Climate Emergency Case Study Template

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Introduction

The UK water industry has made the pledge to reduce leakage by 50% by 2050 and water companies are working to meet the first regulatory target to reduce leakage by 16% by 2025. Leakage reduction targets are pursued at a time when there is a significant pressure on water resources in the UK, with risks to service delivery driven by ageing infrastructure, climate change and population growth.

The health and integrity of water pipeline networks is a significant factor that affect the amount of water that is lost from the system. In the context of long-term investment planning, understanding which parts of the network have greater deterioration rates and more likely to fail is key to prioritise capital investments in asset replacements and mitigate significant operational costs for emergency and reactive repairs after failure.

Water UK commissioned Mott MacDonald to conduct a UK wide review of the possible impacts of climate change on leakage rates, aiming to better inform the industry on the future leakage challenges it might face because of a changing climate. The objectives of this review were to:

- Identify the key climate drivers responsible for increases in leakage from water networks in the UK;
- Analyse historical information and quantify the impacts of specific weather events such as freeze-thaw and extreme dry weather on pipe bursts; and
- Estimate the scale of the impact of future climate conditions on leakage within the UK drinking water networks.

Description of assets in study

The study looked at the physical impacts of climate change on water distribution networks and on the integrity of buried pipelines. Data from seven water companies in England and Wales was collected and reviewed to conduct a large-scale comparison of impacts across the UK so that geographical patterns could be identified.

When was the activity carried out?

The review was conducted between April and May 2023 and presented the findings to the water companies in May 2023.

Why was the activity carried out?

This review was the first of its kind in the UK water industry and was commissioned to document the influence of various climate stressors on the integrity of the water distribution networks and the associated impacts on network performance, now and into the future. This work aimed to inform the UK water industry on the future leakage challenges it might face as a result of climate change. As companies need to report on their performance related to leakages to the regulator, it is important for those organisations to understand how climate stressors can jeopardise the benefits of past and current investments and further prevent them meeting their performance commitments despite best efforts. This review aimed to provide robust evidence to the industry to confirm the need for greater investments in leakage resilience over the coming decades.

Terminology
UKCP18: Long-term climate projections for the UK

Methodology
The integrity of buried water pipelines, when exposed to a range of environmental and service delivery conditions, can become compromised. These conditions can also accelerate the degradation of assets. This can in turn have a bearing on the number and volume of leaks from the network. Water companies in England and Wales report on their performance to the regulator Ofwat. Historical bursts from water mains and leakage rates are two of the companies' performance commitments that link with business objectives. It is important, for water companies, to better understand the links between climate stressors and the condition of their buried water pipelines to evaluate the long-term impacts of climate change on the performance of their systems.

To support this, a non-exhaustive but comprehensive review was conducted of existing research and other literature demonstrating the links between leakage, pipe burst and extreme weather events and investigating the impacts of climate change on leakage, in the UK and globally. Potential mechanisms for failure of water pipeline networks driven and/or augmented by environmental/climatic factors were investigated alongside factors that would lead to greater vulnerability of water pipeline assets when exposed to changes in environmental conditions.

This review focused on the likelihood and scale of impacts of two main climate risks, namely freeze thaw and drought events, that have the potential to compromise the integrity of buried pipelines. Quantitative risk assessments were conducted following a stage approach to obtain estimates of future pipe burst numbers and leakage rates for different parts of the UK:

1) Review of historical leakage and pipe burst information provided by seven water companies in England and Wales to draw correlations between historical pipe bursts and leakage rates
2) Review of historical asset performance data over time to identify climate-related trends such as increases in pipe bursts during the dry and hot summers of 2018 and 2022 and during historical prolonged cold spell events.
3) Regression modelling between climate stressors, such as decrease in soil moisture during dry conditions, and asset performance (i.e. volumes of pipe bursts and leakage rates)
4) Estimation of future changes in climate stressors using the UKCP18 climate projections and related future impacts on asset performance based on the correlations derived for the historical period.

In the context of leakage reductions required in the short, medium and long-term, this study focused on evaluating the impact of future climate conditions for the 2030, 2050 and 2070 time horizons and the high emissions scenario – RCP8.5, as a worst case. Estimates of net changes in pipe burst numbers and leakage rates were produced for the three time-slices (i.e. 2023, 2050 and 2070) for the seven operating areas across England and Wales to draw regional comparisons.

References

Farewell, T. S., Hallett, S. H., & Truckell, I. G. (2012). Soil and climatic causes of water mains infrastructure bursts. Cranfield University.

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Risk types

This study was commissioned to better inform the industry on the regulatory risk of not meeting the imposed leakage targets despite best efforts. The findings from this study aim to inform the long-term planning of proactive asset repair, refurbishment and replacement activities to achieve the regulator's objectives for leakage and pipe bursts. Documented evidence of increases in failure in water pipeline networks may also directly affect companies' operations.

Risk management process

This study was conducted as an independent industry review and did not link with the companies corporate risk registers. The outcomes of the review were presented to the water companies in a workshop.

Tools used and resources used.

Microsoft suite, Python and R packages were used for modelling activities. The MetOffice HadUK and UKCP18 datasets were extracted using in-house tools for different operating areas across the UK and were used in the models alongside the water companies' historical leakage rates and pipe bursts reporting information.

