SCOTTISH ENVIRONMENT PROTECTION AGENCY

A PRESENTATION TO THE Scottish Contaminated Land Forum

October 2020

SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

SCLF
Scottish Contaminated Land Forum

Groundwater Sampling

David Pearks - Senior Hydrogeologist

THE SCALE OF THE CHALLENGE

If everyone lived as we do in Scotland, we would need three planets to sustain ourselves. Businesses, societies and nations which will thrive in the 21st century are those which have developed ways to prosper within our environmental capacity.

> “The scale of environmental challenges facing humanity is enormous, with a real urgency to act. Poor leaders are going to pretend it isn’t a problem, good leaders will face the reality of the situation. Only great leaders will understand that it is an opportunity for their businesses and organisations.”

Quote attributed

ONE PLANET PROSPERITY

Every day SEPA works to protect and enhance Scotland's environment, helping communities and businesses thrive within the resources of our planet. We call this **One Planet Prosperity.**

In every sector we regulate, this means we will have two simple aims. We will:

1. ensure that every regulated business fully meets their compliance obligations;

2. ensure as many regulated businesses as possible will go beyond the compliance standards. Regulating across whole sectors will help to tackle compliance issues and identify opportunities.

Terry A'Hearn, EPA Network, Edinburgh

Outline

- Reasons for sampling
- Guidance
- Terminology
- Monitoring location types
- Planning
- Borehole design
- Purging
- Sampling
- Decommissioning
- Licensing
- Data management and reporting
- SEPA monitoring and data

Not going to cover:

- H&S
- QA/QC procedures
- Biosecurity
- Specialised sampling

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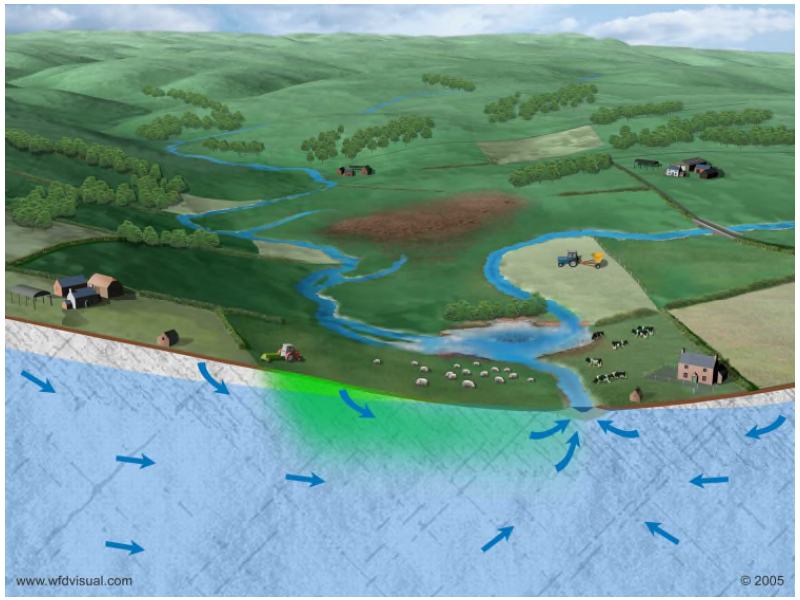
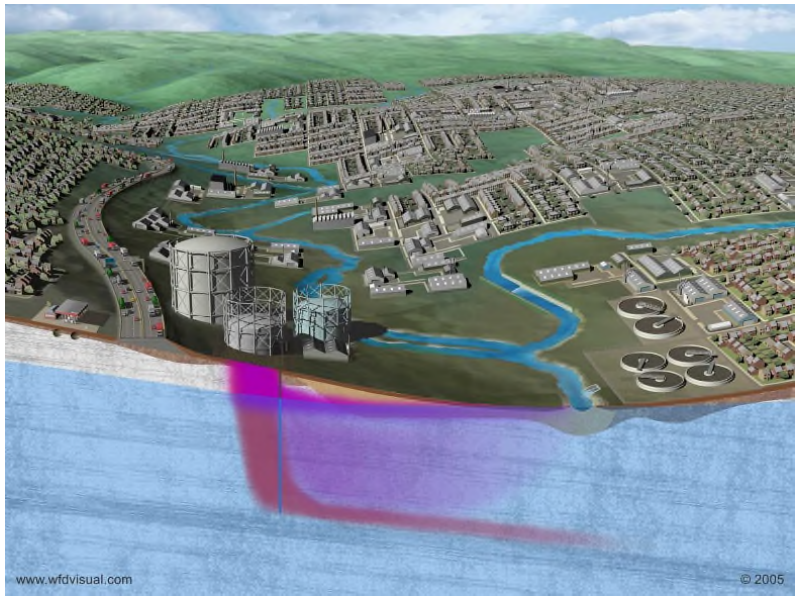
Why do we want to sample groundwater?

What is the legislative context and environmental setting?

