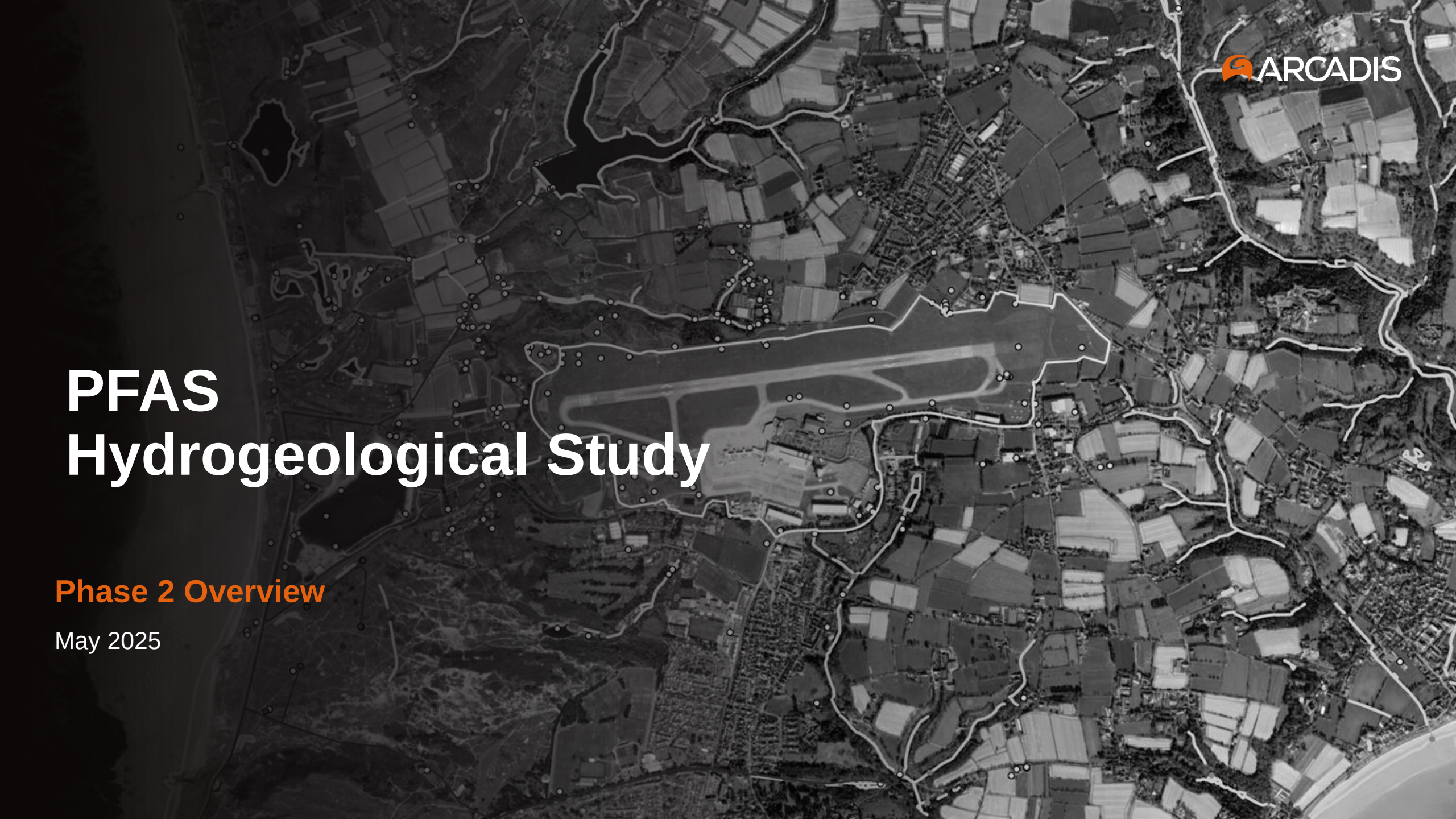


PFAS Hydrogeological Study

Phase 2 Overview

May 2025

Our team

Jake Hurst

PFAS Technical Lead

Arcadis UK PFAS lead, remediation expert and Chartered Environmentalist (CEnv) with over 20 years experience in environmental assessment and restoration.

Fiona Waldron

Project Manager

Fiona is a Chartered Scientist and Principal Geo-Environmental Consultant with over 12 years' experience in Land Quality assessment projects.

Laura Garland

Risk Assessment Lead

Chartered technical expert in the field of PFAS controlled waters and human health risk assessment, with over 15 years experience

Carol Davies

Hydrogeology Lead

Carol is a chartered hydrogeologist of over 30 years experience, specialising in hydrogeological impact studies.

James Lemon

Account Manager

James is a Chartered Environmentalist (CEnv) and Associate Technical Director with over 24 years of experience in the environmental sector as both a Consultant and Regulator.

Full project team includes >20 Arcadis consultants, field engineers and data management experts

Arcadis & PFAS

- Global design and engineering consultancy for natural and built assets. More than 36,000 people, in over 30 countries.
- Arcadis is at the forefront of a global effort to assess and manage PFAS at impacted sites and environments
- **>1000** Global PFAS projects in 12 Countries
- First UK Project in 2005 at Buncefield followed by Guernsey & Alderney Airports in 2008
- Currently supporting multiple airports, oil & gas, industrial facilities and water companies.
- Significant expertise in site investigation, risk assessment and remedial technologies
- Active in research and development

Agenda

1 Project Overview & Objectives

2 Phase 2 Scope of Works

3 Monitoring Results

4 Hydrogeological Conceptual Model

5 Risk Assessment

6 Remediation Options Appraisal

7 Recommendations

1

Project Overview & Objectives

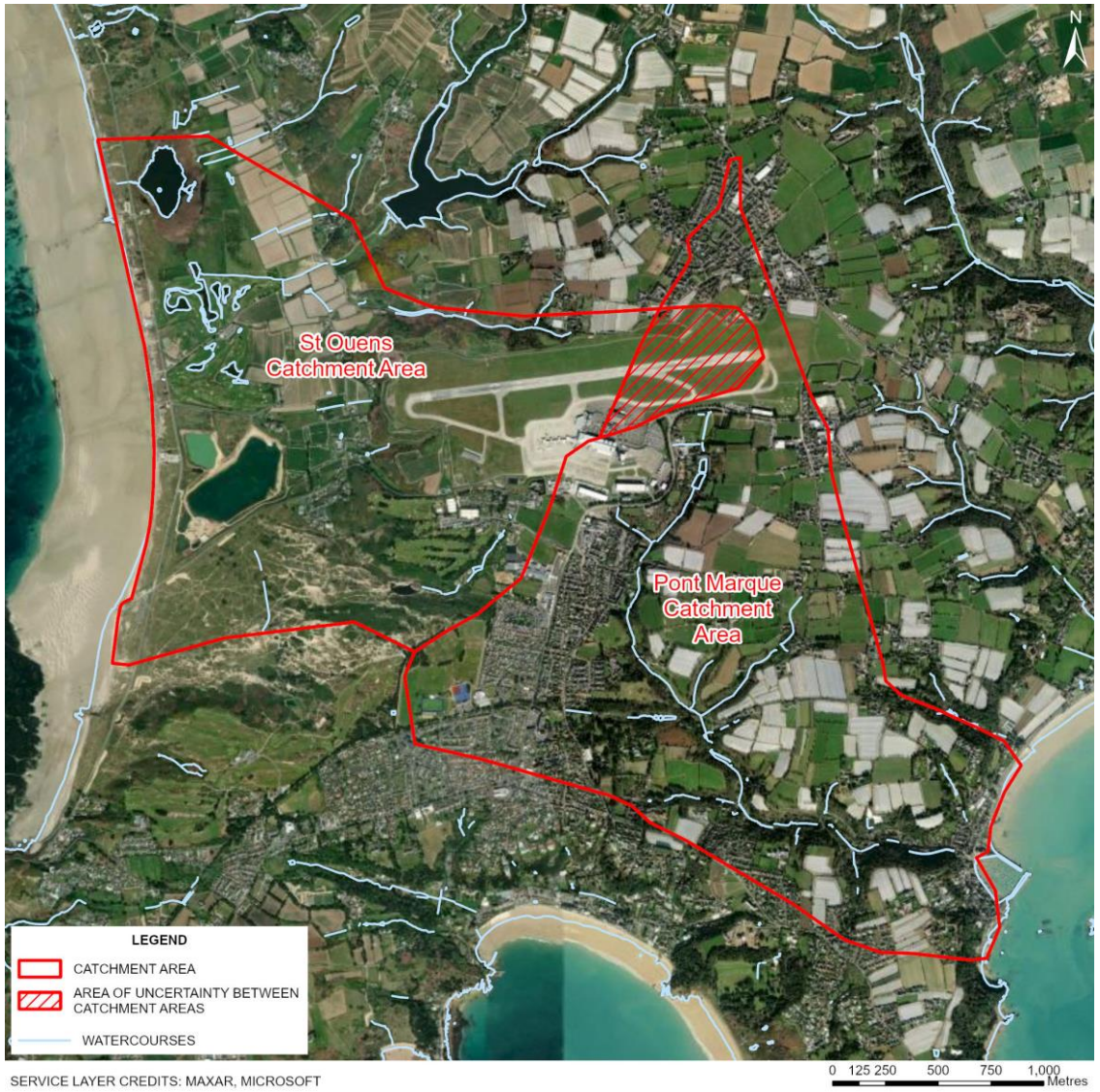
Project Background and Context

- Per- and Polyfluoroalkyl Substances (PFAS) large & diverse group of man-made chemicals
- Perfluorooctane Sulphonate (PFOS) is one PFAS compound

