

Review of Northumbrian Water's response to Storm Arwen

Document no: 001
Revision no: 3.1

Northumbrian Water

Storm Arwen Assessment
13 April 2022



Photo courtesy of Northumbrian Water Ltd taken during Storm Arwen

Review of Northumbrian Water's response to Storm Arwen

Client name:	Northumbrian Water	Project no:	B2435200
Project name:	Storm Arwen Assessment	Project manager:	Alex Reoyo
Client reference:	N/A	Prepared by:	Alex Martin, Graham Hindley, David Price, Alex Lane, Emma Staveley
Document no:	001	Date:	13 April 2022
Revision no:	3.1	File name:	NWL-Storm-Arwen-Review_ProjectReport_v3.0
Doc status:	Draft for client comment		

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
1	11/03/22	Draft for client comment	David Price, Graham Hindley, Alex Lane	Shubby ToloOgunpolo	Alex Martin	Alex Reoyo
2	24/03/22	Further draft for client review	David Price, Graham Hindley, Alex Lane		Alex Martin	
3	13/04/22	Update to reflect client comments	Alex Lane		Alex Martin	Stathis Giannouostas
3.1	13/04/22	Final report	Alex Lane		Alex Martin	Stathis Giannouostas

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments
1	Alex Reoyo	11/03/22	NWL	Draft for client comment
2	Alex Martin	24/03/22	NWL	Further draft for client comment
3	Stathis Giannouostas	13/04/22	NWL	Updated report
3.1	Stathis Giannouostas	13/04/22	NWL	Final report

Jacobs U.K. Limited

The West Wing
1 Glass Wharf
Bristol, BS2 0EL
United Kingdom

T +44 (0)117 457 2500
www.jacobs.com

Copyright Jacobs U.K. Limited @ 2022.

All rights reserved. Reproduction and redistribution without written permission is prohibited. Jacobs, the Jacobs logo, and all other Jacobs trademarks are the property of Jacobs Engineering Group Inc.

NOTICE: This document has been prepared exclusively for the use and benefit of Jacobs' client. Jacobs accepts no liability or responsibility for any use or reliance upon this document by any third party.

Review of Northumbrian Water's response to Storm Arwen

Note about you report:

This report has been prepared for the sole purpose of Northumbrian Water Limited. Its conclusions are based on review of documents provided to Jacobs by Northumbrian Water Limited and descriptions of the event offered by Northumbrian Water Limited staff during discussions with them.

Executive summary

Storm Arwen brought severe northerly winds across the UK over the night of 26 to 27 November 2021. It was one of the most powerful and damaging winter storms of the last few decades. Thousands of trees were felled causing significant transport disruption, three people were killed, and fallen power lines resulted in one million homes experiencing electricity disruption¹. Northeast Scotland, Durham, Darlington and Northumbria councils declared major incidents, triggering a multi-agency emergency response in accordance with powers set out in the Civil Contingencies Act 2004 and which was co-ordinated through the Local Resilience Forums (LRFs). The loss of power impacted Northumbrian Water Limited (NWL) and its ability to supply water to customers and maintain wastewater treatment processes.

The Scottish Government, Ofgem and the Department for Business, Energy and Industrial Strategy (BEIS) have initiated reviews of the response of the electricity sector to Storm Arwen. From what has been published to date, the rarity of the power supply interruptions resulting from Storm Arwen is not clear. As a comparison, the storms in December 2013 resulted in around 53,000 Northern Powergrid (NPG) customers experiencing electricity interruptions with a maximum restoration period of 32 hours². December 2013 was one of the top 10 stormiest months on record and was the stormiest month since January 1993³. Storm Arwen resulted in five times as many NPG customers being affected than the 2013 storms.

Jacobs was commissioned by NWL to understand the nature and severity of Storm Arwen and evaluate NWL's response to it. The project comprised desk-based analysis and interviews with NWL staff involved in the incident response. Jacobs is NWL's independent Security and Emergency Measures Direction Certifier to DEFRA and has fulfilled this role since 1999. Jacobs also provides this certification service to four other major water and sewerage companies in England and Wales and has previously undertaken event response reviews for water companies following significant incidents such as Beast from the East in 2018.

Analysis of the weather event

Storm Arwen brought severe winds across the UK over the night of 26 – 27 November 2021, with the Met Office issuing a red warning for wind with impacts restricted to the eastern coast of Scotland and northeast Britain. In England, the one water and sewerage company region impacted by the red warning was that of NWL.

The main hazard associated with Storm Arwen was wind, though it also brought very low temperatures for the time of year and some significant snow accumulations. The highest (non-mountain) gust speed was 98 mph, recorded at Brizlee Wood in Northumberland (see Figure E-1). A wind gust as high as this is exceptional for this area (the wind gust record for north-east England being 107 mph at Lynemouth, Northumberland in December 1979).

When analysed by wind direction the northerly Storm Arwen winds recorded in and around Northumberland are estimated to have return periods between 1 in 20 years to greater than 1 in 50 years. The unusual wind direction led to the storm felling significantly more trees than would otherwise have been the case if the wind had been from the usual west, south-west direction.

The wintry conditions after Storm Arwen caused additional difficulty with freezing temperatures and snow on higher ground. Compared to the historical temperature records for other major events, this is unusual for extreme wind events.

The infographic in Figure E-2 includes a timeline of important events associated with Storm Arwen.

¹ Source: https://www.ofgem.gov.uk/sites/default/files/2022-02/Interim%20report%20on%20the%20review%20into%20the%20networks%27%20response%20to%20Storm%20Arwen_0.pdf

² Source: https://www.ofgem.gov.uk/sites/default/files/docs/2014/03/final_december_2013_storms_review_1.pdf

³ Source: <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2013/winter-storms-december-2013-to-january-2014---met-office.pdf>

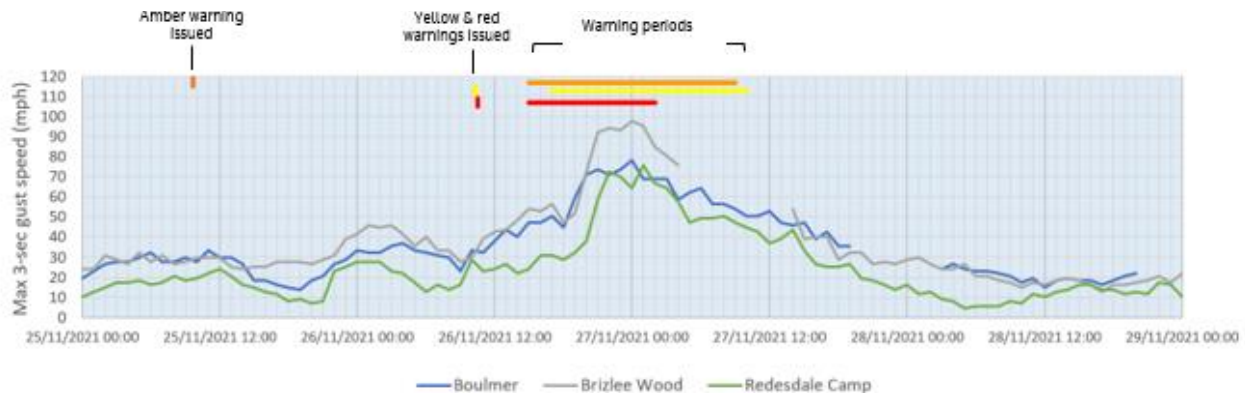


Figure note: Met Office warnings: yellow for snow, amber and red for wind. In all cases, the first marker indicates when the warning was issued. The solid line indicates the period over which the warning applied

Figure E-1: The occurrence of Storm Arwen together with the Met Office warnings

Review of NWL's emergency plans

Jacobs' review of the emergency manuals relevant to NWL's preparedness and response to Storm Arwen confirmed that they are comprehensive in their content and intended use. They are typical of emergency plans currently in use in other water companies in England and Wales. The manuals are reviewed on an annual basis to confirm their appropriateness.

The scenarios that NWL has planned for, as set out in its Emergency Plans Manual, are based on reasonable assumptions. It has exercised response procedures for appropriate incidents, including working with relevant stakeholders and other responders.

The review found no significant shortcomings with the plans and documentation. Some gaps were observed in the Generic Plan for Prolonged or Region Wide Disruption of Electricity Supplies and in the Generic Plan for Severe Weather Conditions. These relate to defining the timescale of a "prolonged" disruption to power supplies and the development or enactment of a portable generator deployment plan.

Review of NWL's response to Storm Arwen

Storm Arwen was a severe event that resulted in disruption to the operation of some of NWL's assets that was beyond its control. Power outages caused shutdowns of some sites and the widescale loss of communications between remote sites and the Regional Control Centre meant that understanding the scale and extent of issues was a challenge. Access to sites was also initially disrupted by fallen trees and unsafe travel conditions.

Data analysed by NWL after Storm Arwen indicates that water supply interruptions peaked at approximately 8,000 properties at 1400 hrs on 28 November 2021. More than half of these interruptions were restored by 2200 hrs on 28 November 2021. By 0900 hrs on 30 November 2021, interruptions were being experienced by fewer than 1,200 properties. All interruptions were restored by 1200 hrs on 7 December 2021.

Jacobs considers that the actions NWL took during and in the aftermath of Storm Arwen were responsive and robust. It quickly mobilised its Incident Management Team (IMT) and effectively organised what resources were available to manage the incident to the best of its ability. In particular:

- The strong teamwork and the personal efforts of those individuals involved ensured a sustained and effective response.
- Support from NWL's supply chain was widely acknowledged as positive. The local knowledge of tankering and bottled water supply contractors was highlighted as particularly helpful.
- The fact that most members of the IMT were working remotely was identified as highly beneficial by several individuals. This meant communication could be more frequent and targeted.
- NWL went beyond its duty in organising alternative water supplies for members of the public and farmers on private borehole supplies who were impacted by the power outages.
- NWL received good customer feedback to its external communications from Monday 29 November 2021 which included time-stamped updates by location.

- There was good coordination between the External Communications and Customer teams (discussing updates, shaping key messages to support the Customer team with calls, and ensuring that questions and comments were being managed by the Customer team).

Although NWL was hampered by a lack of information about power restoration from Northern Powergrid, it engaged well with the LRFs (via attendance at Strategic Coordinating Group and Tactical Coordinating Group meetings) and NWL's contractors and other organisations to provide alternative water and reinstate supplies.

As well as acknowledging NWL's good practice, several areas for improvement were identified. For a review of this type, for an unprecedented incident, it should be expected that there are lessons to learn and areas for improvement identified. Learning from past incidents is a key aspect of the emergency planning continuous improvement process. Identifying areas for improvement comes with the benefit of hindsight and it is important to differentiate between shortcomings in the response at the time and improvements that can be made for future incidents. Most of the improvement areas identified by this review relate to general incident preparedness and to a large extent reflect the widescale and unprecedented nature of Storm Arwen.

Recommended improvement areas are as follows:

- NWL enacts winter readiness procedures each year as part of business-as-usual activity, however these should be reviewed to identify whether preparedness for storms can be enhanced and formalised into written procedures.
- The NWL fleet of mobile generators and fixed generators appears to be based on a legacy assessment. Through discussion with NWL, Jacobs is not aware that the entire fleet has ever been called upon in an incident in the past. However, a review of the requirements for mobile or new fixed generation is recommended.
- NWL has arrangements to hire additional mobile generators from external sources, however Jacobs understands that NWL does not pay a retainer through the contract so may not get priority when ordering in third party provided generators. NWL should consider whether retaining contracts could be established for hired-in generators.
- NWL's generator maintenance programme should be reviewed, in particular to include load testing where appropriate. Notwithstanding this observation, analysis found that generator issues were the major contributing factor in only a small number of interruptions to water supply.
- NWL has conducted less training in incident management over the last three years compared to previous years (impacted by the Covid-19 pandemic in the last 2 years). Whilst there is no evidence that those undertaking roles in the IMT during Storm Arwen were not able to perform the roles appropriately NWL should review the resources needed to deliver each role in its incident response and provide training accordingly. NWL should exercise longer-duration events.
- Whilst that there was no shortage of NWL staff who contributed to the NWL response it is noted that a number of roles relied on the goodwill of the staff to participate. NWL should review its standby rotas to consider whether they can be amended to optimise staff availability for long duration events such as Storm Arwen. NWL should adopt a volunteer register to support incident response and release appropriate staff to deliver technical activities.
- It is understood that electricity distribution network operators receive 10-day and 5-day weather forecasts and that NPG enacted preparations for Storm Arwen on 24 November (in advance of the Met Office weather warnings). NWL should engage NPG to explore what advance notification NPG could provide in future. NWL should review whether its weather warning service could be improved.
- NWL did not form the Electricity Supply Disruption Working Group (ESDWG) in advance of Storm Arwen. Once the impact of the storm became evident the situation was escalated straight to the IMT. NWL should review the triggers for establishing the ESDWG such as the receipt of weather warnings. However, during Storm Arwen there was restricted time between receipt of the weather warnings and the onset of the storm. Earlier warning would have given the opportunity to consider additional preparatory activities in advance of Storm Arwen.

The conclusions to this report explore the potential affect these improvements may have had on customer impact for Storm Arwen. NWL has been proactive in learning lessons about the Storm Arwen response. It has collated feedback from staff members, held an internal debrief and already begun implementing several enhancements to procedures and working practice.

Review of Northumbrian Water's response to Storm Arwen

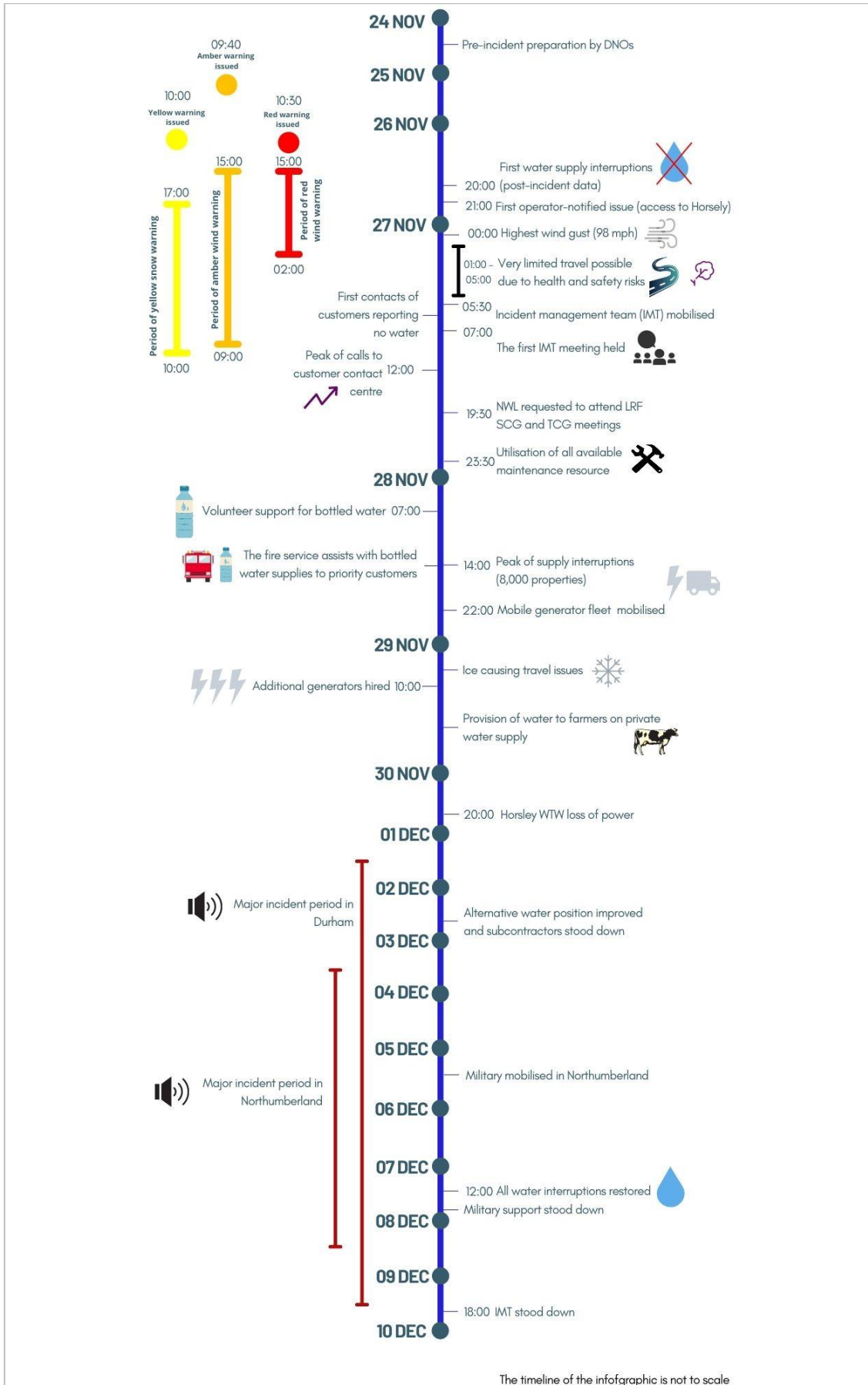


Figure E-2: Infographic of key events during Storm Arwen

Contents

Executive summary	iv
Acronyms and abbreviations	x
1. Introduction	12
1.1 Purpose of the project.....	12
1.2 Methodology.....	13
1.3 Overview of NWL assets.....	14
2. Review of the Storm Arwen weather event	17
2.1 Overview.....	17
2.2 Weather data and rarity analysis.....	19
2.3 Temporal profile of storm.....	24
2.4 Subsequent wintry conditions.....	25
3. NWL's existing emergency management plans	27
3.1 Security and Emergency Measures Direction 1998.....	27
3.2 Policies, Plans and Manuals.....	28
3.3 Corporate policies.....	29
3.4 Emergency Management Manual.....	30
3.5 Emergency Plans Manual - Chapter 2 – Generic Plan for Major Incidents.....	30
3.6 Emergency Plans Manual - Chapter 6 - Generic Plan for a Prolonged or Region Wide Disruption of Electricity Supplies.....	31
3.7 Emergency Plans Manual - Chapter 9 - Generic Plan for Severe Weather Conditions.....	32
3.8 Alternative Water Supplies Manual.....	33
3.9 Bottled Water Distribution Plan and Bottled Water Dispensing Plan.....	33
3.10 Outage plans.....	34
3.11 Winter readiness.....	35
3.12 Assessment for generator requirements.....	35
3.13 Emergency exercises.....	35
3.14 Previous events.....	38
3.15 Summary.....	38
4. Review of general preparedness for storm events and severe weather	40
4.1 Winter readiness.....	40
4.2 Status of plans and procedures in advance of Storm Arwen.....	40
4.3 Underlying staffing issues.....	41
4.4 Training.....	41
5. Review of actions before Storm Arwen	43
5.1 Weather warnings.....	43
5.2 Underlying system performance and preparedness.....	43
5.3 Anticipating likely staffing requirements.....	44
5.4 Preventive action.....	44
6. Reviews of action during Storm Arwen	45
6.1 General operational impacts.....	45
6.2 Overview of the incident response.....	46

6.3	Use of generators	50
6.4	Water supply interruptions.....	51
6.5	Disruption to wastewater management	54
6.6	Review of support provided to customers.....	55
6.7	Review of external communications.....	56
6.8	Review of the alternative water response.....	57
6.9	Review of the interface to the local resilience forums.....	58
7.	Review of actions after Storm Arwen	59
8.	NWL reflections on the incident response	61
9.	Conclusions and recommendations	63

Appendices

Appendix A. Interviewees.....	71
-------------------------------	----

Tables

Table 2-1: Summary of the severe weather warnings issued by the Met Office.....	18
Table 2-2: Summary of rarity analyses.....	24
Table 3-1: Service level agreement with Wincanton.....	33
Table 3-2: Record of exercises.....	36
Table 3-3: Record of external exercises.....	38
Table 4-1: Incident training records	41
Table 6-1: Total supply interruptions.....	52
Table 6-2: Supply interruptions by ODI category.....	52
Table 6-3: Root cause of major interruptions.....	53
Table 9-1: Summary conclusions and recommendations.....	64

Figures

Figure 1-1: Overview of NWL's clean water sites.....	15
Figure 1-2: Overview of NWL's wastewater sites.....	16
Figure 2-1: The occurrence of Storm Arwen together with the Met Office warnings.....	18
Figure 2-2: Met Office storm warnings issued for Storm Arwen and the location of the Met Office gauges considered in the analysis.....	20
Figure 2-3: Storm Arwen maximum 3-second gust rarity analysis (without consideration of wind direction)	21
Figure 2-4: Maximum 3-second gust (mph) of Storm Arwen and the other AMAX events plotted by wind direction and compared to directional rarity analysis (RP = return period in years).....	22
Figure 2-5: Storm Arwen timeseries compared to the top 5 AMAX events at Boulmer.....	24
Figure 2-6: Minimum and maximum temperatures recorded at Redesdale Camp the day after the storm event peak plotted against maximum 3-second gust of the storm.....	25

Acronyms and abbreviations

AMAX	Annual Maximum
AMP	Asset Management Plan
AWC	Alternative Water Coordinator
AWS	Alternative Water Supplies
BCM	Business Continuity Management
BEIS	Department for Business, Energy & Industrial Strategy
CMT	Crisis Management Team
CFS	Customer Field Services
DEFRA	Department of Environment, Food & Rural Affairs
EMI	Electrical, Mechanical, Instrumentation
EMM	Emergency Management Manual
ESDWG	Electric Supply Disruption Working Group
GEV	Generalised Extreme Value distribution
HV	High voltage
IMT	Incident Management Team
JESIP	Joint Emergency Services Interoperability Programme
Kt	Knots
LRF	Local Resilience Forum
LV	Low voltage
NA	Network Analysts
NCC	Northumberland County Council
NEWSAC	North-East South-West Area Consortium
NPG	Northern Power Grid
NWL	Northumbrian Water Limited
OET	Operational Emergency Team
OFGEM	Office of Gas & Electricity Markets
OFWAT	Water Services Regulation Authority
OPM	Operational Planning & Management
PSR	Priority Services Register
PSTN	Public Switched Telephone Network
RCC	Regional Control Centre
SCADA	Supervisory Control and Data Acquisition

SCG	Strategic Coordination Group
SEMD	Security & Emergency Measures Direction 1998
SPEN	SP Energy Networks
SSA	Site Specific Management
UKHSA	UK Health Security Agency
TCG	Tactical Coordination Group
TCTF	Too Critical to Fail
UKHSA	UK Health Security Agency

1. Introduction

1.1 Purpose of the project

Storm Arwen brought severe winds across the UK over the night of 26 to 27 November 2021. The Met Office had issued a rare red warning for wind and consider Arwen to be one of the most powerful and damaging winter storms of the latest decade⁴.

The storm tracked south and brought northerly winds gusting generally at over 69 mph. The highest gust speed was 98 mph at Brizlee Wood, Northumberland.