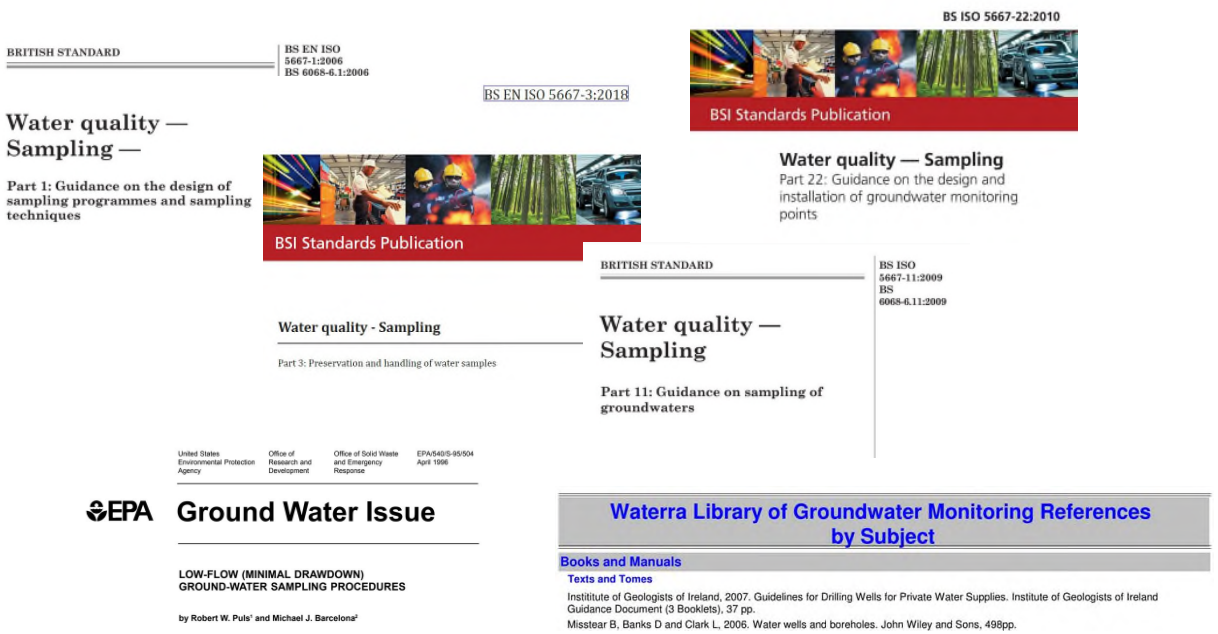
- WFD classification
- Regional baseline studies
- Diffuse pollution
- Compliance monitoring
- Legacy land contamination
- Risk assessment
- Pollution incidents
- Waste crime

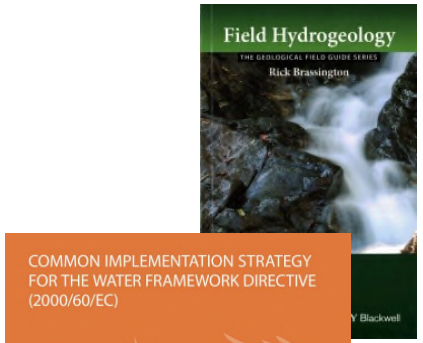


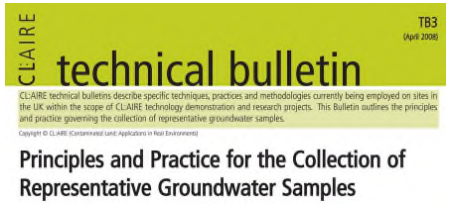


Guidance

- BS ISO 5667-
  - 1:2006
  - 3:2018
  - 11:2009
  - 22:2010
- BS 5930
- BS 10175
- CL:AIRE
- Regulatory guidance
- Published literature







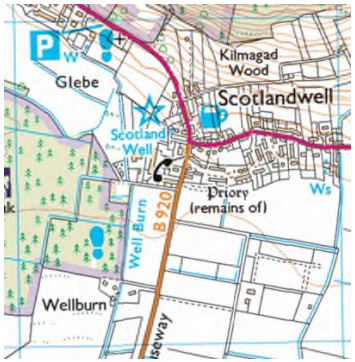
Geological Society, London, Engineering Geology Special Publications

Borehole sampling techniques and field analysis of groundwater in landfill pollution studies

A. Stuart and S. P. Hitchman

Geological Society, London, Engineering Geology Special Publications 1986; v. 3; p. 225-246
doi: 10.1144/GSL.ENG.1986.003.01.26

Terminology: what is a well?



It depends on the context

- Traditional, shallow, dug
- Spring
  - Often important for cultural or religious reasons
- Purpose drilled borehole
  - Monitoring
  - Water supply borehole
- Oil and gas
  - Exploration
  - Production

Terminology: what is a sample?

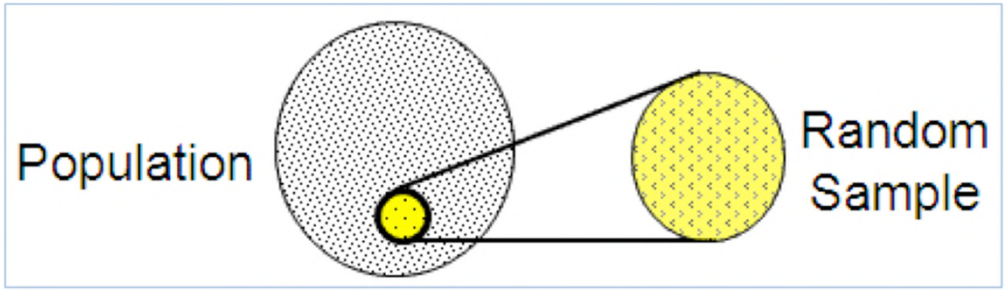
1

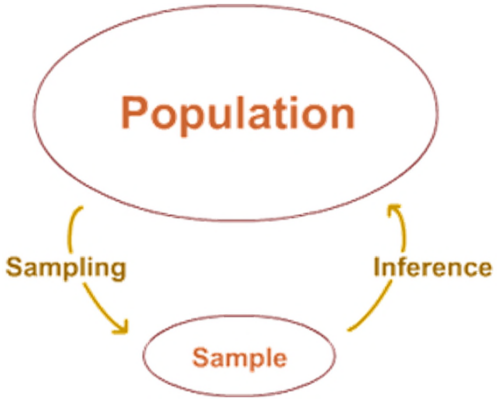
1: *a small amount of something that shows you what the rest is or should be like*

