Pathways and Poorly Productive Aquifers

ANNUAL IAH FIELDTRIP

28-29th September 2013

This year we will be heading north where we will be taken through some of the sites researched as part of the Poorly Productive Aquifer research and the Pathways Project.

The trip will take us to Co. Louth where we will visit the Mattock Catchment and Rockmarshall Wetland. We will move on to Newry before arriving in Belfast for our overnight. The second day will focus on the Mount Stewart Catchment site after a geophysical logging demonstration and a visit to Scrabo Quarry. A brief summary on each of the stops is provided below.

We are intending to base ourselves in the Malone Lodge Hotel, where we have been offered an excellent IAH fieldtrip rate of **£55 dinner, B&B pps and £80 for single occupancy (~ €65 pps / €95 single).** **Please note you are responsible for booking of your own accommodation. The hotel is holding rooms for us until the 23rd September. Other accommodation (including hostels) is available nearby**

There will be a bus leaving from Dublin in the morning taking us around the sites. The estimated charge to attendees will be ~ €55 for those taking the bus and availing of lunch on the Saturday. For unwaged members, there will be no charge for bus and lunch. Please contact fieldtrip secretary for more information.

If you are considering attending this year's fieldtrip can you please notify the fieldtrip secretary as soon as possible. Fieldtrip Secretary: Caoimhe Hickey (Caoimhe.hickey@gsi.ie)

Indicating if you

(1) Are attending
(2) Wish to travel on bus from Dublin?
(3) Wish to stay in group hotel ?
(4) Wish to attend group evening meal ?

Saturday28th September

Mattock catchment

- Detailed conceptual model: geology, groundwater, surface water, nutrient sources and transport
- Determining human v animal sources of microbiological contamination
- Lessons from geophysics
- GW public supply and interactions with surface water
- Role of deep gravel unit in discharging groundwater out of the catchment

Rockmarshall wetland

- Pressures on a coastal groundwater dependant terrestrial ecosystem.
- Ecological impacts
- Wetland instrumentation and monitoring
- Groundwater / surface water interactions and nutrient delivery

Newry Granite

- Outcrop observations of a poorly productive aquifer
- Newry Boreholes: Productive supplies in a poorly productive system

Sunday 29th September

Downhole geophysical logging demonstration

- General application of geophysical logging
- Case study in the Triassic Sandstone
- HiRAT: A valuable tool for obtaining supplemental information

Scrabo Quarry

- Overview of Geology of the North Down area
- Outcrop observations of Triassic Sandstone and Tertiary intrusives
- Petroleum Geologist's perspective.

Mt. Stewart

- Detailed conceptual model: geology, groundwater, surface water, nutrient transport
- Determining human v animal sources of contamination
- Fracture analysis: Outcrop observations vs results of downhole testing.
- Role of gravels in discharging water out of the catchment

Please note that the programme of visits is preliminary and subject to change pending landowner permission to access sites.

