SRN51 Resilience – Heat Enhancement Business Case

2nd October 2023
Version 1.0

WATER for LIFE

from Southern Water

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Executive Summary

The summer of 2022 turned out to be the hottest on record in the Southern Water (SW) regions, with ambient temperatures breaking through the 40deg C barrier for the 1st time. Many treatment sites were reported by operations as being affected, which required temporary measures to manage and maintain service. This included the hire of air conditioning units, fans and increasing ventilation. Key lessons learnt from this response revealed that the supply and effectiveness of hire equipment could not be guaranteed and that crude measures of leaving buildings open and unmanned posed additional risks from a H&S and security perspective. Our plan is for 2 Water supply & 22 Wastewater treatment sites to enhance their capability to operate under adversely elevated temperatures > 40-degree C. SW is looking to deliver these enhancement measures in AMP8 for circa £7.23Mil.

Summary of Enhancement Case	
Name of Enhancement Case	Climate Change Adaptation – Heat Stress
Summary of Case	▪ Propose the need to invest in protecting 2 Water Supply Works and 22 Waste Treatment Works from climate change related heat stress ▪ Assets requiring investment recognised from both a climate change modelled approach and previous historic events ▪ Circa £7 Mil investment being sought for AMP 8, based on most plausible solutions / costs and CBA
Expected Benefits	From the 24 sites identified, we expect to see a reduction in variability of operational performance in the following areas ▪ Unplanned outages / Low pressure ▪ Customer contacts about water quality ▪ Treatment works compliance failures ▪ Legal Compliance (H&S@WA) ▪ Pollution incidents ▪ Bathing Water quality Additional benefits: ▪ H&S - Destressing through reduced extra working ▪ H&S – less likely to incur injuries to 3rd parties ▪ [redacted]
Links to Performance Commitments (PCs)	It is difficult to attribute benefits to our PCs quantitatively but qualitatively our pollution / supply interruption performance is stretching, and overall operational resilience investment that this business case is a part of, considers this investment programme in the round
Enhancement TOTEX	£7.2m
Enhancement OPEX	N/A
Enhancement CAPEX	£ 7.2m
Is this enhancement proposed for a direct procurement for customer (DPC)?	DPC has not been proposed for this enhancement case as the Capex investment is less than £200m, so it does not pass the materiality threshold for DPC.

1. Introduction and Background

Introduction

Both globally and within the UK, it has been accepted that the Climate has changed and continues to do so. Climate change is one of the four material drivers for Water Companies and Ofwat has identified two Representative Common Pathways (RCP) - RCP 2.6 and RCP 8.5 - as the common reference climate change scenarios to be used for PR24.

> Ofwat are setting common reference scenarios for climate change based on Representative Concentration Pathways (RCPs), as adopted by the Intergovernmental Panel on Climate Change (IPCC) in its 5th assessment report. The RCPs are also used by the latest UK Climate Projections (UKCP18), which provide the most up-to-date assessment of how the climate in the UK may change in the future.

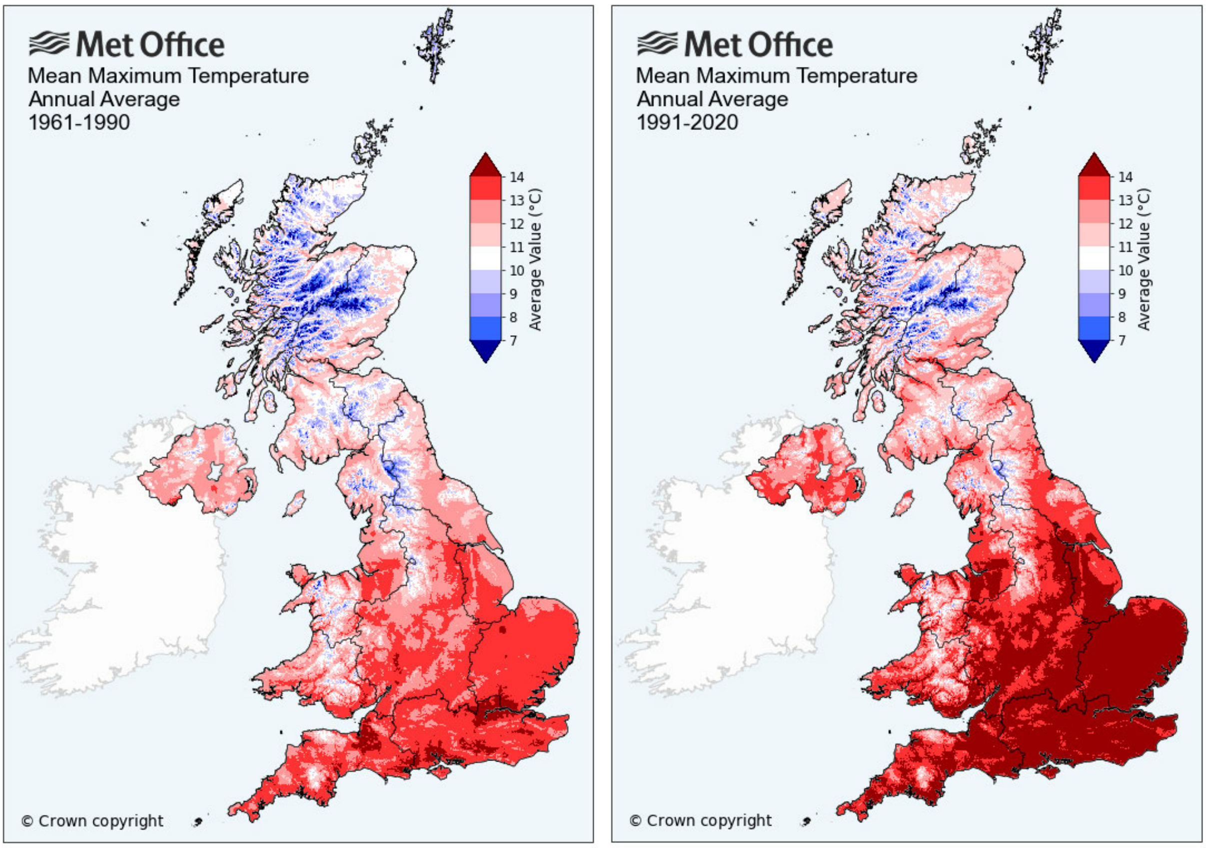
Southern Water has used these latest UK Climate Projections (UKCP18) to explore how different climate futures affect our investment strategies across our geographical region. Climate hazards and asset vulnerabilities have been identified and the asset capability examined to determine our 2023 baseline resilience position.

