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Hydro Nation Scholars Programme

Water scarcity in eastern Scotland: Groundwater pathways to a drought-resilient future

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Policy Brief

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Overview

- Groundwater levels across eastern Scotland in 2025 are at the lowest levels in over a decade due to below average precipitation in winter and an abnormally warm dry spring.
- Lower groundwater levels can impact the performance of shallow wells and spring flows, with deeper boreholes generally less affected.
- Groundwater is the dominant source of river baseflow in the summer and primary source of water for more than 15,000 private supplies in Scotland, especially in the Northeast region.
- Groundwater is recharged primarily in winter; therefore summer levels can generally be forecast by late spring to help inform decision-makers on interventions.
- Groundwater can be a more resilient source of water during times of water scarcity, but increased groundwater abstraction can impact baseflow to rivers and affect other users and thus requires careful monitoring and management.
- Groundwater modelling can provide insight on the impacts of drought and abstraction under future climate scenarios but will require sustained support through monitoring data and additional research to refine conceptual and parameter inputs into the models.
- Updates to Scotland's National Water Scarcity Plan should aim to more fully incorporate the role of groundwater in managing water scarcity.

Introduction

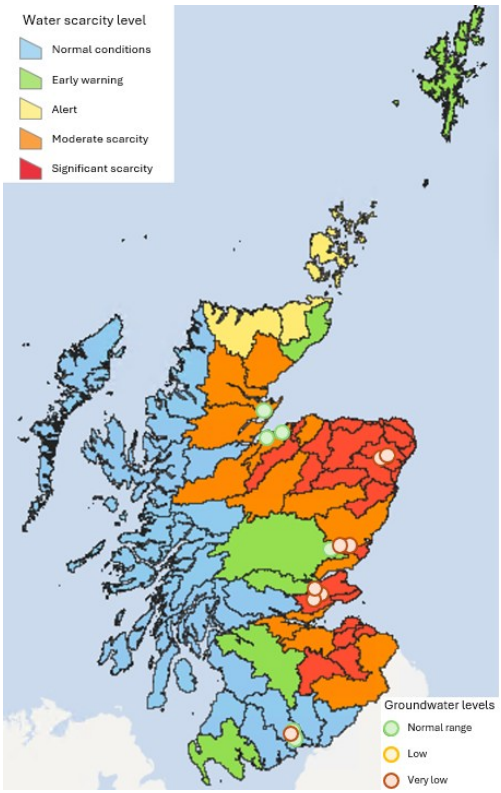


Figure 1. SEPA catchment water scarcity levels 11 September 2025 and mean monthly groundwater levels (SEPA 2025).

SEPA groundwater level monitoring in 2025 shows that despite summer rainfall, groundwater levels remain near record lows due to below average winter recharge and an exceptionally dry spring over much of the country. On 11 September 2025, SEPA classed 17 catchments in the east as being at Significant Scarcity, a scarcity level where restrictions on licences to abstract water can be imposed. When surface water is scarce there is increased pressure on groundwater stored in subsurface aquifers. However, groundwater can offer a more resilient and secure supply of water during water scarcity events.

Groundwater sustains the majority of rivers through baseflow during the summer months. Groundwater is also a critical water source for more than 70% of private water supplies (PWS), particularly in rural areas outside of the public distribution system. There are more than

23,000 PWS – of which over 15,000 are sourced from groundwater – supplying nearly 200,000 people as a primary source of water. In addition, groundwater is abstracted to meet the water demands from agriculture and industries, such as distilling. However, the storage capacity of the aquifers supporting these groundwater abstractions (including PWS, agricultural, industrial and other sectors) is poorly quantified. Aquifer storage is dictated by the local geology type, thickness, and depth below ground; all of which vary considerably across the country. The strategic importance and potential capacity of these groundwater systems are clear; over 8,000 private water supplies operate in Aberdeenshire alone.

The geology in eastern Scotland is dominated by two main rock types: crystalline rocks with low storage potential (porosity); and sedimentary rocks such as sandstones which have much higher porosity and capacity to store water. These are frequently overlain by unconsolidated alluvial or glacial sands and gravels, which can be significant in terms of water storage and usage, but highly variable spatially. In the crystalline bedrock, locally significant fracturing and deep weathering may combine with superficial sand and gravel aquifers to create complex local aquifers sufficient to support domestic, agricultural, and commercial industries in the east.

In general, shallow wells and springs are often more vulnerable to drought since they are linked closely to recent precipitation and can fail if the water table falls. Deep wells and boreholes generally tap groundwater that has accumulated over a longer period and wider catchment and are therefore much less vulnerable to drought. Still, shallow wells can provide some additional resilience to short term periods of water scarcity compared to sources solely reliant on surface water. When surface water levels are low in times of water scarcity, private and public water users turn more to groundwater to help maintain downstream flows.