Metrics

Pipe networks are susceptible to cracks and bursts under specific conditions when soil moisture deficits increase and lead to shrinkage of soils. Building on the understanding of this failure mechanism, regressions were sought between the number of pipe bursts during dry periods and a Standardised Precipitation Evapotranspiration Index (SPEI). SPEI is a drought metric calculated from rainfall, temperature and wind speed data and represent a good proxy to soil moisture deficit, with negative values signalling drier conditions than average. It is a well-known drought index used worldwide to determine the onset, duration and magnitude of drought conditions.

For each geographic regions included in this review, SPEI values were calculated using the Met Office HadUK gridded datasets that provide records of relevant climate variables for the most recent period of observations. SPEI was calculated for different durations of 1, 3, 6 and 12 months (SPEI-1, SPEI-3, SPEI-6 and SPEI-12). Pipe bursts between April and August were compared against the different SPEI metrics and the best correlations were found for SPEI-3 and SPEI-6, with some variations between different water company areas. The period of analysis was extended beyond the summer months as a result of dry conditions also being experienced during spring, resulting in stronger correlations. Changes in SPEI and soil moisture deficits in the future were calculated using the UKCP18 regional projections up to 2080.

Pipes are also susceptible to freeze-thaw events whereby the fluctuation of temperatures above and below freezing levels exerts extra pressure and can lead to winter bursts. A second quantitative analysis was conducted with different climate representations of freeze-thaw events tested based on daily maximum and minimum temperate extracted from the Met Office HadUK gridded datasets for the different supply areas.

Regressions were estimated between the number of freeze-thaw events in a month and the number of monthly pipe bursts during the period from December to April. The period of analysis was extended into the early spring to reflect the likelihood of freeze-thaw events to occur then too. Overall, the inclusion of April strengthened the correlations. Satisfactory regressions were found for all seven water companies included in the review with exponential increases in pipe bursts with increases in the number of freeze thaw events.

Costing

No financial analysis was conducted as part of this review.

People

The project was commissioned by Water UK. Literature review of failure mechanisms and climate risk assessments were conducted by a team of climate risk and resilience experts.

Stakeholders from the UK water companies were involved from the outset. Seven water companies in England and Wales provided data to conduct the modelling activities. The findings were presented to all the water companies involved in a delivery workshop.

Evaluation

What was the main output of the activity?

This review documented the possible impacts of climate change on the integrity of the water distribution networks and on their associated performance, now and into the future.

Findings of the quantitative assessments highlighted significant increases in leakage volumes in some areas of the southeast of England by 2050, mainly driven by more extreme dry conditions. Results have further highlighted different vulnerabilities for different pipe characteristics, with iron pipes being particularly susceptible to both freeze-thaw conditions and dry conditions, whilst asbestos cement pipes are seen to be mainly affected by dry conditions. Given that these are predominant pipe materials in UK water supply networks, their vulnerability to climate conditions will affect the resilience of the systems during future extreme weather events.
The outcome of the modelling emphasises the risk for companies to not meeting the regulatory targets as a result of changes in climatic conditions. While this directly affects their leakage targets, other performance indicators could also become affected. In addition, increases in dry weather bursts and associated leakage could pose additional pressure on service at certain times of the year (ie heatwaves) where customer demand is high and networks are already strained by increased flows and pressure rates.

The outcomes of these assessments provide evidence to inform the industry on the future leakage challenge it might face in the future and for companies to plan ahead to increase the resilience of water pipeline networks.

Validation

The models were developed based on regressions derived from observed historical trends. Models were peer-reviewed internally by technical experts. Future potential improvements to the models were captured and presented to the water companies.

Outcome

The analyses of historical data confirmed the vulnerability of water supply networks to freeze-thaw and dry conditions, with significant increases observed in the number of pipe bursts and leakage volumes during historical events. Findings also highlighted geographical variability in the level of impact of extreme weather events seen on the networks with the southeast and east of England historically recording greater impacts during extreme dry conditions. The review further highlighted different vulnerabilities for different pipe characteristics, with iron pipes being particularly susceptible to both freeze-thaw conditions and dry conditions, and asbestos cement pipes being seen to be mainly affected by dry conditions. These findings correlated with water companies understanding of drivers for failure in water pipe networks.

The quantitative analyses undertaken highlighted projected decreases in freeze-thaw related bursts as well as significant increases in dry weather induced bursts in the future. In the short term (2030), the two trends were found to cancel each other, resulting in minor net changes in comparison to baseline (1991-2020) conditions. At mid-century (2050) and into its second half (2070), increased dry conditions are estimated to lead to net annual increases in bursts and leakage volumes. Findings from the modelling indicated that these trends will be prevalent in the southern part of the country, with the southeast and east experiencing the greatest increases in pipe bursts and leakage, up to 17% increase in bursts and 69% increase in leakage volumes by 2070 in comparison to 1991-2020 baseline. These findings align with the Met Office projections for future trends in rainfall and temperature in the south and south-east of England.

Lessons learned and challenges.

This review was conducted for the UK water industry and follow-on work is required to expand the analyses at a company level to inform the financial impacts of these trends and the implications for the companies' investment plans. There were limitations and assumptions had to be made in the modelling. In the future, it is recommended to:

- Review the models in light of changes in network properties over time, for example by considering age of pipes and changes in rates of replacements
- Expand the current analysis to cover more water companies
- Evaluate magnitude of impacts under less conservative climate scenarios (eg RCP2.6)
- Investigate impacts of leakage reduction investments on mitigating impacts of recent extreme weather events