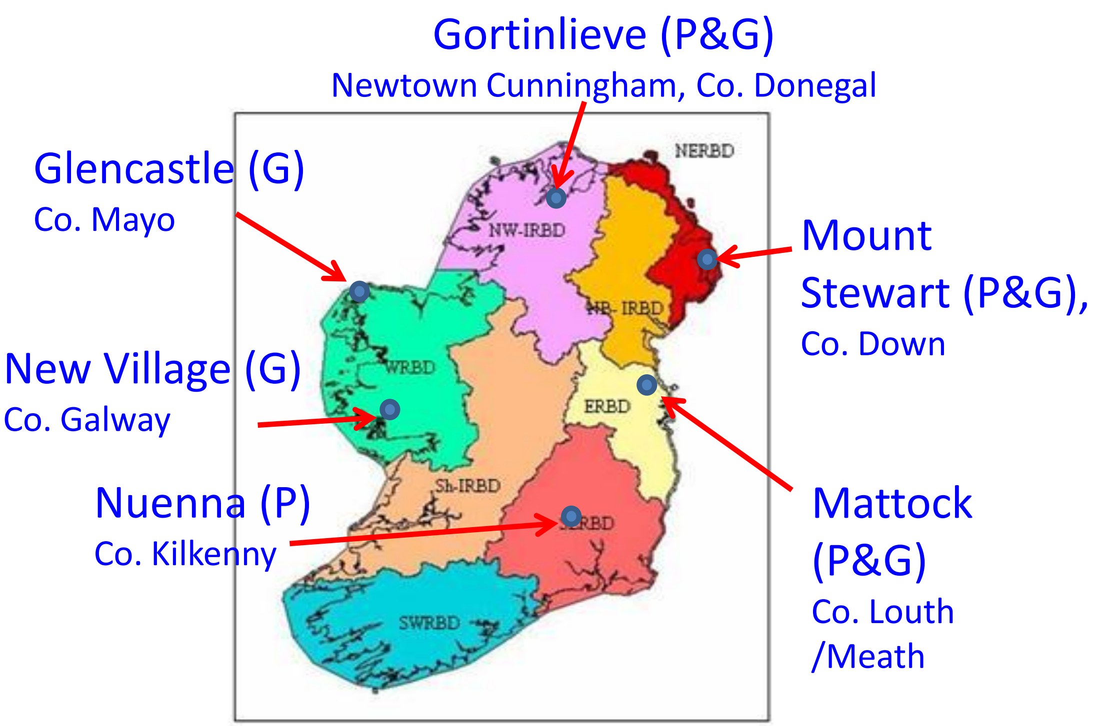
IAH Field Trip 2013

Queen's University Belfast

TRINITY COLLEGE DUBLIN
COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH
THE UNIVERSITY OF DUBLIN

Site 1: Mattock Catchment

Stop 1: Drogheda Drinking Water Diversion



Map 1-1 – River Basin Districts on the island of Ireland

Base Image: WFD Ireland

Stop 1: Upper catchment
- Pathways project intro
- Hydrogeological setting
- River water quality/issues
- Pressures and pathways

Stop 2: Mid catchment
- Drinking water supply and SW-GW interactions
- Microbial source tracking

Stop 3: Lower catchment
- Hard rock hydrogeology
- Geophysics
- Role of the gravels

P: EPA Strive Pathways
G: Griffith Geoscience Research

Figure 1.1

Pathways conceptual model

Contaminants of concern (COCs)