2: *a group of things that is chosen out of a larger number and is tested in order to get information about the larger group*

Cambridge English Dictionary

2





Types of groundwater sampling locations

Surface waters

Standpipe in backfill

Shallow well

Public water supply / commercial abstraction

Less uncertainty / more representative sample

Trial pit / excavation

Springs

Purpose built borehole

- Level of confidence required
- Tolerable uncertainty
- Cost / reliability

Planning

Careful planning to optimise sampling programme is essential.

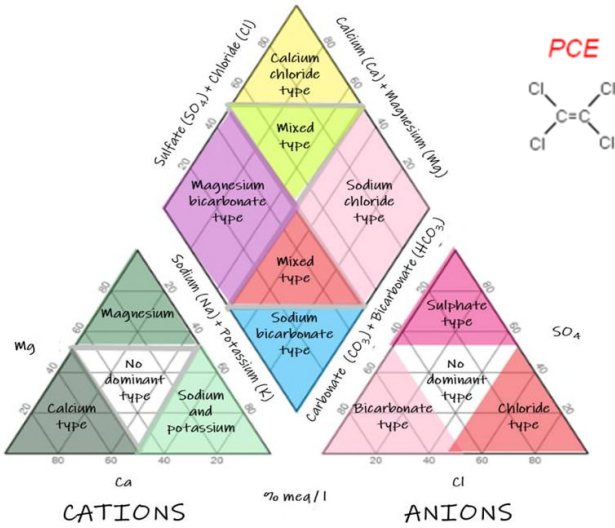
Data gaps → unacceptable uncertainty

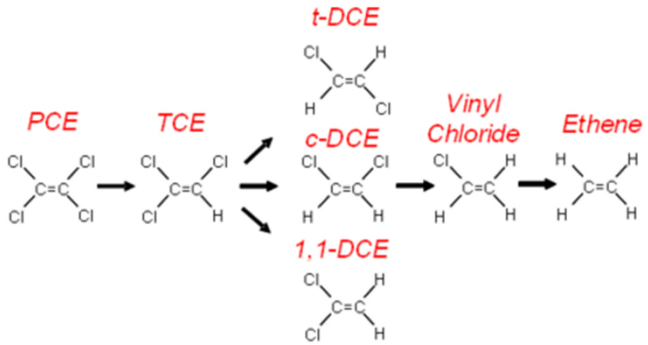
Groundwater investigation aims

- Clear
- Measureable

Key considerations

- Locations
- Analytical parameters
- Sampling duration
- Sampling frequency
- How many samples?





Integrated investigations: cost savings?

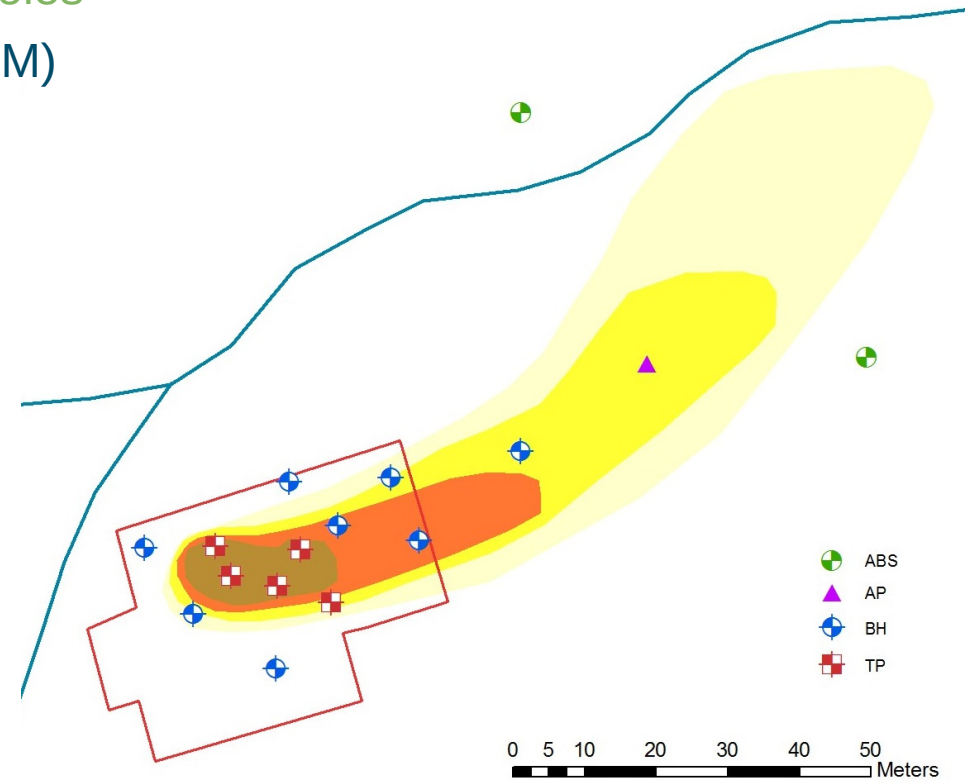
Monitoring network design

Number & distribution of monitoring boreholes

- Preliminary Conceptual Site Model (CSM)
  - Location and type of receptors
- Stage of investigation
  - Exploratory
  - Main phase
  - Supplementary
- Remediation
- Verification

Water Environment Aims

- Sufficient groundwater monitoring to:
  - Understand flow regime
  - Define source
  - Support risk assessment
  - Allow compliance monitoring



Monitoring wells should be up and downgradient of source to enable isolation of the influence of the site on groundwater quality (BS10175).