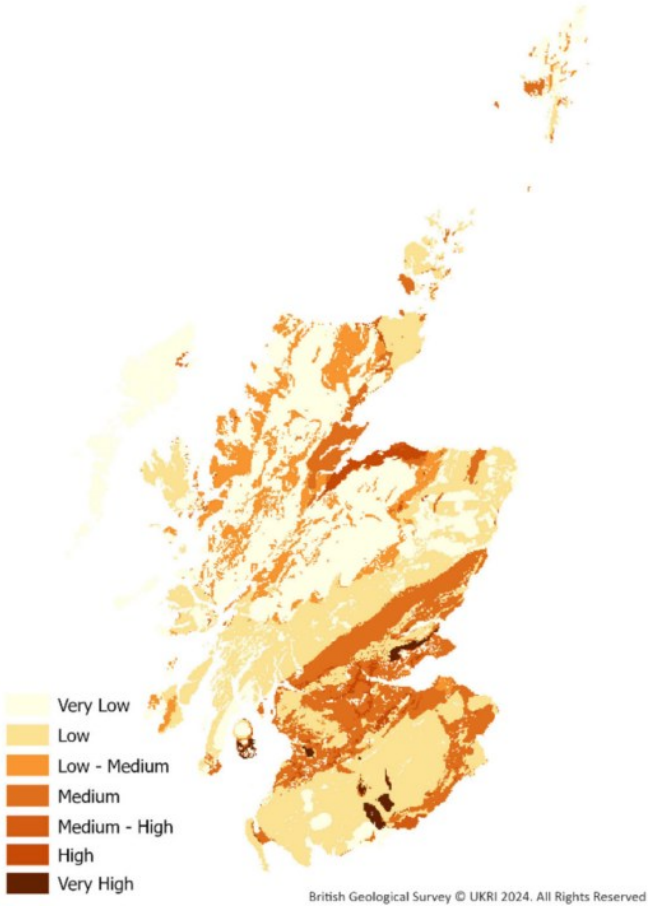


Figure 2. Bedrock aquifer storage map showing estimated aquifer storage volumes across Scotland (from BGS). Groundwater storage is highest in the sandstone aquifers of the southwest and Fife. Crystalline rocks of the north typically have lower storage potential but may have secondary porosity from weathering and fracturing of the rock (BGS © UKRI 2024).

With drought predicted to occur more frequently, last longer, and be more severe, stress on groundwater systems is expected to increase in the future. In addition, abstractions are expected to increase to meet demands. It is vital that actions are taken now to improve characterisation of aquifers and monitor groundwater levels to ensure sustainable resource management and secure supply for all users.

Research Undertaken

Analysis of groundwater level data from the 34 SEPA monitoring boreholes that have continuous records of at least 14 years, along with data collected from a new (started 2025), expanded groundwater monitoring network by researchers at University of Aberdeen provide new insights to groundwater status and help identify areas and aquifers that are most vulnerable to drought. New monitoring gives insight into a more diverse set of aquifer types and supply designs commonly used by private water users but not typically represented in traditional monitoring networks.

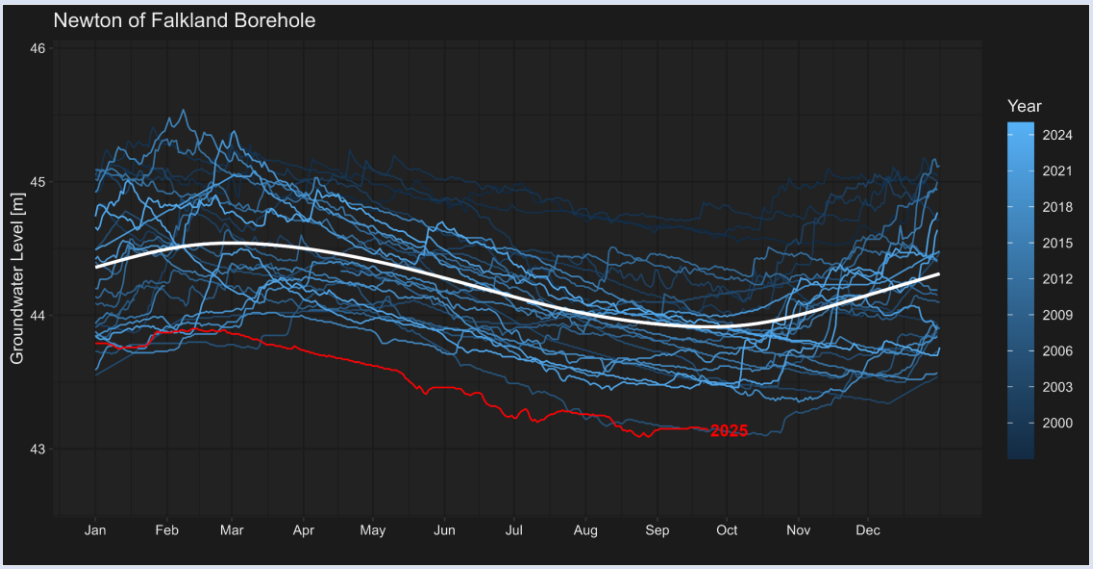
Groundwater indices have been derived from the existing records to assess relationships between drought indicators such as precipitation and evapotranspiration. These relationships help determine areas and aquifers more resilient to drought and predict how long it may take for drought conditions to impact groundwater and how long it may take groundwater to recover.