Since 1950, global mean temperatures have risen by around 1°C and are projected to increase by 2 to 4°C by 2100 (1.5°C by 2020). In our region, the resulting impacts of the changing weather patterns caused by these changes fall into four principal areas:

1. Increased temperature and more extreme variation in temperature.
2. Less rainfall or longer dry periods (drought);
3. More rainfall, or more intense rainfall (increased storminess);
4. Sea level rise

The images below provided by the Met Office reveals the extent to which temperature has increased over the last 60 years, with the SW regions experiencing the largest overall annual average increases.

Figure 1: Met Office mean maximum temperature 1961-1990 and 1991-2020



Our overheating world is likely to break a key temperature limit for the first time over the next few years, scientists predict.

Researchers say there is now a 66% chance we will pass the 1.5C global warming threshold between now and 2027. [1]

In practical terms, in the summer months where ambient temperatures have been reaching close on 40deg C, SW has been operating many of their treatment and distribution processes beyond their original thermal design limits. This has led to an increase in electrical & mechanical failures which in turn has resulted in a drop in operating performance. SW has learnt lessons in how to keep sites running, albeit on a purely reactive basis. This has to a substantial extent relied on the availability of temporary hire equipment. E.g., fans and air conditioning units.

[1] BBC Reference on 18/05/23 - https://www.bbc.co.uk/news/science-environment-65602293#:~:text=Our%20overheating%20world,now%20and%202027.

To help shape our PR24 investment plan, this project uses the latest UK Climate Projections (‘UKCP18’) to undertake a high-level risk assessment of our operational assets in terms of the climate change hazard of heat, over different future epochs and climate sensitivities.

This enhancement business case has therefore been compiled to address the investment required to ensure that an identified number of key Water Supply & Waste Treatments sites are protected from extreme heat temperatures (identified as occurring through Climate Change), which are affecting the original design thresholds of key process equipment e.g., electrical / electronic components. As such, the normal route of applying capital maintenance funding is not suitable. The reason being that Climate Change and the stress that excessively elevated temperatures present, requires additional asset capability to be added, which is enhancement of the asset base.

Background Information

The scenario that this investment proposal is predicated on is based around modelling and actual experiences of critical water and waste treatment works becoming affected by the adverse heatwave of 2022. The potential to impact upon water quality, supply, compliance, premature flooding / pollution of the environment & customer properties along with odour issues becoming realised, was only averted through reactive operational response and recovery of the processes affected. [redacted], as did excessive noise through deployment of some makeshift air conditioning units. In other instances, [redacted] another issue to contend with.

Prior to engaging with Operations to understand the extent of actual events, SW engaged with their Strategic Service Partner - [redacted] to draw on their renown resilience expertise to provide a modelled view of potential heat affected areas across SW. Their work was to identify using GIS (Geographical Information Systems) mapping and Hot spot identification which assets (from the entire company’s asset Base) were theoretically vulnerable to Heat Stress caused by the effects of Climate Change.

Heat Stress in relation to SW’s production assets / sites can be regarded as:
“The potential inability of assets to perform, as a direct result of being subjected to elevated ambient temperatures above operational design criteria”

The 3 datasets used in this Heat stress assessment were as follows:

- UKCP18 Extreme Temperature Grid: this showed predicted maximum summer (i.e., June to August) air temperature for the year 2070 for a 1 in 100-year return period event, using a baseline period of 1981 to 2000 for Representative Concentration Pathway (RCP) 8.5
- Ordinance Survey Terrain 50 dataset: this was used to identify whether each asset was located on a north or south facing slope. Assets on south facing slopes are potentially more susceptible to heat stress.
- Forestry Commission National Forest Inventory (Woodland England) & Historic England Park & Gardens layers:

These layers were used to determine which assets are most likely to benefit from shading.

This work outlined that, ’Climate Change’ can be simply defined as:
“An anticipated rise in average ambient global temperatures (currently predicted to be 1 – 2 °C)” and can be caveated for the Water Industry, from this understanding, to be the root cause of: Prolonged periods of dry weather, absent of any rainfall.

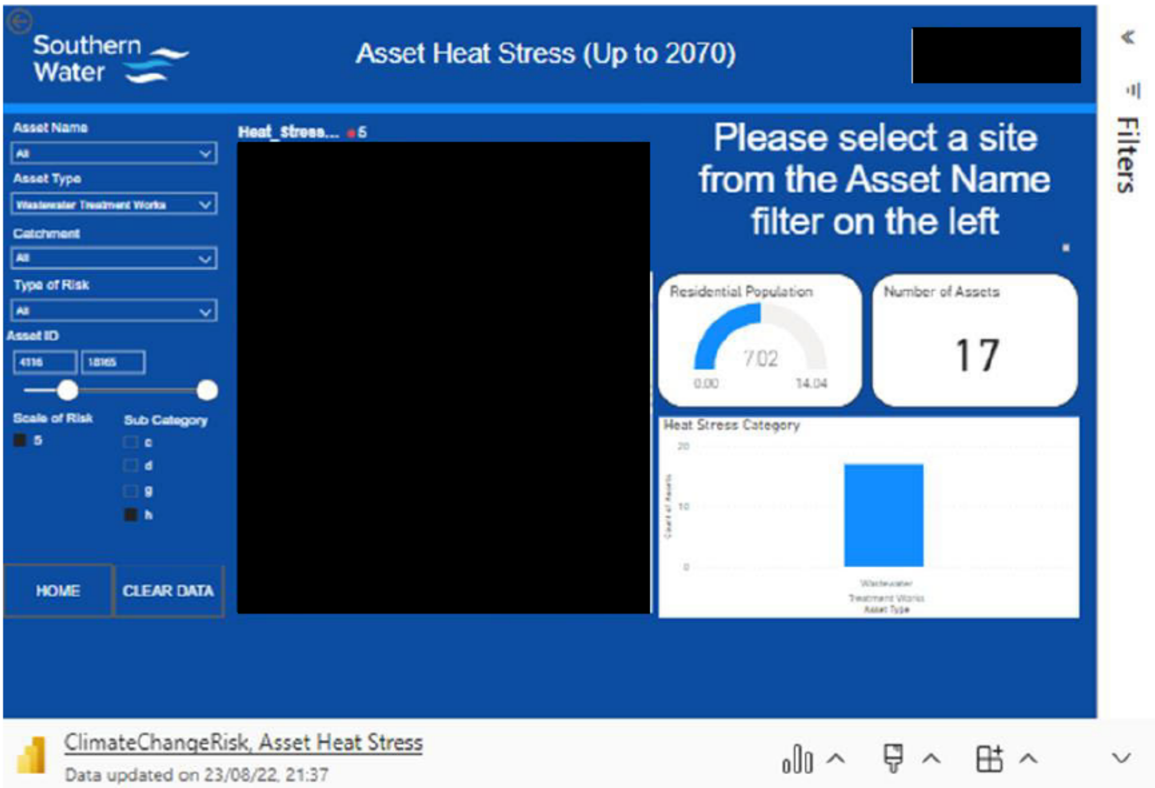
To further evidence this scientific view, the Climate Change Committee's (CCC's) Third UK Climate Change Risk Assessment (CCRA3, 2021) notes that, by "2050 the heatwave summer of 2018 will be a typical summer, where summer rainfall could reduce by as much as 24%".