Borehole design

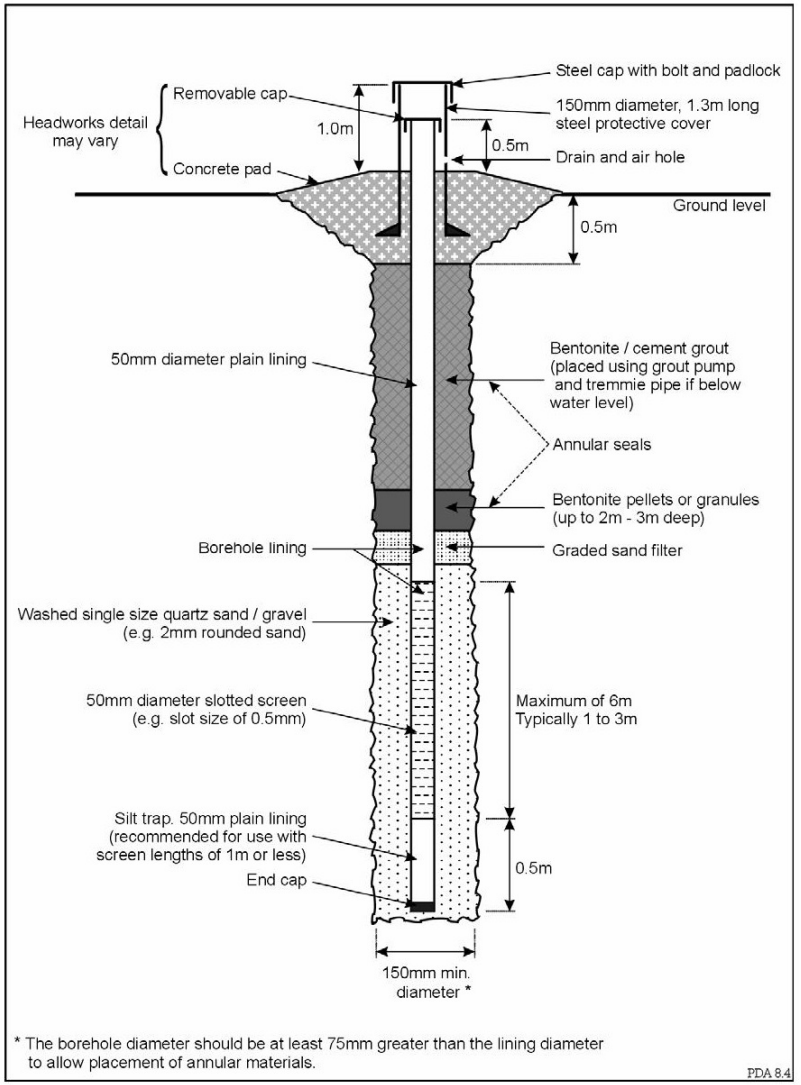
Key design parameters

- Expected depth to groundwater (CSM)
- Lithology
- Drilling method / equipment
- Diameter
- Type of installation (single, dual, multichannel)
- Design screened interval(s)
- Sealing

Generally avoid

- ✘ Long screened sections
- ✘ Screened sections across multiple aquifers / lithologies
- ✘ Screening perched horizons
- ✘ Screening at significant depth below groundwater table*

*(unless there is a specific need to do this e.g. DNAPL)



SEPA 2003, Guidance on monitoring of landfill leachate, groundwater and surface water

Borehole construction

During drilling

- Lithology (BS5930)
- Water strikes
- Obstructions
- Visual / olfactory evidence of contamination
- Field tests

Optimise borehole design based on field information

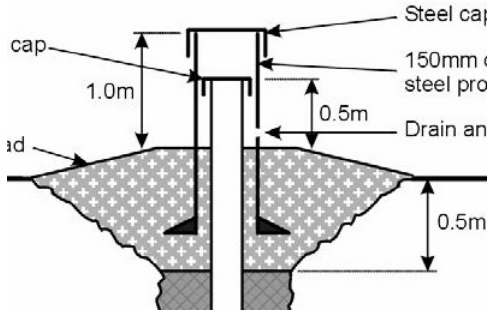
Headworks

- Avoid surface water entry
- Provide protection & security
- Clearly marked with unique borehole number

SEPA 2003, Guidance on monitoring of landfill leachate, groundwater and surface water
SEPA 2010, An applicant's guide to water supply boreholes

Post-installation

- Well development
- Survey – co-ordinates and levels
  - 'As-built', preferably to maOD and BNG
- Borehole logs – clear, detailed, comprehensive