Thousands of trees were felled by Storm Arwen. Three people were killed by falling trees across Cumbria, Aberdeenshire, and Northern Ireland. Falling trees brought down power lines and one million homes experienced electricity disruption⁵. Fallen trees also caused significant transport disruption and the high winds caused structural damage to buildings¹.

The main hazard was wind, though Arwen also brought some extremely low temperatures for the time of year and some significant snow accumulations.

The Department for Business, Energy, and Industrial Strategy (BEIS) described Storm Arwen as an exceptionally severe storm and explained that the atypical northerly wind direction caused more damage than wind gusts coming from the prevailing south-west would have done⁶.

Northumbrian Water Limited (NWL) was impacted by Storm Arwen in several ways:

- Loss of power causing failure of fixed telecommunications – NWL's Supervisory Control and Data Acquisition (SCADA) system was impacted with data feeds from sites to the Regional Control Centre (RCC) being disrupted.
- Loss of power causing failure of mobile telecommunications. Mobile signal was disrupted in several areas, making it difficult for operations staff to report back to team leaders and the RCC.
- Loss of power causing sites and assets without on-site generation to fail (water treatment, water pump stations, water reservoirs, wastewater treatment sites and wastewater pump stations).
 - For water assets this caused source water production to cease and water in service reservoirs to continue to supply customers until these reserves were exhausted. At this point, interruptions to customer water supplies occurred.
 - For wastewater assets this caused pumps to cease operation, leading to chambers filling and then, potentially, overflowing to watercourses.

No NWL sites were directly impacted by the high winds of Storm Arwen. Indirect impacts associated with loss of power and disrupted access to sites were the overriding causes of operational issues for NWL.

Jacobs has been commissioned by NWL to:

- **Task 1:** understand the nature of the Storm Arwen weather event, its impact on NWL operating regions, and its impact on other regions of the UK.
- **Task 2:** understand the effectiveness of NWL's existing plans to manage risks associated with extreme weather events.

⁴ Source: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2021/2021_07_storm_arwen.pdf

⁵ Source: https://www.ofgem.gov.uk/sites/default/files/2022-02/Interim%20report%20on%20the%20review%20into%20the%20networks%27%20response%20to%20Storm%20Arwen_0.pdf

⁶ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf

- **Task 3:** understand the effectiveness of NWL's response to Storm Arwen.
- **Task 4:** based on the preceding tasks, determine whether there is more NWL could have done to mitigate the impacts on service customers experienced during and following Storm Arwen.

1.2 Methodology

This project comprises desk-based analysis and interviews of NWL staff involved in the response to Storm Arwen.

The following data has been analysed:

- Related to understanding the weather event:
 - Weather data obtained from the Met Office.
 - Discussions with Forestry England.
- Relating to understanding effectiveness of NWL's emergency plans:
 - Corporate policies for Business Continuity Management and Emergency Management.
 - Suite of emergency plans.
 - Alternative water manual.
 - Outage plans.
 - Training records and records of incident exercises.
- Related to understanding NWL's response to the weather event:
 - Data describing which assets were impacted by the storm.
 - The Incident Management Team incident log.
 - The personal logs of several staff.
 - Minutes from the relevant Local Resilience Forums (LRFs).
 - Supply interruptions data.
 - Customer contact centre data.
 - Records of generator deployment.
 - Reports submitted to the Drinking Water Inspectorate (DWI).

To further understand and evaluate NWL's response to Storm Arwen, interviews were held with NWL staff who were involved in the Storm Arwen incident response. Appendix A lists the roles of the persons interviewed.

This report presents an assessment by exception, identifying areas of the NWL response to Storm Arwen which were identified by interviewees and/or data as particularly good, or that could be improved, rather than identifying and analysing every aspect of the response. This means that some aspects of the response which progressed as expected may not be referred to.

For a review of this type, for an unprecedented incident, it should be expected that there are lessons to learn and areas for improvement identified. Learning from previous incidents is a key aspect of the emergency planning continuous improvement process. Identifying areas for improvement comes with the benefit of hindsight and this report attempts to differentiate between shortcomings in the response at the time and improvements that can be made for future incidents.

1.3 Overview of NWL assets

NWL supplies water and sewerage services to just under 4.4 million people. In the northeast of England, NWL supplies 1.3 million properties (referred to as the northern supply area). The supply area covers the urban populations of Tyneside, Wearside and Teesside as well as rural areas such as Northumberland and County Durham.

NWL's northern supply area is divided into eight operational areas:

1. Berwick
2. Tyne Valley
3. Mid Northumberland
4. Tyneside
5. Wear Sunderland
6. South Durham
7. Honey Hill
8. Teesside

Generally, there is connectivity between these operational areas although Berwick operates as a discrete zone.

To supply customers in the northern supply area with water, NWL own and operate 30 water treatment works. The location of these works can be seen in Figure 1-1, along with the location of borehole sources and storage reservoirs.

The treatment works vary in size and supply area. The largest treatment works is Broken Scar, supplying 155,000 properties with clean water and routinely operating at an output of 80 ML/day.

NWL own and operate over 420 wastewater treatment works and over 2,300 sewage pumping stations over their northern supply area. The location of these can be seen in Figure 1-2.

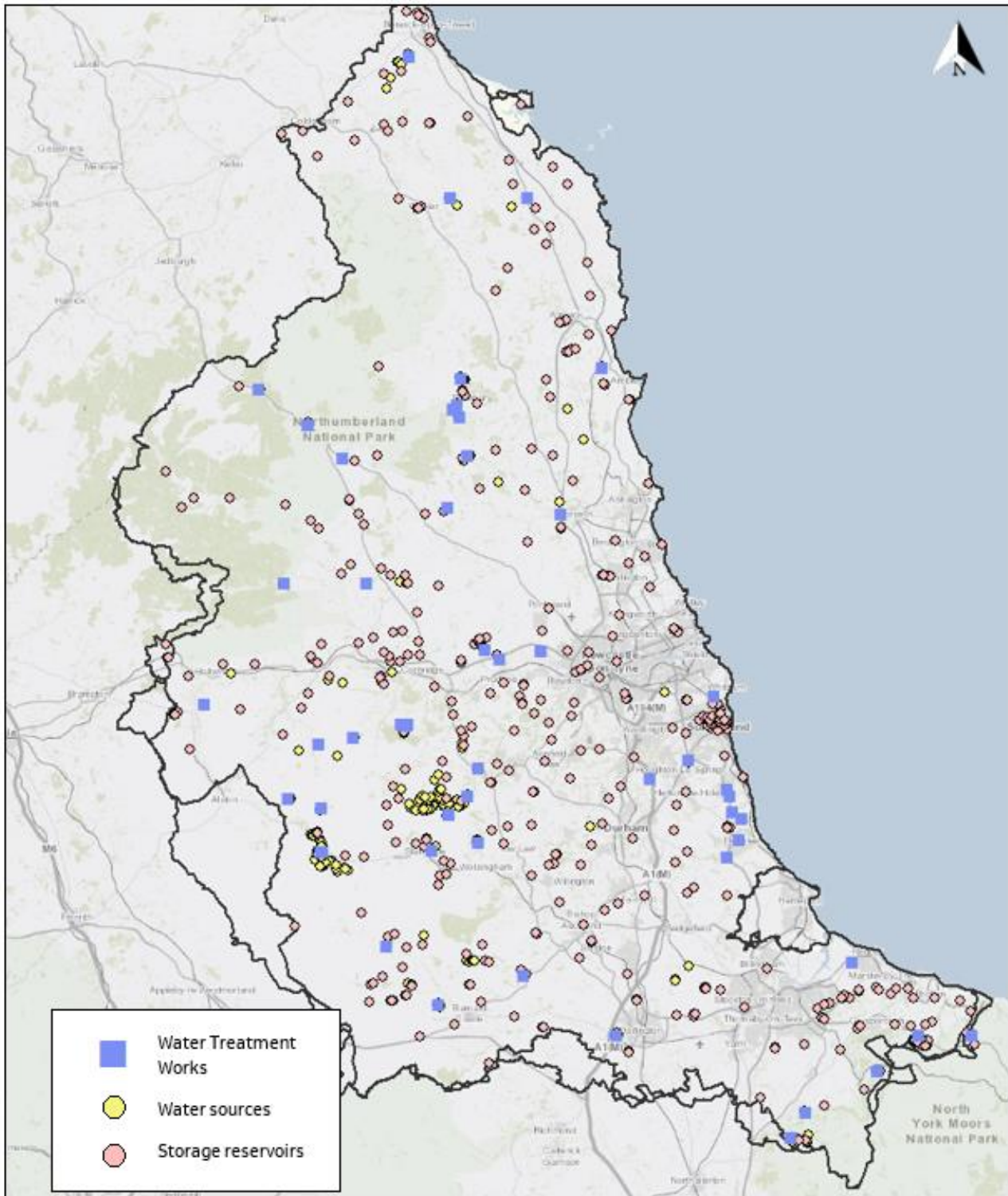


Figure 1-1: Overview of NWL's clean water sites

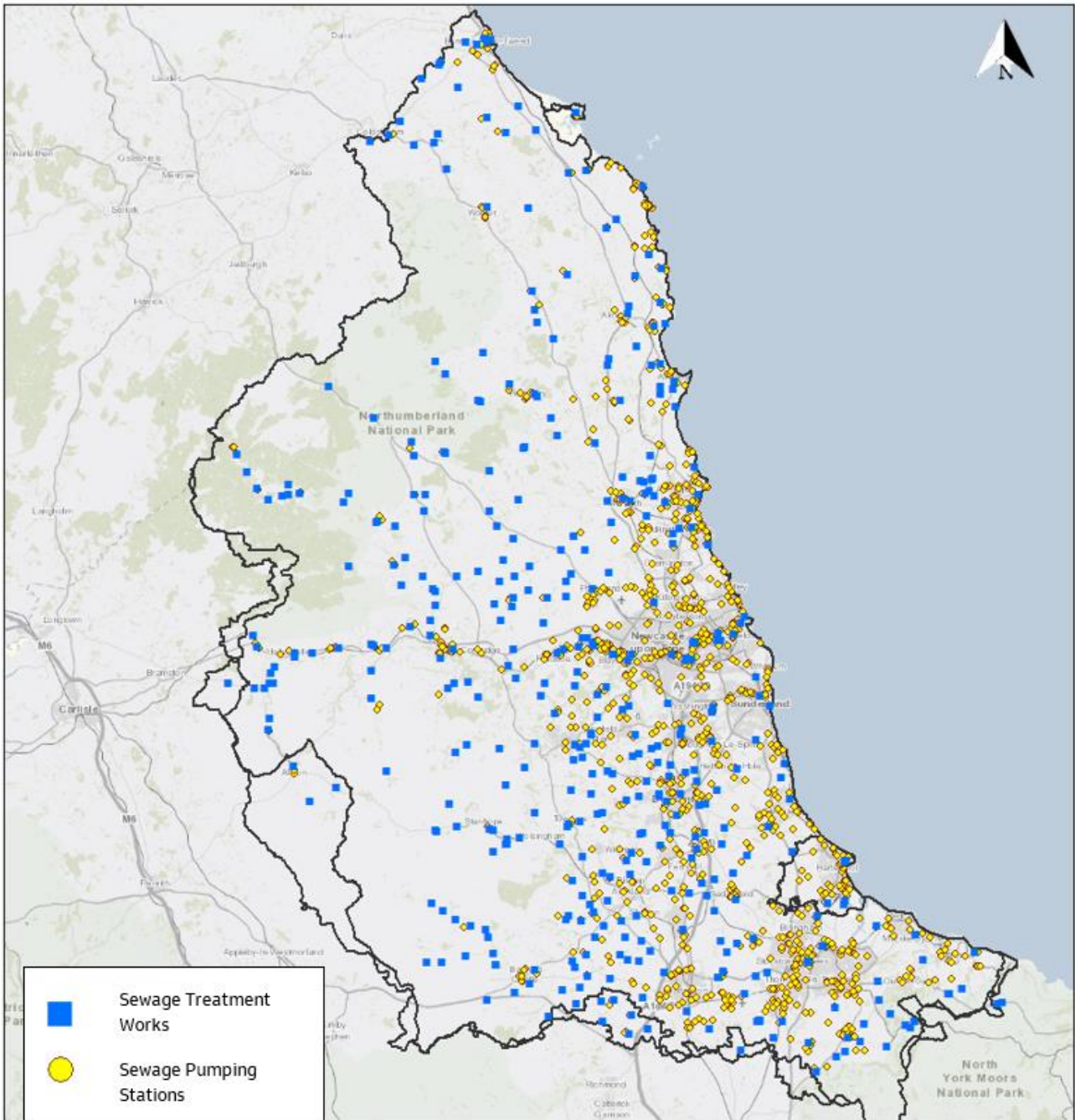


Figure 1-2: Overview of NWL's wastewater sites

2. Review of the Storm Arwen weather event

Summary

Storm Arwen brought severe winds across the UK over the night of 26 – 27 November 2021, with the Met Office issuing a red warning for wind with impacts restricted to the eastern coast of Scotland and northeast Britain. Within Britain, the one water and sewerage company region impacted by the red warning was that of NWL. The storm, tracking south to the north-east of the UK, brought northerly winds gusting widely at over 69mph (60Kt). This was one of the most powerful and damaging UK winter storms of the last few decades, with the highest (non-mountain) gust speed of 98 mph being recorded at Brizlee Wood in Northumberland. The main hazard was wind, though Arwen also brought some very low temperatures for the time of year and some significant snow accumulations, particularly to parts of the Pennines.

The Met Office amber severe warning issued on Thursday 25 November provided a 35-hour lead time. The red warning issued on Friday 26 November provided a 9.5-hour lead time.

This section of the report provides findings of a series of analyses that investigate the rarity and characteristics of the storm event in comparison to other storms experienced in the northeast of England. Met Office data from the MIDAS database has been accessed for weather stations in and close to the Met office red weather warning.

Unusually the extreme wind speeds from Storm Arwen came from the north. In this direction the return periods of the maximum recorded 3-second gusts in and around Northumberland are estimated to be between 1 in 20 years to greater than 1 in 50 years. This unusual extreme wind direction led to the storm causing significantly more tree damage than would otherwise have been the case.

The wintry conditions after Storm Arwen caused additional difficulty with freezing temperatures and snow on higher ground. Compared to the historical temperature records for other major events, this is unusual for extreme wind events.

The wind direction and subsequent freezing weather set Storm Arwen apart from other extreme storm events.

2.1 Overview

Storm Arwen brought severe winds across the UK over the night of 26 - 27 November 2021, with the Met Office issuing a red warning for wind down the north-eastern coast of Britain. The storm, tracking south to the north-east of the UK, brought northerly winds gusting widely at over 69mph (60Kt). This was one of the most powerful and damaging UK winter storms of the latest few decades, with the highest (non-mountain) gust speed of 98 mph being recorded at Brizlee Wood in Northumberland. The main hazard was wind, though Arwen also brought some very low temperatures for the time of year and some significant snow accumulations, particularly to parts of the Pennines. The Met Office provided yellow, amber, and red warnings for wind and snow, as shown in Figure 2-1, Table 2-1, and Figure 2-2.

The extreme wind speeds at the Boulmer and Brizlee Wood Met Office stations peaked over a 6-hour period (20:00 Friday 26 November – 02:00 Saturday 27 November) about 35 hours after the Amber warning was issued, and 9.5 hours after the Red warning was issued. The winds peaked 2 hours later at the Met Office Redesdale Camp station to the west.

Storm Arwen brought the highest recorded gust speeds since 2002 at Boulmer and since 1998 at Redesdale Camp, though Arwen's northerly wind direction was a notable difference. Historically, one of the most devastating storms of this type with a northerly wind occurred on 31 January 1953. Coinciding with a high spring tide it resulted in the greatest storm surge on record in the North Sea and the loss of 300 people due to coastal flooding. However, Storm Arwen coincided with a period of neap tides and did not cause significant coastal flooding. Wind speed comparisons of the 1953 storm to that of Arwen in north-east England is difficult as no current weather station has records that extend for long enough to have recorded both storms. Though, it is noted a gust of 101mph was recorded during the 1953 storm at Aberdeen (Dyce) and 85mph at South Shields (County Durham) suggesting that storm may have had higher wind speeds than Arwen.



Figure note: Met Office warnings: yellow for snow, amber and red for wind. In all cases, the first marker indicates when the warning was issued. The solid line indicates the period over which the warning applied

Figure 2-1: The occurrence of Storm Arwen together with the Met Office warnings

Table 2-1: Summary of the severe weather warnings issued by the Met Office

Warning	Issued	Details
Amber	09:39 Thu 25 Nov 2021	Active between 15:00 Fri 26 Nov and 09:00 Sat 27 Nov 2021 Storm Arwen will bring high northerly winds southwards across Scotland during Friday afternoon and evening, the highest winds then becoming confined to northeast England early Saturday. Gusts of 65 to 75 mph are expected in coastal areas with gusts more than 75 mph in a few places
Yellow	10:22 Fri 26 Nov 2021	Active between 17:00 Fri 26 Nov and 10:00 Sat 27 Nov 2021 An area of rain and hill snow will move southwards over southern Scotland and northern England during Friday night. Much of this will clear to the south early on Saturday but some sleet and snow showers will follow. Snow is expected mainly above 300 to 400m, particularly over the Pennines where 10-15 cm of snow may fall in some places. At lower levels mostly rain is expected but there is a chance of some falling snow – mostly as the system clears south. With very strong winds expected as well as some exceedingly difficult travel conditions are likely, with blizzards leading to reduced visibility and the potential for some drifting of snow.
Red	10:30 Fri 26 Nov 2021	Active between 15:00 Fri 26 Nov 2021 and 02:00 Sat 27 Nov 2021 A spell of exceptionally strong northerly winds will affect eastern coastal districts of Scotland from later this afternoon moving south into south-east Scotland and north-east England this evening. Gusts of 80 – 90 mph are likely, and these will generate some enormous waves.

2.2 Weather data and rarity analysis

Figure 2-2 shows the location of Met Office stations selected from the Met Office database⁷ that were used to investigate the characteristics of the storm. Selection was based on their proximity to the Met Office red warning, as well as having long periods of record to facilitate the analysis of event rarity. The available record length for each gauge is annotated on Figure 2-2. Analysis in this report particularly focuses on four key gauges, which are in or close to Northumbrian Water's service area. These are Boulmer, Albemarle, Charterhall, and Redesdale Camp.

Three gauges were ruled out of the rarity analysis after acquiring the data. These were Peterhead Harbour, Durham, and Brizlee Wood. Peterhead Harbour was not recording during the latter half of November 2021, and similarly, Durham has not been actively recording since 2020. Brizlee Wood is a new Met Office Gauge, brought online in 2021. Whilst it did record the highest UK 3-second gust speed for a non-mountain site during Storm Arwen (98 mph), it does not have an historical record long enough from which to meaningfully estimate rarity, and thus was excluded from the rarity analysis.

The data includes hourly mean wind speeds and hourly maximum 3-second gusts (henceforth referred to as the mean wind speed and maximum gust), together with the direction of both.

Before the rarity of Storm Arwen could be assessed, the data was checked for inconsistencies or missing periods. Years with significant gaps during the winter period were excluded from the analysis. For each year in the record, the annual maximum 3-second gust was extracted based on wind years⁸ starting July 1 and ending June 30 of the following calendar year.

2.2.1 Non-directional analysis

To undertake the statistical analysis the annual maximum (AMAX) series from each gauge was fitted to the Generalised Extreme Value distribution (GEV). The GEV curves for the four key gauges of most relevance to the NWL area are shown in Figure 2-3, plotted together with the Gringorten plotting positions of the AMAX data. From these curves the rarity of the Arwen winds is estimated. Figure 2-3 also shows the ranking of Arwen within the AMAX series.

⁷ MIDAS database - MIDAS Open: UK mean wind data, v202107 (<https://catalogue.ceda.ac.uk>). Supplies hourly data for period of record.

⁸ It is the nature of high wind events in the UK to occur during the winter. To prevent the possible (though unlikely) event of the biggest storm straddling the 31 December - 1 January change in calendar year (and hence possibly being double counted) the wind year has been taken to be 1 July to 30 June.

