for any location on written request to info@geosmartinfo.co.uk or via our website.

The map should be interpreted as an initial indicative screening tool to help focus resources, but site specific assessment remains necessary where flooding impacts would lead to significant loss of asset or other harm to humans, the environment, or property. GeoSmart provides a tiered range of services to assist where a more detailed assessment of likelihood and consequences of groundwater flooding is required. Our reports include groundwater flood risk assessments, basement impact assessments, flood risk assessments, sustainable drainage assessments and Phase 1 contaminated land.

Groundwater flooding and climate change

The UK's climate is changing, and this will potentially increase the frequency, severity and extent of groundwater flooding. Businesses and individuals should take action to assess vulnerability and improve resilience if they are at risk. The first step in this process is to establish the current baseline risk of groundwater flooding using the GW5 risk envelopes.

Geosmart's national scale mapping of groundwater flood risk incorporates several mechanisms that are affected by climate change. Climate models cover a range of scenarios and include significant uncertainties which make precise predictions difficult. However, we have summarised how groundwater flood risk currently identified within GW5 may change in the future. A site specific assessment can then be undertaken to determine the groundwater flood mechanism that is applicable to the site and the climate change impacts on this.

Predictions for the UK over the next century suggest mild, wetter winters and hot, drier summers, with an increase in the frequency and intensity of extremes, both flood and drought. The groundwater recharge season could become shorter, but more recharge may occur within the shorter period, leading to flashy responses in groundwater level. Rainfall recharge patterns vary regionally resulting in changes to average groundwater levels which may go up or down. The potential for higher peaks in groundwater level and more flooding, driven by rainfall recharge, increases under many of the climate change scenarios, but results are not uniform across the UK.

A rise in peak river levels leading to a response of increased groundwater levels in adjacent aquifers is also expected. The Environment Agency have set out climate change allowances for changes in peak flow ranging from +25% to +105% in extreme cases that suggests very significant increases in some areas, particularly in South East England. Despite on-going efforts to build higher river flood defences, groundwater may by-pass these, causing flooding even if the river remains behind the flood barriers. Changes to groundwater flood risk for sites located on permeable material adjacent to river flood plains would be subject to the predicted climate change increases in peak river level for the local catchment.

Sea level rises of between 0.4m and 1m are predicted by 2100, leading to a rise in average groundwater levels in the adjacent coastal aquifer systems, and potential increases in water levels in the associated drainage systems. There is potential that these rises may occur more quickly, even as soon as 2050. Changes to groundwater flood risk for sites located on permeable material adjacent to the coast would be subject to these predicted climate change increases in average sea level.

The 'backing up' of groundwater levels from both coast and tidal estuary locations may extend a significant distance inland and affect infrastructure previously constructed above average groundwater levels. The impact of coastal surges will be in addition to the rise in average sea levels. Many of the UKs coastal areas are relatively low lying and therefore susceptible to small changes in groundwater levels. Several UK towns and cities have infrastructure that copes with current groundwater levels but which have never experienced the increases that are now expected, and this can lead to new and unexpected impacts rather than purely incremental changes to previous risks.

Careful water level management ensures that farmland, properties and infrastructure are protected from flooding. As sea levels rise some catchments that can currently be drained to the sea by gravity will need to be pumped with increasing frequency. Catchments that already require the assistance of pumped drainage will require additional pumping capacity.

Groundwater flooding in response to sea level change and climate change impacts on recharge has not been systematically assessed hitherto, and is the subject of ongoing work at GeoSmart. Contact us for further information. Further details on different aspects of groundwater flooding can be found on our knowledge hub at www.geosmartinfo.co.uk .

User group

Updates to our model are on-going and additional information is being collated from several sources to improve the database and allow increased confidence in the findings.

Specifically, further information on groundwater levels and flooding are being incorporated in the model calibration to enable improved accuracy to be achieved in future versions of the map. Please contact us if you would like to join GeoSmart's Groundwater Flood Risk User Group and help with feedback on flood events and mapping suggestions. We can be reached at info@geosmartinfo.co.uk or at +44 (0)1743 298 100.