From related government published Climate Change guidance (the Government's Climate Change 'Adaptation Reporting Power' known as 'ARP3 (Adaptation Reporting Power Period 3)' - that uses the latest UK Climate Projections ('UKCP18')), [redacted] previously advised SW that the effects of Climate Change could be articulated in the form of six specific shocks/stresses (including Heat), from which Water Industry assets were notionally vulnerable. [2]

In that document, the desk top approach is outlined to identify Southern Water sites that are vulnerable to being impacted by Climate Change.

The Desktop approach to identify asset vulnerability consisted of the assets (sites) within the corporate asset register having their locations overlaid with the predicted mapped areas at risk from Heat stress.
The image below revels how Heat stress features.

Figure 2: Mapped areas of heat stress



[2] [Refer to the document Climate Change Risk Assessment for PR24 Investment Planning – Phase 1: Technical Methods and Initial Results (07/10/22), for further information]

The mapped areas at risk from Heat Stress, used were publicly available risk predictions for the areas impacted by different root causes highlighted.

It is acknowledged that the mapped risk predictions were modelled on the currently available climate data (not future modelled projections of Climate Change risk, should ambient global temperatures increase) so a worsening Climate change position has not been explored

Interviews with Operational Field Performance Managers were conducted to determine the extent to which the assets were affected. Through these interviews, it was identified that 115 sites were reported by operations as being affected by heat during 2022. The approach taken was to ask available Operational SMEs (Subject Matter Experts) three high level questions about each of the site's assets within the context of the Heat Event Scenario.

The questions were:
1. “Has the site ever previously been affected by Heat Stress?
2. If it has, how and what service provision (asset or service) are you aware off was affected, or put at risk?
3. What site resilience was / is available now and have any resilience enhancement measures been put into place to prevent service impact from occurring into the future?

Answers were kept to a high-level overview, based on each Operational SME’s individual experience, and did not provide a deep dive into any highly technical consequences, impacts upon service, or increased operational stress.

2. Needs Case for Enhancement

The Needs case in support of this application for enhanced funding is based solely upon the 24 'most vulnerable' sites listed in table 1 below. These will inevitably be susceptible to repeat failures during the next heat stress scenario, like the record-breaking temperatures experienced during the summer of 2022.

The process for selecting these 24 sites was arrived at by combining modelling work which overlaid maps of the asset estate set against temperature squares to determine the "most vulnerable" sites. This along with sites deemed as being "extremely critical" [3] set against the "actual events" witnessed by operations. These 24 sites are therefore the ones to benefit most of all from funding in AMP8.

As this heat stress event is so recent, this proposed enhancement investment or any part of it does not overlap with any other activities to be delivered through earlier identified base capital investment. If we fail to address the need, future episodes have the potential to result in greater impacts upon water supplies to our customers, as experienced for example with the loss of borehole pump supplies at both [redacted] and [redacted]. Also increased water quality issues at the point of discharge into our rivers / sea outfalls E.g. through the loss of the complete DAF plant at [redacted] which impacts upon final effluent compliance. This is, especially so when relying on a finite supply of suitable temporary hire equipment. E.g., blowers and air conditioning units, as highlighted by the [redacted] example in table 1 below. In addition, operators stress levels brought about through unplanned extra working is also a concern.

Table 1 below reveals the extent to which the assets on the sites were affected and these are the ones to be considered for enhancement funding, to combat Climate Change heat related stress. This being especially so as many of these mitigations are short term only and funding is required to properly address the issues.

Table 1: Water Assets affected

Site Unit Title	Site Type Description	Operational SME (Subject Matter Experts) description of the effect that the Climate Change Shock / stress previously caused?
[redacted]	Water Supply Works	Experienced the overheating of borehole pump drives. Temporary fans used to mitigate, by Ops report these were not a particularly satisfactory solution.
[redacted]	Water Supply Works	UV (Ultraviolet) plant controls affected. Kiosk overheats in hot temperatures. Borehole A is located at the WSW (Water Supply Works). B, C & E are remote (approximately 1 mile away). In elevated temperatures temporary A/C is used to mitigate. [redacted]

[3] Extremely Critical Assets are descr bed in SW's Asset Criticality Framework document as being of "very high service impact"