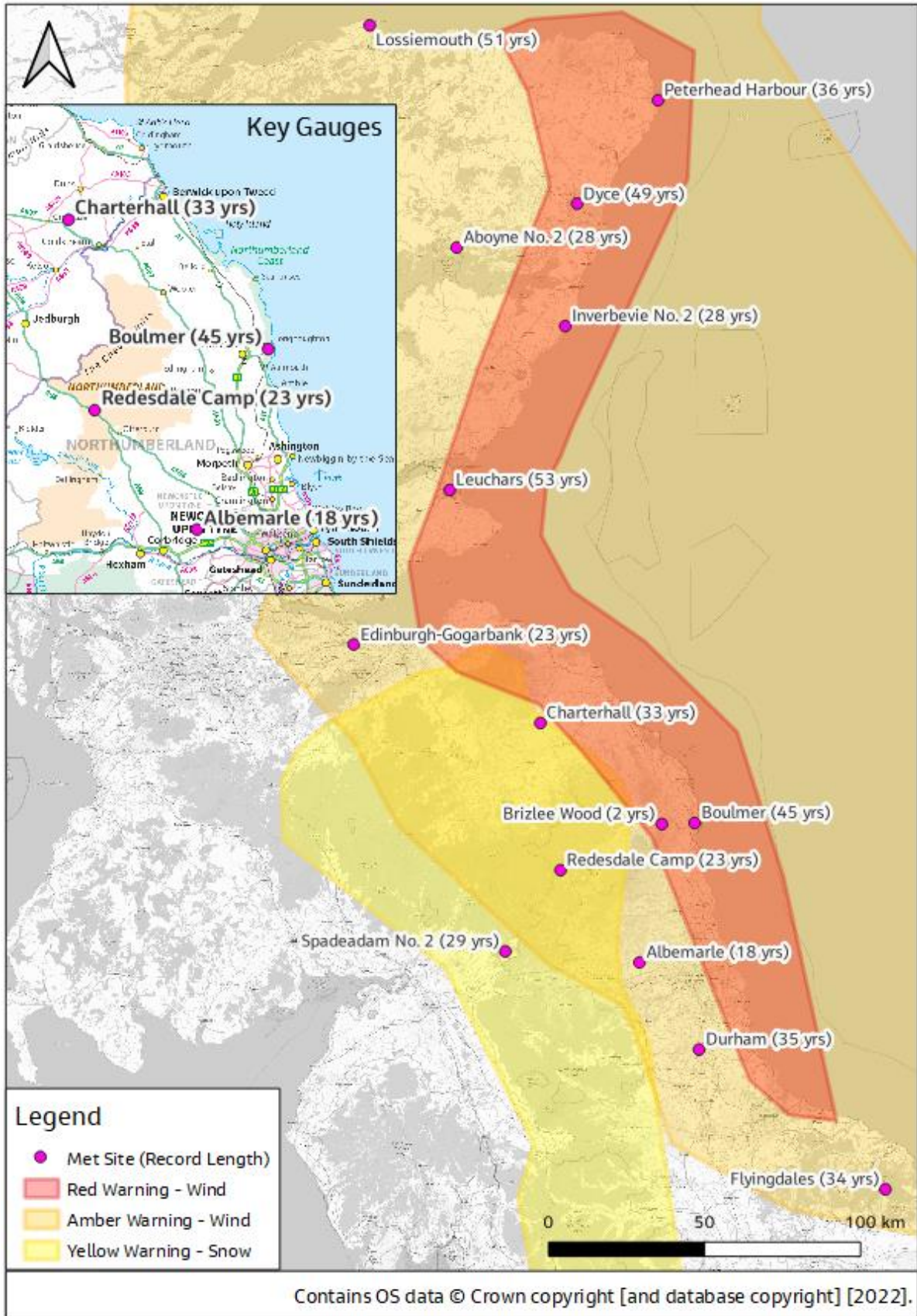


Figure 2-2: Met Office storm warnings issued for Storm Arwen and the location of the Met Office gauges considered in the analysis

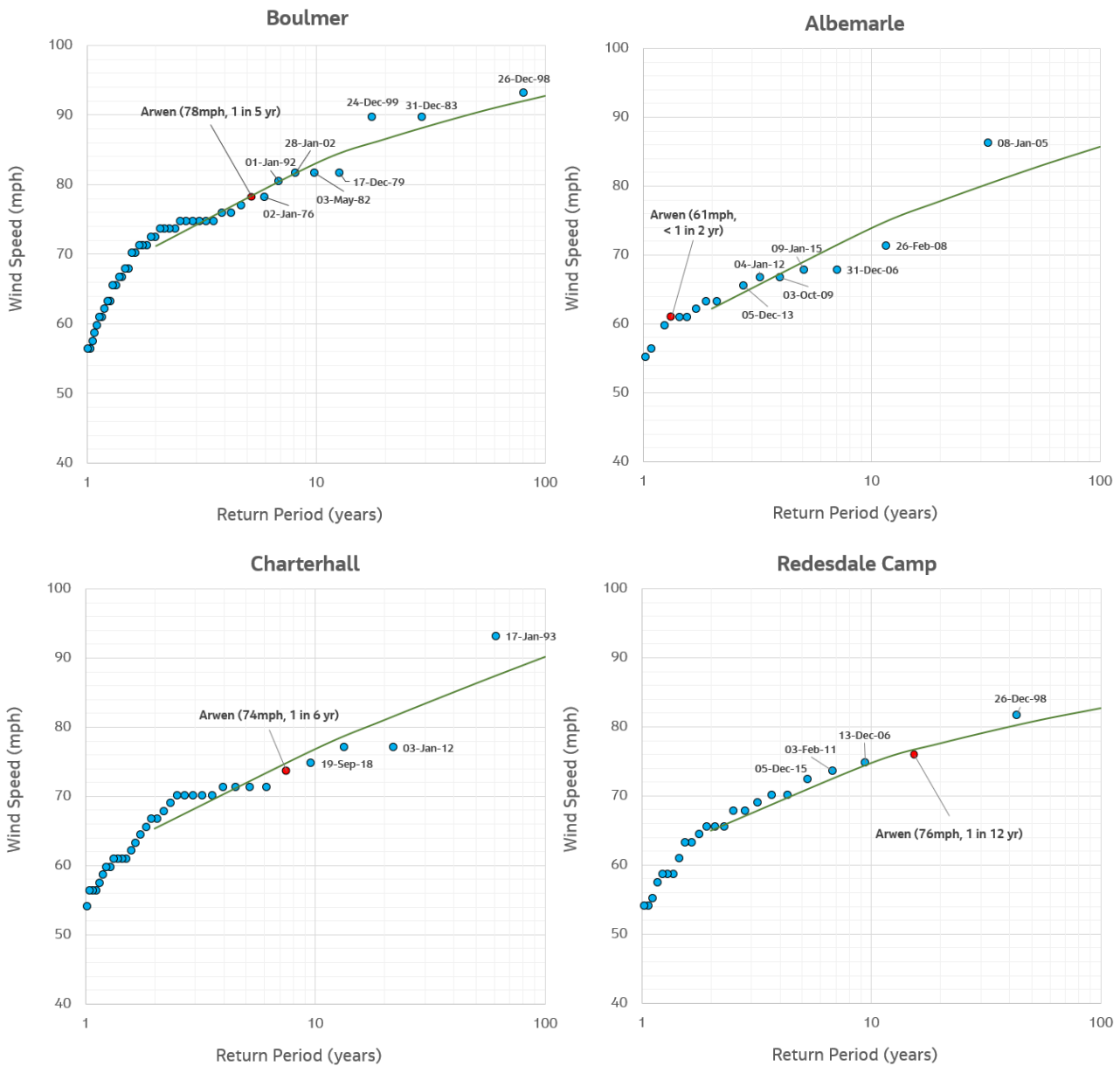


Figure note: Dots indicate the plotting position of the 3-second gust speed annual maximum series. Green line is the fitted GEV distribution to the data.

Figure 2-3: Storm Arwen maximum 3-second gust rarity analysis (without consideration of wind direction)

2.2.2 Directional analysis

The direction of the northerly winds of Storm Arwen has been cited by multiple sources^{9,10} as playing a significant role in the amount of damage that was caused. In the UK, prevailing winds are predominantly westerly/south-westerly.

With regards to Storm Arwen, the Met Office said: *“The unusual direction of the strongest winds – as opposed to prevailing westerly – may have been an additional factor influencing the number of trees brought down”.*

⁹ Met Office, 2021. Storm Arwen, 26 to 27 November 2021. (<https://www.metoffice.gov.uk/weather/warnings-and-advice/uk-storm-centre/index>)

¹⁰ BEIS, 2022. Storm Arwen Review (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf)

Communication with Forestry England suggested that 1,500 – 2,000 hectares of trees in northern England had been blown down (equivalent to 1 to 2 years of their annual harvesting programme), and that there were significant impacts to the forests of Kielder and Rothbury in addition to localised damage in other areas in Northumberland. Forestry England believed that Arwen was probably the most damaging storm to their operations in their North England Forest District in at least the last couple of decades. They indicated that wind direction was likely to be a key factor since the anchorage of the trees via their roots systems would have adapted to accommodate the strong forces from the prevailing west/south-westerly winds but not from the north.

To investigate the directional rarity of the storm, statistical analysis of the wind data was undertaken in each of eight directions (N, NE, E, SE, S, SW, W, NW). The annual maximum series for each of the eight directions were created based on 45-degree segments. For example, records with a maximum gust recorded at a compass bearing of between 337.5 to 22.5 degrees were categorised into north, records from 22.5 to 67.5 degrees into northeast, and so on.

As for the non-directional analysis, the GEV distribution was fitted to each of the directional AMAX series. The results are plotted on rose-diagrams in Figure 2-4. Added to the diagrams are the plotting positions of the AMAX storms obtained in the non-directional analysis. As expected, the plots show that most extreme winds are a result of westerlies or south-westerlies (the prevailing wind direction). However, Arwen’s extreme winds stand out as being different (from the north). Figure 2-4 shows that the speed and direction of Arwen’s winds had a return period of between 1 in 20 and more than 1 in 50 years.

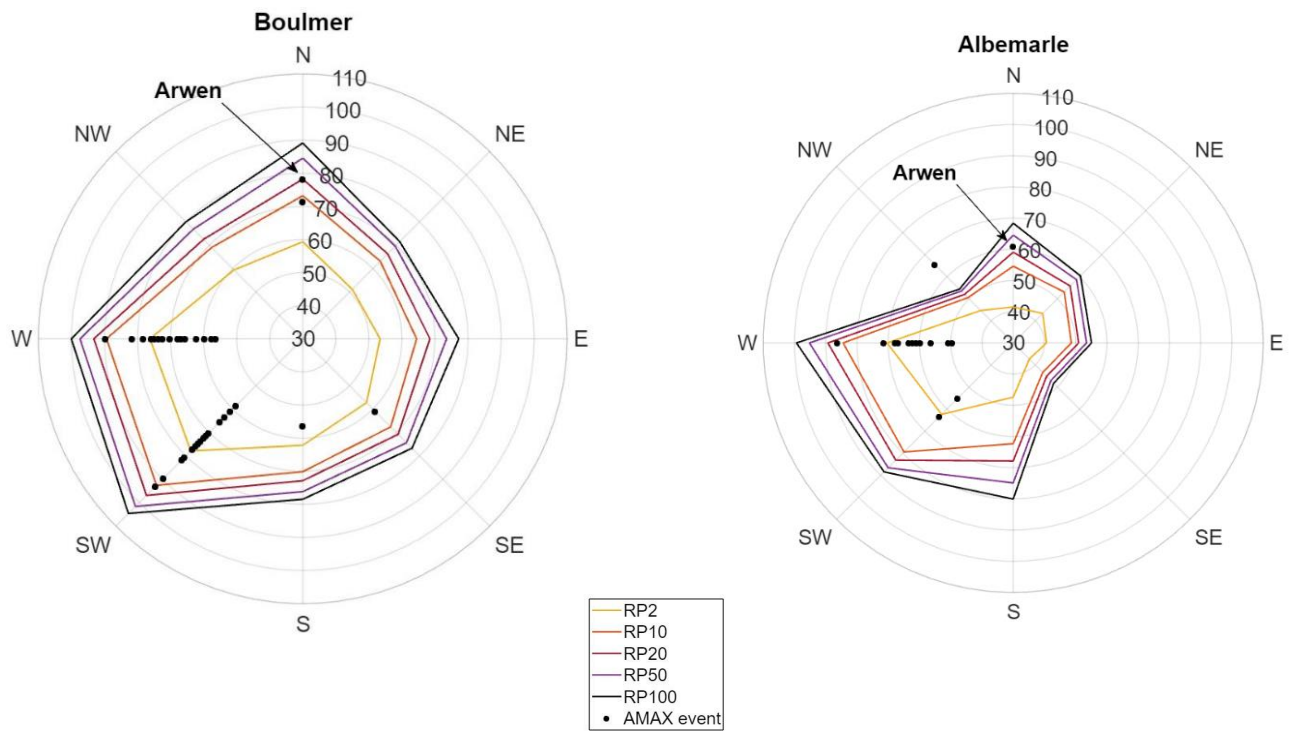


Figure 2-4: Maximum 3-second gust (mph) of Storm Arwen and the other AMAX events plotted by wind direction and compared to directional rarity analysis (RP = return period in years)

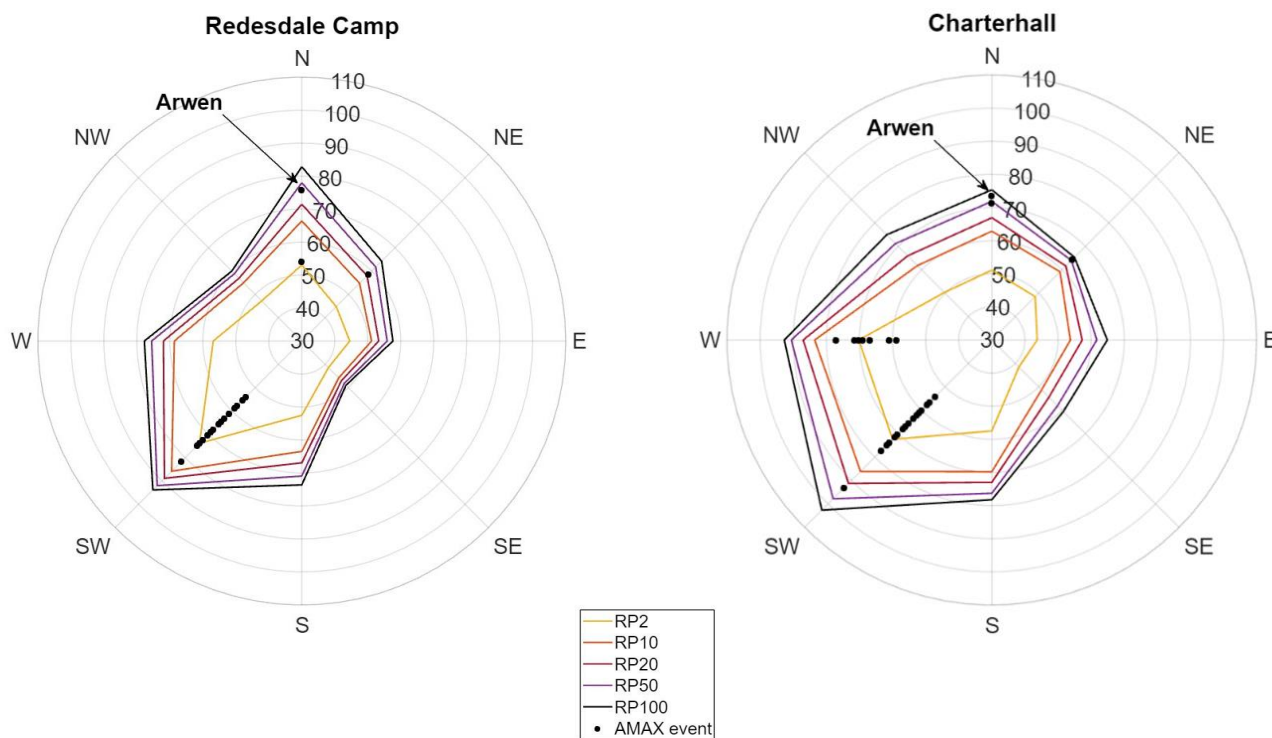


Figure 2-4 (cont.): Maximum 3-second gust (mph) of Storm Arwen and the other AMAX events plotted by wind direction and compared to directional rarity analysis (RP = return period in years)

2.2.3 Summary of event rarity

Table 2-2 summarises the findings of the rarity analyses undertaken on the Storm Arwen maximum 3-second gust speeds.

In and near Northumberland the Storm Arwen maximum 3-second gust speeds are not suggested to be especially rare when wind direction is not considered. Estimated return periods for the maximum gusts are estimated to be between 1 in 2 years and 1 in 10-years. This is slightly rarer than equivalent estimates for the storm along the north-east coast of Scotland (return periods ≤ 1 in 3 years).

However, when the direction of the wind is accounted for, the rarity is estimated to be considerably higher. Unusually the extreme wind speeds from Arwen came from the north. In this direction the return periods of the maximum 3-second gusts in and around Northumberland are generally estimated to be between 1 in 20 years to greater than 1 in 50-years.

As indicated before, the highest Arwen gust speed in the UK (excluding mountain stations) was recorded at Brizlee Wood at 98 mph. A wind gust as high as this is exceptional for this area (the wind gust record for north-east England being 107 mph at Lynemouth, Northumberland on 17 December 1979). Brizlee Wood is located on a hill, and it is likely the interaction of the northerly airflow with the local topography will have influenced the remarkably high gusts record at this station¹¹. Without a long-term record it has not been possible to estimate the rarity of the maximum gust.

¹¹ Met Office, 2021. Storm Arwen, 26 to 27 November 2021. (<https://www.metoffice.gov.uk/weather/warnings-and-advice/uk-storm-centre/index>)

Table 2-2: Summary of rarity analyses

Location	Maximum 3-sec gust speed (mph)	Non-directional rarity analysis	Directional rarity analysis	
		Return period (years)	Gust direction	Return period (years)
Lossiemouth	73	2	N	5
Dyce	68	3	N	10
Aboyne No 2	52	<2	N	(NA) ¹
Inverbervie No 2	78	3	N	15
Leuchars	64	<2	N	10
Edinburgh Gogarbank	46	<2	N	6
Charterhall	74	6	N	>50
Boulmer	78	5	N	20
Redesdale Camp	76	12	N	40
Albemarle	61	<2	N	30
Spadeadam No 2	76	<2	N	9
Fylingdales	66	<2	N	3

¹ Directional data suspect

2.3 Temporal profile of storm

Figure 2-5 compares the temporal profile of Storm Arwen to the top five AMAX storms as recorded at Boulmer. Although the direction of the wind was different to the other events, the temporal profile for Arwen was not unlike other AMAX events, though the windspeeds were slightly slower to drop after the peak.

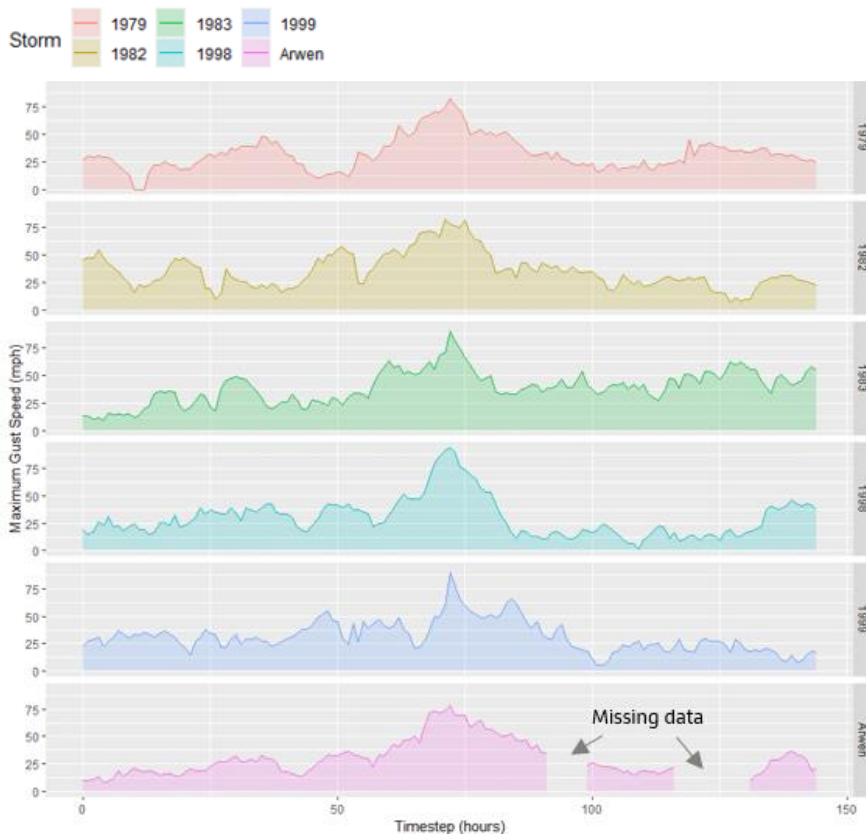


Figure 2-5: Storm Arwen timeseries compared to the top 5 AMAX events at Boulmer¹²

¹² AMAX event dates: 14/12/1979, 30/04/1982, 01/01/1984, 24/12/1998, and 21/12/1999.

2.4 Subsequent wintry conditions

The wintry conditions after Storm Arwen caused additional difficulty, with freezing temperatures and snow on higher ground. Compared to the historical temperature records for other AMAX events at the available gauges, this is unusual for extreme wind events. Figure 2-6 plots the minimum and maximum air temperature range on the day after the storm against the maximum recorded gust during the storm for Arwen and the 10 other top ranked storms recorded at Redesdale Camp. For comparison, the same information is plotted for the Beast from the East event (1 March 2018).

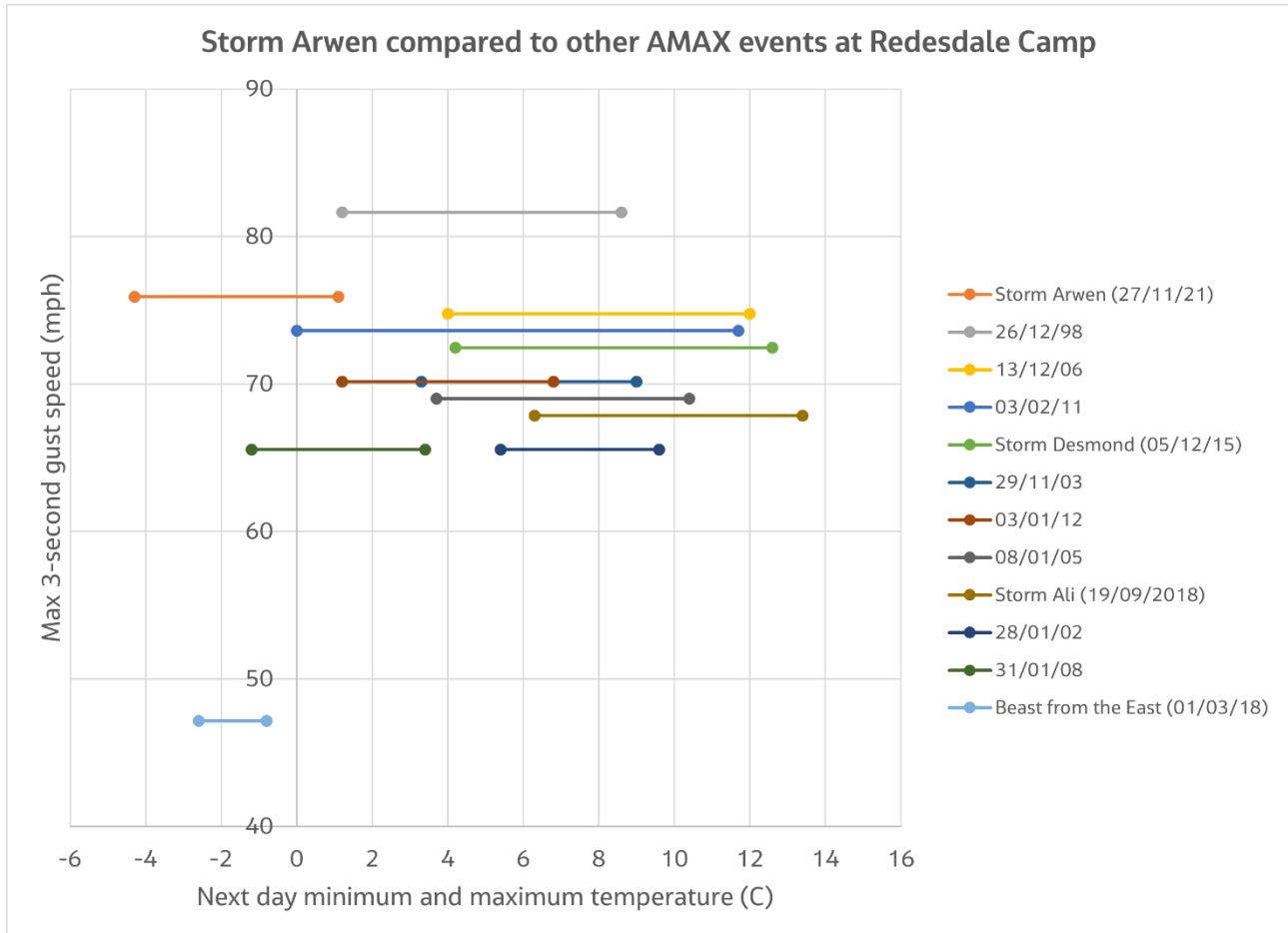


Figure 2-6: Minimum and maximum temperatures recorded at Redesdale Camp the day after the storm event peak plotted against maximum 3-second gust of the storm

The northerly airstream associated with Storm Arwen resulted in some significant snow accumulations, mainly to parts of the Pennines. The low temperatures combined with the strong northerly airflow led to significant wind chill. As indicated in Figure 2-6 the following day (as recorded at Redesdale Camp) was largely below zero suggesting that wintry conditions did not ease and that any snow that fell during the event on the higher ground did not melt. Warmer air did not come in until late on the 29 November (more than 48 hours after the storm).