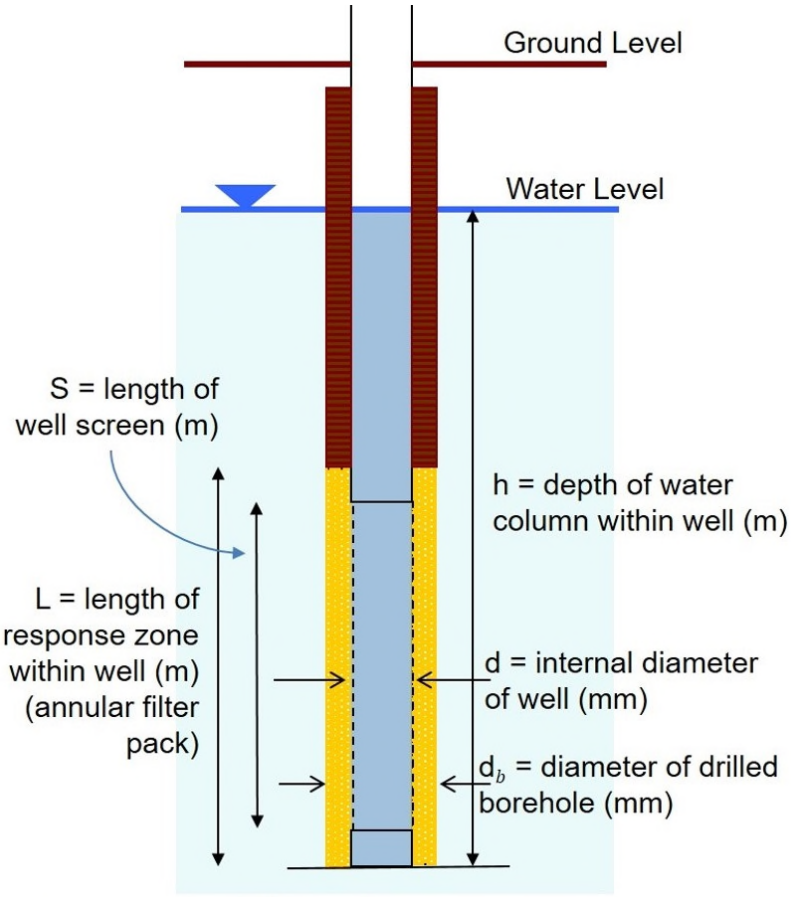
Purging strategies

Borehole water may not be representative of aquifer conditions due to stagnation, oxidation, loss of volatiles and debris.

Unless boreholes / wells are in continuous use for abstraction they should be purged before sampling to ensure a representative sample.

Purging strategies are dependant on:

- Borehole construction
- Well yield/purging rate
- Sample type
  - Integrated/composite - volume purging
  - Point/spot sample - low-flow purging



BS5667-11 Volume purging

$$V = 3 \times \pi d_b{}^2 L/4$$

BS5667:11 Guidance on sampling of groundwaters
CL:AIRE TB03 Principles and Practice for the Collection of Representative Groundwater Samples

Purging and sampling equipment

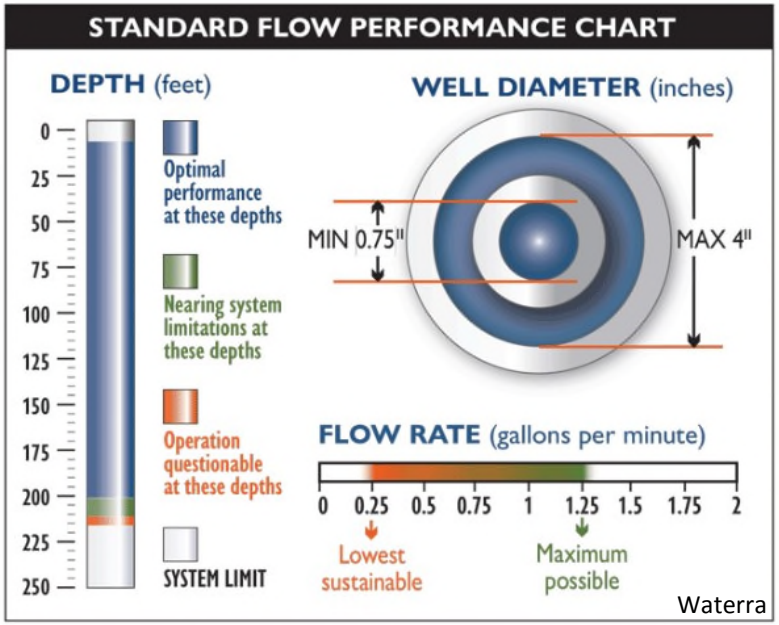
Choice of equipment dependant on:

- Hydrogeological conditions
- Borehole construction
- Purpose of monitoring
- Contaminant type

Equipment types:

- Bailer / depth sampler
- Inertial pump
- Surface pump (suction, peristaltic)
- Submersible impeller pump
- Bladder pump

Always wear gloves to avoid cross contamination



Purging records and disposal of purged water

Before purging

- Dip well to check groundwater level (and base of borehole)
- Use interface probe if there is a possibility of free phase NAPL
- If free phase NAPL present do not purge, review sampling strategy

During purging

- Estimate flow rates & purge times
- Regular dips of groundwater level
- Appearance of purged water
- Olfactory/visual evidence of contamination
- Weather conditions

After purging

- Appropriate collection and disposal of purged water
- Detailed records presented in sampling report

Wellhead measurements (field parameters)

Key parameters

- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Temperature

Potential additional parameters

- pH
- Redox potential (Eh / ORP)
- Turbidity

✓ Always use flow-through cell
✓ Ensure all equipment is calibrated

✘ Not in bucket or similar

Can be measured continually during purging or following completion of purging

May be used to indicate purging is sufficient based on parameter stabilisation. DO is usually last parameter to stabilise. Stabilisation criteria should be defined.