Table 2: Wastewater Assets affected

Site Unit Title	Site Type Description	Operational SME description of the impact has the Climate Change Shock previously caused?
[redacted]	Wastewater Treatment Works	Some parts of the site were affected in 2022 E.g., Centrifuges / outside pumps / blowers / compressors and some MCC's all suffered from overheating. Not much that can be done locally above what Ops did. FPM (Field Performance Managers) reports that it was a struggle to manage. Where [redacted] until the temperature lowered. also used temporary air conditioning units, etc
[redacted]	Wastewater Treatment Works	In the 2022 summer heat, Ops needed to [redacted] when Ops were on site, to prevent overheating assets (not a manned site). [redacted].
[redacted]	Wastewater Treatment Works	BAF affected. Low risks to service with given measures. Blowers have resilience (D/S). If duty trips due to the heat the standby takes over. [redacted] during the 2022 summer. This is an unmanned site, [redacted]
[redacted]	Wastewater Treatment Works	in 2022 heat impacted the Sand Filter compressors (D/S) and the de-sludge system in both the PSTs & Humus system. [redacted].
[redacted]	Wastewater Treatment Works	Ambient temperature affected the MCC and Blower building. [redacted] in MCC & blower building. Temp A/C used when available.
[redacted]	Wastewater Treatment Works	Heat affected the Sand filter compressors. D/S. Housed in a green kiosk. Elevated risk as the site needs all 4 Sand Filters operational, to maintain compliance Failure risk mitigate by [redacted]
[redacted]	Wastewater Treatment Works	Sand filter compressors (D/S) affected by the heat. Low risks to service with given measures. [redacted] on unmanned sites [redacted]
[redacted]	Wastewater Treatment Works	Heat affects the Sand filter compressors (D/S). Low risks to service with given mitigation measures used in 2022. [redacted]. [redacted]
[redacted]	Wastewater Treatment Works	Heat affects the compressor for the DAF (DISSOLVED AIR FLOTATION) plant. They overheat and trip. DAF plant is service critical. It is a Duty Only asset configuration. Significant risk of Compliance issues if it fails
[redacted]	Wastewater Treatment Works	Sand filter compressors (D/S) impacted by heat. The Sand filter compressors are housed in a green kiosk. The high heat was mitigated by [redacted]
[redacted]	Wastewater Treatment Works	Mitigation needed for heat during 2022. [redacted] when Ops were on site to manage heat (not a manned site).

Site Unit Title	Site Type Description	Operational SME description of the impact has the Climate Change Shock previously caused?
[redacted]	Wastewater Treatment Works	Ferric dosing pumps unreliable in the heat. Asset operates D/S, so low risks to service with given resilience measures. Heat Stress mitigation is to [redacted]
[redacted]	Wastewater Treatment Works	The ambient temperature affected the ASP Blowers in 2022. Response resilience provided using Portable AC as for mitigation for the heat. [redacted].
[redacted]	Wastewater Treatment Works	Heat caused the aeration process to struggle with DO. This was due to overheating blowers. The surface aerators drive kept tripping due to the kiosk getting too hot. Portable air conditioning unit installed but that got stolen. When the units trip Ops reset them, [redacted].
[redacted]	Wastewater Treatment Works	Heat caused the aeration process to struggle with DO. This was due to overheating blowers. The surface aerators drive kept tripping due to the kiosk getting too hot. Portable air conditioning unit installed but that got stolen. When the units trip Ops reset them, [redacted].
[redacted]	Wastewater Treatment Works	In 2022 the Blowers were affected by the heat. Assets are in a kiosk. [redacted]. This is an unmanned site.
[redacted]	Wastewater Treatment Works	MCC impacted. In 2022 6 panels over heated.
[redacted]	Wastewater Treatment Works	Sand filter compressors (D/S) affected. Low risks to service with given measures. [redacted]
[redacted]	Wastewater Treatment Works	Heat stress impacting asset treatment performance. SAF (SUBMERGED AERATED FILTER) blowers and SF compressors (D/S) - no AC in building. The heat is also causing algal bloom issue for treatment. This is now (12/22) a critical works. SAF cannot treat flows adequately when it gets hot. [redacted]
[redacted]	Wastewater Treatment Works	The compressors for the Sand Filters fail all the time due to the heat. This has a significant compliance risk. Fan installed in building and [redacted] These have not solved the problem.
[redacted]	Wastewater Treatment Works	SAF blowers impacted. No AC installed in the MCC building. Low risks to service with used mitigation measures. [redacted]
[redacted]	Wastewater Treatment Works	Sand Filter compressors impacted. No A/C in MCC building Low risks to service with given mitigation measures. [redacted]

Overall, our review found that heat stress typically affected MCCs, PLCs, and blower/compressor assets, particularly those housed in cabinets for sites that are exposed and in unshaded locations.

Following on from the recent 2022 event that affected the sites captured in table 1, the current mitigation is still to Respond & Recover using temporary hire air conditioning units and [redacted]. This method of resilience is far from robust and cannot be guaranteed to be adequate against future events, especially when trying to source adequate supplies of air conditioning units, that in many instances are partially effective due to form / fit constraints

With regards future investment, for the remaining portion of the 115 sites initially identified but not being invested in, these should be taken forward to be reassessed in AMP8.

3. Best Option for Customers

All of the 24 sites to be treated during AMP8 by having their Service Resilience Enhanced, are at Service delivery risk because they have been previously affected by heat. The accelerated impact of climate change means that repeated events will occur with an increasing frequency, and at an increasing magnitude, into the future.

Affordability
From feedback received in the run up to PR24, a high priority for our customers was affordability. Although our PR24 customer engagement questioning showed that a significant majority of customers (86%) told us that they feel that bills are currently affordable, they do want us to ensure that current billing will not push necessary work out for future generations to pick up the cost.

Through the site identification and Decision-Making process used, to prioritise those sites requiring additional resilience investment against heat, we have then taken a pragmatic approach to our proposed investment. Specifically, those sites where enhanced resilience is needed now to address issues with sites having been affected (rather than risks where sites are of concern) that have been prioritised for AMP 8. Where there were vulnerable sites with a high-risk profile identified through modelling, but we only had limited evidence of a service risk from heat, these have been deferred for investigation with the potential inclusion for investment during AMP 9.

To ensure that affordability was a major part in the decision process for Heat stress investment, we arrived at circa £7Mil for the 24 named sites through not only the recognition of 115 sites that were affected in 2022, but only took forward the ones that were deemed to be most critical. In terms of affordability, we have arrived at an investment of circa £7mil instead of a potential £33.5Mil ((115 / 24) x 7), had investment all 115 affected sites been pursued.