- Nitrogen
- Phosphorus
- FIOs
- *Sediment*

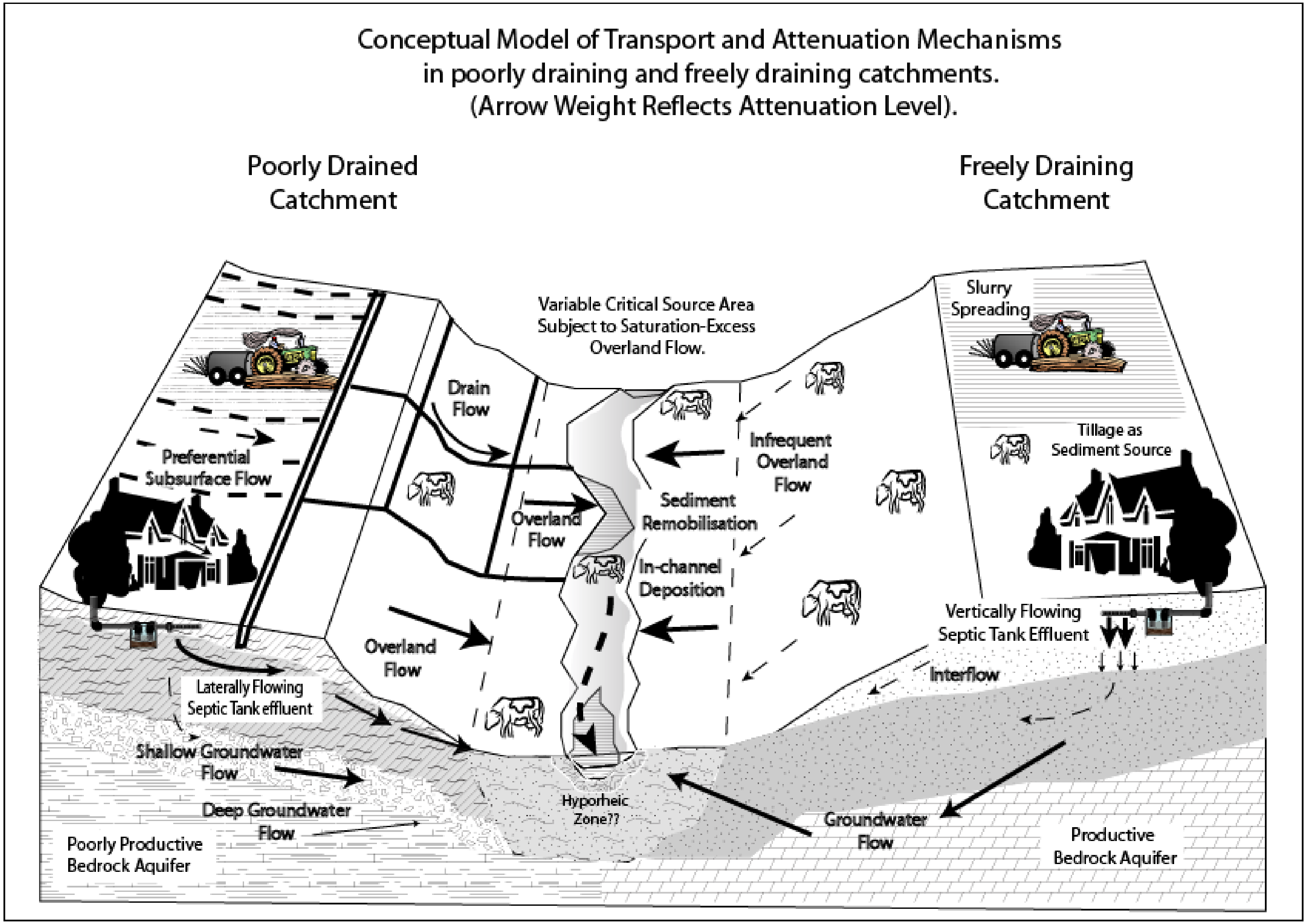
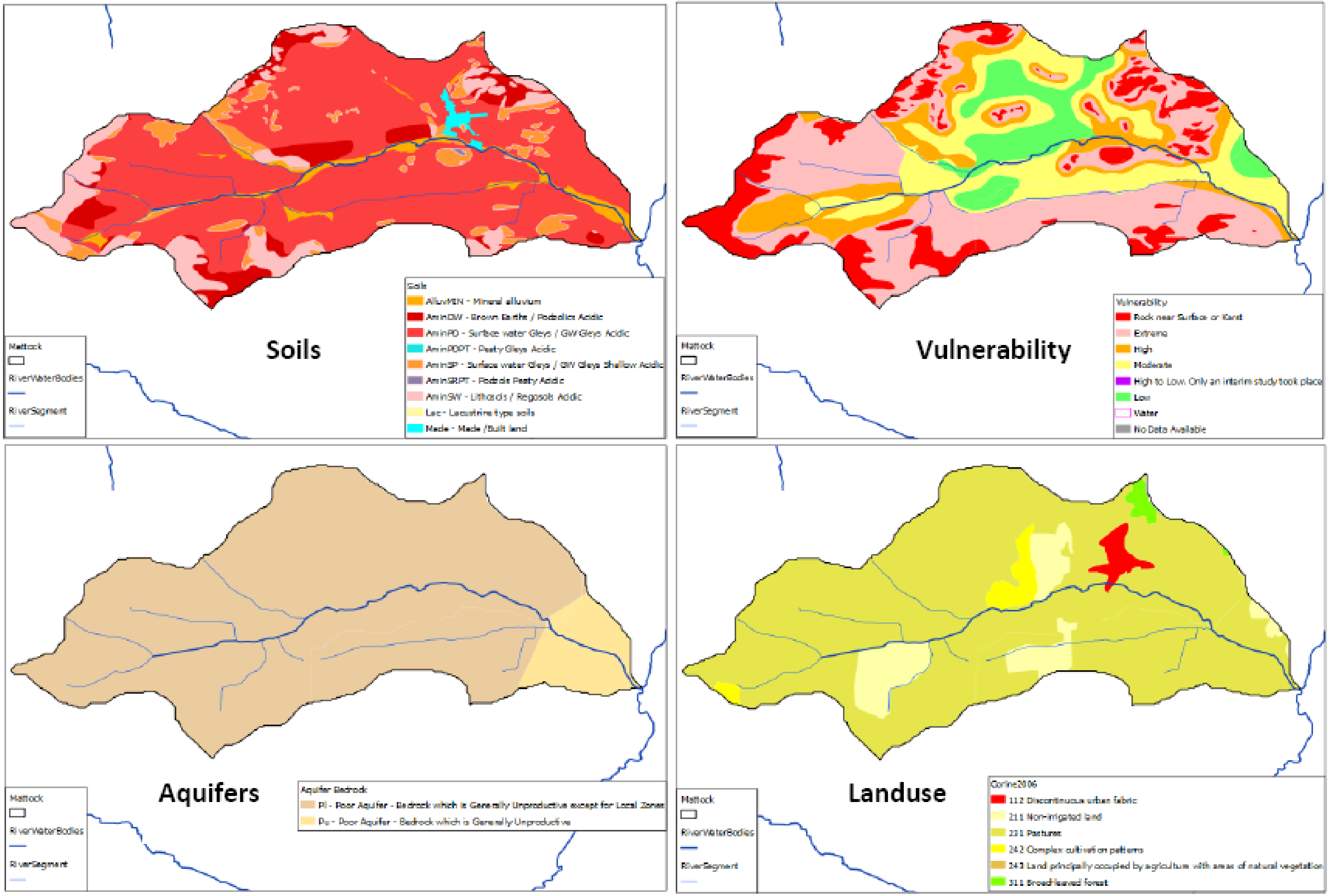