- Historical use of PFAS-containing firefighting foams at Jersey Airport
- PFAS identified in surrounding environment and private drinking water supplies
- Response activities included
  - **Ports of Jersey (PoJ)** - Fire Training Ground (FTG) redevelopment, remediation, changing foams, on-going assessment
  - **Jersey Water** - extension of mains public water supply, treatment optioneering
  - **Government of Jersey (GoJ)** Officer Technical Group established – monitoring & recommendations
  - **Independent PFAS Scientific Advisory Panel** formed – health and environmental focus
- PFAS remain present in groundwater, surface water and airport drainage outfalls
- Restrictions on current & future drinking water supply with ongoing public health concerns
- PFAS science and regulations continue to evolve rapidly

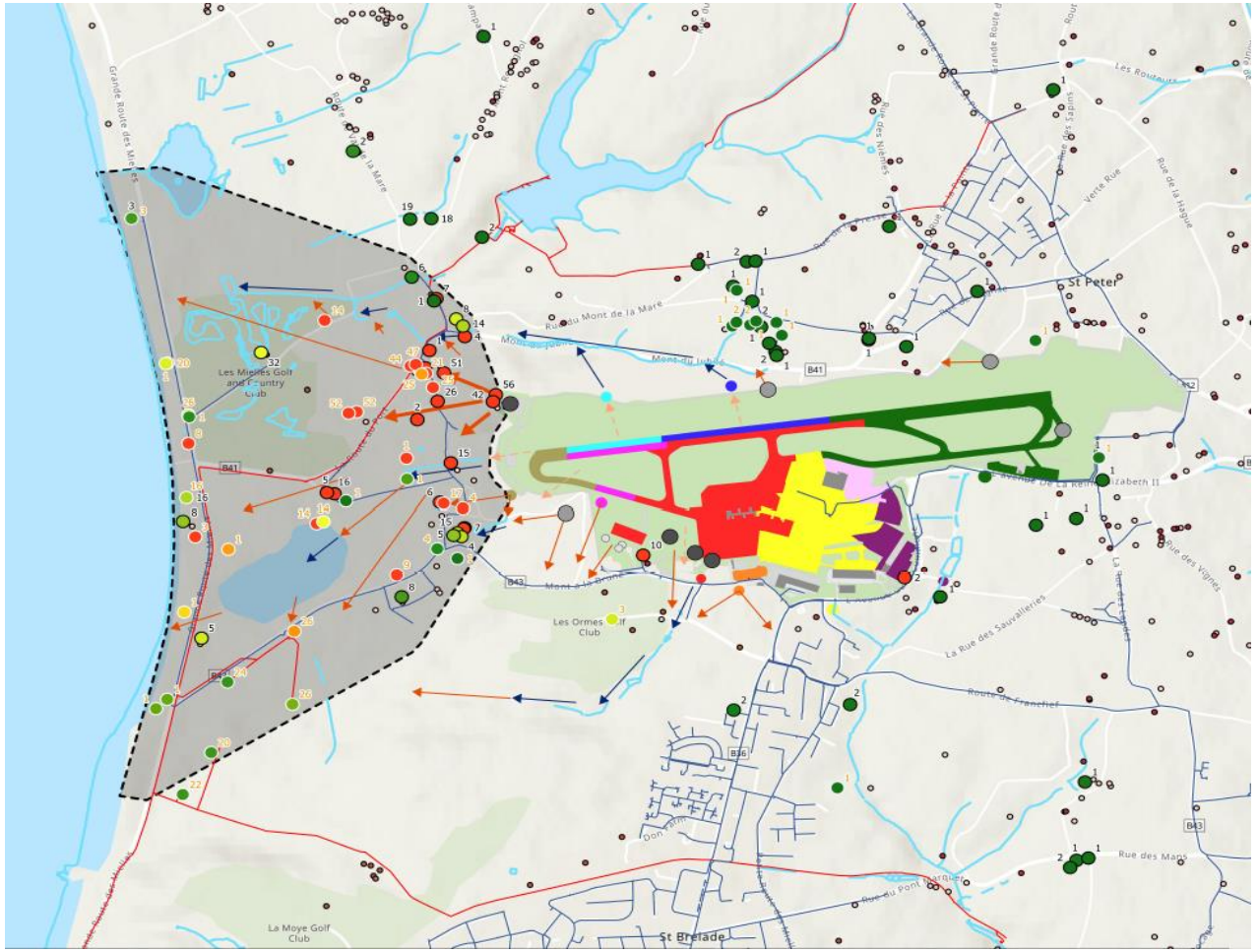
Project Objectives

- PFAS hydrogeological study and risk assessment within the St Ouen's Bay and the upper Pont Marquet catchments (2021)
- Overarching objectives
  - Further understand PFAS fate & transport and assess the potential risks to human health and the environment
  - Ensure safety and future security of public and private water supply
  - Build public confidence through effective communication
  - Help identify pragmatic and sustainable risk management options
- Commissioned by the GoJ – working with Water and Air team, Natural Environment Department with information provided by PoJ and JW
- Two phases of work - December 2021 to May 2025



Phase 1 Overview

1	Define Objectives
2	Review Existing Available Data
3	Update ArcGIS Model
4	Initial Conceptual Site Model (CSM) Development
5	Data Gap Assessment
6	PFAS Standards Review
7	Further Assessment / Monitoring Scoping
8	Tender Support



- Database of historical PFAS data (1999 to present)
- Data visualisation
- Initial Conceptual Site Model (CSM)

Source – Pathway – Receptor (SPR) linkage concept

- Holistic – but focus on foam-related impacts to drinking water & the environment
- Preliminary Risk Assessment (PRA)
- Data gaps – informing Phase 2

2

Phase 2 Scope of Works

Phase 2 Scope of Works

1	Further Assessment Monitoring
2	Update GIS Model
3	Hydrogeological CSM Development
4	Numerical Modelling to Support Risk Assessment
5	Risk Assessment
6	Waste Management Action Levels
7	Remediation Options Appraisal (ROA)

- Quarterly visits to collect samples – Jul 2023 to May 2024
- Field work by GoJ W&A team and Arcadis
- PFAS specific sampling protocols
  - 31 groundwater boreholes
  - 27 surface water locations
  - 6 drainage outfalls
  - ~230 samples + 34 QAQC
- PFAS passive samplers
- Groundwater elevations & property testing
- 3 new boreholes – Le Mont a la Brune and Blanches Banques
- Constraints, permissions & complex logistics