The purpose of this approach is to therefore deliver the greatest positive impact to resilience, while minimising the impact our investment plan will have on customer bills. We believe that this approach best ensures that both our customers' needs will get met, with vulnerable customers getting support, by ensuring that the AMP8 bill increase is marginal.

The Need for Enhancement Vs. Base Investment

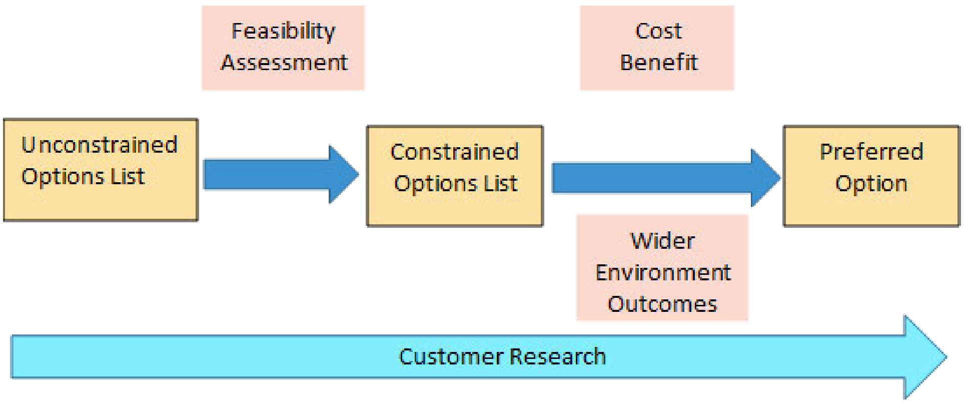
Base service maintenance funding (BOTEX) does not include within its scope the planned investment required to address assets being affected by extreme events. Neither is a purely reactive incident response approach valid for sites that are inadequately designed. Vulnerability has increased because the environment at the location that sites are required to operate in and to cope with Heat stress has externally changed. High stress heat events are unpredictable. Climate change has increased this unpredictability. Managing the risks caused by climate change has therefore become a significant challenge for us delivering service maintenance. It now requires a different and innovative approach to understand, and enhance, what our infrastructure service resilience should look like.

3.1. Plausible Solution Options to Address Resilience Enhancement Need

In the absence of conducting in-depth site specific optioneering for PR24 investment planning, plausible solutions were required to address the heat stress identified.

We have identified a thorough list of potential 'unconstrained' options that may or may not be effective, feasible or cost beneficial. Feasibility assessment supported by Engineering Technical Services (ETS) has been carried out to understand technical viability and / or suitability to validate the list of constrained options. These options (where practical) have then been tested for cost benefit against our public value framework, to understand the solution which provides the 'best value' for the customer. Customer research has also been considered as part of the solution selection process, as shown by the option assessment diagram in Figure 3.

Figure 3: Option Assessment Diagram



Further to the initial resilience modelling work conducted by [redacted] SW engaged them once again, drawing on their expertise in the Climate Change Adaptation (CCA) arena to assist in identifying plausible generic solution options.

The scope of the task included:

1. Providing 3 plausible levels of solution complexity (low, medium & high) that could be invested in.
2. Setting complexity levels for 3 sizes of asset/site (small, medium, and large) with solution costs scales accordingly
3. Different solutions, for various levels of asset complexity

Table 3 shows generic investment options that can be applied to any size of Water or Wastewater Treatment sites:

Table 3: Generic Investment Options

Shock category	Heat Stress affecting electrical and ICA equipment on WTW (Wastewater Treatment Works) and WSWs (Water Supply Works)		
Option label	Option A	Option B	Option C
Expected outcome from heat stress	Heat stress places critical electrical assets at risk. Asset failure would lead to service delivery risk.	Heat stress has the potential to cause essential assets to fail leading to process performance loss. Wastewater treatment/Water Treatment works are / could either become un-usable or the process performance is severely deteriorated	Heat stress has caused sensitive assets to fail or trip. Process performance is reduced and risks breaching EA (Environment Agency) requirements for final effluent quality, storm flow, water quality etc.
Option description	Site specific remedial work: • Update existing asset data base/s with details of existing equipment operating temperature ranges. • Operational response planning to reset any faults/alarms etc. • Add and increase temperature monitoring for critical assets. • Reactive Replacement of equipment on failure with new equipment that potentially has better resilience to heat. • Critical Spares purchased where appropriate	• Understand how existing high heat producing equipment is ventilated. • Ensure existing high heat producing equipment have suitable ventilated/cooling through the options below: - Provide additional ventilation to existing buildings/kiosks as required. - Provide air conditioning for existing buildings/kiosks where additional ventilation cannot meet the equipment cooling requirements. - Relocate existing high heat producing equipment into new buildings/kiosks where ventilation/air conditioning cannot meet equipment cooling requirements. • Provide temporary shading to existing assets	* Power and Control Contingency action plan (Criticality Led) to eliminate critical single points of failure. • Provide permanent shading to existing assets e.g., trees or artificial screening • Replace existing assets (panels and components) affected by elevated temperatures with more heat resistant options.

Options Considered

Overall, we identified four potential options as set out in Table 4 below.
The most viable solution option for the sites was then identified using the following method:

1. Engineering subject matter experts (SME) were engaged to ensure the [redacted] product used for the Climate Change Resilience Enhancement Need proposal did not include any other options being considered to address other PR24 service enhancement needs (e.g., Water Industry National Environment Programme).
2. With the approach approved by ETS, they then validated that option 3 should be the most appropriate solution for all sites.

3. Information about the solution options were considered, which also explains why the preferred solution was adopted, see table 4 below:

Table 4: Unconstrained to constrained list.