Figure 1.2



Soils
Soils
AlluvMIN - Mineral alluvium
AminDW - Brown Earths / Podzolics Acidic
AminPD - Surface water Gleys / GW Gleys Acidic
AminPDPT - Peaty Gleys Acidic
AminSP - Surface water Gleys / GW Gleys Shallow Acidic
AminSRPT - Podzols Peaty Acidic
AminSW - Lithosols / Regosols Acidic
Lac - Lacustrine type soils
Made - Made /Built land
Mattock
RiverWaterBodies
RiverSegment
Vulnerability
Vulnerability
Rock near Surface or Karst
Extreme
High
Moderate
High to Low. Only an interim study took place
Low
Water
No Data Available
Mattock
RiverWaterBodies
RiverSegment
Aquifers
Aquifer Bedrock
Pl - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones
Pu - Poor Aquifer - Bedrock which is Generally Unproductive
Mattock
RiverWaterBodies
RiverSegment
Landuse
Corine2006
112 Discontinuous urban fabric
211 Non-irrigated land
231 Pastures
242 Complex cultivation patterns
243 Land principally occupied by agriculture with areas of natural vegetation
311 Broad-leaved forest
Mattock
RiverWaterBodies
RiverSegment

Figure 1.3

Mattock catchment

Catchment hydrology

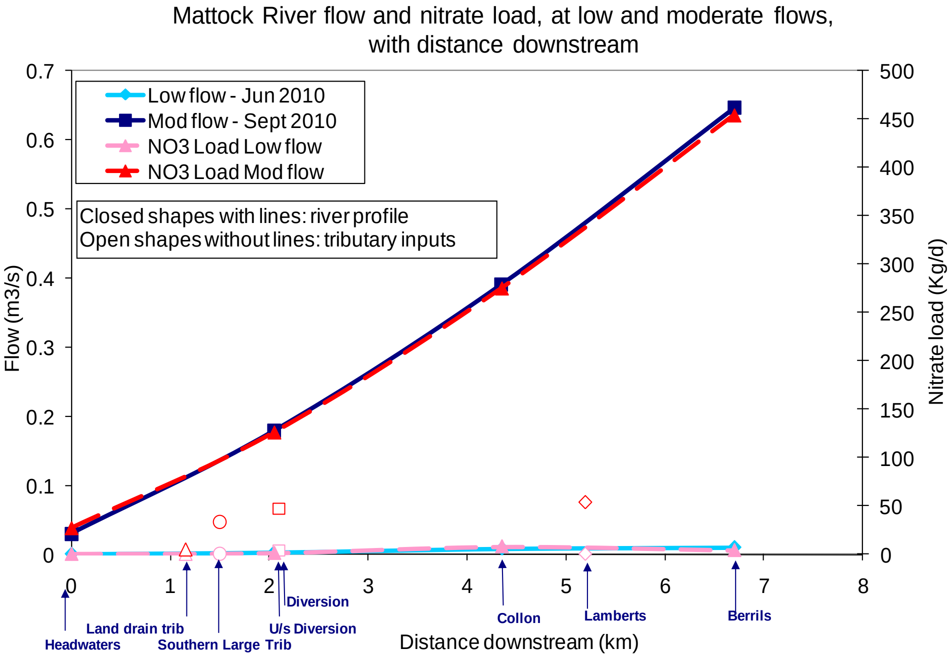
Area	17 km^2
Rainfall	900 mm
Potential evapotranspiration	480 mm
Effective rainfall	444 mm
Median flow at catchment outlet	0.14 m^3/s [0.002 – 15 m^3/s] (Feb 2011-Feb 2013)
Runoff coefficient (Q/rainfall)	0.44

Geological setting

Soils	Poorly drained gleys dominant, shallow well drained soils in upper catchment and on gravels
Subsoils	Low permeability lwr Palaeozoic till. Alluvium and gravels
Bedrock	Silurian and Ordovician sediments
Vulnerability	Extreme to Low
Aquifers	Pl, Pu

Water quality

Land use	83% Pasture 7% Tillage 1000 pe WWTP (modern) in the mid catchment
River	**NO_3:** Moderate (15 mg/l as NO_3) **MRP:** High (0.064 mg/l as PO_4)
Groundwater	NO_3: Moderate in subsoil boreholes and MK2 Deep (10-20 mg/l as NO_3), otherwise low (<2 mg/l as NO_3) **MRP:** High in MK3 Gravel (0.050 mg/l P), Moderate in MK1 Subs (0.028 mg/l P), Low to moderate in bedrock boreholes (mostly <LoD, otherwise 0.020-0.030 mg/l P).
Q-Value	Q3 to Q4/5
Status	River: Moderate Groundwater: Good