Phase 2 Further Assessment Monitoring

PFAS Sampling Training

Groundwater Monitoring

Surface Water Monitoring

Drilling new groundwater boreholes

Sampling from Residential Properties

Passive Samplers

All weathers

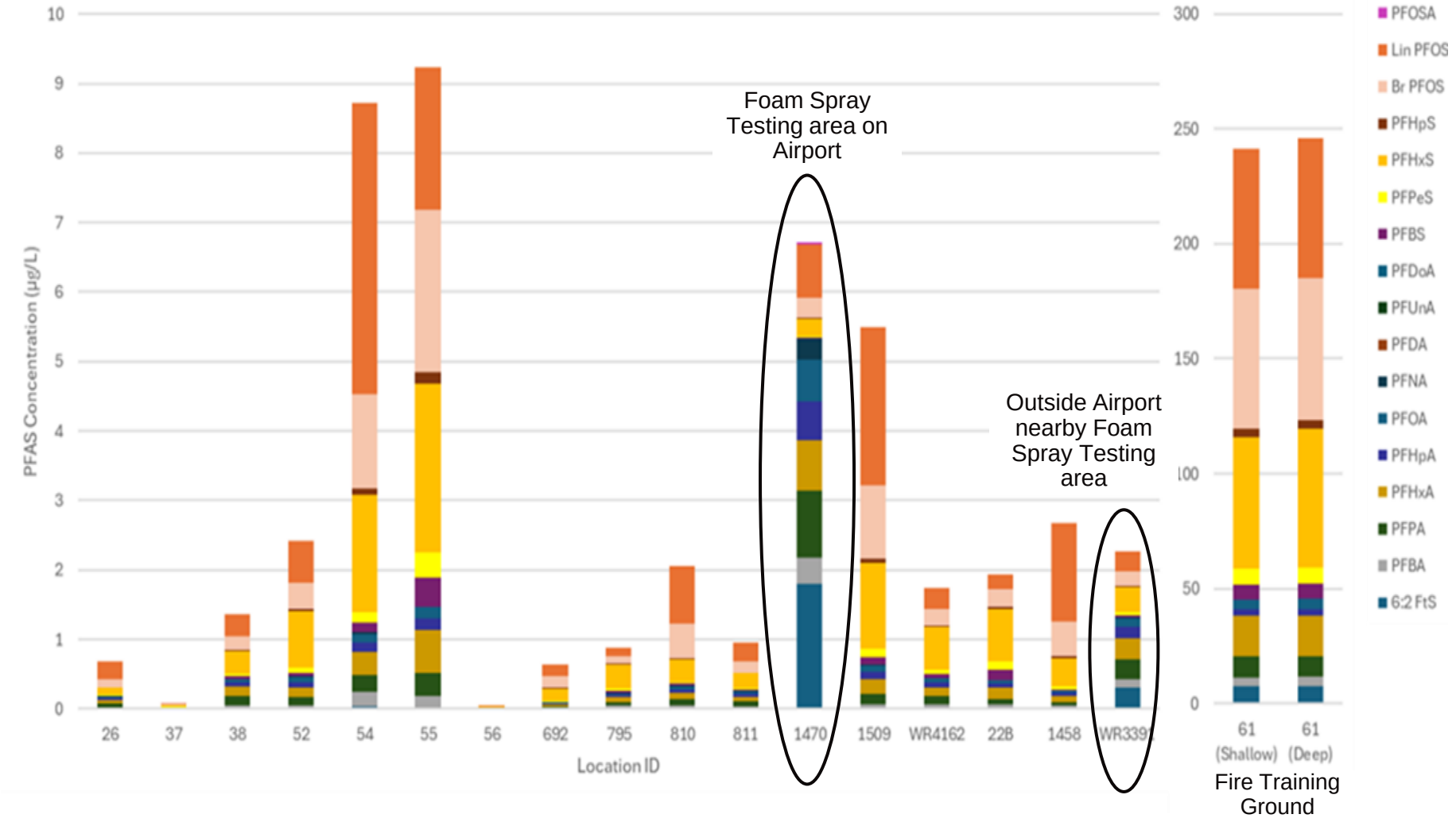
3

Monitoring Results

Monitoring Results – Characterisation

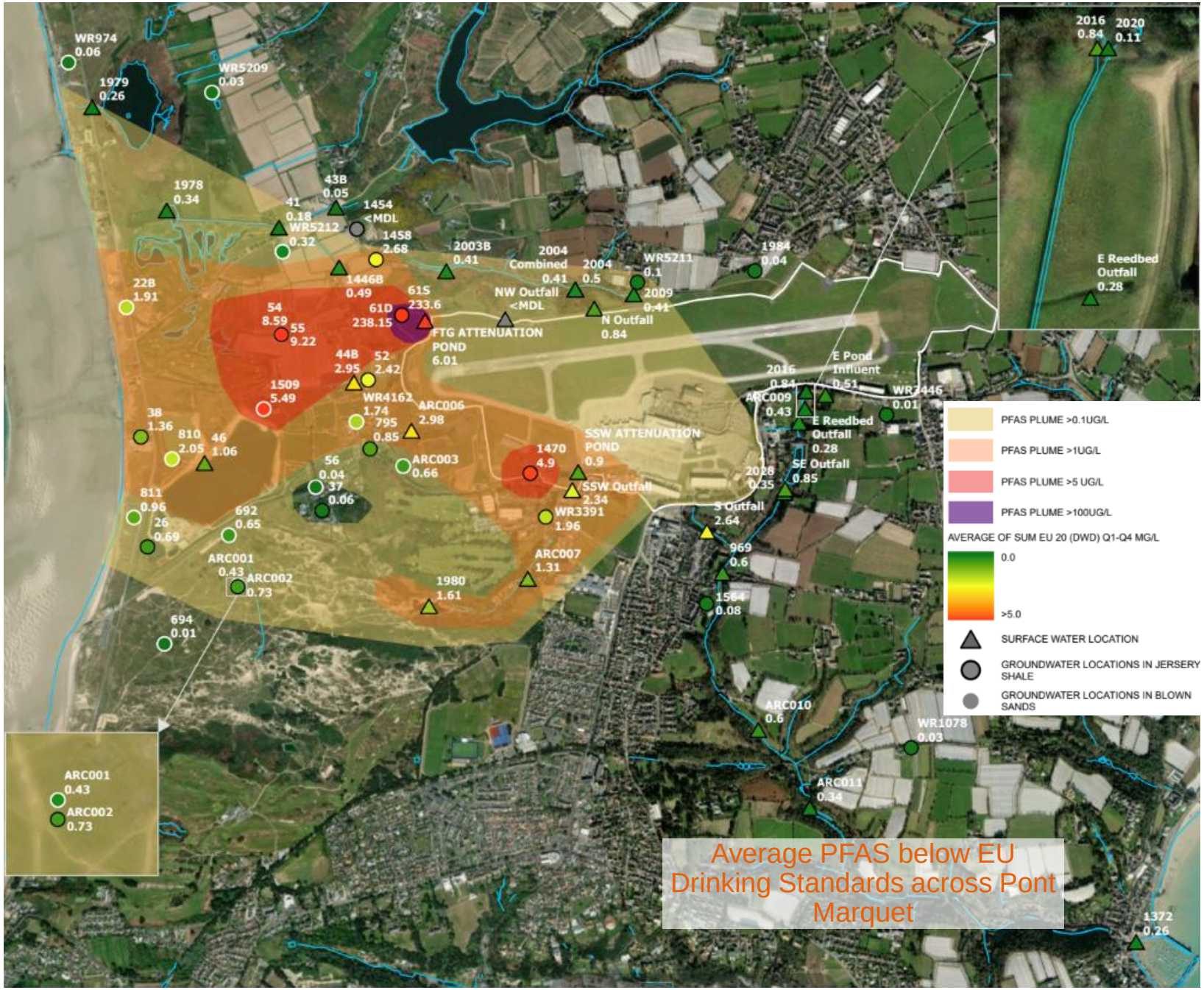
- Similar PFAS ‘fingerprint’ in nearly all wells – from FTG to Blanche Banques well field
- Indicative of a legacy PFOS-based foam – mature plume

- Exception is former foam spray testing area – different fingerprint
- Reflects mix of PFOS-based and other foam types
- The same fingerprint also observed groundwater outside the airport nearby