In summer 2025, a survey of 33 private water users in the northeast was completed to understand their experiences and perceptions of the resilience of their groundwater sources. These interactions and insights, paired with quantitative data from wells, help build a fuller story of drought impacts and water scarcity in eastern Scotland. The results will help to inform policy makers and practitioners in developing guidance on navigating water scarcity issues.

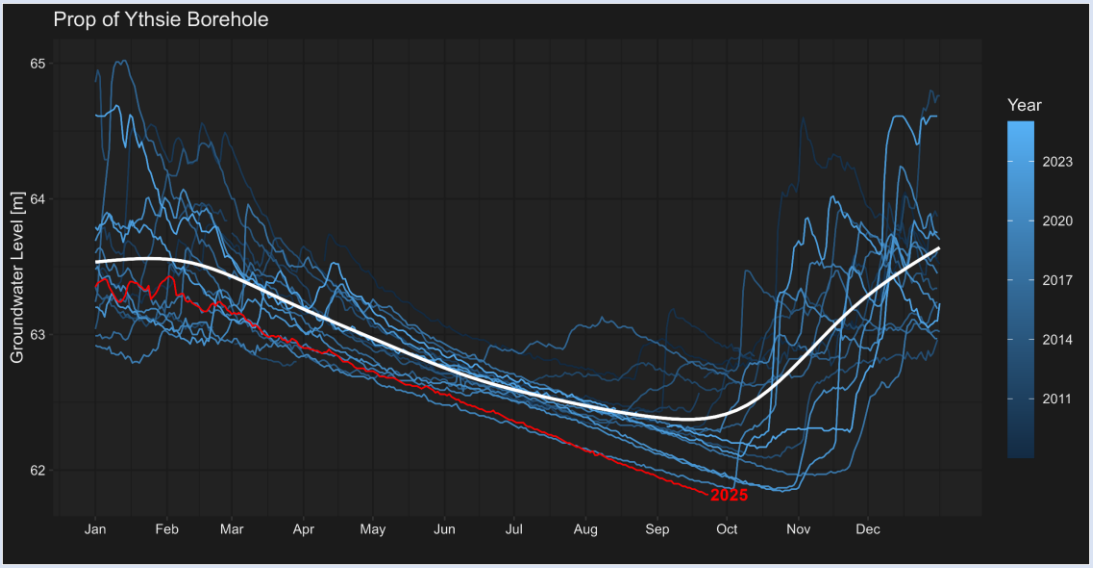
Key Findings

Analysis of the 34 groundwater level datasets shows that in many areas in 2025, these remain near record lows due to the exceptionally warm dry spring following below average winter precipitation. Annual water level response depends on the local aquifer geology, with changing weather conditions (e.g., dry winter, hot summer) explaining much of the inter-year variability in water levels at a particular monitoring location. Lower groundwater levels appear to occur in years where the preceding winter and spring precipitation is below normal. These antecedent conditions cause increased drought risks to persist throughout the summer in areas like eastern Scotland. Precipitation in summer is unlikely to lead to recharge of the aquifers, primarily due to evapotranspiration losses.

Water level response in monitoring boreholes



The Newton of Falkland borehole (*above*), located in Fife, represents a relatively high storage, sandstone aquifer system in eastern Scotland. The Prop of Ythsie borehole (*below*) in Aberdeenshire is completed in a lower storage bedrock aquifer where the movement of water within is dominated by fracture flow. The average groundwater level response for each borehole is shown in white.