Option considered (Unconstrained)	Option retained or not? (Constrained)	Rationale – Discounted or Accepted
Option 1 Do Nothing)	No	Doing nothing relies on Operations to be able to respond on an "As Needs" basis, which may not be sufficient, especially if there is a shortfall in the availability of temporary / portable air conditioning units. Typical site costs for 10 large 7.2KW units being: £2.5K / Day[4] for 2 months (60 days) = £150K / season **Discounted: as deemed to be an unreliable / reactive costly option**
Option 2 (Do Minimum)	No	Provide ventilation by [redacted]. **Discounted: Even if effective leaves a security / 3rd party safety risk that is unmanaged.**
Option 3 (Do More)	No	Site specific remedial work: • Ensure air filters are maintained during routine MSTs (Market Scenario Testing). Update existing asset data base/s with details of existing equipment operating temperature ranges. • Operational response planning to reset any faults/alarms etc. • Add and increase temperature monitoring for critical assets, including remote monitoring • Reactive Replacement of equipment on failure with new equipment that potentially has better resilience to heat. • Critical Spares purchased where appropriate **Discounted: as deemed to be insufficient measures by ETS**
Option 4 (Optimal)	Yes	Option 2 Plus • Understand how existing high heat producing equipment is ventilated. • Ensure existing high heat producing equipment have suitable ventilated/cooling through the options below: - Provide additional ventilation to existing buildings/kiosks as required. - Provide air conditioning for existing buildings/kiosks where additional ventilation cannot meet the equipment cooling requirements. - Relocate existing high heat producing equipment into new buildings/kiosks where ventilation/air conditioning cannot meet equipment cooling requirements. • Provide temporary shading to existing assists **Accepted: as deemed to be best suite of measures by ETS**

[4] Hire costs obtained from HSS Pro Service online [redacted]

All of the 24 sites to be treated during AMP8 by having their Service Resilience Enhanced, are at Service delivery risk because they have been previously affected by asset heat stress. The accelerated impact of climate change means that repeated events will occur with an increasing frequency, and at an increasing magnitude, into the future.

Doing nothing at these sites during AMP8 was therefore not considered as a viable option. Doing nothing would not align with our business priorities or with the values our customers have articulated that they expect us to prioritise investment in.

We have assessed this programme against the criteria for low regret investment identified in the LTDS guidance and Appendix 9 of the Final Methodology. The guidance identified that low regret investments meet the needs across a wide range of plausible scenarios, meet short-term requirements; or keep future options open, including cost minimisation.

We consider that the investment proposed in this enhancement case is a low regret investment for the following reasons:

- Need - This programme is required to meet the increasing need for our site assets to be sufficiently resilient to continue operating in extreme ambient temperatures (typically 40°C and above)
- Timing - Climate change is increasing the frequency of elevated temperature events that are expected to impact the entire company region. Targeting the most vulnerable and previously affected critical sites for resilience enhancement during AMP8 will increase our response resilience to additional sites into the future.
- Options - We have assessed options and identified that the solutions being sought are low regret items
- Future - We have assessed the range of plausible futures, and this option will be sized to ensure that the worst-case outcome within the life cycle of the asset is accounted for.

3.2. Aligning Outputs – Applying Cost Benefit Analysis

To be able to demonstrate that the solutions being promoted provide the greatest economic benefit for our customers, the environment and society, with payback occurring in a reasonable cost beneficial payback (years), Cost Benefit Analysis has been applied, based on the following methodology:

$$CBA = \frac{\text{Cost (of Project)}}{\text{Risk before – Risk after (Benefit)}}$$

where: Cost of Project is the Direct & Indirect Costs (of construction) + Opex (maintenance WLC)

And: Risk = Likelihood / Freq. of Event x Scale of Service Measure Impact x Chance of Impact

Regarding Value for Money (VFM), the following thresholds apply in the Cost Benefit Table 5 below:

Table 5: Cost Benefit Table

Cost Benefit Thresholds	VFM	Challenge	RAG
Ans < 1,	Excellent value,	Risk reduction is greater than the cost of intervention,	Green light to go.
Ans >1, < 10,	Valuable	Cost of intervention could be up to 10 times > than risk being managed	Amber light, proceed with caution
Ans >10,	Cost prohibitive	Question why we need to manage the risk with such an expensive option.	Red light, promotion only by exceptional circumstances

[redacted] **CBA Worked Example**

Number of properties supplied: 25024[5]

<u>Annual Service Impact Risk Valuation</u>

Extreme heat will cause a facility outage with a likelihood of one-in-5-years. The impact will in all probability be compensated by wider network resilience (i.e., surplus network capacity), however low pressure may be a secondary impact, leading to approximately 5% of the properties experiencing low pressure.
N.B. This example is consistent for any one of the 24 sites being promoted for investment, where historically site failure has occurred only once in the current AMP, hence the rational in selecting a likelihood of 1 - 5 yrs.

Service Risk Calculation:
[Event Likelihood] x [property service impact value] x [properties at risk] x [Chance of properties being impacted by low pressure]

[5] Ref: Resilience Assessment File Name [redacted]

0.2 x £2,432 x 25024 x 0.05 = £608,583

Solution Option Proposed – Option 4

The Option 4 solution to enhance the sites resilience to heat events causing service is costed as [redacted]

This solution will involve the best combination of interventions to ensure that existing high heat producing equipment has suitable ventilation / cooling through the options below:

- Provide additional ventilation to existing buildings/kiosks as required.
- Provide air conditioning for existing buildings/kiosks where additional ventilation cannot meet the equipment cooling requirements.
- Relocate existing high heat producing equipment into new buildings/kiosks where ventilation/air conditioning cannot meet equipment cooling requirements.

Annual Customer Cost Benefit Analysis

If the resilience solution reduces the Chance of service impact to highly unlikely (0.01% chance of impact)

The residual risk is: 0.2 x £2,432 x 25024 x 0.001 = £12171.67
The risk reduction is therefore: Inherent risk – Residual risk
£608503 - £12171.67 = £596331.33

Solution cost/Annual residual impact value = Years to the solution being cost neutral

[redacted] / £596331.33 = 1.3 years

The solution will be beneficial to the customer within < 2 years of the project's completion, therefore setting out a compelling case for promotion.

In applying Cost Benefit Analysis to all the sites for option 4, the Cost Beneficial Payback came out to be in the range 0.4 – 10 years.