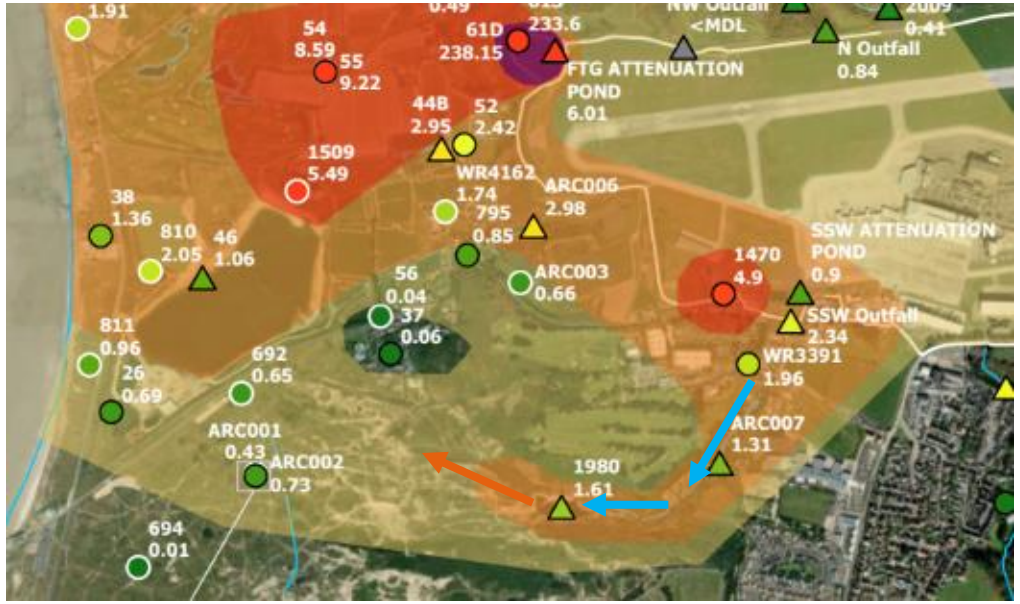
PFAS Distribution in Groundwater

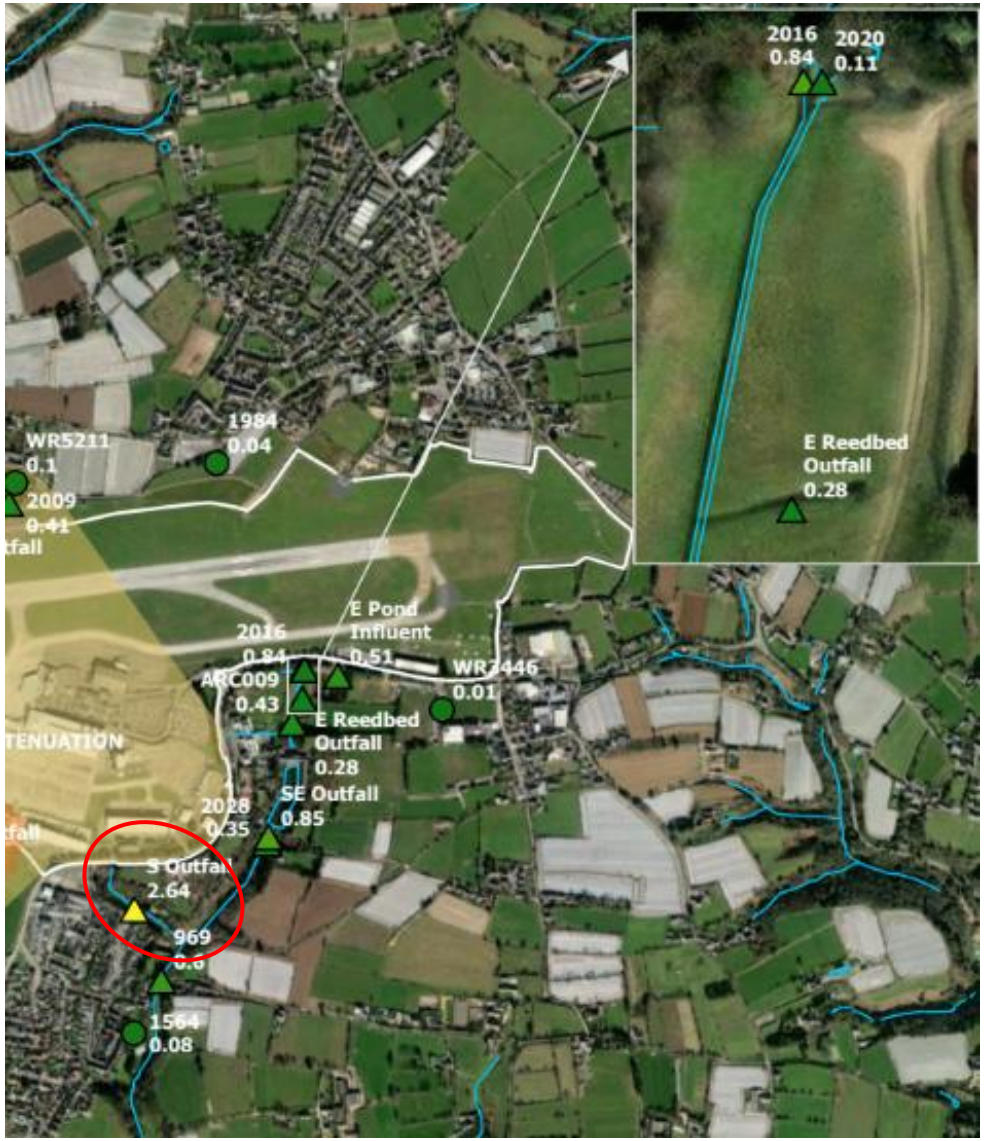
- Data shows Sum of 20 PFAS compounds in the EU drinking water standard
- Highest PFAS concentrations beneath the FTG – also foam spray testing area
- Plume follows westerly groundwater flow – reducing with distance
- Southwesterly flow component likely due to Simon Sand Pit and historical pumping from the well field
- Data indicates a significant residual PFAS source beneath FTG
- Concentrations beneath FTG variable – PFAS likely present both above and below groundwater



PFAS Distribution in Surface Water

- Creepy Valley stream fed by SSW Outfall - important pathway to Blanche Banques via seasonal pond
- The South Outfall - highest PFAS concentrations to Pont Marquet stream





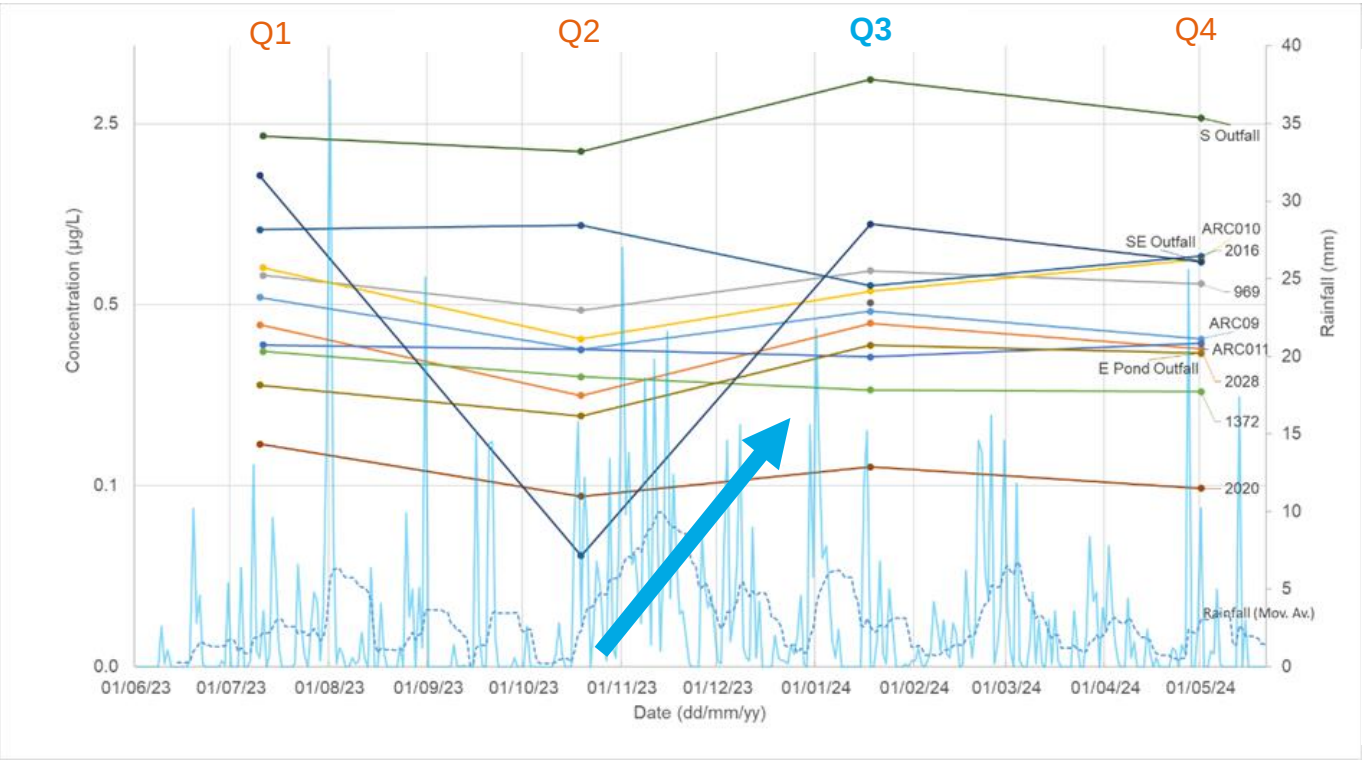
PFAS Distribution in Surface Water

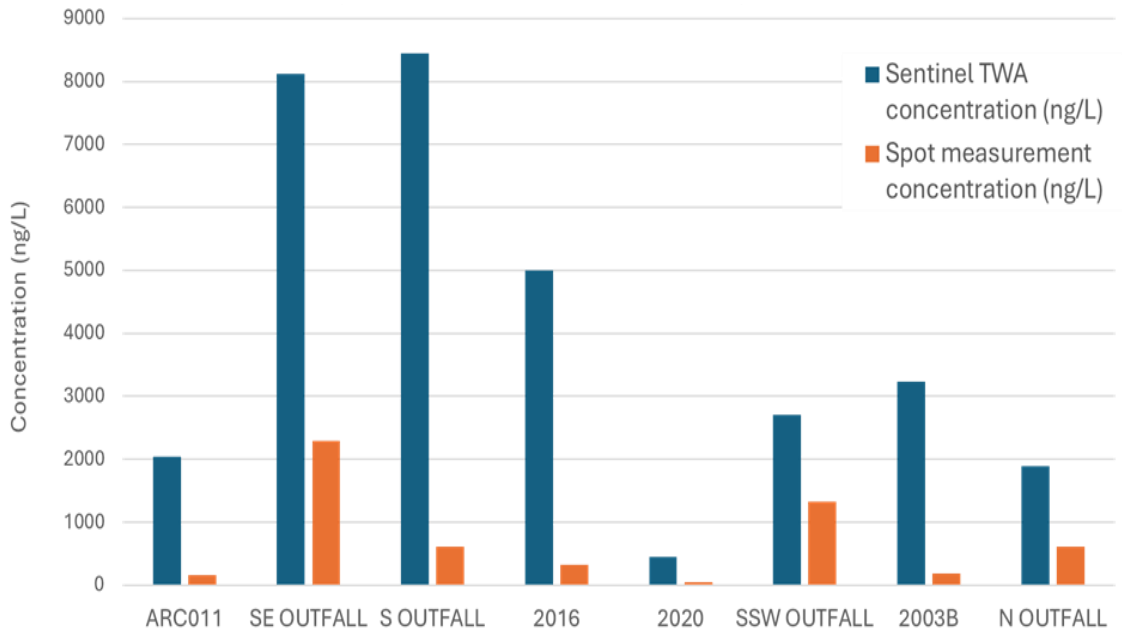
- Rainfall, and potentially airport de-icing events, increases PFAS concentrations from certain outfalls