Bedrock aquifers like this typically have lower storage potential due to lower porosity and lateral connectivity. These systems, while more resilient than surface water sources, can be impacted by short term water scarcity but often recover quickly in response to autumn and winter recharge. Sandstone aquifers with their higher porosity can store more water within the same volume of rock and have smaller changes in groundwater level throughout the year. Additionally, active groundwater circulation in these aquifers tend to be deeper and more laterally extensive than fractured systems which implies a larger area of potential recharge. Both aquifers are at or near record low levels (27 year record for Newton of Falkland; 17 years for Prop of Ythsie) for the summer of 2025. In times of drought, higher storage aquifers are often more resilient to short term drought because of the greater storage but can still be impacted by long term drought from successive dry years.

The specific impact of low groundwater levels on water supplies is not always well known but shallow wells and springs will be most vulnerable to supply interruptions from declining levels. Taking this knowledge, and expanding monitoring to more source types and aquifers, can lead to earlier predictions of water scarcity or highlight areas of increased resilience to the particular drought conditions currently experienced.

Survey highlights:

- 15% of our survey respondents had experienced an interruption in their water supply during the recent droughts – more than twice that knew others in the area that suffered interruptions.
- Aging infrastructure: Only 1 of the 33 PWS sources was constructed within the last 10 years
- More than 70% were confident their PWS would meet all their needs over the next 20 years.

The survey of private water users across eastern Scotland confirms significant use and confidence in groundwater from PWS users. Well and borehole depths varied from 6-75 metres reflecting: the geological variability of the area; the different use cases (i.e. domestic v. agricultural); and financial investment available. 85% of the PWS were constructed more than 20 years ago and of these, only 20% have been modified (either deepening the well or borehole or changing the intake position of the spring) to mitigate against declining or unreliable water supplies.

Conclusions

Groundwater is generally considered a more resilient source of water during short- to medium-term periods of water scarcity. Water deficits that propagate through surface water and soils in weeks may not show up in aquifer levels for months because of their larger, buffering storage capacity. Unfortunately, the converse is also true – longer term drought and over-abstraction can lead to persistently low groundwater levels as recharge from precipitation takes place on a significantly longer time scale than recovery in surface flows, which can be near immediate. While recommendations to utilise groundwater to preserve surface water levels during times of water scarcity have not led to notable conflicts between users in the region to date, longer, more severe and more frequent periods of drought are set to stress groundwater sources to levels that have not been studied or tested. Groundwater is and will continue to be vital during future drought events. Additional monitoring is needed to improve characterisation of the storage potential and vulnerability of resources across Scotland and ensure adequate supplies are available to support surface water baseflow and the private water users reliant on groundwater year-round.

Policy Implications and Recommendations

1. **Expanded, enhanced groundwater monitoring across Scotland:** Groundwater commonly provides a more drought resilient water supply during water scarcity events. Outside of major aquifer systems, little direct and quantitative information exists about groundwater resources, their response to water scarcity events, and consequent impacts to water users. SEPA is currently expanding their existing groundwater level monitoring network; ongoing support is required to improve monitoring network coverage in higher risk areas. Additional monitoring will improve understanding of how groundwater resources respond to climate change and during water scarcity events. Self-monitoring by water users and proxy data from surface water gauging can provide additional lines of evidence.
2. **Real-time data access for groundwater monitoring:** SEPA is rolling out telemetry across their groundwater level monitoring network to facilitate increased access to data in real time. Improving stakeholder access to data will further support data driven decision making, by both regulators and water users, into the future. Improved characterisation of groundwater resources and access to data is vital to support existing users in industries like whisky distilling and agriculture and to ensure the sustainability of new developments in renewable energy and data storage.
3. **Development of indicator metrics for groundwater levels:** Indicator metrics for groundwater should be developed to quantitatively assess groundwater drought risk and water scarcity across Scotland, similar to SEPA river flow and the days below Q95 metric. Metrics to evaluate the severity of water scarcity events affecting groundwater together with any new rules around temporary restrictions in groundwater abstractions need to be supported by key stakeholders.
4. **Groundwater modelling tools to understand areas of water scarcity:** Development of groundwater flow models in regions that have previously experienced significant water scarcity should be prioritised to help evaluate available groundwater resources, climate change responses and the sustainability of abstraction during water scarcity events. Modelling can help understand current conditions within river catchments, the interaction of groundwater and surface waters and refine conceptual models of groundwater recharge and storage more broadly. Additional monitoring data are also required to support development of regional groundwater models and improve confidence in model results.
5. **Securing water resiliency for private water users:** To help ensure water resilience for private users, proactive maintenance, monitoring, and enhancement of existing boreholes, wells, and springs should be encouraged, rather than waiting for system failure. In areas with adequate groundwater, deeper sources (even in moderate productivity, bedrock aquifers) could sustainably support small, remote communities where connection to the public supply is not viable.

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