In the other top ten Redesdale Camp AMAX events the presence of wintry conditions on the day after were either absent or to a much lesser degree. Arwen is therefore uncommon and suggests that challenging wintry conditions will have been experienced in some areas of the Northumbrian Water service area for several days after the storm, challenging conditions that would not have been experienced immediately after the other AMAX storms.

The most notorious episode of wintry conditions to have occurred in the last couple of decades was the Beast from the East (over the period 27 February – 10 March 2018). This severe weather event caused a longer duration of freezing temperatures and more significant amounts of snow than Arwen, but as can be seen from Figure 2-6, it did not bring the extreme winds that Arwen did.

Assessment of the rarity of Storm Arwen:

The key findings from this analysis are:

- Atypically the extreme wind speeds from Arwen came from the north. In this direction the return periods of the recorded maximum 3-second gusts in and around Northumberland are estimated to be between 1 in 20 years to greater than 1 in 50-years. This unusual extreme wind direction led to the storm causing significantly more tree damage than would otherwise have been the case.
- The temporal profile of the Storm Arwen wind is similar to other major storm events, though the wind speeds were slightly slower to drop after the peak.
- The wintry conditions immediately after Storm Arwen caused additional difficulty with freezing temperatures and snow on higher ground. Compared to the historical temperature records for other major events, this is unusual for extreme wind events.
- The wind direction and subsequent freezing weather set Storm Arwen apart from other extreme storm events.

3. NWL's existing emergency management plans

Summary

This section of the report describes NWL's emergency management plans which are relevant to NWL's response to Storm Arwen. Jacobs has reviewed the relevant documents commencing with NWL's corporate policies for Business Continuity Management and Emergency Management and the suite of emergency plans that are designed to ensure the policies are implemented. Under the *Security & Emergency Measures Direction 1998*, water and sewerage companies are required to establish, keep under review and revise plans considered necessary to ensure the continued provision of water and sewerage services.

The Emergency Management Manual sets out the measures NWL adopts to ensure the management of different but reasonably foreseeable scenarios which are set out in individual chapters of the Emergency Plans Manual. The scenarios applicable to Storm Arwen are:

- Generic Plan for Major Incidents
- Generic Plan for a Prolonged or Region Wide Disruption of Electricity Supplies
- Generic Plan for Severe Weather Conditions

Jacobs' review has confirmed that emergency plans are in place which have been formulated using reasonable assumptions around scenarios that could impact upon NWL's service provision. The manuals are reviewed on an annual basis to confirm their appropriateness. They were last reviewed in November 2021 (annual review) and previously August 2020 to add some Covid-19 measures. These plans do not have any significant shortcomings.

Some gaps were observed in the Generic Plan for Prolonged or Region Wide Disruption of Electricity Supplies. These relate to defining the timescale of a "prolonged" disruption to power supplies, and the development or enactment of a portable generator deployment plan. The ongoing replenishment of reservoirs using NWL/Wincanton tanker fleet and designated tanker fill points is covered by the Alternative Water Supply arrangements through its own chapter of the Emergency Plans Manual.

Similarly, in the Generic Plan for Severe Weather Conditions, logistics support does not appear to be considered. The engagement, mobilisation, and provision of tankers through Wincanton does not appear to be part of the plan, however this is covered in the separate Alternative Water Supplies manual. The timing of receipt of the weather warning trigger point is key to the successful implementation of the plan.

Jacobs observes that the NWL fleet of mobile generators appears to be based on a legacy assessment. Through discussion with NWL Jacobs is not aware that the entire fleet has ever been called upon for deployment in an incident in the past. NWL has arrangements to hire additional mobile generators from external sources, however Jacobs understands that NWL does not pay a retainer through the contract so may not get priority when ordering in third party provided generators. A review of the requirements for mobile (or new permanent) generation is recommended.

The winter readiness plan appears to be based on informal arrangements which should be developed into an official procedure, with the requirements reviewed annually.

Overall, Jacobs considers the scenarios that NWL has planned for, as set out in its Emergency Plans Manual, are based on reasonable assumptions. NWL has exercised the region-wide loss of telemetry and loss of local telemetry to operate a major water treatment works (WTW). Storm Arwen was an extreme event bringing additional consequences of widescale power outages and blocked roads/site access due to fallen trees. Even with the benefit of hindsight we consider this scenario is one that would not have been exercised.

3.1 Security and Emergency Measures Direction 1998

NWL makes its annual submission under *Security & Emergency Measures Direction 1998* (SEMD) to DEFRA. A requirement of the Direction is for companies' annual submissions to be independently certified by an appropriately experienced professional. Jacobs is NWL's independent SEMD Certifier to DEFRA and has fulfilled this role since 1999. Jacobs also provides the certification service to four other major water and sewerage companies in England and Wales. For NWL, Jacobs provides a two-person audit team which includes the named Certifier.

SEMD applies to all water undertakers in England and Wales. It requires NWL to "make, keep under review and revise plans the Company considers necessary to ensure the provision of essential water supply or, as the case may be, sewerage services, at all times, including a civil emergency or any event threatening national security." The Company is to use "reasonable assumptions" in its scenario/event planning.

Under SEMD, plans for essential water supply and sewerage services shall make provision for:

- Trained and experienced personnel
- Strategically stored stockpiles of sufficient types and quantities of equipment and materials
- Dedicated emergency communication facilities
- Analytical services and other back up facilities
- Carrying out security work on vital installations
- Suitable equipped permanent or mobile accommodation to act as command-and-control centres
- Training of all staff who may be called upon

Companies are to review their plans at least once per calendar year.

Jacobs' role as the independent certifier is to confirm that the Company complies with these requirements and that the Company's planning is based on reasonable assumptions. To provide this certification, Jacobs seek evidence of compliance such as confirming the emergency plans have been reviewed annually and updated (if necessary), confirming records of staff training in emergency activities, and confirming the existence and operation of dedicated emergency facilities such as incident rooms.

As part of the SEMD review, Jacobs reviews learnings from exercises and actual incidents, assessing how these feed into continuous improvement and how plans are revised as a result. Jacobs' findings throughout its role as the independent SEMD Certifier with NWL confirm that NWL's planning is based upon reasonable assumptions of scenarios that it could face. The Emergency Management Manual (EMM) sets out the measures that NWL will adopt to ensure appropriate management of different foreseeable scenarios which are set out in the Emergency Plans Manuals. NWL's set of emergency manuals is similar in content to those Jacobs has observed in other water and sewerage companies.

3.2 Policies, Plans and Manuals

NWL has two corporate policies relevant to Emergency Management and Business Continuity, both endorsed by the Chief Executive Officer:

- BCPO 01 NWL Business Continuity Management Policy
- BCPO 03 NWL Emergency Management Policy

NWL's Emergency Management Manual (EMM) comprises 12 sections which explain the measures it will adopt to ensure appropriate management of different foreseeable scenarios set out in the Emergency Plans Manuals. The EMM details:

- The roles and responsibilities expected of an Operational Emergency Team, an Incident Management Team, and a Crisis Management Team.
- Considerations for the recovery phase of an incident/crisis.
- Arrangements for external liaison with stakeholders.
- Mutual aid.
- Exercise and training requirements.

The EMM is supported by a suite of corporate level event-specific plans for emergencies ("Emergency Plans Manual") such as prolonged or region-wide disruption of electricity supplies, severe weather, fuel shortages, and contamination. These plans supplement the EMM with additional matters to be considered and actions to be taken for these specific events. The structure of NWL's EMM and Emergency Plans Manual is shown in Figure 3-1.

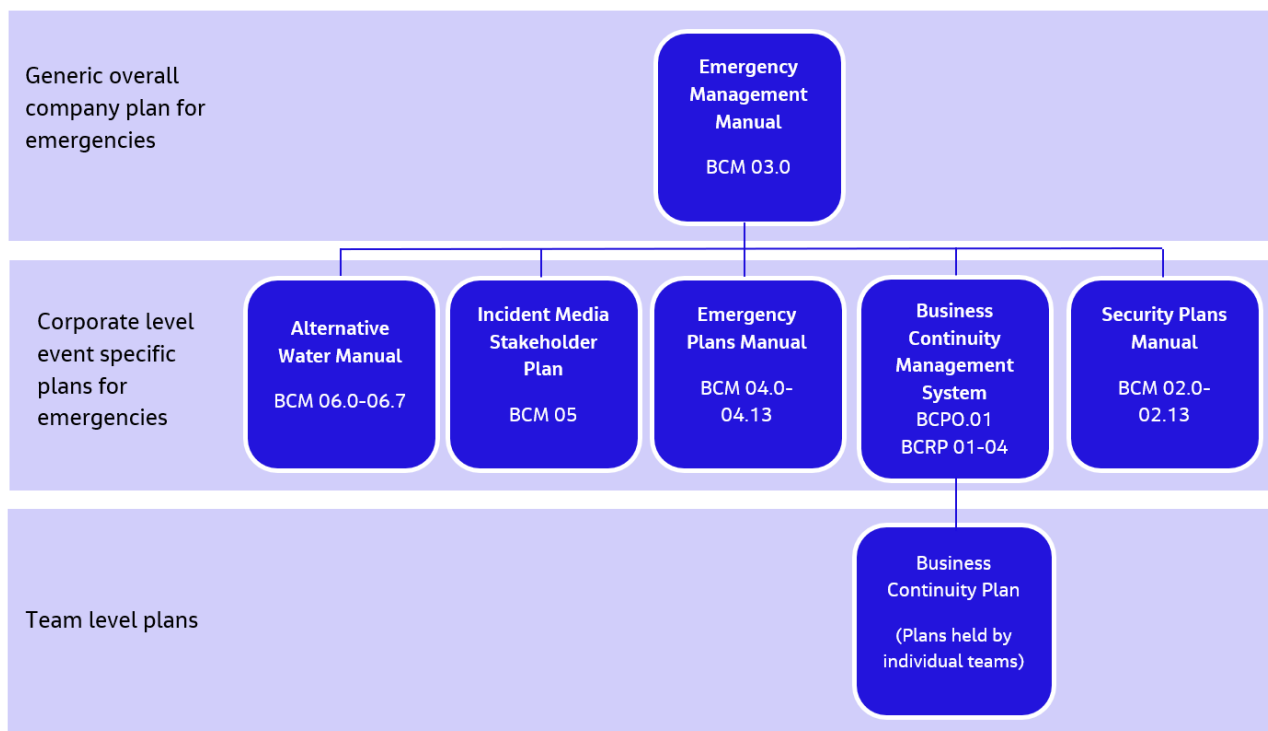


Figure 3-1: Structure of NWL's emergency management plans

The following chapters of the Emergency Plans Manual are considered relevant to the Storm Arwen response:

- BCM 04.2 NWL Emergency Plans Manual - Chapter 2 - Generic Plan for Major Incidents
- BCM 04.6 NWL Emergency Plans Manual - Chapter 6 - Generic Plan for a Prolonged or Region Wide Disruption of Electricity Supplies
- BCM 04.9 NWL Emergency Plans Manual - Chapter 9 - Generic Plan for Severe Weather Conditions

Whilst the chapters of the Emergency Plans Manual are focused on how the Company responds to provide water services during an emergency, Chapter 2 (Generic Plan for Major Incidents) also includes arrangements for dealing with incidents affecting the provision of the wastewater service.

There are also other related manuals that are part of NWL's overall emergency management response. Manuals considered relevant to the Storm Arwen response are as follows:

- BCM 05 Incident Media Stakeholder Management Plan
- BCM 06.1 Alternative Water Supplies Manual - Chapter 1 – Introduction
- BCM 06.2 Alternative Water Supplies Manual - Chapter 2 - Technical Description
- BCM 06.3 Alternative Water Supplies Manual - Chapter 3 - Routine Procedures
- BCM 06.4 Alternative Water Supplies Manual - Chapter 4 - Operating Procedures
- BCM 06.5 Alternative Water Supplies Manual - Chapter 5 – Forms
- BCM 06.6 Bottled Water Distribution Plan
- BCM 06.7 Bottled Water Dispensing Plan

3.3 Corporate policies

NWL has two corporate policies relevant to this project: BCPO 01 NWL Business Continuity Management Policy and BCPO 03 NWL Emergency Management Policy.

Assessment of the documents:

These documents are high level corporate statements stating NWL's policies for business continuity and emergency management. They are characteristic of policies established by large organisations which are endorsed by the top management and effective in setting the company's strategy and contain what is to be expected in a corporate strategy. The policies are cascaded effectively into the organisation by top management and are implemented at departmental level through the formulation of the Emergency Management Manual and the Emergency Plans Manual chapters.

3.4 Emergency Management Manual

The EMM defines the categories of escalation of events and how the decision to declare an incident is made. Flow charts are provided to describe the stages of declaring an incident, forming an incident management team and how the incident should be managed.

NWL follows the 'Gold-Silver-Bronze' (or 'Strategic-Tactical-Operational') command hierarchy used by the emergency services. The EMM describes how a crisis management team is formed, its membership and role, and physical location. Arrangements for de-escalation, recovery and incident debriefs, together with categories of debriefs, are described.

The procedure for liaison with internal and external stakeholders is fully described. This includes NWL's role and process of interaction with LRFs.

The EMM contains live links to the separate set of documents for the activation and management of Alternative Water Supplies.

The appendices to the EMM contain stakeholder considerations, the incident and crisis management teams' roles and responsibilities, example meeting agendas for these teams, together with forms and checklists for incident recovery and debriefs. Appendix L describes DEFRA's Covid-19 data sharing protocol, to allow utility companies access to the addresses of those shielding in the event of an incident.

The manual is reviewed annually as a minimum. It is currently version 12 and was last reviewed in November 2021 for the annual refresh and to update job titles.

Assessment of the document:

The EMM is an appropriate high-level document describing NWL's policy and arrangements for defining incident levels, formation and roles of incident management teams and how they should operate to enable NWL to effectively manage and recover from emergencies.

3.5 Emergency Plans Manual - Chapter 2 – Generic Plan for Major Incidents

Chapter 2 of the Emergency Plans Manual details the methods in which NWL initiates a multi-agency/ 'external' agency response in the event of a 'major' water/wastewater incident. Major incidents are those of a size greater than the response capability of the water or other utility company concerned even with assistance from other water or utility companies via Mutual Aid.

The aim of the information in the document is to provide a framework for a multi-agency response in the event of severe service disruptions resulting from major water and wastewater incidents. The guidance is additional to, and supports existing national, regional and local generic command and control protocols.

Multi-agency responses are initiated by the LRFs using their powers and obligations under the Civil Contingencies Act and the supporting Civil Contingences Act 2004 (Civil Contingencies Planning) Regulations 2005 to respond to civil emergencies.

Assessment of the document:

The manual is considered appropriate to enable NWL to initiate the joint planning process with other agencies in the event of a major incident for water or wastewater. Actions to react to a major incident are contained in this manual and in Jacobs' opinion appear suitable to initiate an appropriate response so that in the event of an incident each agency, and Category 1 responders in particular, should be aware of what NWL is striving to deliver.

3.6 Emergency Plans Manual - Chapter 6 - Generic Plan for a Prolonged or Region Wide Disruption of Electricity Supplies

Chapter 6 of the Emergency Plans Manual sets the responsibilities and/or actions that NWL should consider to be able to maintain services should there be a prolonged or regional disruption to electricity supplies.

The plan assumes advance warning of disruption of electricity supplies will be provided by UK government. However, it is possible that electricity suppliers may provide warning.

If a warning is received by NWL, it establishes the Electricity Supply Disruption Working Group (ESDWG) which is a working group to manage the emerging problem. When a loss of power occurs affecting NWL's assets, the situation is escalated to the Incident Management Team (IMT) (assuming one has been formed), and the ESDWG is stood down.

The manual describes actions to be taken by NWL departments that are likely to be affected. For example, Operations should agree with the ESDWG, or the Incident Management Team, suspension of activities such as mains flushing and reservoir cleaning. Operations should also "consider" the availability of emergency equipment, stocks and supplies such as portable generators and diesel supplies. Other actions are to ensure service reservoirs and water towers are full.

The Communications team should refresh communication output to ensure a consistent message is provided to customers, whether it be via NWL's website, social media or telephone channels.

The Business Continuity department is to liaise with DEFRA, the LRFs and other emergency planning units to ensure a consolidated approach. The team should also consider security/access arrangements at sites in lieu of power supplies and override electronic access control arrangements to ensure site entry is possible.

Different types of power failure scenarios are considered such as unplanned failures which are assumed to be short term (up to 3 hours), planned rota cuts, and industrial action. Black starts are considered which can be planned or unexpected for restoration in "islands" across the region, resulting in wide-scale disruption to customers and utility services.

Assessment of the document:

The manual is considered suitable to respond to a loss of power scenario and reasonable assumptions have been used to develop its content, however it has limitations in the following areas which should be addressed:

- The duration of a "prolonged" failure of power supplies is not specifically defined. The plan would benefit from the inclusion of a definition of timescales to plan an appropriate scale of response.
- The plan assumes a warning of a possible power failure is received. This may not happen and in the case of Storm Arwen no warning was provided by Northern Powergrid (or others). This is not a failure of the plan. It is noted that NPG started preparations for Storm Arwen on 24th November in advance of the weather warnings and this was a missed opportunity for them to share this information with other utilities and local authorities.
- The plan should also seek to identify advance warning through other avenues such as media reports, Met Office warnings, warnings from power supply companies, the Environment Agency or via LRFs.
- The plan does not account for ongoing replenishment of reservoirs using NWL/Wincanton tanker fleet and designated tanker fill points. This is covered in the Alternative Water Supply Manual, however a cross reference should be provided.
- The plan does not include the development or enactment of a portable generator deployment plan – it states to "consider" sourcing hired generators.
- It is not clear whether all strategic water supply assets have plug in generation connection points to easily maintain operation. This should be provided in a mobile generator deployment plan including a list of NWL's mobile generators, locations where they are stored, transport requirements and sites they could be used at, and whether the sites have plug-in facilities.

3.7 Emergency Plans Manual - Chapter 9 - Generic Plan for Severe Weather Conditions

Chapter 9 of the Emergency Plans Manual defines responsibilities and/or actions that NWL should consider to be able to maintain water and wastewater services during severe weather conditions. The plan considers severe weather scenarios of high winds, snow, freezing / thawing, exceptional heat / dryness. Flooding is covered separately in Chapter 8 of the Emergency Plans Manual. Drought is covered by NWL's drought plans. There are two drought plans which cover NWL North and NWL South.

The Generic Plan for Severe Weather assumes advance warning of severe weather is provided through a variety of trigger points or outlets such as the media, Met Office, power supply companies, the Environment Agency or via the LRF. The IMT is established to consider potential impacts of the severe weather, such as site access, water treatment works output and pumping.

The plan prompts the IMT to consider the availability of emergency equipment, stocks and supplies such as mobile generators and diesel supplies. Essential support services such as plant hire contractors and fuel suppliers should be contacted.

Assessment of the document:

The plan is considered suitable and based on reasonable assumptions, however logistics support does not appear to be considered. Engagement with Wincanton to mobilise the provision of tankers is covered in the separate Alternative Water Supplies manual. A link to this document should be provided.

The timing of receipt of the weather warning trigger point is key to the successful implementation of the plan.

Whilst the plan provides for high wind events, the strength of the wind and the potential impacts that are considered to be "severe weather" are not defined.

3.8 Alternative Water Supplies Manual

The Alternative Water Supplies (AWS) manual is an Operating Manual principally for the purpose of transporting treated water to service reservoirs and deploying Arlington tanks and blue static tanks for alternative water supplies for customers. The AWS manual is currently being updated to simplify the content into flow charts and diagrams. The AWS manual in use at the time of Storm Arwen was version 2 dated February 2021.

The manual comprises five chapters which describe the arrangements for AWS including the stocks and locations of equipment (road tankers, Arlington tanks, static tanks, disinfection supplies and consumables), site plans identifying rapid fill hydrant facilities, access and egress routes for tankers.

The contract with Wincanton for the provision of additional road tankers and bottled water supplies is included with details of the equipment available to NWL and the service level provided through the agreement. When the arrangements with Wincanton have been activated in past incidents, Wincanton has performed in accordance with the service level agreement set out in Table 3-1. The service levels are considered to be appropriate for NWL's needs.

Table 3-1: Service level agreement with Wincanton

Tankers	Flatbeds	Bottled Water
4 tankers in 4 hours	5 with Hiabs within 24 hours	120 pallets in 24 hours
8 in 6 hours		Thereafter a guaranteed daily minimum of 48 pallets but endeavouring to supply 96 pallets
11 in 8 hours		
14 in 10 hours		
36 in 48 hours		

Chapter 4 contains the operating procedures which are required to ensure the provision of alternative water supplies are carried out without compromise to water quality. This includes disinfection of tanks and fittings, filling of road tankers, discharge of water into service reservoirs, disinfection and filling of Arlington and static tanks.

Assessment of the document:

The AWS manual is a comprehensive set of documents that describe in detail the arrangements for the provision of alternative water supplies whilst maintaining water quality and safety. The arrangements as described are in Jacobs' opinion effective and have been successfully implemented in previous, less extreme, incidents. The refresh of the AWS manual will simplify the document making the contents more concise and easier to understand. Wincanton performed to these criteria during Storm Arwen, although providing the service was challenging to deploy road tankers from Wigan in Lancashire to Northumberland.

3.9 Bottled Water Distribution Plan and Bottled Water Dispensing Plan

These two manuals are similar in content describing NWL's arrangements for distributing bottled water then dispensing it to customers.

The manuals establish roles and responsibilities of the Alternative Water Supply Co-Ordinator and the bottled water distribution team, communication during the incident, resourcing the bottled water operation, identifying a location for the bottled water station(s) ordering bottled water, setting up the station, stock control and record keeping.

The requirement for security guards to be mobilised and the arrangements for provision of the resource is detailed in the manual. Procedures for decommissioning the bottled water station are also provided.

Assessment of the document:

The manuals are comprehensive in content. Whilst bottled water is a form of alternative water supplies, the AWS manual is specifically for the transport of mass volume of water to refill service reservoirs and deploy Arlington/static tanks. This is a different operation to identifying locations from which to distribute bottled water and actually distributing it. It is therefore appropriate to be in a separate document.