Average concentration over 2 weeks from Passive Sampler

>

Spot Measurements on a single day



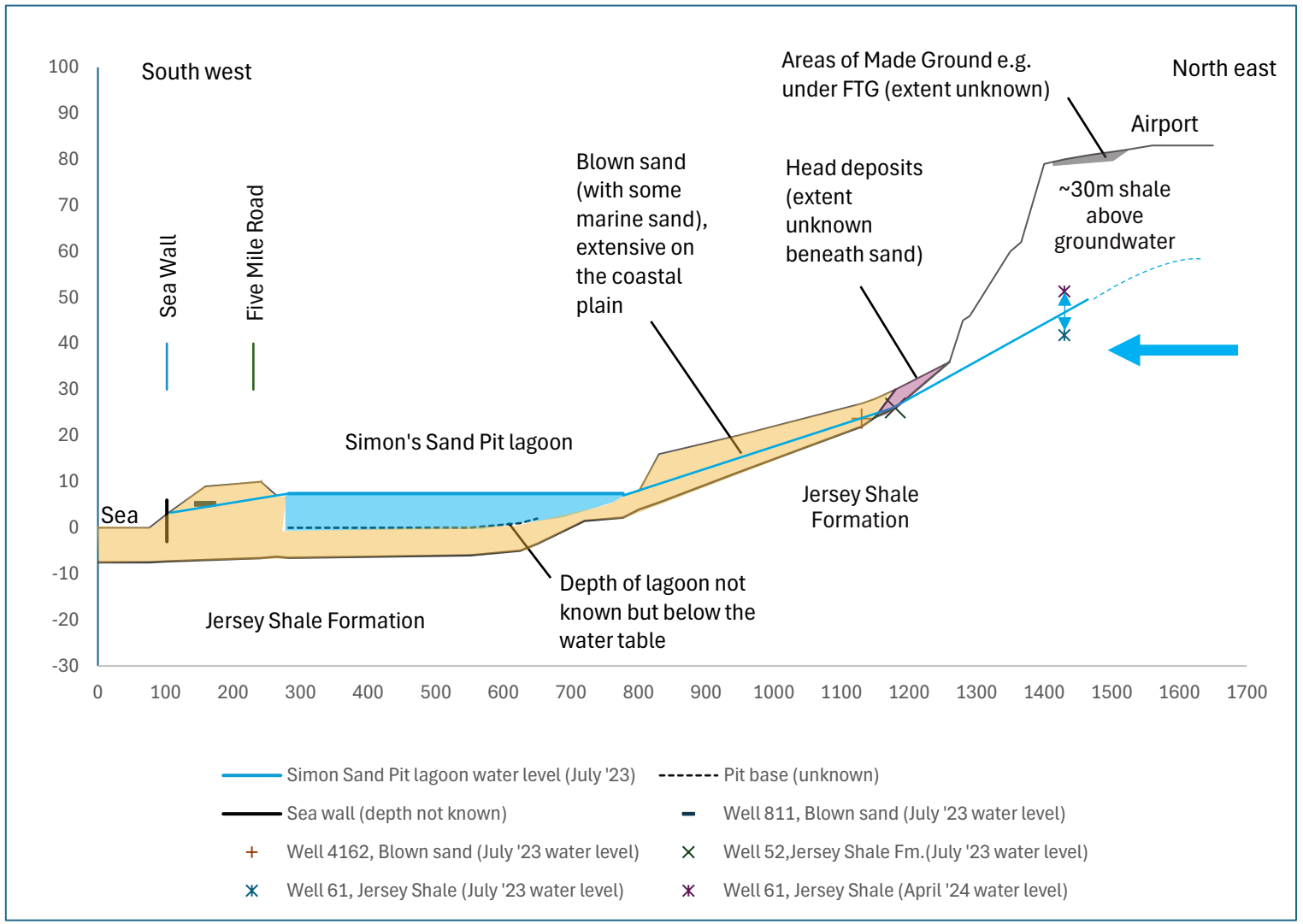


4

Hydrogeological Conceptual Model

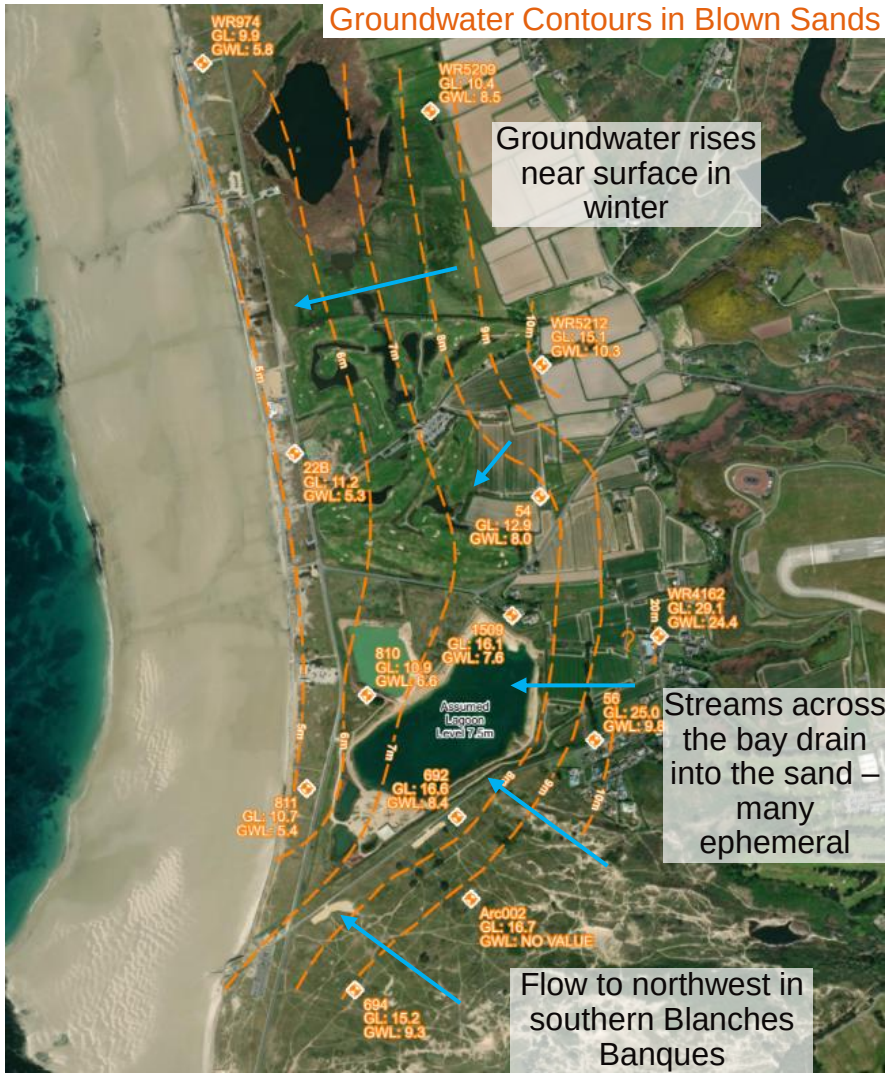
Hydrogeological Model – St Ouen's Bay

- **Jersey Shale Aquifer** – deeper bedrock, highly fractured at upper surface
- **Blown Sand Aquifer** – shallow, majority of abstractions incl. JW drinking water
- Similar groundwater levels in both – so in continuity (connected)