CL:AIRE 2008, TB03 Principles and Practice for the Collection of Representative Groundwater Samples

Sampling

The same equipment may be used for purging and sampling or it may be appropriate to use a different method.

- Always wear gloves to avoid cross contamination
- Filter if necessary (e.g. metals)
- Use the right bottles
- Preservatives may be used (e.g. acidification for metals)
- Generally rinse bottle and cap with sample water, unless preservative used
- Generally fill bottle to brim unless otherwise specified
- If in doubt speak to lab

Filtering

Think carefully before deciding whether to filter

- Minimise sample turbidity through optimising well construction and development
- Avoid disturbance of fines at the base of the borehole
- Could there be particulate material in the aquifer that filtering might remove?
- Could precipitation prior to filtering result in loss of analyte?
- If in doubt analyse both filtered and unfiltered samples

If filtering

- 0.45µm filter (BS5667)
- Recommend on-site immediately after sampling
- Preservation by acidification

✓ Dissolved metals	✗ Organics
- inc. Fe, Mn	✗ VOCs

ALS, The Importance of Field Filtering and Preservation for Dissolved Metals to Prevent Significant Bias in Sampling and Analysis
https://mcusercontent.com/7a9b2635edc6e3252173b2f29/files/1fa51c82-99c0-4c78-af16-2b6370db4286/SCLF_Article_Field_Filtering.pdf

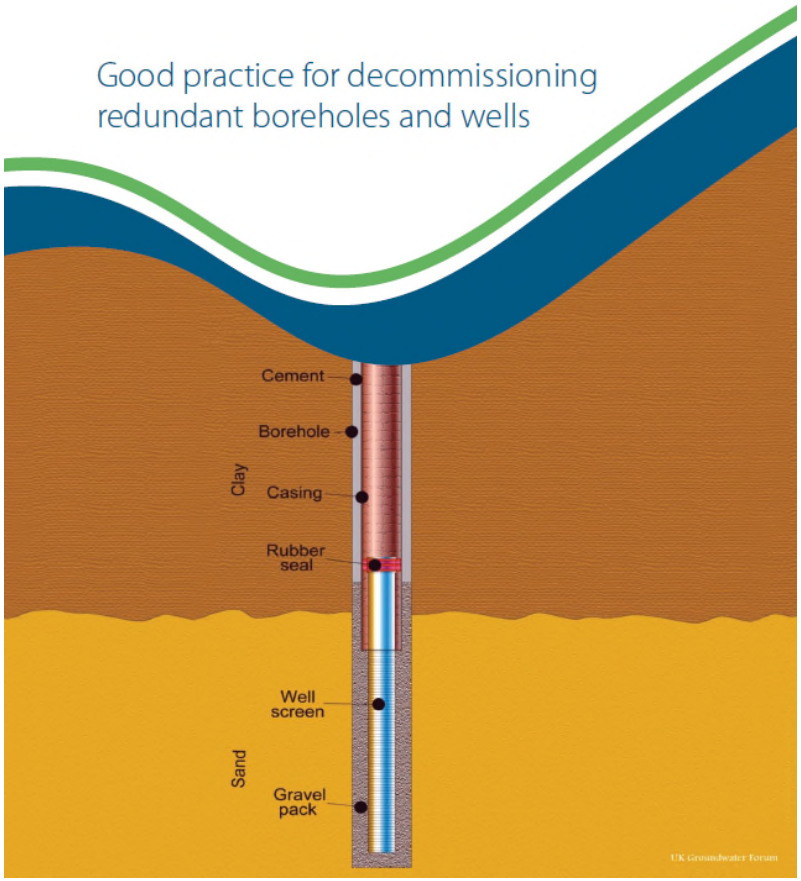
Sample transit, preservation and handling

- Sample chemistry may change following sampling due to:
  - action of bacteria, algae and other micro-organisms,
  - oxidation, precipitation,
  - CO_2 absorption,
  - adsorption of dissolved/colloidal metals to particulate matter or surfaces,
  - polymerisation/depolymerisation.
- Samples should be kept cool (5±3°C), in the dark, protected for transport and accompanied by CoC forms etc.
- Consider holding times (check with lab)

Leaving Site

- Dip base of wells to check borehole condition and check for blockages
- Ensure all borehole caps and covers are in place
- Remove everything from site including all waste

Decommissioning



- Redundant wells and boreholes should be suitably decommissioned to avoid:
  - Preferential pathways
  - Entry of hazardous substances and/or pollutants to groundwater
  - Mixing of groundwaters of different quality
  - Loss of piezometric head
- Decommissioning backfill should either:
  - Mimic the permeability of the natural strata or,
  - Be of very low permeability (e.g. bentonite cement grout)
- Materials which could leach hazardous substances or cause pollution should not be used as backfill

https://www.sepa.org.uk/media/34618/decommissioning-redundant-boreholes-and-wells.pdf

Licensing

GBR4: The abstraction from a borehole, and any subsequent discharge of abstracted water, if the total volume abstracted is less than 150m^3 in any period of one year and the purpose of the abstraction is either-

a) to test the yield of the borehole or well or the hydraulic properties of the aquifer; or

b) to sample the water quality.