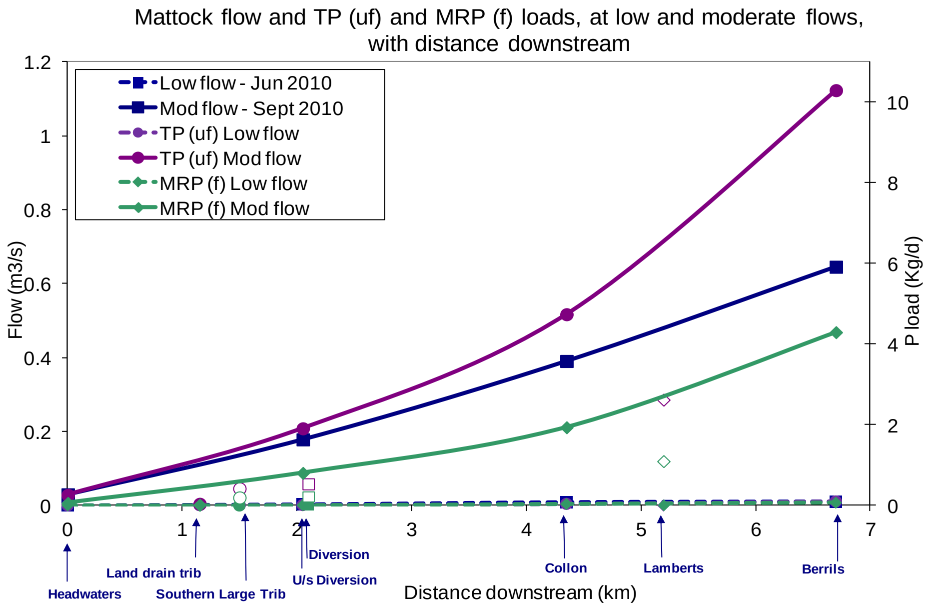
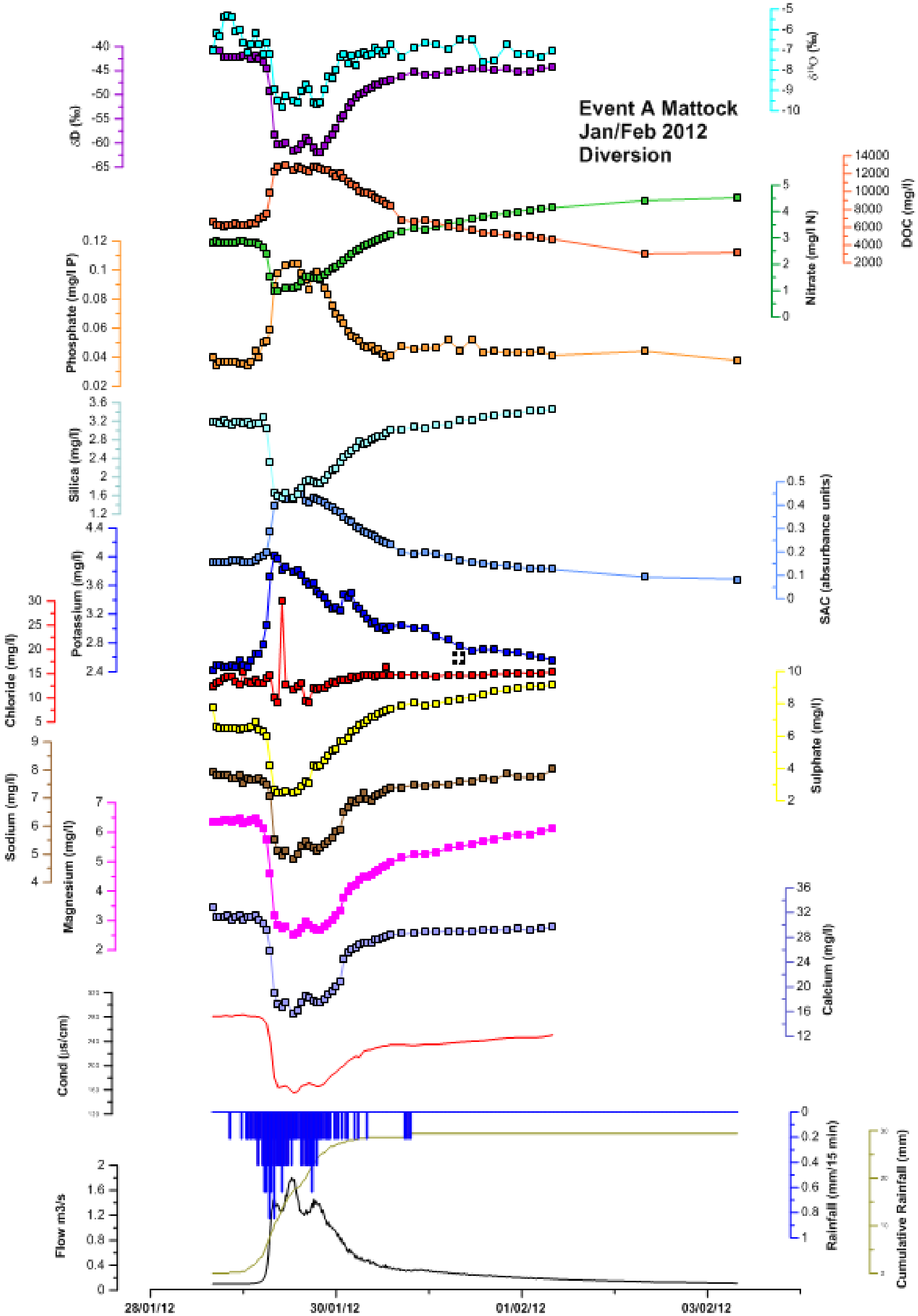