3.10 Outage plans

3.10.1 Water sites

NWL has outage plans for its major water treatment works, service reservoirs and towers, pumping stations and strategic valves. A sample of these plans were reviewed for assets that were impacted by the loss of power during Storm Arwen. The outage plans are comprehensive containing specific detail on the actions to be taken in the event of a loss of an asset. However, implementing some actions is reliant on a power supply or telemetry connectivity, for example running alternative pumps or remotely operating valves. Manual operation of some valves would be possible but would rely on deployment of staff to carry out this activity. It is recommended that the outage plans are reviewed for their effectiveness in the event that power is not available.

3.10.2 Wastewater sites

Each of NWL's wastewater treatment works has a site emergency plan. Users are linked to procedures and other information to enable an appropriate response to be implemented. The wastewater asset base is significantly different compared to the water assets, with over 1,000 different pumping stations and 425 wastewater treatment works. As a result, NWL has produced workflows rather than individual outage plans for the teams to follow. The flow chart for wastewater pumping stations under the scenarios of loss of power was reviewed. The actions to be taken focus on preventing where possible a discharge to the environment by tankering wastewater from the affected site and/or deploying power generators. Where the risk of a discharge is higher, the workflow prompts the user to notify the Environment Agency. Considering the temporary loss of a wastewater asset generally involves tankering, the workflows are relatively straightforward in the actions to be taken. Jacobs considers these to be effective in managing the loss of a wastewater asset.

3.10.3 Telemetry failure

NWL's RCC has a procedure "Network Control Telemetry Failure" which is the procedure to be followed by the RCC following loss of the regional telemetry system. The procedure details the dual server set up and the back-up arrangements in the event of a server failure. The servers have UPS power supplies which take over in the event of a loss of mains power to the site location until the emergency power generation is operating. Jacobs has previously inspected the physical UPS assets and server rooms as part of the annual SEMD certification. The server sites and the RCC all had power throughout Storm Arwen.

The procedure sets out the steps to be followed in the event of a loss of telemetry communications to remote sites which was the situation that occurred during Storm Arwen. The procedure describes actions to be taken during office hours when IS staff and other support staff are readily available, and during out of office hours when NWL relies on shift staff and standby/callout arrangements. Where restoration of the telemetry links is not feasible Water Supply, Distribution and Wastewater staff have to be in a position to effectively replace the telemetry system with staff on the ground. Operations managers are to organise staff to check their sites. These checks would have to be done on a regular basis essentially replacing the scheduled dial-ups and interrogations of the telemetry system. Assets that are controlled by RCC staff, i.e. electrically operated valves and pumps in all three distribution areas, are to be included in the rota.

The procedure for telemetry failure is supported by the "Key Site Frequency Check List" which documents each water distribution site and the frequency of physical checks to be made based on the criticality of each site. Visit frequency to all sites will be an absolute minimum of once per day. Distribution Operations Controllers will ensure these visits are undertaken in liaison with RCC staff.

The procedure is clear that Water and Wastewater staff are to assume full responsibility for implementing physical checks of the sites for which they are responsible.

The procedure and supporting visit frequency check list contain appropriate arrangements to be implemented in the event of a loss of regional telemetry. However, their success relies on the availability of communications with the RCC through the mobile phone or fixed line network. During Storm Arwen, mobile and fixed line communications operated by telecoms providers failed in some areas and communication with the RCC was not possible. NWL may wish to consider a back-up for loss of the public telephone network. For example, considering the remoteness of many of NWL's sites, a satellite phone could be located at key remote sites to minimise the number of phones required and avoiding the need for deployment of the equipment. However, during Storm Arwen, access to remote sites was difficult in the early stages due to road blockages and closures and therefore deployment of satellite phones would have been delayed until roads became accessible.

3.11 Winter readiness

As part of our review of NWL's preparedness for Storm Arwen, Jacobs asked if NWL has a Winter Readiness Plan setting out preparatory activities to be taken in advance of a winter season. These can include, for example, ensuring plant and equipment is in a maximum state of readiness, contractors have capacity to increase resources if needed, non-essential operations are scaled back, leakage and mains repair teams are fully resourced and gritting arrangements are in place. Through our discussions, Jacobs understands that NWL implements actions as part of business-as-usual activity such as reviewing the level of resources in advance of a winter season and ensuring the fleet of mobile generators is available, fully maintained and fuelled, similarly for fixed generators. From interviews (see Section 5.2.1), Jacobs understands this maintenance does not include load testing of generators. Whilst these are appropriate actions, they appear to be informal, and an official company winter plan is not in place. NWL should review its business-as-usual winter readiness procedures to consider whether learnings from Storm Arwen could enhance any existing readiness activities. NWL should also review its generator maintenance programme to include load testing where appropriate. Analysis found that a lack of load testing resulted in the failure of one generator (Section 6.4).

3.12 Assessment for generator requirements

NWL owns 23 mobile generators in the north-east as in-house equipment (from mobile generator register). During discussions Jacobs sought to understand how the size of the fleet was derived. It is understood that the required number was based on a legacy assessment. Through discussion with NWL Jacobs is not aware that the entire fleet has ever been called upon in an incident in the past. However, a review of the requirements for mobile or new fixed generation is recommended.

NWL has arrangements to hire additional mobile generators from external sources, however Jacobs understands that NWL does not pay a retainer through the contract so may not get priority when ordering in third party provided generators. NWL should consider whether retaining contracts could be established for hired-in generators.

A number of mobile generators were hired in at short notice to support NWL's response to Storm Arwen. It is noted that mobile generators are generally of smaller power capacity and often two need to operate in parallel to provide the required power output. Higher power mobile generators are typically physically larger pieces of equipment and may require bases/plinths on which to be placed in order to operate. It is recognised that there are a number of challenges in deploying mobile generators.

3.13 Emergency exercises

A requirement of SEMD is for companies to ensure they periodically exercise their emergency plans. As part of Jacobs' SEMD certification work it confirmed that NWL complies with this requirement by reviewing the exercises that have been run during the year. These are internal exercises where a specific scenario is facilitated and played out by NWL staff with injects to vary the scenario as the exercises progress. The exercises can be desk based or site based such as mobilising and deploying alternative water equipment (Arlington and static tanks). NWL also takes part in external exercises organised by the LRFs, Local Authorities and the blue light services.

In 2020/21 internal exercises were scaled back significantly because of Covid. Four security penetration tests were completed at sites to test the physical security arrangements.

Exercises that have taken place in previous years (2018/19 and 2019/20) are outlined in Table 3-2.

Table 3-2: Record of exercises

Date	Region	Exercise	Description
Mar 20	North	Exercise Arlington	Alternative Water training and practical exercise for NWL and Fastflow staff.
Jan 20	North & South	Exercise Guardian	To test the NW Heightened Response Plan and capabilities of the contracted security provider in meeting requirements. Combined NW/ESW/Security Contractor exercise.
Oct 19	South	Exercise Hanningfield	Trial/demonstration of Arlington "Always in Supply" system, attended by Customer Field Services managers and supervisors.
Jul 19	South	Exercise Siskin	Site initiated response exercise, developed to test the ESW response procedures to activation of an Enhanced treated water structure security alarm system. The focus was on the operational response to alarm activation at an unmanned and a remote Enhanced SR in a rural area.
Apr 19	North	Exercise Comms	Exercise of the updated communications plan with media/comms and Customer staff.
Mar 19	South	Exercise Waxwing	Site initiated response exercise, developed to test the ESW response procedures to activation of an Enhanced treated water structure security alarm system.
Dec 18	North	DEFRA exercise	Exercise at the request of DEFRA to gauge capabilities and gain assurance from all English water companies that they can maintain service provision to customers manually if equipment or systems that usually use automated controls are compromised (Region wide SCADA Failure).
Dec 18	South	DEFRA exercise	In tandem with NWL's DEFRA Exercise, the ESW exercise tested the ability to run a major WTW in true hand control, as a table-top exercise.
Sept 18	North	Exercise Arlington	An alternative water exercise to allow AWS operatives the opportunity to practice the use of Arlington Tanks, including filling and deployment. Wincanton attended to pro-vide participants an overview of the Wincanton contract.
Aug 18	North	Exercise Bluewater	Live play service reservoir rescue exercise. The scenario included NWL staff who were injured in a service reservoir and requiring rescue from responders from the Ambulance Services HART team.
Aug 18	North & South	Exercise Neptune	A specialist third party (F-Secure) were employed to compromise the IT and Operational Technology (OT) infrastructure at a cyber, personnel and physical level.
Jul 18	North	Exercise Resolution	Security exercise at Stoneygate borehole and service reservoir to test the Security Alarm Monitoring Unit's response to an intruder.

Exercise DEFRA took place in December 2018 in both the North and South regions at the request of DEFRA to all water companies. The loss of telemetry is similar to the circumstances of Storm Arwen and is therefore likely to have benefitted the NWL response. Notwithstanding this, Storm Arwen was an exceptional event with additional consequences of blocked access to sites and road closures resulting from uprooted trees. Whilst NWL has exercised the widespread loss of telemetry in its North region and loss of local telemetry at a major WTW in the South region, the circumstances brought by Storm Arwen are events that would not have been reasonably exercised previously.

The findings of the exercise are below.

NWL North

This exercise was to assess capabilities of NWL North to maintain service provision in the event of a widespread systems/equipment failure. NWL already had a contingency plan for this scenario (as discussed

above). The desk top exercise held at the RCC, assessed NWL's ability to physically visit and monitor key operational assets in the event of a region wide SCADA failure. The 'Control Centre Procedure Following the Loss of the Regional Telemetry System' was used to manage this scenario. Also detailed was the automated processes and the schedules in place to cover a rolling 24-hour period. The RCC would also use the previous day's Aquadapt reports to set manual pumping/valving schedules based on historic trends. The Company Incident Logs were used to record incident team information. A spreadsheet developed on the day was used to capture and record the manual network readings.

Calls were made within the business to gauge a true picture of the resources available over the next 7 days. Contractors were identified to carry out business as usual work, to enable NWL staff to visit sites. The numbers of extra resources identified in the RCC plan was achievable. It was identified however that should a large incident also occur in addition to the loss of communications and monitoring, resources would become stretched.

NWL anticipated it could continue operations for a prolonged period. However, it was identified that this would have a severe impact on resources and impact on staff. As the incident progressed the goodwill of staff would become very important.

As a result of the exercise a full review of the 'Control Centre Procedure Following the Loss of the Regional Telemetry System' took place. The exercise identified that the procedure named people instead of roles, however, the procedural content was correct and relevant. A recording spreadsheet was formulated for use in any future monitoring outages.

NWL South

A similar exercise took place in the South region to simulate loss of local telemetry and control of a major WTW. The exercise was carried out at Layer WTW where the scenario was loss of all SCADA and telemetry communications for the Layer site during unmanned hours. It commenced with the call out of the duty standby manager and the appropriate staff were called upon to enable the works to be operated manually. These were the site controller, site supervisor, M&E technicians (x2), process technicians (x2) and a SCADA technician. The exercise assessed what resources would be needed to run the works.

With knowledge of the works, the number of regulatory monitoring points (24 No) required 15-minute readings and the level of resources to achieve this over a 24-hour period was assessed and confirmed as achievable. The response during the exercise was considered a success. Actions that came out of the exercise were the need to develop a Standard Operating Procedure template for the site and extend this to other sites, emphasis on the importance of maintaining records of decisions and possible constraints if mobile phone coverage was lost. Two-way radios are available at Layer as a contingency for loss of communications.

A total of 24 staff took part in these exercises (14 North, 10 South).

For completeness, Table 3-3 below contains the 'external' exercises in which NWL took part during 2020/21.

Table 3-3: Record of external exercises

Date	NW/ ESW	Title	Organiser	Scenario	Location
Nov 20	NW	Pipeline Exercise	Tyne & Wear Fire & Rescue Service	Statutory virtual exercise to test the Northern Gas Networks offsite emergency plan.	Via Microsoft Teams
Nov 20	NW	Winter Management Workshop	Met Office & Cleveland LRF	A Cleveland LRF workshop regarding winter management and preparedness	Via Microsoft Teams
Dec 20	NW & ESW	Exercise Tempesta	Water UK	National Water UK exercise to test water companies response to a number of scenarios including EU Exit, Covid-19 and severe weather	Via Microsoft Teams
Jan 21	NW	Winter Plan Exercise	Durham LRF	Virtual Teams exercise to test the Durham LRF Winter Plan. Scenario TBC	Via Microsoft Teams
May 20	ESW	Contingency and Response Plan Standardisation	Essex Police CTSA and Operational Response	Review of all major WTW contingency plans, including insertion of new aerial images provided by Essex Police drone team.	Langham, Layer, Hanningfield, Langford
May and Sept 20	ESW	Sizewell REPPiR off-site plan	Suffolk LRF/ Suffolk County Council	Various workshops to review and update off-site plan ahead of implementation of new version. Review and updating of ESW assets listed in plan.	Virtual
Ongoing	ESW	Firearms Training	Essex Police Special Operations	Organisation for use of operational areas of Hanningfield WTW for firearms training by Essex Police Special Operations.	Hanningfield WTW
Sept 20	ESW	COMAH Plan Workshop	IFF, Haverhill	To review and validate COMAH response plan.	Virtual

3.14 Previous events

In late February and early March 2018, severe winter weather impacted much of the UK, causing disruption across much of the country (the Beast from the East). OFWAT requested all water companies in England and Wales to report on their performance throughout the freeze and thaw event, outlining their preparation, planning, operational approach and any customer service impacts.

Ofwat's analysis described NWL as performing well and largely meeting customer expectations¹³. Throughout this period, NWL customers experienced no major disruption to services. NWL lost supplies to only 0.1% of customers. NWL's reporting to DEFRA was good, as was its liaison with LRFs, with representation on Tactical Co-ordinating Groups and Strategic Co-ordinating Groups. The EMM received a refresh after the incident, but nothing significant was changed.

3.15 Summary

Review of the manuals relevant to NWL's preparedness and response to Storm Arwen confirm they are comprehensive in their content and intended use. They are typical of emergency plans currently in use in other water companies in England and Wales. Jacobs has not identified any significant deficiencies.

Some gaps were observed in the Generic Plan for Prolonged or Region Wide Disruption of Electricity Supplies (BCM 04.6). These relate to defining the timescale of a "prolonged" disruption to power supplies, and the development or enactment of a portable generator deployment plan. The ongoing replenishment of reservoirs using NWL/Wincanton tanker fleet and designated tanker fill points is covered by the Alternative Water Supply arrangements through its own chapter of the Emergency Plans Manual.

¹³ Source: <https://www.ofwat.gov.uk/out-in-the-cold/>

Similarly, in the Generic Plan for Severe Weather Conditions (BCM 04.9), logistics support does not appear to be considered. Engagement, mobilisation and provision of tankers through Wincanton is covered in the separate Alternative Water Supplies manual. It is noted that the timing of receipt of the weather warning trigger point is key to the successful implementation of the plan.

The NWL fleet of mobile generators appears to be based on a legacy assessment. Through discussion with NWL Jacobs is not aware that the entire fleet has been called upon for deployment in the past. NWL has arrangements to hire additional mobile generators from external sources, however it is understood that NWL does not pay a retainer through the contract so may not get priority when ordering in third party provided generators. It is recommended that a review takes place of the requirements for mobile (or new permanent) generation.

The winter readiness plan appears to be an informal arrangement which should be developed into an official procedure, with the requirements reviewed annually.

Overall, Jacobs considers the scenarios that NWL has planned for, as set out in its Emergency Plans Manual, are based on reasonable assumptions. NWL has exercised the region-wide loss of telemetry and loss of local telemetry to operate a major WTW. Storm Arwen was an extreme event bringing additional consequences of widescale power outages and blocked roads/site access due to downed trees. Even with the benefit of hindsight, it is considered that this scenario is one that that would not reasonably have been exercised. There would be benefit in exercising aspects of a longer duration event, for example by introducing restricted availability of staff.

4. Review of general preparedness for storm events and severe weather

Summary

This section of the report evaluates the effectiveness of NWL's general preparedness for storm events. It is based on interviews with NWL staff and review of supporting information provided by NWL.

Jacobs identified improvement areas in NWL's general preparedness. These include:

- NWL enacts winter readiness procedures as part of business-as-usual activities however these appear to be informal. Winter readiness procedures should be reviewed to identify whether preparedness for storms can be enhanced and formalised. This may include for example, preparing the vehicle fleet and considering winter driving precautions.
- NWL's generators undergo annual servicing however it is understood this does not include load testing. Analysis found that a lack of load testing resulted in the failure of one generator (Section 6.4). NWL should review its generator maintenance programme to include load testing.
- The NWL fleet of mobile and fixed generators is based on a legacy assessment. Through discussion with NWL Jacobs is not aware that the entire fleet has ever been called upon in an incident in the past. However, a review of the requirements for mobile or new fixed generation is recommended.
- NWL should review the resources it needs to deliver each role in its incident response and provide training accordingly. It should exercise longer-duration events.
- Whilst that there was no shortage of NWL staff who contributed to the NWL response it is noted that a number of roles relied on the goodwill of the staff to participate. NWL should review its standby rotas to consider whether they can be amended to optimise staff availability for long duration events such as Storm Arwen. NWL should adopt a volunteer register of staff who can help support with non-technical activities and free up appropriate staff to deliver technical activities.

Detailed conclusions and recommendations are presented in Section 9.

4.1 Winter readiness

NWL enacts business-as-usual winter readiness procedures each year though it is understood these are not documented and do not include any significant provision for preparing for high winds (the primary concern from Storm Arwen from NWL's perspective). This is a potential area for improvement. Note that this general winter readiness is not targeted at preparatory action in advance of particular events. Preventative action that was taken in advance of Storm Arwen is described in Section 5.4.

As a component of winter preparedness, the External Communications team has a suite of standard messaging related to winter weather that was being communicated at the time of Storm Arwen. This focuses on helping customers maintain their own supply such as via lagging pipes to prevent bursts caused by freezing water, emphasising ways to get in touch and publicising the Priority Services Register.

The Wholesale team also prepares tailored winter readiness communications for retailers.

4.2 Status of plans and procedures in advance of Storm Arwen

Section 3 of this report details Jacobs' review of the effectiveness of relevant aspects of NWL's emergency plans and procedures for response to emergency incidents like Storm Arwen.

The following observations relate to the status of plans and procedures in advance of Storm Arwen:

- NWL's Alternative Water Supply Manual was under review at the time of Storm Arwen. Discussions with NWL staff suggest there is generally limited awareness of the Alternative Water Coordinator (AWC) role in NWL and limited training in its delivery. The improvements to the Alternative Water Supply Manual should help to address this. It is noted that the AWC role is currently delivered by a single person based on their (extensive) previous experience and relies on their availability in an incident. This is a significant risk of a single point of failure.
- It is understood that no other incident response or emergency management plans were being reviewed at the time of Storm Arwen.

4.3 Underlying staffing issues

It is understood that most teams operate standby rotas intended to support response to incidents or staff absence. Normal out of hours standby is as follows:

- **Electrical, Mechanical, Instrumentation (EMI):** each of the following areas has 1x electrician/installation tech and 1x fitter (Tees, Central, Tyneside and Northumberland). It is noted that the Northumberland area is large and so travel time responding to call outs can be significant.
- **Water quality:** 1x person for whole operating area
- **Wastewater:** Each operating group has 1x operator on standby
- **Customer Field Services (CFS):** Each operating group has 1 x operator on standby and one supervisor/manager
- **Water Supply:** Standby team manager and area manager
- **Customer:** 1x supervisor and 1x call handler.

It is noted there is no standby rota for Network Analysts who are often required during incidents. The Business Continuity team are also not part of a standby rota. Involvement from these teams during an incident relies on goodwill and availability. It is understood there was full involvement of both Network Analysts and the Business Continuity team during the Storm Arwen incident and that not having a standby rota for these areas did not impact the response. However, it is considered that having rotas which cover all key areas required during incidents would reduce the impact on staff.

It is understood that staffing of the RCC has been under review for some time but that no decisions have yet been made to change the current approach.

4.4 Training

NWL provides two levels of training for those staff who may be called on to form part of an Incident Management Team: either Bronze team or Silver team training. There is targeted role specific training provided for the role of Alternative Water Coordinator and Incident Secretary. Other Incident Management Team roles are fulfilled by staff who's day job is closely aligned to the IMT role and hence role specific IMT training is not required.

Table 4-1 shows the number of staff taking each of three incident training courses in 2019 and 2021. There are no records for 2020, which may be due to restrictions associated with the COVID-19 pandemic. The records do not show any training for the Incident Secretary.

It is understood that staff in NWL remain in the business on average 17 years and therefore have significant experience to draw on in the event of incidents. Whilst this is acknowledged it is clear that incident training has been limited over the last three years, especially for alternative water supplies. A lack of incident training was also identified by NWL staff in interviews. Whilst Jacobs saw no evidence that staff delivering incident roles during Storm Arwen were not able to undertake the role appropriately it is recommended that training needs are reviewed and the training schedule reinvigorated now that Covid-19 restrictions have been removed.

Table 4-1: Incident training records

Course	No. of staff completing course			
	May and June of 2019	Directorates Represented	May, June and July of 2021	Directorates Represented

Review of Northumbrian Water's response to Storm Arwen

No. of staff completing course				
Incident controller training (bronze)	13	Water (7) Wastewater Operations (3) Asset Management (1) Customer Service (2)	9	Water (6) Wastewater Operations (3)
Incident management (silver team)	11	Water (2) Wastewater Operations (1) Customer Service (7) Information Services (1)	4	Water (1) Regulation and Assurance (3)
Incident management – alternative water supplies co-ordinator	Zero	N/A	Zero	N/A

5. Review of actions before Storm Arwen

Summary

This section of the report evaluates the effectiveness of the actions NWL took before Storm Arwen. It is based on interviews with NWL staff and review of supporting information provided by NWL.

It is understood that NWL received no advanced warning of electricity interruptions from NPG or SP Energy Networks (SPEN) in advance of Storm Arwen. NPG started preparatory actions from 24th November. NWL should engage with NPG to understand whether NPG could provide notification of such actions for future incidents. Though the time between the issuing of weather warnings and the arrival of Storm Arwen was limited, NWL should consider how it engages with NPG and SPEN as well as other organisations to prepare once yellow and amber warnings (which indicate likely power disruption) are issued. NWL should also review whether its weather warning service could be improved (it is understood that NWL does receive a long-range weather forecast but the extent to which it would allow for preparation in advance of an event such as Storm Arwen is unknown).

Detailed conclusions and recommendations are presented in Section 9.

5.1 Weather warnings

The first amber wind warnings, indicating a risk to life, damage to trees and buildings, and likely power, transport, and communications disruption, were issued at 0940 hrs on 25 November 2021. The amber warnings were reinforced by a rare red warning for exceptional wind speeds on the east coast of Scotland and northern England issued at 1030 hrs on 26 November 2021. Evidence from a review of the response of electricity distribution network operators suggests the timing of the red warning did not give sufficient time for the network operators to take proactive steps that had not already been implemented / commenced¹⁴.