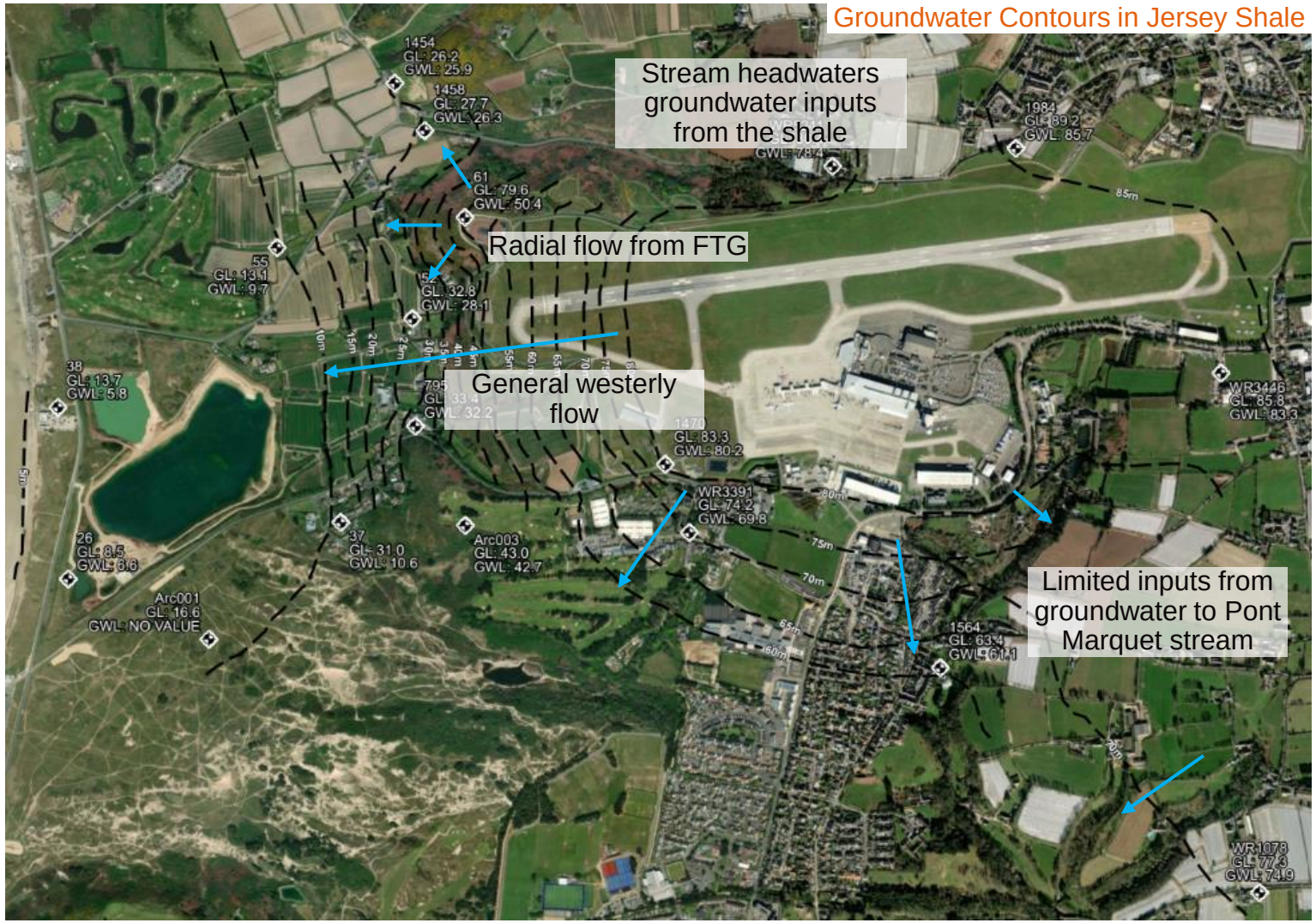


Hydrogeological Model – Groundwater Flow

Groundwater Contours in Blown Sands

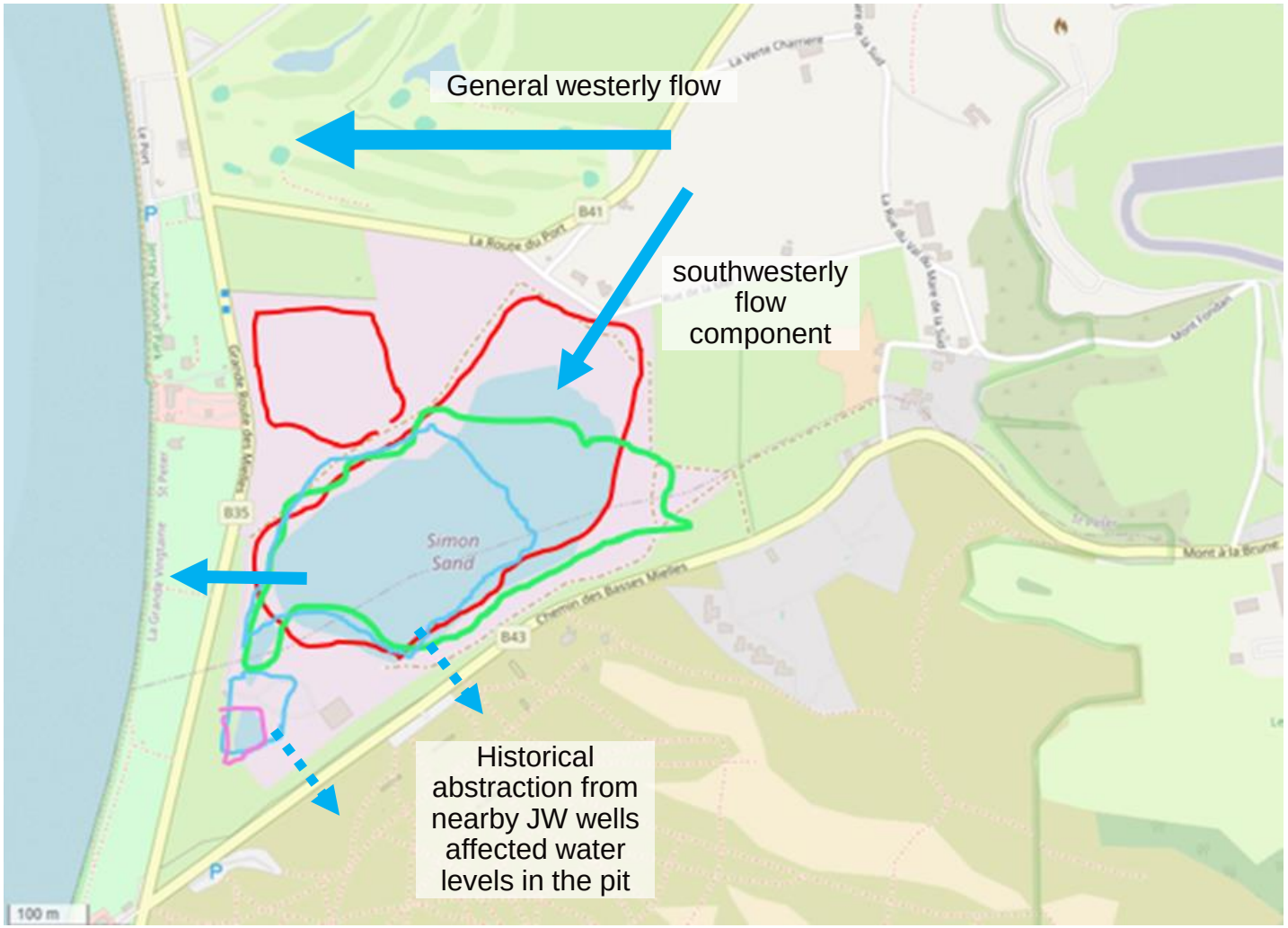


Groundwater Contours in Jersey Shale



Hydrogeological Model – Groundwater Flow

- Simon's Sand Pit likely influencing groundwater flow direction – especially in summer
- Easy pathway for groundwater migration - PFAS plume showing a southwesterly component
- Historical pumping from JW well field affected water levels in the pit – potentially pulled water into the abstraction area
- Similar PFAS fingerprint across the pit – groundwater to surface water.

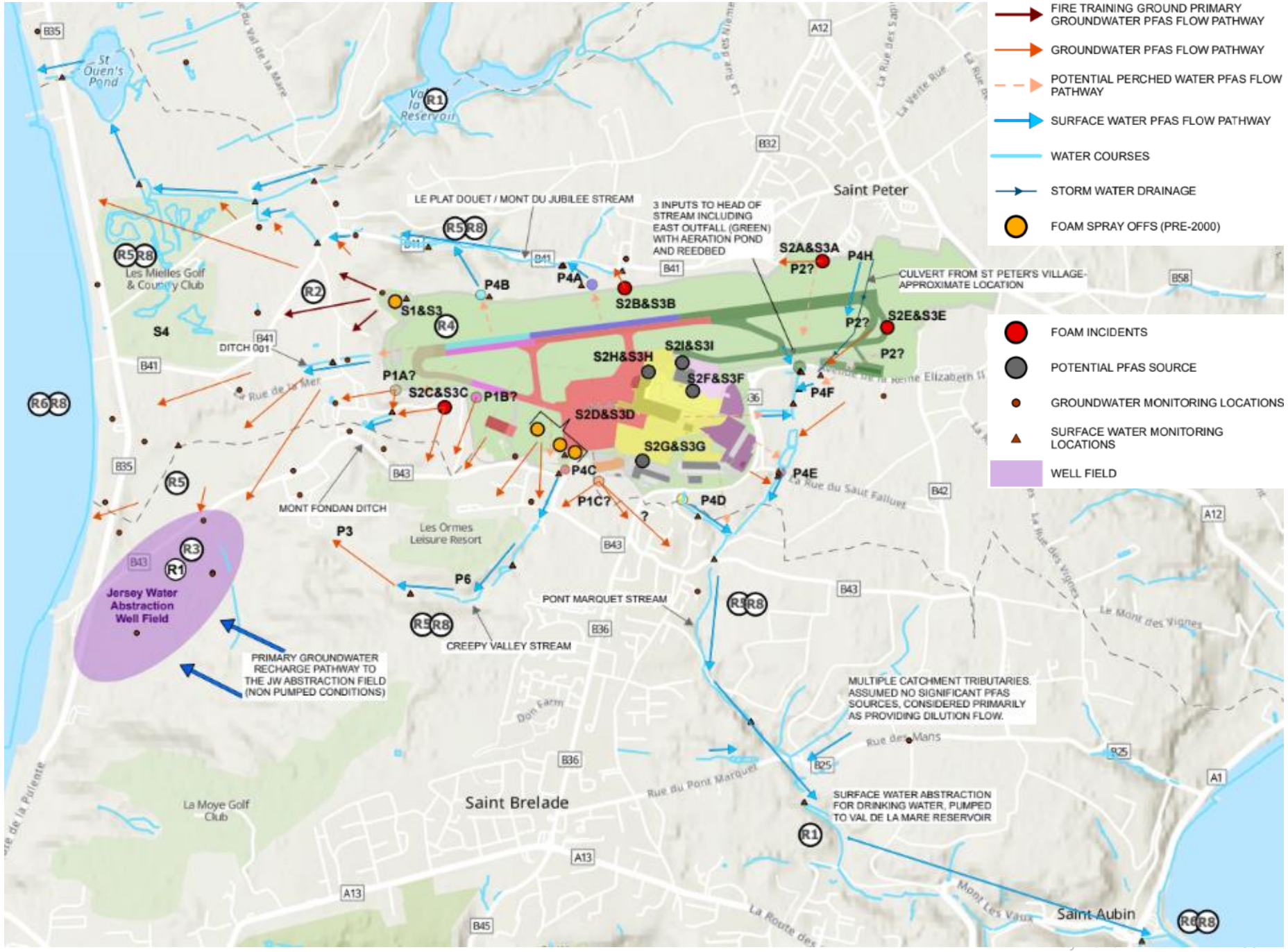


5

Risk Assessment

Updated Conceptual Site Model (CSM)

- Updates the initial CSM from Phase 1
- Confirms active Source Pathway Receptor (SPR) linkages
- Underpins risk assessment and remediation options appraisal.