Rules:

a) The abstraction must not cause the entry of pollutants or water of a different chemical composition into any body of groundwater; and

b) when the borehole is not being used for abstraction, it must be back-filled or sealed to the extent necessary to avoid loss of groundwater from any aquifer.

- GBR16 covers direct discharge to groundwater of substances used in borehole construction and decommissioning
- Speak to SEPA if in doubt

The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide
https://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf

Data Management and Reporting

Data Management

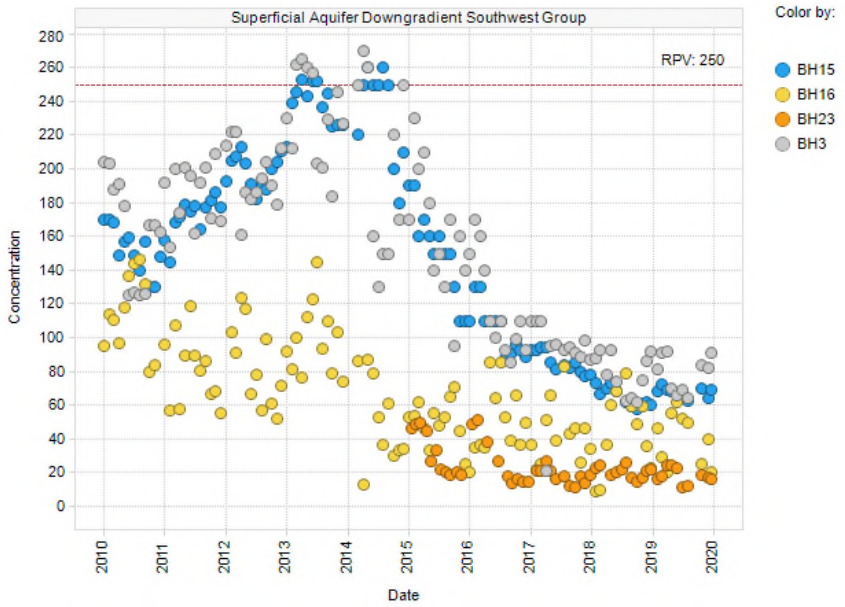
- Suitable platform
- Determinand names
- Units
- Table format
- Descriptive fields & flags

Date	Location	Determinand	Unit	Sign	Result	Value	Outlier	Comment
25/12/19	BH1	NH4-N	mg/l as N	<	0.1	0.05	0	
01/01/20	BH1	NH4-N	mg/l as N		0.23	0.23	0	
08/01/20	BH1	NH4-N	mg/l as N		3.5	3.5	1	Flag

Narrow vs wide format

Reporting

- Aggregated data
- Summary statistics
- Trend analysis
- Outliers
- Time series plots
- Digital data
- Lab results sheets



SEPA's Groundwater Monitoring Network

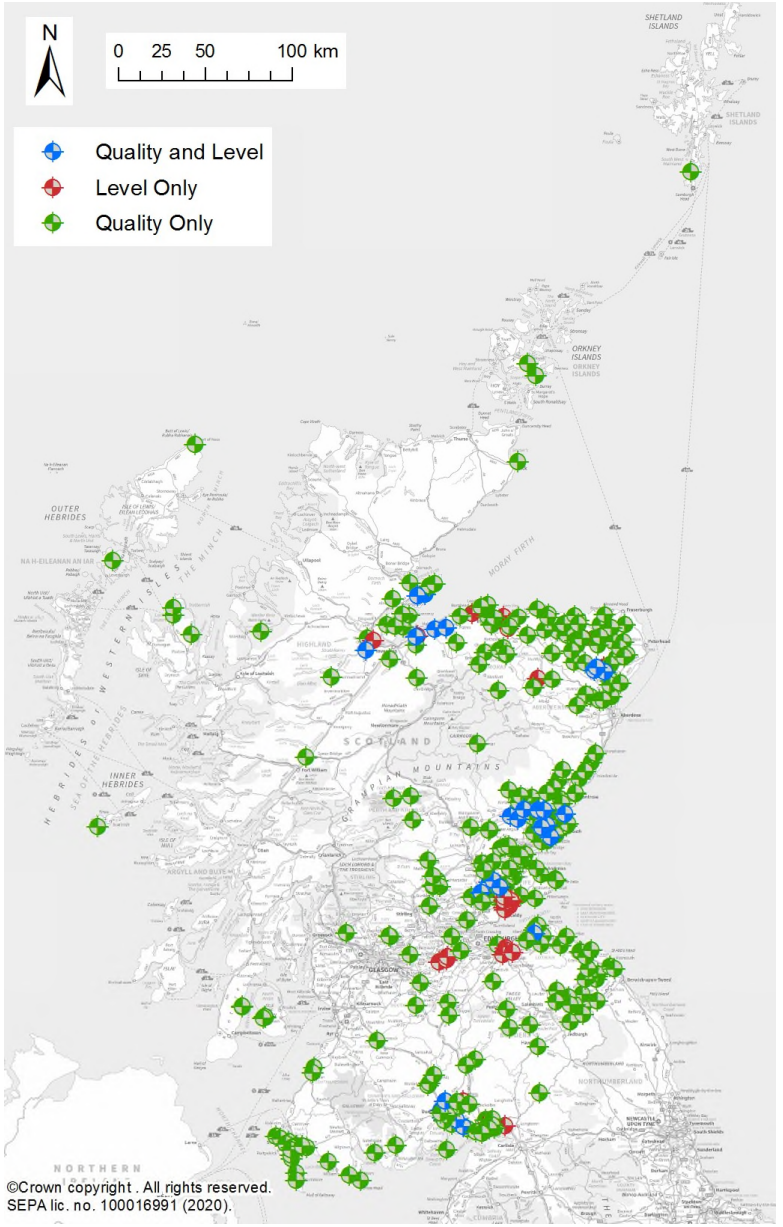
Key drivers

- WFD / RBMP Classification
- Nitrates Directive
- Abstraction pressures / drought