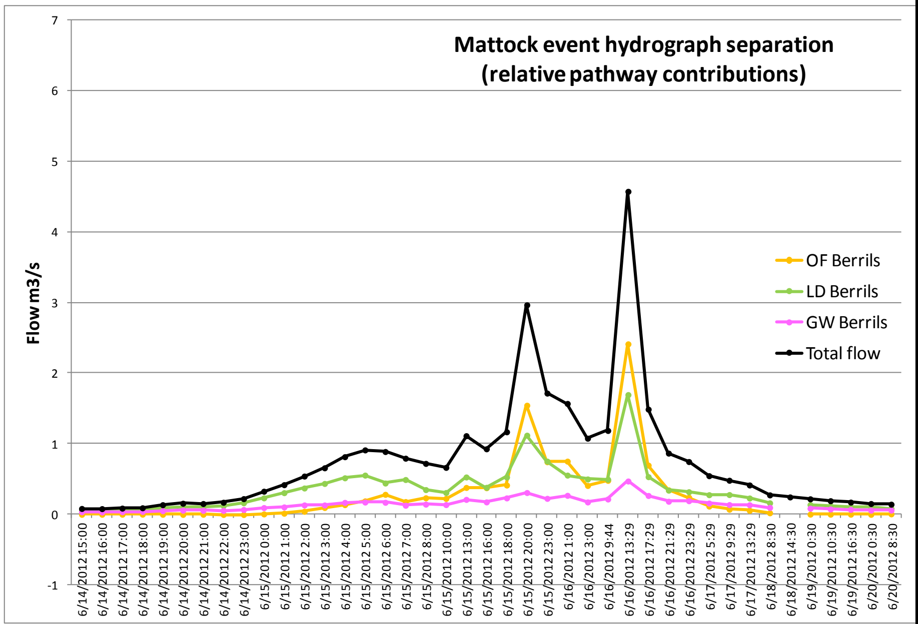