Impact of our Solutions

Delivering our Heat stress schemes in AMP 8 will help us prepare for and tackle our Climate Change challenges that affect our treatment assets, as evidenced in Table 1 and 2 previously. By sustaining the performance of these assets during periods of heat stress, will help us to deliver improved reductions in Pollutions and Unplanned Outage outcomes, while also increasing overall resilience and workforce capabilities. This is highlighted against the suite of expected AMP8 performance outcomes set out in Table 6. The anticipated solutions delivered will be to address the current and the foreseeable worsening instances of plausible heat stress events. They will deliver a defined new level of protection;

[redacted]

Table 6: How our solutions impact our challenges and how it will help us improve performance

Our Challenges	Heat Stress Schemes we are doing in AMP 8		What is the expected AMP 8 performance outcomes (Cumulative impact of Inflight + AMP 8)						
	22 Wastewater Treatment Works	2 Water Treatment Works	Pollutions	Leakage	Flooding	People Capability	Unplanned Outage	Sewer Collapses	Mains repairs
Drought									
Climate change (Extreme Weather Impacts)	X	X							
Population & Demand Growth									
Transition to Net Zero									
Rapid changes in technology									
Cyber security									
Ageing Assets									
Capability	X	X							
Alignment to 4R's + A									
Anticipation									
Reliability									
Resistance	X	X							
Redundancy									
Response & Recovery									

Key	
	Mapping between Heat Stress Resilience schemes and our Challenges
	Alignment between Heat Stress Resilience schemes to 4R's +A
	Alignment between Heat Stress Resilience schemes and our expected performance outcomes

4. Cost Efficiency

This chapter provides detail on how we have developed our options and the associated costs for our AMP 8 Heat Stress Resilience schemes by applying our standard Cost Estimation and Optioneering approaches to ensure they are based on robust cost-evidence and represent efficient delivery for our customers.

Whilst developing different schemes to increase the resilience of our key sites to combat heat stress interruptions, we have applied our organisational optioneering process, which is governed by our Decision-Making Framework. This framework allows for a granular level of detailed optioneering and is aligned to our Risk and Value (R&V) process, which manages the full lifecycle delivery of a project. Information on how we have applied this Decision-Making Framework as part of our optioneering for each of the two types of Power Resilience Enhancement schemes are provided in the following section.

More information on the general approach to cost estimation and optioneering, which all the associated definitions is provided in the **'SRN15 Cost and Option Methodology Technical Annex'**.

Our Approach to Estimating the Direct Costs

We have used a combination of approaches to attempt to make sure our costs are comparatively efficient and will not adversely impact our customers. These approaches include:

- Using Engineering Consultants to develop initial scope breakdowns for our proposed solutions
- Engaging with industry Cost Intelligence experts to develop a bespoke costing tool that uses a range of cost data sources
- Using the outputs of this tool within our solution optioneering process to increase our operational resilience, whilst considering the impact on customer affordability.

Specifically for these solutions we have worked extensively with [redacted] who developed our initial solution options and [redacted] who developed our [redacted] to estimate the costs associated with our AMP 8 solutions. More information on this process is provided below:

- As an outcome of our work to investigate the threats posed to us by Climate Change, we asked [redacted] to develop several climate change adaptation solution options.
- [redacted] provided several investment options to each threat.
- These options were fed into our [redacted], developed and operated by [redacted] to use their industry benchmarking expertise to estimate the direct Capex, Opex and Carbon costs associated with each solution.
- The tool used several cost data sources to build the costs for each solution, these included:
  - Early-Stage Contractor Quotes
  - Southern Water Cost Curves
  - Industry Benchmarking data provided by [redacted]
  - [redacted] Subject Matter Expertise on cost estimates for specific scope items in the solution design where other quotes/cost curves or benchmarking data could not be aligned to the solution scope items
- The outputs of the [redacted] were then taken forward to be assessed as part of our Optioneering process to prioritise investment in schemes for AMP 8.

As set out in SRN15 Cost and Option Methodology Technical Annex, we separate our capital expenditure into the following four categories:

- Direct Costs (or Net Direct Works)
- Indirect Costs
- Risk
- Corporate Overheads

Our organisational process builds up the full cost stack by applying cost multipliers for Indirect, Risk and Corporate Overhead cost categories onto the Direct Costs for each scheme. More information on the definitions and rationale for the criteria is provided in SRN15 Cost and Option Methodology Technical Annex.

What cost multipliers have been applied for our Heat Stress Resilience Schemes?

Table 7 shows the overall Cost Multiplier for our Heat Stress Resilience solutions we propose to deliver in AMP 8.

Table 7: Heat Stress Resilience Enhancement Scheme Cost Multiplier Breakdown

Scheme	Overall Cost Multiplier
Heat Stress Resilience	2.17

More information on how the overall cost multiplier and associated costs for our heat stress resilience scheme is provided below.

Heat Stress Schemes
Table 8 shows the breakdown of costs and Cost Category Multipliers for our Heat Stress Resilience Schemes solutions we propose to deliver in AMP 8.

Table 8: Heat Stress Resilience Enhancement Scheme Cost Multiplier Breakdown and Total Cost Contribution

Scheme	Direct Cost	Indirect Cost	Risk	Corporate Overhead	
Costs	£3.33m	£2.55m	£0.58m	£0.76m	£7.22m
Multiplier (%)	100.0%	76.5%	9.9%	11.7%	2.17

The Heat Stress resilience scheme's cost multipliers are based on the following criteria:

- The scheme involves delivery of **Non-Infrastructure** Projects
- The scheme is to be **'Traditionally Funded'**
- We have **Low degrees of confidence in design maturity and medium degrees of confidence in scheme complexity** for the activity to be delivered at each site.

Table 9: Heat Stress Resilience Schemes Risk Cost Multiplier

Design Maturity	Complexity	Risk (%)
Low	Medium	9.9%

The cost breakdown between Water and Wastewater sites included in this scheme is provided in Table 10.