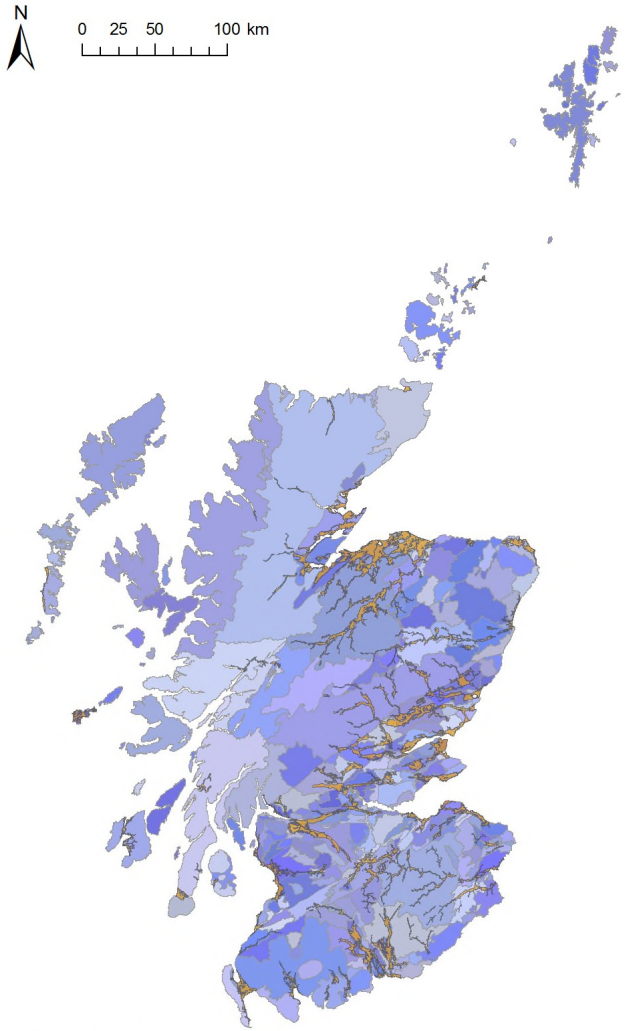
Key network statistics (2020)

Usage	No. of Sites
Quality	309
Level	77
Quality and level	39
Total	**347**

70% Private
14% Scottish Water
11% SEPA
5% Coal Authority



WFD Classification



Groundwater bodies

- 300 bedrock
- 103 superficial

Classification tests

Overall status	Quantitative	Saline intrusion
		Surface water impacts
		Water balance
	Chemical	Saline intrusion
		Surface water interactions
		Drinking water protected areas
		General chemical test

- Priority substances
- Specific pollutants
- Other substances
- ‘One out all out’

Where to find SEPA data

Information on WFD classification, pressures and measures

Water Environment Hub
https://www.sepa.org.uk/data-visualisation/water-environment-hub/

Classification Hub
https://www.sepa.org.uk/data-visualisation/water-classification-hub/

Environmental data list

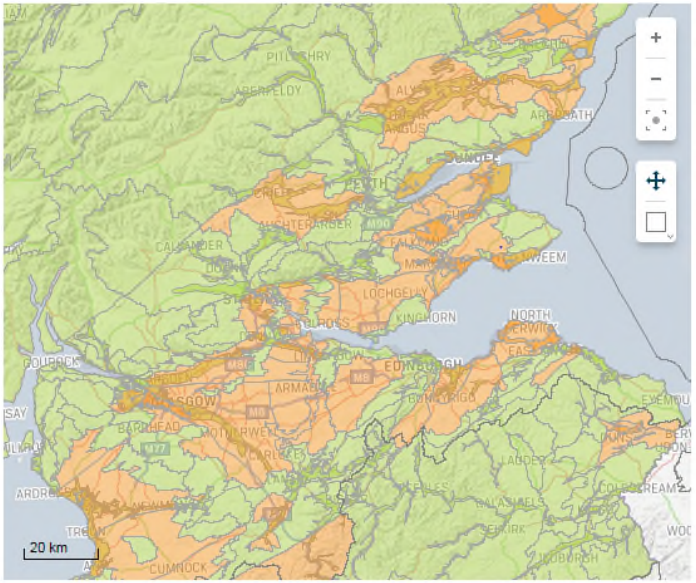
https://www.sepa.org.uk/environment/environmental-data/

Water monitoring points

Scotland's Environment Web
https://map.environment.gov.scot/sewebmap/?layers=waterMonitoringPoints

Groundwater quality and level data

Request via SEPA website online form
https://www.sepa.org.uk/contact/contact-us-by-email/



This map displays bodies of groundwaters coloured by overall status for the latest available year

Condition

- Good
- Poor

‘Take home’ messages

- Ensure borehole location and construction is suitable for investigation aims.
- Make sure all monitoring locations are surveyed-in and adequately and uniquely labelled.
- Think carefully about the most robust and efficient way to manage your data.

Thanks for listening.

Questions

Contact details

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