It is understood that NWL received no advanced warning of electricity interruptions from NPG or SPEN in advance of Storm Arwen. BEIS suggest NPG started preparatory actions from 24th November¹⁵. NWL should engage with NPG to understand whether NPG could provide notification of such actions for future incidents. Though the time between the issuing of weather warnings and the arrival of Storm Arwen was limited, NWL should consider how it engages with NPG and SPEN as well as other organisations to prepare once yellow and amber warnings (which indicate likely power disruption) are issued. As the red warning was issued on the morning on 26 November 2021, NWL's available window to upscale its preparedness from amber warning levels was limited. It is likely this gave insufficient time for NWL to take proactive steps that had not already been implemented.

NWL's Emergency Management Manual (BCM 04.6) identifies that when an advanced warning of electricity interruptions is received, NWL should assemble the Electricity Supply Disruption Working Group (ESDWG), thereby initiating the Alert phase of the incident response. The ESDWG would comprise senior NWL managers representing Operations, Maintenance, Human Resources, Corporate Affairs, Customer, Networks, the Company Electrical Maintenance Manager and be chaired by the Business Continuity Manager. The ESDWG was not assembled in advance of Storm Arwen. The incident was escalated straight to Incident Management Team. It is not clear what might trigger the establishment of the ESDWG in the absence of a direct warning of electricity interruptions and NWL should review whether other triggers such as the receipt of weather warnings should be considered.

5.2 Underlying system performance and preparedness

It is understood that at the time of Storm Arwen, the Tyneside area was experiencing a water storage issue that had been ongoing for several weeks. Whilst this was not causing water supply problems, it is understood some staff resources were deployed to manage the event.

¹⁴ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf

¹⁵ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf

No other operational concerns associated with the performance of NWL's water or wastewater systems in advance of Storm Arwen were identified by interviewees.

There was a good (low) level of outstanding maintenance work in the storm-impacted areas. The launch of a new computerised maintenance management system (Maximo) meant that the backlog of jobs was higher than normal, but it is understood this did not impact the storm response.

5.2.1 Generators

It is understood that NWL has fixed standby generators at 112 of its sites. Prior to Storm Arwen NWL had a fleet of 21 mobile generators which are stored at various locations in the northeast of England. It is understood two additional mobile generators were purchased during the incident giving a current fleet of 23 mobile generators.

All NWL fixed generators undergo a third-party annual service which generates a report with any required actions which is sent to NWL's maintenance team for follow up. It is understood that this does not include load testing of generators. The contractor for this service also provides NWL with out of hours support.

NWL's mobile generator register indicates they were manufactured between 1985 and 2021. Four of the generators are described as new. All mobile generators undergo a roadworthiness service each year with a third party and an in-house operational service. All mobile generators have dates of last service in 2021.

5.3 Anticipating likely staffing requirements

In response to the weather forecast, the Customer and Water Networks teams added additional staff to their standby rota.

Employment contracts and working time directives are a factor in NWL's ability to resource significant and long-term events. Bringing on additional staff early in a prolonged event can risk them 'timing out' later in the event and becoming unavailable. NWL consider this when planning staff availability.

In the Water Networks team, some staff were sent home in advance of the storm to make sure they were available in case they were needed during the incident. The Berwick area standby operator was also stood down at midday on 26 November 2021 to preserve hours for the evening.

5.4 Preventive action

In response to the weather warnings, Honey Hill water treatment works (Water Production North) was switched over to its fixed generator (at approximately 0900 on Friday 26 Nov). A mobile generator was also deployed to Tosson water treatment works and prepared for operation, should it be needed.

These decisions were made because these sites are known to be susceptible to power outages during storm events. Jacobs is not aware of any other preventive measures in the water network such as topping up water levels in service reservoirs.

No other sites were switched on to fixed or mobile generators in advance of the event as they typically do not experience power outages during storms.

Four by four vehicles were distributed to those on standby as snow and freezing conditions were also forecast.

6. Reviews of action during Storm Arwen

Summary

This section of the report evaluates the effectiveness of the actions NWL took during Storm Arwen. It is based on interviews with NWL staff and review of supporting information provided by NWL.

It is considered that NWL's response during and in the aftermath of Storm Arwen was responsive and robust. It quickly mobilised the IMT and effectively organised what resources it had to manage the incident to the best of its ability. In particular, strong teamwork and the personal efforts of those individuals involved ensured a sustained and effective response. NWL engaged well with the LRFs and NWL's contractors and other organisations to provide alternative water and reinstate supplies. The NWL response was hampered by a lack of information about power restoration from NPG.

The following improvement areas in NWL's actions during Storm Arwen were identified:

- Ensuring all relevant teams are present in the Incident Management Team from the outset and improving clarity in the IMT log.
- NWL should revisit its outage plans to consider their suitability during incidents that affect large areas.
- NWL should develop a procedure for prioritising the storage and deployment of mobile and hired generators to its sites.
- NWL should continue to work with the LRF and other organisations to feed in lessons learnt from Storm Arwen to improve the flow of information during future incidents.
- NWL should act on its positive feedback for communications from 29 Nov onwards to enhance its communications during future events.

Detailed conclusions and recommendations are presented in Section 9.

6.1 General operational impacts

The highest wind gusts associated with Storm Arwen were experienced during the night of Friday 26 November 2021 into Saturday 27 November 2021.

No NWL sites were directly impacted by the high winds or other weather associated with Storm Arwen. They were indirectly impacted by electricity disruption and difficulties accessing sites. The impacts on NWL operations were as follows:

- Loss of power causing failure of fixed telecommunications – NWL's SCADA system was impacted with data feeds from sites to the RCC being disrupted.
- Loss of power causing failure of mobile telecommunications. Mobile signal was disrupted in several areas, making it difficult for operations staff to report back to team leaders and the RCC. The Public Switched Telephone Network (PSTN) was down in some locations.
- Loss of power causing sites and assets without on-site generation to fail (water treatment, water pump stations, water reservoirs, wastewater treatment sites and wastewater pump stations).
 - For water assets this caused source water production to cease and water in service reservoirs to continue to supply customers until these reserves were exhausted. At this point, interruptions to customer water supplies occurred. To mitigate this deployment of mobile generators was prioritised.
 - For wastewater assets this caused pumps to cease operation, leading to chambers filling and then, potentially, overflowing to watercourses. To mitigate the risk of pollution incidents at wastewater sites, we were told that waste was tankered away from some affected sites and that diesel pumps were hired in to prevent overflow at others.

The primary cause of loss of power was damage from flying debris, falling trees, and strong winds snapping poles and bringing down overhead lines which were also affected by ice build-up¹⁶.

Around one million homes were affected by the storm, significantly impacting all electricity distribution network operators (DNOs) in the northeast. Northern Powergrid (NPG) had the largest number of affected customers (280,867). It reported 1,217 faults. SP Energy Networks (SPEN) had 189,133 customers off supply and 1,331 faults¹⁷.

Many DNO customers had their electricity restored reasonably quickly, with 85% of customers across all DNOs reconnected within 24 hours. Around 3,000 customers were off supply for a week or more. NPG had 280,867 customers off supply for less than 24 hours and 2,537 customers off supply for more than 7 days. SPEN had 189,133 customers off supply for less than 24 hours and zero customers off supply for more than 7 days¹⁸.

The Scottish Government, Ofgem and BEIS have initiated reviews of the response from the power sector to Storm Arwen. From what has been published so far it is not clear what the rarity of the power supply interruptions resulting from Storm Arwen is. As a comparison, the storms in December 2013, resulted in around 53,000 NPG customers experiencing electricity interruptions with a maximum restoration period of 32 hours¹⁹. December 2013 was one of the top 10 stormiest months on record and was the stormiest month since January 1993²⁰. Storm Arwen resulted in five times as many NPG customers being affected than the 2013 storms.

6.2 Overview of the incident response

Key events: 26 November 2021 to 27 November 2021

Over this period, IMT meetings were held and recorded in the incident log at approximately 3-hour intervals between 0700 hrs and 2300 hrs.

- **2000hrs, 26/11/21:** Data analysed by NWL after the Storm Arwen event indicates that water supply interruptions to customer properties first commenced at this time (Figure 6-3).
- **2100hrs, 26/11/21:** NWL's first operator-notified issue. An operator reported that an alternative access route to Horsley water treatment works was required because trees were down.
- **2100hrs, 26/11/21:** Phone calls from NWL staff to duty managers flagging operational issues at sites started around this time, mostly in the Northumberland area (Berwick boreholes, Fontburn and Tosson). An operator was sent to Berwick to restart boreholes and Fontburn was changed over to a generator immediately. An operator was also sent to Tosson but trees blocking roads meant the site could not be accessed. Another operator tried to access Tosson, but again, this was not possible.
- **2230hrs, 26/11/21:** The Water Networks team deployed staff to visit rural sites.
- **2100hrs, 26/11/21:** Power was lost at Lumley water treatment works (which does not have a fixed generator). An operator was sent to this site in response.
- **0200hrs, 27/11/21:** The impact of the storm was becoming significant and the number of available NWL staff limited. Access to several sites was not possible and interviewees explained that NPG had asked all employees to stand down until travel conditions were safe. These access and health and safety constraints meant that NWL's physical incident response to sites was essentially on hold until conditions improved. Examples of trees down blocking roads are provided in Figure 6-1.

¹⁶ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf

¹⁷ Source: https://www.ofgem.gov.uk/sites/default/files/2022-02/Interim%20report%20on%20the%20review%20into%20the%20networks%27%20response%20to%20Storm%20Arwen_0.pdf

¹⁸ Source: https://www.ofgem.gov.uk/sites/default/files/2022-02/Interim%20report%20on%20the%20review%20into%20the%20networks%27%20response%20to%20Storm%20Arwen_0.pdf

¹⁹ Source: https://www.ofgem.gov.uk/sites/default/files/docs/2014/03/final_december_2013_storms_review_1.pdf

²⁰ Source: <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2013/winter-storms-december-2013-to-january-2014---met-office.pdf>

- **0500hrs, 27/11/21:** Tosson, Fowberry and Lumley water treatment works were not operational, and issues were being experienced at several others.
- **0530hrs, 27/11/21:** NWL's IMT was mobilised by the Water Director.
- **0715hrs, 27/11/21:** The first IMT meeting was held comprising Water Treatment Works, Water Quality, Water Networks, Maintenance, Alternative Water Supply (AWS), Business Continuity, RCC, Customer, and External Communications. The IMT incident log commences now.
- **0900hrs, 27/11/21:** Significant numbers of properties impacted were recorded in the post incident data from the morning of 27 November 2021 (Figure 6-3).
- **27/11/21:** appears that mobile generators are being deployed (notes could be clearer)
- **~1900hrs, 27/11/21:** The IMT was extended to include the Water Quality team.
- **2030hrs, 27/11/21**
 - Resourcing plans in place for the RCC, Water Supply, Water Networks and Maintenance.
 - Maintenance crew reported to be in a reasonable position with labour. Seven mobile generators were available.
 - Alternative water supply contractor (Wincanton) put on standby but not willing to travel overnight (health and safety concerns).
 - Bottled water delivery commencing.
 - Holding 'if asked' statements prepared by External Communications team.
 - NWL requested to attend future Northumbria Regional Tactical Coordination Group (TCG) meetings. NWL also attended TCG meetings in Durham as well as Strategic Coordination Groups (SCG) in both areas.
- **2330hrs, 27/11/21:** All available maintenance resource utilised.
 - Log states that mutual aid was to be requested by NWL through one of the TCGs however it is understood from interviews that this did not take place.



Figure 6-1: Trees blocking roads photographed by NWL staff

Assessment of the response: 26 November 2021 to 27 November 2021

NWL received no notification of electricity disruption from NPG or SPEN. Phone calls from NWL site operators and interruptions to data displayed on NWL's SCADA system were the primary means by which NWL became aware of electricity disruption at its sites.

It is clear that during the night of 26-27 November, many roads were blocked because of fallen trees and this restricted access to NWL's sites. These access and health and safety constraints meant that incident response was necessarily on hold until conditions improved. The Water Production North team leader explained that access constraints lost that team around a day of time. In one example, a blockage of the A1 meant the outage plan for Murton WTW (involving tankering from another site) could not be followed. This picture of access and health and safety constraints mirrors that experienced by the DNOs. BEIS identified that access and safety issues limited the ability of DNOs to assess the scale and volume of damage for 48 – 72 hours after the storm.

Northumberland County Council explained that all roads affected by fallen trees were quickly reopened, except for the C145 at Garden House which was closed for several days due to the large number of trees affected. All roads temporarily closed had signed diversionary routes in place and where the council had specific requests for assistance from utility companies to clear fallen trees to assist them to access their facilities/equipment they responded and prioritised these.

Durham County Council provided a list of more than 20 road closures which were in place on 27 November. These had all been reopened by 28 November.

NWL's fleet of vehicles has not been analysed for their suitability for incident response however, it is understood that the availability of vehicles that could tow required loads may have been a constraining factor on the response. The vehicle fleet has recently been updated and the towing capacity is now reduced overall. NWL should revisit whether its fleet remains appropriate.

Key events: 28 November 2021 to 1 December 2021

Over this period, IMT meetings were held and recorded in the incident log at approximately 3-hour intervals between 0700 hrs and 2300 hrs. Notable entries during this period include:

- **0700hrs, 28/11/21:** Resource constraints led to consideration of sending out an all-company text to identify volunteers to hand out bottled water. The need for the contractor to visit generators to top up diesel supplies was identified. Widespread communication issues were persisting, making it hard to anticipate where supply interruptions would occur.
- **0700hrs, 28/11/21:** The need for an additional bottled water coordinator was identified and discussions were to be held with the Fire Service to distribute bottled water.
- **1900hrs, 28/11/21:** Supply issues at Berwick Hospital were recorded. Responses were discussed and identified. 210 priority service customers in Berwick were a focus of the response at this time.
- **0700hrs, 29/11/21:** 32 network sites running blind (without communications). Alternative water tanker stuck on road due to ice.
- **29/11/21:** Major Incident declared in Northeast Scotland.
- **1000hrs, 29/11/21:** Maintenance team approaching suppliers for additional generator hire.
- **1300hrs, 29/11/21:** Contact from farmers on private water supply requesting water for livestock.
- **2000hrs, 30/11/21:** Horsley water treatment works lost power as NPG worked to restore a larger proportion of its network. NWL were not notified. Restoring operation at Horsley became a priority focus for the incident response on 1 December with tankering contractors being diverted to this site.
- **01/12/21:** Major Incident declared in Durham and Darlington.
- **1400hrs, 01/12/21:** The Wholesale team first attended the IMT. NWL has already identified earlier involvement of the Wholesale team as an improvement action.

Assessment of the response: 28 November 2021 to 1 December 2021

During 28 and 29 November 2021, the widespread and severe nature of the storm impacts were being recognised. LRFs and Partnerships stood up their response mechanisms for Storm Arwen and major incidents were declared in Northeast Scotland on 29 November and Durham and Darlington on 1 December²¹.

A Major Incident is defined by JESIP as "beyond the scope of business-as-usual operations, and is likely to involve serious harm, damage, disruption or risk to human life or welfare, essential services, the environment or national security".²²

Evidence from NWL staff, and from the electricity distribution network operators, suggests that access across the region was a challenge and posed health and safety risks during and in the first days after Storm Arwen, particularly at night. This would have impacted NWL's ability to get on top of emerging issues, a situation compounded by the widespread communication challenges that meant NWL's visibility of the status of its remote assets was incomplete. Both these factors may have contributed to the spike in water supply interruptions seen on 28 November (see Figure 6-3).

The RCC became inundated with alarms and responded by asking the Wastewater team to manage alarms directly. It is understood this worked well: the Wastewater team used their laptops to log-in to SCADA remotely. This enabled the RCC to focus on the response to water asset alarms. This approach may have reflected learning from past exercises (see Section 3.14).

It is understood that NWL has Outage Plans for all its water sites but that these could not be implemented in all cases due to the widespread nature of the storm (the normal outage response would be to rezone or tanker). A few of the actions in the outage plans also rely on the availability of power.

On 29 November, as NPG was trying to restore power to its networks, it cut power to Horsley water treatment works. The response to this issue became a priority focus for NWL. Mechanisms and procedures to ensure greater collaboration and communication between NPG and NWL, and the broader LRF, would have helped to prevent the issues at Horsley.

Under the Civil Contingencies Act 2004, DNOs must cooperate with local authorities, emergency services, and health services by providing information necessary for the performance of their functions under the act. As far as reasonably practical, DNOs must be a part of a forum of all relevant LRFs, to respond in a coordinated manner to the emergency.

BEIS identified that NPG did not share final expected restoration times with government or customers until 1 December, at which time they estimated restoration would be complete by 3 December. This date then continued to be pushed back one day at a time for many customers for several days. All NPG customers were restored by the 9 December. The way in which these moving estimates were communicated to customers made it difficult for households and LRFs to make informed decisions about their welfare.

Key events: 2 December 2021 to 9 December 2021

On 2 December and 3 December 2021, three IMT meetings were held each day, at approximately 0800 hrs, 1300 hrs and 1700 hrs. Over the weekend of 4 December and 5 December 2021, Microsoft Teams was used to pass instant message updates between IMT members. There were no formal IMT calls during this weekend.

Northumbria County Council declared a major incident on 3 December 2021, two days after Durham and Darlington. On 5 December 2021, the IMT notes that military assistance had arrived in Northumberland and would start welfare checks on all those without power supply (military support was eventually stood down on the evening of 7 December 2021).

On 6 December and 7 December 2021, two IMT meetings were held each day, at approximately 0830 hrs and 1630 hrs, supported by communication over Microsoft Teams.

The IMT was stood down on Wednesday 9 December 2021 at 1800hrs.

Northumbria County Council's major incident was stood down on 8 December 2021. Durham LRF's major incident was stood down on 9 December 2021 with the LRF response then moving into the recovery phase.

²¹ Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055504/arwen-review-interim-report.pdf

²² Source: <https://www.jesip.org.uk/uploads/media/app/Jesip-web-version/major.html>

Assessment of the response: 2 December 2021 to 9 December 2021

Figure 6-3 shows that supply interruptions to properties because of Storm Arwen had ceased by 9 December 2021 when the IMT was stood down however it is understood from our interviews that some customer contacts for discolouration were being received around this time. Documenting of future incidents should include a clear justification for the stand down of the IMT along with any remaining remedial activities.

6.3 Use of generators

Given that electricity disruption was a primary cause of failures at NWL sites, this review has evaluated the operation of fixed generation, deployment of mobile generators and sourcing of hired generators.

Of NWL's water and wastewater sites, 112 have fixed generators (see Figure 6-2). As explained in Section 5.4, one site was switched over to its fixed generator in advance of Storm Arwen.

NWL's mobile generator register lists 23 mobile generators at depots in the northeast on England (we understand two of these generators were purchased during the Storm Arwen response). At various stages during the Storm Arwen response, all of these mobile generators were deployed. Since the event, NWL has updated its mobile generator deployment log to make the record of where mobile generators are deployed clearer.

NWL's mobile generator deployment log also lists 15 short term generator hires deployed to various sites.

The IMT log records that:

- 27 November 2021: mobile generators are first deployed (noting that one was deployed in advance of the event, see Section 5.4).
- 28 November 2021: deployed mobile generators were being kept topped up with diesel by a contractor.
- 2200 hrs on 28 November 2021: generator fleet described as being mobilised (we are unsure if this means fully mobilised).

NPG deployed an average of 139 generator units per day during the Storm Arwen restoration period. SPEN deployed an average of 157 generators. Across the DNOs, an average of 456 generator units were deployed per day. There were no reported issues in DNOs accessing generators; they own some themselves and then supplement this with pre-agreed hire contracts with multiple suppliers²³.

The use of generators by DNOs would have constrained the ability of NWL to hire additional generators. Notwithstanding this, NWL should improve the way it records its deployment of mobile generators (already identified and being actioned by NWL) and evaluate how the deployment of its mobile generator fleet can be optimised for future incidents, particularly those of long-duration. Questions to be considered during this review should include:

- Where mobile generators are stored and whether this should be optimised in advance of an incident.
- How requests for mobile generators from teams are prioritised.
- How mobile generator deployments are recorded (already actioned).
- If and how retaining contracts for hired generators should be secured and maintained.
- How generators could be shared with other organisations.
- How the human resources required to deploy and connect generators is managed and how fuel supplies are organised to ensure generators can keep running as required.

²³ Source: https://www.ofgem.gov.uk/sites/default/files/2022-02/Interim%20report%20on%20the%20review%20into%20the%20networks%27%20response%20to%20Storm%20Arwen_0.pdf

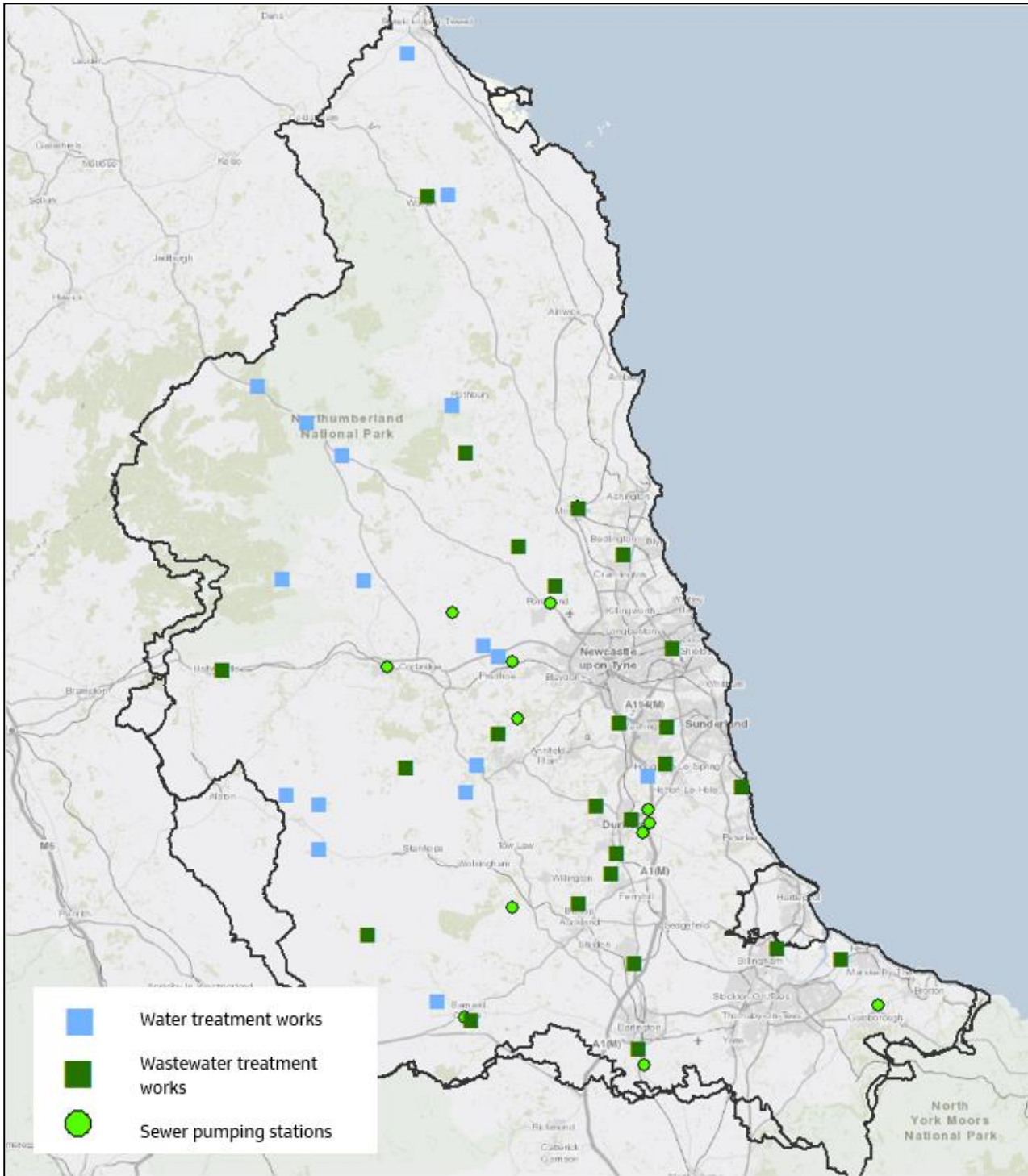


Figure 6-2: Water and wastewater sites with fixed generators

6.4 Water supply interruptions

Data analysed by NWL after the Storm Arwen event indicates that water supply interruptions peaked at approximately 8,000 properties at around 1400 hrs on 28 November 2021 (see Figure 6-3). More than half of these interruptions were restored by 2200 hrs on 28 November 2021. By 0900 hrs on 30 November 2021, interruptions were being experienced by fewer than 1,200 properties. All interruptions were restored by 1200 hrs on 7 December 2021.