Table 10: Site Specific Cost Breakdown – Heat Stress Resilience Schemes

Site	Direct	Indirect	Risk	Corporate Overhead	Total Cost
Water	£0.71m	£0.54m	£0.12m	£0.16m	£1.54m
Wastewater	£2.62m	£2.01m	£0.46m	£0.60m	£5.68m
Total	£3.33m	£2.55m	£0.58m	£0.76m	£7.22m

How we have applied our optioneering approach to our Heat Stress Resilience Schemes Solution

- Need for investment in heat stress resilience has been identified through a combination of:
  - learning lessons from the impact of record-breaking temperatures on our assets in the summer of 2022
  - modelling activity to identify the most vulnerable sites in our network.
- Investigations to understand the operational impact of the 2022 Heat Stress events on our assets were carried out through interviews with Operational Field Performance Managers, identifying 115 sites that were impacted.
- An Unconstrained list of 5 potential solution options was developed through Engineering Subject Matter Expert input, more information on these options is provided in Table 2 above
- ETS reviewed the proposed options and validated Option 3 as being the most appropriate solution.
- Based on the assumptions listed below, Level 1 direct costs for each site were calculated by Cost Intelligence Team (CIT) using Southern Water Cost Models (More information on these cost models is available in **SRN15 Cost and Option Methodology Technical Annex**.),
  - Assumptions based around:
    - Size of Works, Small, Medium, Large
    - Asset Type, WSW or WTW
    - Investment Option, 1,2 or 3
- CIT applied updated cost multipliers based on solution details and delivery method and confidence weightings on the Maturity of Design and Scheme Complexity for the Risk component.
  - The cost multipliers have been refined throughout the design process as our cost models have continued to develop

More information on our Optioneering process can be found in **SRN15 Cost and Option Methodology Technical Annex**.

4.1. Investment Costings

Following on from the overview of how we have calculated the costs for our solutions earlier in this chapter, the breakdown of the overall solution investment costs is provided in Table 11 and is in the region of £7.2 Mil

Table 11: Investment Costings

Site`	Direct Cost	Indirect	Risk	Corp. Overhead	Adjusted Cost
[redacted]	£0.36m	£0.27m	£0.06m	£0.08m	£0.77m
[redacted]	£0.36m	£0.27m	£0.06m	£0.08m	£0.77m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.36m	£0.27m	£0.06m	£0.08m	£0.77m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.36m	£0.27m	£0.06m	£0.08m	£0.77m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.36m	£0.27m	£0.06m	£0.08m	£0.77m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
[redacted]	£0.08m	£0.06m	£0.01m	£0.02m	£0.18m
Total	£3.33m	£2.55m	£0.58m	£0.76m	£7.22m

5. Customer Protection

The proposed Heat Stress reduction programme is below the materiality threshold applicable for a Price Control Deliverable to be set. The principal benefit of this investment case is to ensure that resilience is increased sufficiently to meet the challenges arising from adverse heat events. In doing so, will reduce SW's dependency to solely rely on Response and Recovery, in favour of more robust resilience means.

- We have evidenced where previous events have occurred and how climate change is becoming more prevalent for heat and the extent to which customers and the environment can be impacted. The full benefit therefore needs to be seen in terms of the resilience it provides in the most challenging summers.
- Our approach is designed to achieve the maximum benefit for customers for the least cost I.e., not undertaking investment in schemes that are inappropriate or proven through CBA to be poor VFM to SW (Southern Water) and its customers, whilst still striving to achieve the desired outcome.

As part of our case, we have set out how the proposed investment enables us to prioritise the various schemes to ensure that the intended solutions are delivered successfully, whilst also acting upon lessons learnt for remaining similar schemes. This will ensure that delivery of the overall programme will be done as effectively as possible, having checked off each project successfully, before proceeding further.

In addition, to ensure that we are not using enhancement funding to rectify existing operational issues, which should be undertaken as part of our OPEX budgets, we will utilise condition grade assessments on existing heat reduction assets e.g. extractor fans for any defects identified (i.e., structural grade 4 and 5) will be rectified and funded by Capital Maintenance budgets and not through this Enhancement Case.

6. Conclusion

Section	Key Commentary	Page
Introduction & Background	SW experienced the highest ever recorded temperatures in 2022. Some115 sites were investigated, with criticality being applied to determine that a final number of 24 sites should be considered for investment.	4
Need for Enhancement Investment	As this heat stress event is so recent, this proposed enhancement investment or any part of it does not overlap with activities to be delivered through base. If we fail to address the need at this time, then future episodes may well result in greater impacts upon water supplies to our customers and increased WQ issues at the point of discharge into our rivers / sea outfalls, especially when relying on the supply of temporary hire equipment	9
Best Option for Customers	3 plausible options (A B &C) were produced by [redacted] which were used to produce 4 unconstrained / constrained options to be considered by ETS (Engineering Technical Solutions). They then validated Option 3 (which included Option 2) to be the best suite of "Acceptable" measures for all sites.	13
Cost Efficiency	The solution options that have been selected are costed where appropriate using a costing tool that utilizes a set of selectable criteria. The costing elements used in the tool have been produced by [redacted] To be able to demonstrate the greatest economic benefit for our customers, the environment and society, with payback occurring in a reasonable cost beneficial time (years), Cost Benefit Analysis has been applied, and considers cost against risk reduction. The total Investment being sought is £7.22Mil	21
Customer Protection	The proposed Heat Stress reduction programme is below the threshold applicable for a Price Control Deliverable to be set. Heat stress is linked to extreme elevated levels in temperature (typically > 40 degree C) conditions which can cause treatment processes to fail These events are variable in level and duration and may be difficult to predict, though data shows they are becoming more frequent. It is difficult therefore to state with accuracy the absolute benefit to be delivered by a heat stress reduction programme in terms of impacts such as interruption to supplies, WQ or pollution incidents being prevented however, it is anticipated that there will be improvement in the following areas: ▪ Category 3 pollution incidents ▪ Interruptions to supply ▪ Customer complaints associated with taste and odour ▪ Reactive Operational costs associated with obtaining and deploying temporary measures.	25

References

1. BBC Reference on 18/05/23 - https://www.bbc.co.uk/news/science-environment-65602293#:~:text=Our%20overheating%20world,now%20and%202027.
2. [Refer to the document Climate Change Risk Assessment for PR24 Investment Planning – Phase 1: Technical Methods and Initial Results (07/10/22), for further information]
3. Extremely Critical Assets are descr bed in SW's Asset Criticality Framework document as being of "very high service impact"
4. Hire costs obtained from [redacted]
5. Ref: Resilience Assessment File Name [redacted]