Tier 2 Generic Quantitative Risk Assessment

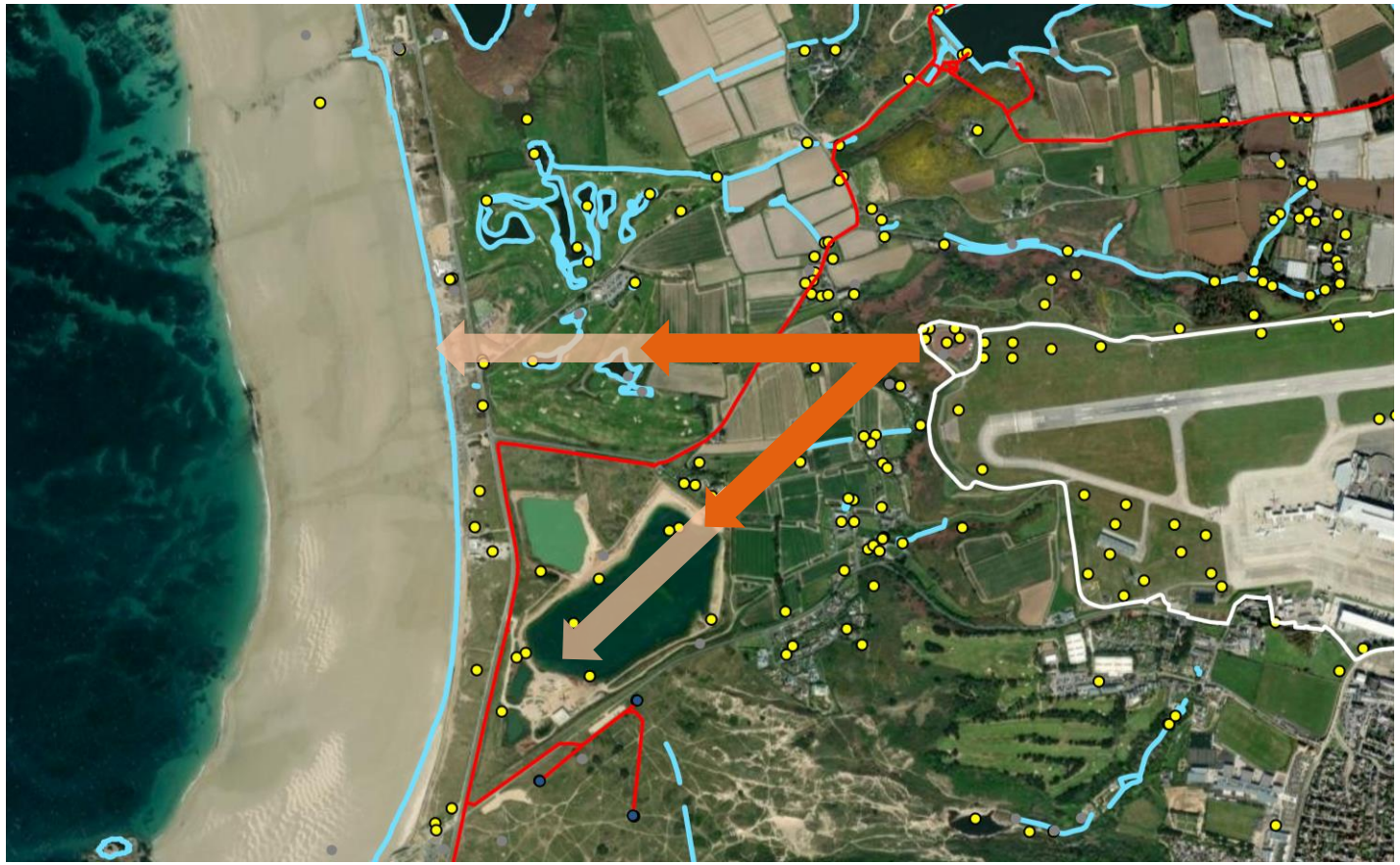
UK Land Contamination Risk Management (LCRM) guidance

- Concentrations of PFAS in groundwater and surface water compared to generic screening criteria:
  - UK DWI guidance (47 individual PFAS)
  - EU Sum 20 drinking water standard
  - Environmental Quality Standard (EQS) for PFOS.
- Widespread and regular exceedances of these screening criteria across both catchments
- Both JW abstractions are above drinking water criteria
- Elevated PFAS in soil and soil leachate in airport FTG and other ‘hotspots’

Tier 3 Detailed Quantitative Risk Assessment

Stage 1: PFAS Fate & Transport Model from the Fire Training Ground (FTG)

- Model used to estimate PFAS travel times - calibrated by measured concentrations
- Estimated travel times for PFAS to reach maximum predicted concentrations (‘steady state’) via Blown Sand aquifer:
  - JW abstraction field and Les Mielles golf course ponds **20 – 60 years,**
  - Marine environment **40 – 100 years**
- If ‘complete’ FTG remediation undertaken – improvements at JW well field <5 years but 20-60 years for lower, stable concentrations to establish;
- Pont Marquet stream catchment - respond faster



Tier 3 Detailed Quantitative Risk Assessment

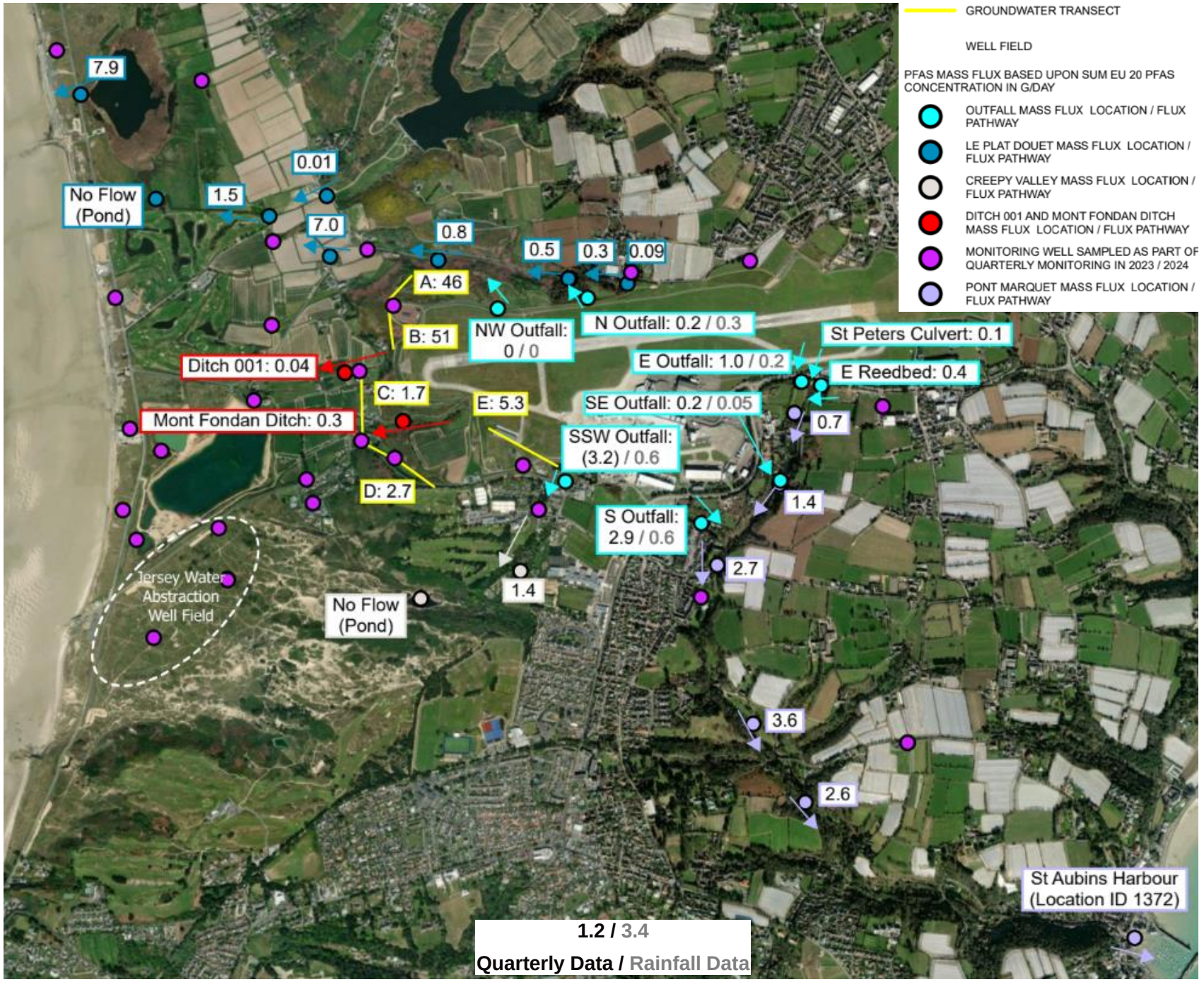
Stage 1: PFAS Fate & Transport Model from the Fire Training Ground (FTG) continued…