Review of Northumbrian Water's response to Storm Arwen

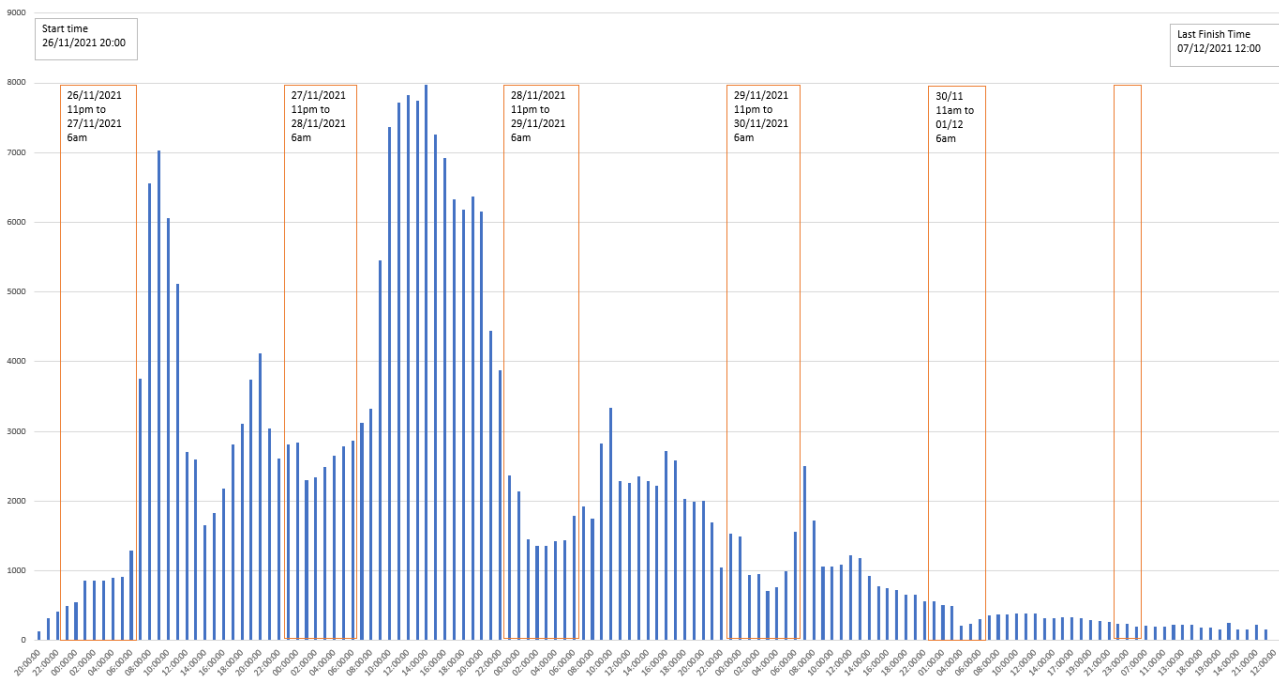


Chart shows total number of properties interrupted in any given hour due to Storm Arwen

Figure 6-3: NWL analysis of properties impacted by supply interruptions

Table 6-1 presents data derived by NWL for the total number of properties impacted by water supply interruptions of different time periods (24,966). This indicates that 1,666 properties experienced supply interruptions which lasted more than 24 hours. 5,533 properties experienced supply interruptions which lasted more than 12 hours.

Table 6-1: Total supply interruptions

Total Supply Interruptions		
Category	Number of incidents	Number of properties affected
Total less than 12hrs	477	19,433
12-18hrs	130	3,152
18-24hrs	91	715
24-48hrs	85	890
48-72hrs	40	553
More than 72hrs	10	223

NWL has three ODIs related to water supply interruptions. The numbers of properties affected for each of these measures is shown in Table 6-2.

Table 6-2: Supply interruptions by ODI category

Total Supply Interruptions		
Category (breakdown by ODI)	Number of incidents	Number of properties affected
1-3 hours	181	6,635
More than 3 hours	638	17,376
More than 12 hours	356	5,533

NWL has reviewed the root cause of the supply interruptions greater than 12 hours during the Storm Arwen incident. That analysis indicates that approximately 90% of the interruptions were due to power outage, approximately 3% due to loss of comms, approximately 6% due to power and comms combined and approximately 1% due to a burst main caused by a fallen tree brought down by the wind.

There were 13 interruptions that lasted more than 12 hours which affected more than 100 properties each. They affected 4,300 properties of the total interruptions greater than 12 hours. For these interruptions, NWL has conducted further analysis to trace the cause of the event. Specific consideration was given to the extent to which factors associated with generator use within the control of NWL contributed to the interruptions.

Table 6-3 shows that issues with generators were a major contributing factor in three of the 13 interruptions (776 properties in total), a minor contributing factor (not the majority contributing factor) in six interruptions (2,745 properties in total), and not a contributory factor in the other four interruption (779 properties in total).

Table 6-3: Root cause of major interruptions

Interruption	No. of properties impacted for greater than 12 hours	Cause	Extent to which generator issues contributed
Springhill B.P.T Meter District	1,170	Power	Minor contributory factor. Major factor was sporadic mains power outages.
Springhill Reservoir Outlet	587	Power	Minor contributory factor. Major factor was sporadic mains power outages.
Cow Road Spittal	506	Power	Minor contributory factor. Major factor was sporadic mains power outages.
Parkgates Lower Meter District	318	Power	Major contributory factor – fixed generator failure.
Hillside Thropton Reservoir Outlet	294	Power	Generators not a factor. Major factor was failure of pump station with no fixed generator that was inaccessible due to fallen trees.
Ford Common / Watchlaw Meter District	239	Power	Major contributory factor – fixed generator failure (would not start as never tested under load) and issues with hired generator.
High Fair	219	Power	Major contributory factor – fixed generator failure (would not start as never tested under load) and issues with hired generator.
Pagecroft Meter District	212	Power and communications	Generators not a factor. Major factor was lost communications.
Scremerston Village	184	Power	Minor contributory factor. Major factor was sporadic mains power outages.
Cambo	150	Power	Minor contributory factor. Major factor was airlocks in network.

Interruption	No. of properties impacted for greater than 12 hours	Cause	Extent to which generator issues contributed
Hillend / Cambo (Rothley)	148	Power	Minor contributory factor. Major factor was airlocks in network.
Harbottle / Hepple / Alwinton Meter District	141	Power	Generators not a factor. Major factor was failure of pump station with no fixed generator that was inaccessible due to fallen trees.
Slaley from Cocklake Meter District	132	Power	Generators not a factor. Major factor was failure of pump station with no fixed generator that was inaccessible due to fallen trees.

6.5 Disruption to wastewater management

Storm Arwen impacts on wastewater services were managed separately to the IMT by the wastewater team. Alarms were monitored remotely by team members from home who were able to log on to SCADA using laptops. This allowed the RCC to focus on water sites. There was liaison between the water and wastewater teams to co-ordinate priorities for the maintenance teams and deployment of mobile generators, although it is understood that water takes priority. Wastewater Treatment Works and Sewage Pumping Stations which experienced power outages during Storm Arwen are shown in Figure 6-4.

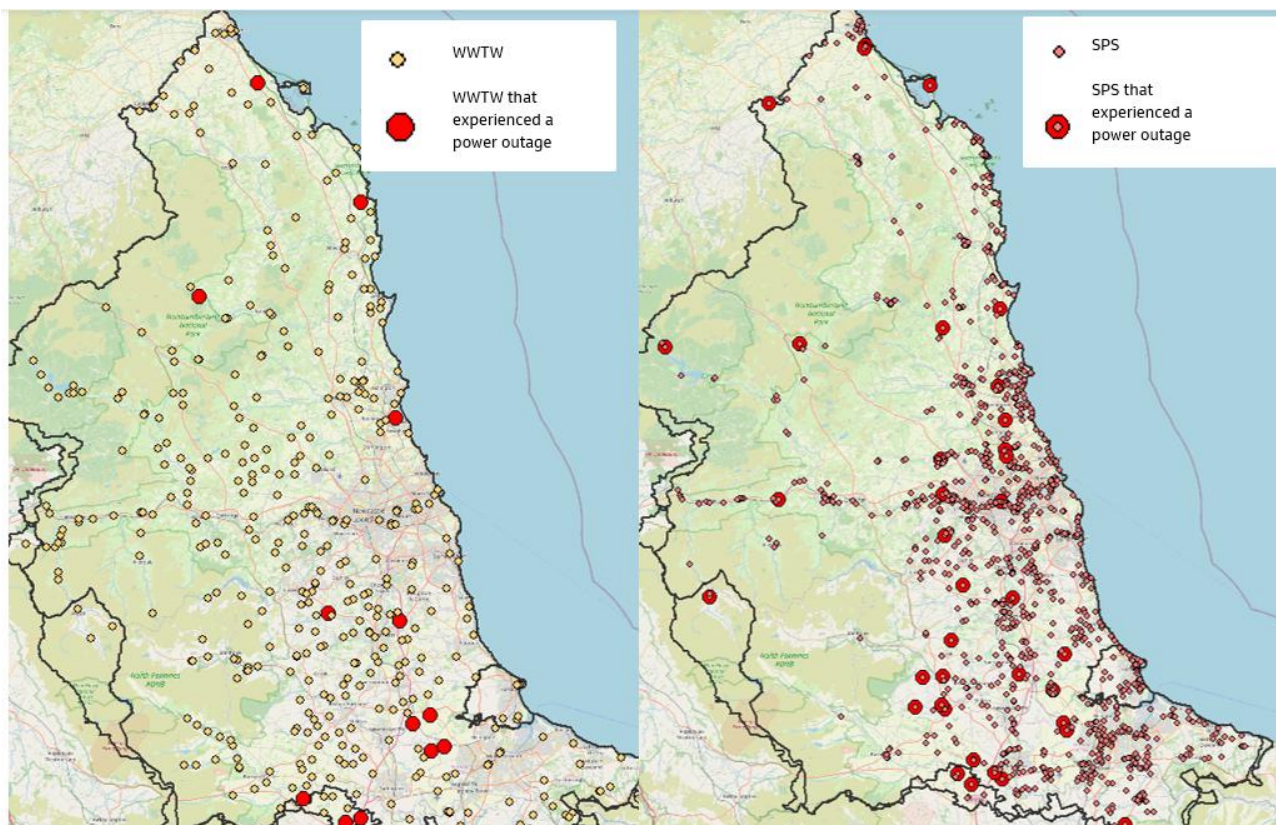


Figure 6-4: Overview of the wastewater sites that experienced power outages during Storm Arwen

It is understood there is an embedded practice in place where the wastewater team proactively notify the Environment Agency of potential overflows. The team notified the EA of 55 potential overflows at the time of the incident which potentially impact on the Company's EPA rating. Post incident the team has reviewed

each one and provided detailed information to the Environment Agency to confirm where overflows occurred. The EA has subsequently confirmed that having assessed the summary Storm Arwen report provided to them and the information on the individual incidents they are satisfied that the total of 55 incidents attributed to Storm Arwen will not influence the EPA. In the confirmation, the EA note they expect some work to be undertaken to build on learning points from Storm Arwen to improve the response and the reporting to storm events in general with an expectation that more guidance will come through National routes.

6.6 Review of support provided to customers

It is understood that customer contacts reporting no water were first received on the morning of Saturday 27 November 2021. At the time, call handlers were predominantly working from home (a common situation at weekends). This was identified as being beneficial as those staff members who could not commit to supporting for a whole shift were able to log on for shorter time periods.

In the past, NWL had a contract for external call handling support during events however we were told the contract was never used and its suitability was considered poor (it took a few hours to mobilise resources and they did not have access to NWL corporate systems). In 2021, the decision was taken not to renew the contract for this service. There was therefore no external resource available during the Storm Arwen incident.

Calls to the customer contact centre were high on the 28 November 2021 and were described to us as being much higher than normal. Figure 6-5 has been created by Jacobs based on data supplied by NWL. It shows the forecasted number of calls per day (grey line), the actual calls received (blue line) and the number of calls abandoned (not answered) (red line). It shows that during and immediately after Storm Arwen, actual calls exceeded forecast calls (222 forecast calls compared to 1,397 actual calls on 27 November 2021 for example).

Northumbrian Water Group provides water in the northeast of England and in the Essex and Suffolk region. Calls from customers in these two areas are handled through one route meaning that customers in Essex and Suffolk were adding to the queue of customers in the northeast calling in to report no water.

Interviewees explained that in advance of the storm, additional staff were added to the Customer standby rota however this was evidently insufficient to meet demand. During and immediately after Storm Arwen, the number of abandoned calls was significantly higher than usual (62% of calls on 27 November 2021 for example). Over the calendar year January 2021 to December 2021, NWL's average rate for abandoned calls was 13%.

After 28 November 2021, calls to the customer centre gradually reduced and they were described as at normal levels by 1 December 2021. This is validated by Figure 6-5.

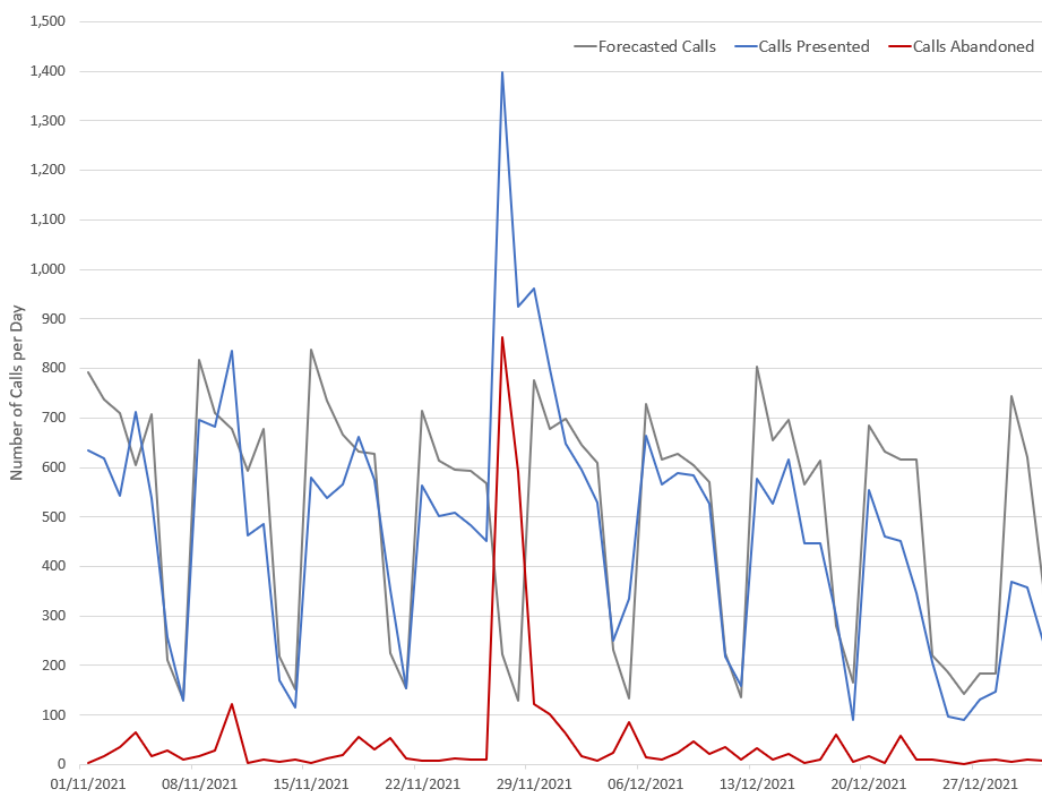


Figure 6-5: Customer call statistics

6.6.1 Customers on the Priority Services Register

Ensuring customers on the Priority Services Register (PSR) were kept up to date about supply outages and were provided with bottled water was a focus for NWL. Frequent reference is made to bottled water provision for PSR customers in the IMT log.

The IMT log notes that on the evening of 28 November 2021, the fire service was confirmed as a resource to assist with bottled water supplies to priority customers. At this point, text messages were also being sent directly to priority customers. We were told that NWL has the capability to request messages are broadcast on local radio but did not do this during Storm Arwen.

During our interviews with NWL staff it was explained that during the incident customers were requesting to be added to the PSR. Customers were added to the PSR register during the event however staff were unaware that they would need to re-run the report to identify the new additions. This has since been resolved and is now used routinely for subsequent events.

6.7 Review of external communications

The first involvement of the External Communications team with the incident response was on 27 November 2021. They prepared statements to be used by NWL staff if approached by customers, stakeholders and the media. Social media updates were then issued. These initial activities were completed by 1200hrs on 27 November 2021. The Customer team then responded to specific comments from users on social media.

Network outage updates were issued on the morning of 28 November 2021 emphasising ways customers could contact NWL. On the evening of 28 November 2021, the IMT log indicates that messaging was being prepared for DEFRA and Councillors. The DWI were notified on 29 November 2021 and updates to the media were also provided. Interviewees explained that the Water Quality team kept DWI, councils and UK Health Security Agency (UKHSA) informed as required throughout the event.

Given that Storm Arwen caused significant electricity disruption, getting messages to customers was more challenging. During our interviews, it was explained that NWL sought to address this by asking customers and staff to spread the message on to neighbours and other members of the public they might come across but that might not have electricity or mobile communications.

Our interviews highlighted that the approach to external communication changed on the morning of 29 November 2021. The previous responses had been generic, but from this point onwards, the communication to customers became more targeted, focussed on specific areas and time stamped. The NWL website was updated to give short updates on each of the affected areas (10-15 initially). Interviewees explained that customer feedback indicated this approach to communications was much better received. NWL should apply this learning to future incident response.

6.8 Review of the alternative water response

The Alternative Water Coordinator (AWC) became involved in the incident response on the afternoon of 27 November 2021, organising the tankering of water to fill strategic reservoirs and the provision of bottled water.

NWL has a fleet of tankers that are operated by a contractor, Norman Bell, on a 24/7 availability basis. NWL also has an emergency arrangement for tankering with a second contractor, Wincanton.

During the evening of 27-28 November 2021, interviews explained that NWL called both Norman Bell and Wincanton to mobilise the tanker fleet. Both subcontractors considered it too dangerous to travel until first light on 28 November 2021. The AWC estimated that it was around 8 hours between requesting contractor mobilisation and having tankers in the required locations (strategic reservoirs). In the intervening period, NWL was able to mobilise networks staff to ensure qualified staff were able to meet tankers at sites.

On 28 November 2021, the IMT log identifies several challenges the AWC was grappling with simultaneously. It is understood that alternative water knowledge is largely held by one experienced member of staff. Additional staff were supporting the AWC however the need for an additional AWC for bottled water was identified in the incident log and this was actioned. A call for volunteers to staff bottled water stations was also made however bottled water stations in certain areas were left unstaffed for periods of time. Unstaffed stations can pose a security concern and are also a missed opportunity for NWL to communicate directly with customers when access to the internet and phone lines may not have been possible.

The first bottled water station was established on 28 November 2021. There was concern over maintaining stock by relying on Wincanton and so a request was made for additional supplies through Water Direct by the Business Continuity team.

On the evening of 28 November 2021, health and safety concerns regarding travel were again raised by the tankering and bottled water contractors and travel was curtailed until first light.

By 29 November 2021, the IMT incident log suggests an improved situation with regards the AWS response, particularly over bottled water. It was noted in the incident log that meeting OFWAT's requirements for alternative water in the first stages of the incident was challenging because the IMT was focussed on establishing bottled water stations and mobilisation of tankers. It was also acknowledged that improvements in the testing of bottled water supplies is required and that these improvements are being formalised in the updates to the Alternative Water Manual.

The Water Quality team explained that all sampling of the water network for regulatory purposes was completed in accordance with regulations during Storm Arwen. Some operational sampling was however deferred.

On 30 November 2021, the IMT log records contacts from farmers over concerns providing water for livestock. These customers were on private water supplies however NWL coordinated with the Fire Service to organise water provision.

By the evening of 2 December 2021, the alternative water position was such that Wincanton was stood down and Norman Bell was retained on standby.

6.9 Review of the interface to the local resilience forums

Throughout the incident, NWL attended the Durham and Northumbrian SCG and TCG meetings. Interviewees explained that these forums were useful for NWL to share information with other responders, however information on when power supplies would be restored (a critical information requirement) was not forthcoming from NPG. This is acknowledged in the OFGEM and BEIS reports.

As NPG worked to restore power, intermittent electricity disruption was common, without forewarning, and this caused problems for NWL (for example at Horsley water treatment works). This extended the overall period of outages, resulting in further drawdown of service reservoir levels and impact on customer supplies.

7. Review of actions after Storm Arwen

Summary

This section of the report evaluates the effectiveness of the actions NWL took after Storm Arwen. It is based on interviews with NWL staff and review of supporting information provided by NWL.

NWL has been proactive in learning lessons about the Storm Arwen response. It has collated feedback from staff members, held an internal debrief and already begun implementing several enhancements to procedures and working practice.

NWL should evaluate whether its procedures could be improved to support the internal and external reporting process.

It should consider if and how it can improve the process so that customers are paid any compensation they are owed faster.

Detailed conclusions and recommendations are presented in Section 9.

BCM 04.6 identifies that once the IMT ceases to operate, the ESDWG may be reconvened if necessary. No ESDWG was formed before or after Storm Arwen.

BCM 04.6 also states that practical testing should be conducted on all equipment that is normally in standby mode, or that hasn't already been tested to ensure that systems work following an outage. It is not clear whether any testing has been carried out.

The Water Quality team explained that the 72-hour and 20-day reports required by the DWI were submitted on time. Producing these plans was described as challenging, due to the difficulty of identifying the number of customers affected.

NWL has committed to paying its customers compensation for certain service failures. Its 'Our promise to you' document includes the following statements:

- *During emergency work, such as a burst water main or another emergency, we will not be able to warn you that your water will be off. We will do our best to let you know what is happening and if necessary, we will provide an alternative water supply. In most emergencies we will turn your water back on within 12 hours unless doing this would cause even greater inconvenience, for example, loud noise from repairs carried out at night. We will automatically pay you £30 if you are a domestic customer (£75 if you are a business customer affected by the interruption) if we do not turn your water back on within these times.*
- *If your water is off for longer than the times mentioned, we will pay you an extra £30 (£75 if you are a business customer affected by the interruption) for any further complete periods of 12 hours that your water is off.*
- *You should receive these payments automatically and if you do not it may be because we did not know you were affected. If you wish to make a claim, you should do this within three months of the incident. If we are aware of any interruption to your water supply and we do not make a payment within 20 working days, we will automatically pay you an additional £20 (£50 if you are a business customer).*

NWL had made payments to the majority of customers who are eligible on 11th March 2022. This was a complex task, involving the validation of data for around 1,500 district meter areas. These payments are due to the occupier and where they are the bill payer this is made as credit to the customer NWL account. Where the occupier is not the bill payer and NWL do not have contact details to make the payment it is possible that a few additional claims are still to come forward.

During our interviews with NWL staff, interviewees were asked whether any improvements to processes or procedures had already been implemented in their teams (acknowledging a company-wide review in to Storm Arwen is ongoing):

- The AWC explained that the AWS Manual was in the process of being updated. This includes: a single location for guidance, more concise guidance generally, new check sheets for users to follow consistent processes, a training and competency section (which remains to be populated), a

documented alternative water supply sampling process (interviewees explained that previously, this was not written down).

- The AWC also explained that the contract with Wincanton was under review to include clearer requirements for provision of alternative water support.
- The Customer team has trialled the use of a script to give customers calling during an incident targeted answers. This has been trialled since Storm Arwen.
- The Wholesale team was not present at the IMT calls prior to 1 December. This has already been identified by NWL as an improvement area.
- The Wholesale team has been evaluating how they contact retailers during events such as Storm Arwen to make the process more efficient. During a more recent storm event, individual contacts had to be made with around 20 retailers. NWL is evaluating ways to improve this process.
- For recent storm events, NWL has held more detailed discussions in advance of the event about which sites to switch over to fixed generators, where present, and where to send mobile generators.
- For recent storm events, NWL has refined the procedure for recording the location of mobile generators (the new template includes individual columns for each deployment with time and date stamps).
- The response to Storm Arwen provided NWL with useful information about how the water network operates under unusual conditions. This may help it to optimise pressure management for example.

8. NWL reflections on the incident response

During interviews, NWL staff were asked to identify aspects of the Storm Arwen response that they perceived to be good:

- All interviewees identified strong teamwork and the personal efforts of those individuals involved in the response. In multiple teams there was evidence of colleagues working above and beyond expectations to support the response out of hours and over extended periods of time. Staff also identified the need to improve staff resourcing processes to avoid an over reliance on goodwill.
- Support from NWL's supply chain was widely acknowledged as positive. The local knowledge of tankering and bottled water supply contractors was highlighted as particularly helpful. The efforts of the Maintenance team and supporting electrical contractors was acknowledged. The Water Networks team also identified good support from contract partners, though this was informal and could potentially be formalised within contracts for future events.
- The effective functioning of the IMT was highlighted, especially once it established a clear routine with each team giving an update on their respective areas in turn (see note on improvement area about this below). Clear management of the IMT agenda gave equal opportunity for all IMT members to input. The frequency of IMT meetings was felt to be appropriate and the efficient sign-off of communications was highlighted as good.
- The fact that most members of the IMT were working remotely was identified as highly beneficial by several individuals. This meant communication could be more frequent and targeted. The benefits of remote working were also flagged by the Customer teams whose call handlers could provide additional hours of support as they did not have to travel to an office to take customer calls.
- The Wastewater team identified the process of managing wastewater alarms remotely from home through SCADA to be effective. However, this would have been equally impacted by SCADA communications challenges associated with electricity disruption.
- The Business Continuity team identified the LRF coordination groups as effective vehicles for keeping different organisations up to date (though noting the lack of information on electricity disruption). Strong relationships with local councils, the DWI and public health bodies was highlighted as important in enabling the effective flow of information between them.
- NWL went beyond its duty in organising alternative water supplies for members of the public and farmers on private borehole supplies who were impacted by the power outages.
- Whilst the alternative water response was described as challenging, alternative water was successfully routed to where it was needed. There was good coordination with the Fire Service and other authorities. The internal requests for additional resources to support the alternative water response during the latter stages of the event were also helpful.
- The External Communications team felt that from Monday 29 November 2021, the focus of messaging on time-stamped updates by location was effective at getting key information to customers. It was also corroborated by good customer feedback.
- There was also good coordination between the External Communications and Customer teams (discussing updates, shaping key messages to support the Customer team with calls, and ensuring that questions and comments were being managed by the Customer team).

Interviewees were also asked to identify aspects of the NWL response which could be improved:

- NWL received no warning from NPG or SPEN about electricity disruption. OFGEM and BEIS note that NPG and others were reacting to early forecasts of strong wind. This may have been an opportunity for them to give early warning to other utilities. Information on restoration times was also not forthcoming, an issue also identified by OFGEM and BEIS. This hampered NWL's ability to respond, and the response of the LRFs and associated organisations.
- The IMT was formed promptly. The Wholesale team did not attend these calls until 1 December (though this has already been identified as an improvement area by NWL). Improving out of hours

incident response (Storm Arwen occurred during the weekend) is identified as an improvement area by several staff. For example, we understand Business Continuity had limited management cover for several days. The team responded well but having management cover would have lessened the burden.

- NWL's IMT and wider response teams were stretched. There were generally enough staff to fill roles but the goodwill of staff to work extra hours was relied upon. It was explained that incidents typically impact water or wastewater and as such, resources can usually be shared across the Directorates. This was not the case for Storm Arwen as both water and wastewater sites were impacted. It was suggested that a volunteer register could be developed. Jacobs has seen examples of these for other water companies.
- More staff require training in incident management and specific response roles, such as the AWC. NWL is currently reliant on specific individuals for certain roles (e.g. AWC) in terms of knowledge and expertise. In the Business Continuity team, there are plans to train more staff in the LRF liaison role. The Contact Centre also supported the RCC with night shifts for nearly a week. NWL should formalise out of hours arrangements to staff the Customer Contact Centre for extended hours during incidents.
- The maintenance of NWL's fixed generators (including load testing), their use in advance and during an electricity-disruption event and the use of mobile and hired generators could be optimised (for example to include load testing). In advance of more recent storm events, NWL has placed greater focus on considering whether sites need to be switched over to fixed or mobile generators in advance of events. This suggests learning from Storm Arwen is already being acted upon.
- It was identified that the operation of remote sites could potentially be improved to optimise automatus functionality.
- In general, it was identified that NWL's documented response procedures and guidance could be more concise. This is already being addressed through the review of the AWS manual which is being restructured to make greater use of visual flow charts and diagrams.
- It was identified that teams' abilities to respond to the event were made more complicated by continued receipt of business-as-usual requests. This suggests improved business wide communication may help to prevent actions that can be deferred detracting from incident response.
- Initial external communications were identified as being too rigid and not focussed on giving customers the location-specific information they needed. This resulted in negative customer feedback. This had been addressed by 29 November 2021 and received positive customer feedback.
- The Customer team identified that segmenting customers into those from NWL and those from Essex and Suffolk would help to prioritise focus during an event that impacts only one of these areas.
- The Wholesale team joined IMT calls on 1 December (the incident started on 27 November). At that point there had been no updates to retailers. This has already been identified as an improvement area for NWL.
- It was identified that NWL should review how it generates and uses the Operational Planning and Management (OPM) system. OPM reports were used by network analysts to assess the loss of an asset and its downstream impact, to identify locations for bottled water stations and tankering requirements to refill service reservoirs, and to push messages to customers in affected areas. Currently the process can take several hours and during the Storm Arwen event, it was identified that there were delays in getting information onto NWL's website. It was identified by NWL that small areas were missed from the OPMs during Storm Arwen but that it was used for the large areas and significant assets.

9. Conclusions and recommendations

Storm Arwen was one of the most powerful and damaging winter storms of the last few decades. The main hazard associated with Storm Arwen was wind, though it also brought very low temperatures for the time of year and some significant snow accumulations. Major incidents were declared in Northeast Scotland, Durham, Darlington and Northumbria, initiating multi-agency responses outside the scope of business-as-usual activities which were coordinated through the LRFs.

The highest (non-mountain) gust speed was 98 mph, recorded at Brizlee Wood in Northumberland. A wind gust as high as this is exceptional for this area (the wind gust record for north-east England being 107 mph at Lynemouth, Northumberland in December 1979).

When the northerly winds of Storm Arwen are considered, its maximum 30-second gusts in and around Northumberland have a return period between 1 in 20 years to greater than 1 in 50 years. This unusual extreme wind direction led to the storm causing more tree damage than would otherwise have been the case.

The wintry conditions after Storm Arwen caused additional difficulty with freezing temperatures and snow on higher ground. Compared to the historical temperature records for other major events, this is unusual for extreme wind events.

Review of NWL's emergency plans

Jacobs' review of the emergency manuals relevant to NWL's preparedness and response to Storm Arwen confirmed that they are comprehensive in their content and intended use. They are typical of emergency plans currently in use in other water companies in England and Wales. The manuals are reviewed on an annual basis to confirm their appropriateness.

The scenarios that NWL has planned for, as set out in its Emergency Plans Manual, are based on reasonable assumptions. It has exercised response procedures for appropriate incidents, including working with relevant stakeholders and other responders. Storm Arwen was an extreme event bringing additional consequences of power outages and blocked roads/site access due to downed trees. Even with the benefit of hindsight it is considered that this scenario is one that that would not reasonably have been exercised. There would be benefit in exercising aspects of a longer duration event, for example by introducing restricted availability of staff.

The review found no significant shortcomings with the plans and documentation. Some gaps were observed in the Generic Plan for Prolonged or Region Wide Disruption of Electricity Supplies and in the Generic Plan for Severe Weather Conditions. These relate to defining the timescale of a "prolonged" disruption to power supplies and the development or enactment of a portable generator deployment plan. The winter readiness plan appears to be an informal arrangement which should be developed into an official procedure, with the requirements reviewed annually.

Review of NWL's response to Storm Arwen

Storm Arwen was a severe event that resulted in disruption to the operation of some of NWL's assets that was beyond its control. Power outages resulted in shutdowns of some sites and the widescale loss of communications between remote sites and the RCC meant that understanding the scale and extent of issues was a challenge. Access to sites was also initially disrupted by fallen trees and unsafe travel conditions.

Data analysed by NWL after the Storm Arwen event indicates that water supply interruptions peaked at approximately 8,000 properties at around 1400 hrs on 28 November 2021. More than half of these interruptions were restored by 2200 hrs on 28 November 2021. By 0900 hrs on 30 November 2021, interruptions were being experienced by fewer than 1,200 properties. All interruptions were restored by 1200 hrs on 7 December 2021.

Jacobs considers that the actions NWL took during and in the aftermath of Storm Arwen were responsive and robust. It quickly mobilised its Incident Management Team and effectively organised what resources were available to manage the incident to the best of its ability. In particular:

- The strong teamwork and the personal efforts of those individuals involved ensured a sustained and effective response.

- Support from NWL's supply chain was widely acknowledged as positive. The local knowledge of tankering and bottled water supply contractors was highlighted as particularly helpful.
- The fact that most members of the IMT were working remotely was identified as highly beneficial by several individuals. This meant communication could be more frequent and targeted.
- NWL went beyond its duty in organising alternative water supplies for members of the public and farmers on private borehole supplies who were impacted by the power outages.
- NWL received good customer feedback to its external communications from Monday 29 November 2021 which included time-stamped updates by location.
- There was good coordination between the External Communications and Customer teams (discussing updates, shaping key messages to support the Customer team with calls, and ensuring that questions and comments were being managed by the Customer team).

Although NWL was hampered by a lack of information about power restoration from Northern Powergrid, it engaged well with the LRFs (through attendance at SCG and TCG meetings) and NWL's contractors and other organisations to provide alternative water and reinstate supplies.

As well as acknowledging NWL's good practice, several areas for improvement were identified. For a review of this type, for an unprecedented incident, it should be expected that there are lessons to learn and areas for improvement identified. Learning from previous incidents is a key aspect of the emergency planning continuous improvement process. Identifying areas for improvement comes with the benefit of hindsight and it is important to differentiate between shortcomings in the response at the time and improvements that can be made for future incidents. The majority of improvement areas identified during this review relate to general incident preparedness and to a large extent reflect the widescale and unprecedented nature of the Storm Arwen incident.

Table 9-1 summarises the evaluation of different aspects of the incident response and identified areas for improvement. Each recommendation is accompanied by a qualitative indication of whether the recommended action would have had the potential to reduce (low, medium or high) the number and severity of water supply interruptions experienced during and after Storm Arwen

Table 9-1: Summary conclusions and recommendations

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
General Preparedness			
Winter readiness	NWL enacts winter readiness procedures however these appear to be informal. It is understood that preparedness procedures do not include those related to storm events.	Winter readiness procedures should be reviewed to identify whether preparedness for storms can be enhanced and formalised. This may include for example, preparing the vehicle fleet and considering winter driving precautions.	Low It is unlikely that general winter preparedness would have had a significant impact

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Generators	<p>NWL's generators undergo annual servicing however it is understood this does not include load testing.</p> <p>Several NWL sites have fixed generators. It also has a fleet of mobile generators. The number of fixed and mobile generators appears to reflect legacy decision making rather than a up to date risk-based approach.</p>	<p>NWL's generator maintenance regime should include load testing where appropriate.</p> <p>NWL should review whether fixed generators should be installed at more of its sites and/or whether more mobile generators could be purchased.</p> <p>It should also consider whether retaining contracts could be established for hired in generators.</p> <p>NWL should engage NPG and SPEN to understand whether any learning regarding generator deployment during Storm Arwen can be shared, and whether resources could be optimised during future events.</p>	<p>Low / Medium</p> <p>Analysis (Section 6.3) has shown that issues with generators were the major contributory cause of only a small number of interruptions. Therefore, optimisation of the generator fleet and enhanced generator maintenance has low to medium potential to reduce the number of supply interruptions.</p>
Training and exercises	<p>NWL has conducted less training in incident management in the last three years compared to previous years.</p>	<p>NWL should review the resources it needs to deliver each role in its incident response and provide training accordingly.</p> <p>Training for the AWC role is especially required.</p> <p>NWL should exercise longer-duration events to test factors such as staff availability and supply chain performance.</p>	<p>Low</p> <p>All roles were fulfilled during the incident. The AWC role was particularly stretched but alternative water supplies were delivered. Likely to have limited impact on reducing supply interruptions.</p>
Staff standby rotas	<p>NWL operates a series of standby rotas however during Storm Arwen, some concerns over availability of standby staff (for example in the Business Continuity and Network Analysts teams) were identified. Having enough standby persons to take on incident management roles, especially for long duration events such as Storm Arwen is a key piece of learning.</p>	<p>NWL should review its standby rotas.</p> <p>It is recommended NWL adopts a volunteer register of staff who can help support with non-technical activities and free up appropriate staff to deliver technical activities.</p>	<p>Low</p> <p>All roles were fulfilled during the incident. Likely to have limited impact on reducing supply interruptions.</p>

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Before Storm Arwen			
Weather warnings	It is understood DNOs receive 10-day and 5-day weather forecasts. NPG commenced preparations on 24 th November before the weather warnings were issued.	NWL should review whether its weather forecasting service should be improved. NWL should evaluate whether proactive engagement with NPG and SPEN can be formalised into incident planning.	Medium Improved warnings may have enabled NWL to take more preventative action especially if NPG had provided notification of their actions from 24 th November.
Preventative action	NWL did not form a ESDWG in advance of Storm Arwen and its preparations in the days immediately before the storm were limited (1x water site was switched over to its fixed generators) and some teams added extra staff to their standby rotas. There was limited time from receipt of the yellow and amber weather warnings and the onset of the storm.	NWL should review how and when it forms its ESDWG. Proactive engaging NPG and SPEN in contingency planning.	Low / Medium It is difficult to assess whether the formation of a working group would have resulted in NWL taking more preventative action.
During Storm Arwen			
Initial response	During the night of 26-27 November 2021, many roads were blocked because of fallen trees and this restricted access to NWL's sites. These access and health and safety constraints meant that incident response was necessarily on hold until conditions improved. Staff explained that on the night of 26-27 November 2021 delays were between 4 and 8 hours. BEIS identified that poor conditions continued to impact access and safety for DNOs for 48 – 72 hours	None. NWL's initial incident response was appropriate, given the pressures it was facing and resources it had available.	Not applicable

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Incident Management Team	The IMT was formed early on 27 November 2021 and performed well throughout the event. The fact that most staff members could join calls remotely supported the overall response.	Wholesale team were not initially invited to the IMT. This should be improved in future events. The clarity of the IMT log could be improved. There is some repetition of information in the log. Greater rigour in recording of the incident would make identifying lessons learned more straightforward.	Low Likely to have limited impact on reducing supply interruptions.
Outage plans	NWL has Outage Plans for all its water sites but that these could not be implemented in all cases due to the widespread nature of the storm.	NWL should revisit its outage plans to consider their suitability during incidents that affect large areas (interdependencies between sites for example).	Low The widescale nature of the Storm Arwen event limits the effectiveness of site-specific outage plans.
Use of mobile and hired generators	It is unclear whether NWL's deployment of mobile and hired-in generators was based on a risk-based assessment of need.	NWL should develop a procedure for prioritising the storage and deployment of mobile and hired generators to its sites. NWL has already adopted new procedures to improve the recording of mobile generator deployment.	Low Given the widespread access difficulties caused by the storm, deployment of generators in the early stages was constrained.
Customer support	During 27 and 28 November 2021, the Customer Contact centre was overwhelmed with calls. NWL went beyond its duty in organising alternative water supplies for members of the public and farmers on private borehole supplies who were impacted by the power outages.	Efforts to segment calls between Northumbrian Water Group's two regions would help manage future events and NWL has already commenced implementation of this	Low No impact on supply interruptions but positive benefit for customer experience

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Priority customers	Ensuring customers on the PSR were kept up to date about supply outages (text messages and calls for example) and were provided with bottled water was a focus for NWL. The Fire Service assisted with bottled water supplies to priority customers.	During interviews with NWL staff it was explained that during the incident customers were requesting to be added to the PSR. Customers were added to the PSR register during the event however staff were unaware that they would need to re-run the report to identify the new additions. This has since been resolved and is now used routinely for subsequent events.	Low No impact on supply interruptions but positive benefit for customer experience
Working with the LRF and other organisations	Throughout the incident NWL attended the Durham and Northumbrian SCG and TCG meetings. These forums were useful for NWL to share information with other responders, however information on when power supplies would be restored (a critical information requirement) was not forthcoming from NPG. This is acknowledged in the OFGEM, and BEIS reports. Strong relationships with local councils, the DWI and public health bodies was important in enabling the effective flow of information between them.	NWL should continue to work with the LRF and other organisations to feed in lessons learnt from Storm Arwen to improve the flow of information during future incidents.	Low Little impact on supply interruptions though improved information from NPG could have had a major impact.
External Communications	External Communications team identified initial customer messaging as too generic and lacking site-specific context. From 29 Nov, the communication to customers became more specific, focussed on specific areas and time stamped. Customer feedback indicated this approach to communications was much better received.	NWL should act on its positive feedback for communications from 29 Nov onwards to enhance its communications during future events.	Low No impact on supply interruptions but positive benefit for customer experience

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Alternative water	<p>Though we saw no evidence of AWS failures during the event, it is clear that the AWS response was due largely to one person (the AWC) with little to no back-up resource.</p> <p>Contracts of suppliers providing AWS services are being reviewed. Though no specific issues were flagged to us, we understand that subcontracting of activities can occur and this can lead to messages getting lost or poorly conveyed down the supply chain.</p>	<p>NWL should train and resource the AWC role more effectively.</p> <p>The AWS Manual is currently being updated to make the manual easier to use.</p> <p>NWL should reviews its supplier contracts to optimise incident response.</p>	<p>Low</p> <p>The AWC role was stretched but alternative water supplies were delivered.</p>
After Storm Arwen			
Debrief and lessons learned	<p>NWL has been proactive in learning lessons about the Storm Arwen response. It has collated feedback from staff members, held an internal debrief and already begun implementing several enhancements to procedures and working practice.</p>	<p>None.</p>	<p>Not applicable</p>
Reporting	<p>The Water Quality team explained to us that the 72-hour and 20-day reports required by the DWI were submitted on time. Producing these plans was described as challenging, due to the difficulty of identifying the number of customers affected.</p>	<p>NWL should evaluate whether its procedures could be improved to support the internal and external reporting process.</p>	<p>Low</p> <p>No impact on supply interruptions</p>

Aspect of response	Conclusions regarding response	Recommendations	Potential to impact water supply interruptions
Compensation to customers	NWL has committed to paying its customers compensation for certain service failures.	NWL should consider if and how it can improve this process so that customers are paid any compensation they are owed faster.	Low No impact on supply interruptions but positive benefit for customer experience

Appendix A. Interviewees

Name	Role
Alan Willoughby	Alternative Water Manager
Alan Brown	Head of Water Quality and Assurance. Overnight IMT manager during Storm Arwen (Saturday)
Angela Brown	Wholesale Operations Manager
Claire Taylor	Head of Business Continuity
Dave Bartle	Network Control Room Team Manager
Gary Kinson	Water Quality Team Leader (North)
Helen Lumsdon	Head of Customer Operations
Ian Gray	Head of Business Resilience and Sustainability
Jim Howey	Network manager
Jonathan Bargh	Media Manager and Communications Manager
Keith Haslett	IMT Manager
Richard Saunders	Company Electrical Maintenance Manager
Richard Sutcliffe	Head of Water Supply (North)
Richard Warneford	Wastewater Director
Tony Baines	Wastewater Treatment Manager
Will Robinson	Senior manager on standby