- PFAS foam usage ~1970s – 2020 (PFOS foam until 2004)
- Historical pathways via soakaway and drains identified
- FTG replacement 2003/2004 – PFAS contaminated soils placed in containment cell under new FTG
- Remedial groundwater pumping 2004 – 2009
- New FTG captures & reuses rainwater, also coffer dam

Tier 3 Detailed Quantitative Risk Assessment

Stage 2: Assessment of PFAS Mass Flux

- Mass flux = concentration x flow
- Identify linkages with the highest contribution of PFAS to receptors
- Highest mass flux:
  - Groundwater from FTG and foam spray areas
  - SSW and S Outfalls



6

Remediation Options Appraisal

Remediation Options Appraisal

Guiding Principles & Objectives

Overall Remediation Aim

- "To reduce PFAS mass flux to the environment to effectively manage public health and the environmental risks as well as support Jersey Water's 25 year plan in a balanced, proportionate and sustainable manner which is acceptable to key stakeholders"
- More specific objectives to be developed – technology dependent, complex, flux versus compliance

ROA Objectives

- Identify, evaluate & shortlist options – independent & data led
- High level appraisal – first stage in a process, robust & transparent framework, inform stakeholder decision making
- Identify further assessment & design works - targeted & phased

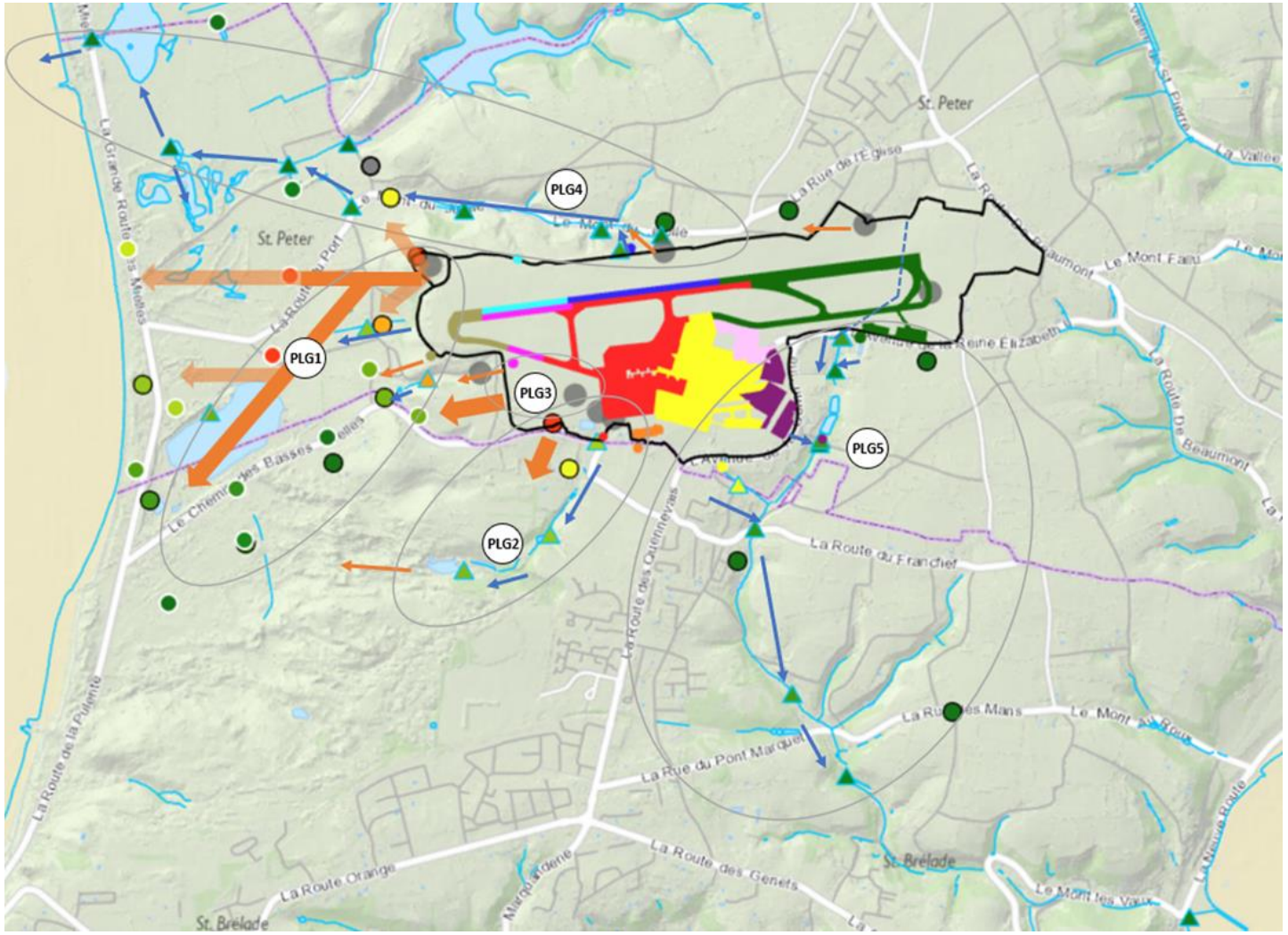
Guiding Principles

- Prioritise the greatest benefit (PFAS flux & risk reduction) at lowest cost and impact to stakeholders
- Typically target highest concentrations in the smallest volume
- Large scale plume treatment often cost prohibitive
- Combination of actions likely required from multiple stakeholders

Relevant Pollutant Linkage Groups (PLGs)

- Interconnected groups of pollutant linkages to address by remediation
- 5 PLGs identified and prioritised based on updated CSM and PFAS mass flux

Relevance Score		
1	PLG 1	FTG to St Ouen's Bay & JW Well Field
1	PLG 5	Outfalls to Pont Marquet JW Abstraction
2	PLG 2	SSW Outfall via Creepy Valley to JW Well Field
4	PLG 3	Foam Spray Area to St Ouen's Bay
5	PLG 4	Outfalls to La Plat Doue to sea via St Ouen's Pond



Remediation Options Appraisal

- Systematic, qualitative appraisal of identified technologies by **12 Evaluation Criteria -** for each PLG

Technical Considerations	Potential to Achieve Remedial & Project Objectives	Suitability to address magnitude and range of PFAS	Technology Development Status & Availability	Suitability to Environmental Setting
Operational Considerations	Impact on Site Operations and Future Area Use	Ongoing Management	Implementation Timescale	
Commercial Considerations	Capital Expenditure	Operational Expenditure		
Liability, Sustainability and Stakeholder Considerations	Long Term Effectiveness & Residual Liability	Environmental Sustainability	Stakeholder Acceptance / Considerations	

- Soil, groundwater and outfall remediations options assessed
- Clear rationale for Red, Amber, Green (RAG) status
- Options shortlisted then further priortised

Shortlisted Options & Suggested Priorities

PLG 1 FTG to St Ouen's Bay & JW Well Field

Remediation / Management Option	Priority
Soil	
Targeted Excavation & Disposal	Medium
Targeted Capping	
In Situ Flushing	Medium
Source Area Groundwater	
Groundwater Pumping & Hydraulic Containment	High
Pathway / Plume	
Groundwater Pumping Barrier / Dynamic Groundwater Recirculation (DGR)	Low
Injectable Colloidal Activated Carbon (CAC) Barrier	Low
Infilling of Simon Sand Pit – Passive Barrier	Medium
Drinking Water	
Abstraction Locations / Blending / Treatment	High

PLG 5 Outfalls to Pont Marquet JW Abstraction

Remediation / Management Option	Priority
Airport Drainage Outfalls	
Drainage Survey / Repairs / Cleaning*	High
Hardstanding Cleaning	
Eliminate any other PFAS uses	
Active Stormwater Treatment	Medium
Passive Stormwater Treatment	High
Soil	
Engineered Containment / Landfill / Stabilisation & Solidification	Further Assess
Source Area Groundwater	
Groundwater Pumping & Hydraulic Containment	Further Assess
Drinking Water	
Blending / Treatment	High

*could include reedbed renewal

7

Recommendations

Recommendations

The hydrogeological study provides valuable insights into PFAS migration and options to manage potential risks

It recommends:

- The study should inform GoJ decision making, in collaboration with stakeholders, to agree a structured process, team and schedule to select remediation and management option(s)
- Inform wider PFAS assessment works by GoJ and Independent PFAS Scientific Advisory Panel
- Key data gaps identified should be addressed
- A targeted and phased assessment of prioritised options – including costs & benefits – to develop a Remediation Strategy with on-going input from:
  - Continued investigation of airport by PoJ
  - Continued investigation of water supply management options by JW
  - Continued monitoring programme by GoJ
  - Review any plans and schedule for Simon Sand pit infilling
- Progress development of waste and remediation criteria

Thank you

Arcadis. Improving quality of life.