Figure 1.4



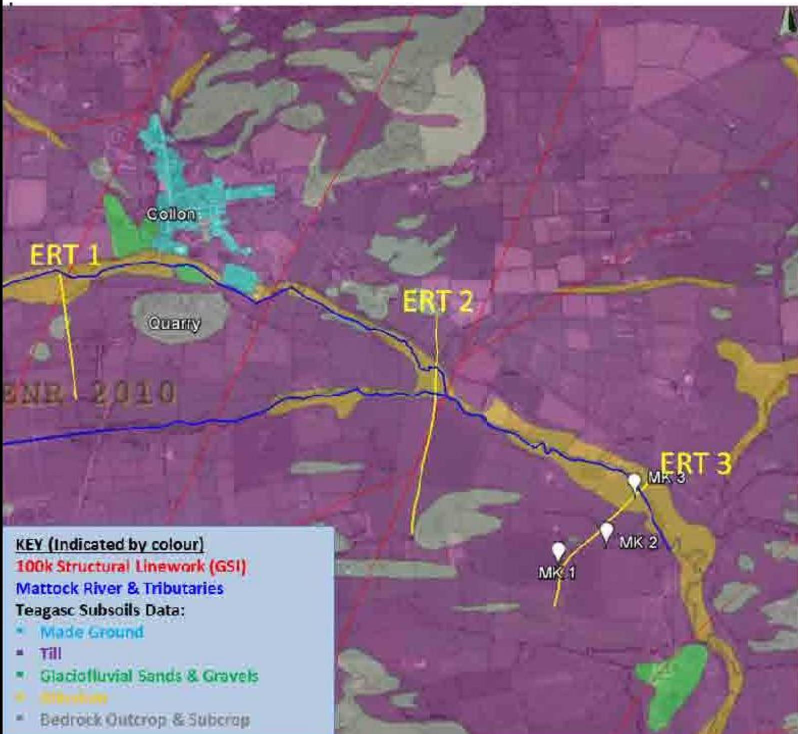


Outlet Jun 2012	% Pathway contribution		
	Low flow	Peak flow	Total
Overland flow:	0	53	35
Land drain:	63	37	47
Groundwater:	37	10	18

Figure 1.5

Stop 2: Pitch and Putt Course

Mattock Geophysical (ERT) Investigation
QUB Groundwater Group,
Griffiths Geoscience Research.



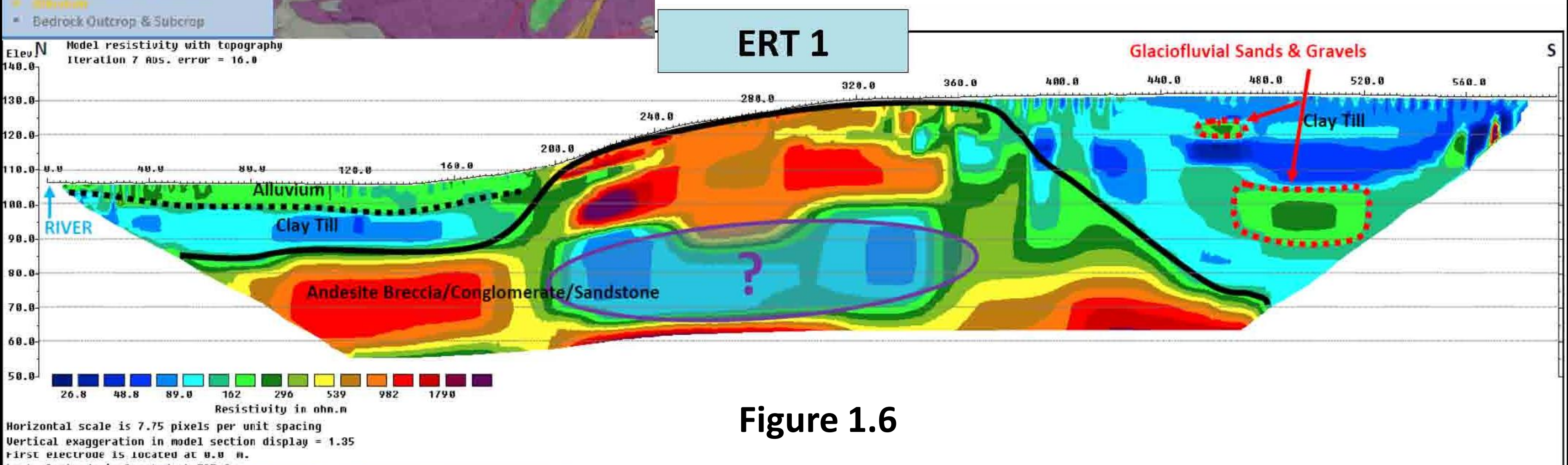
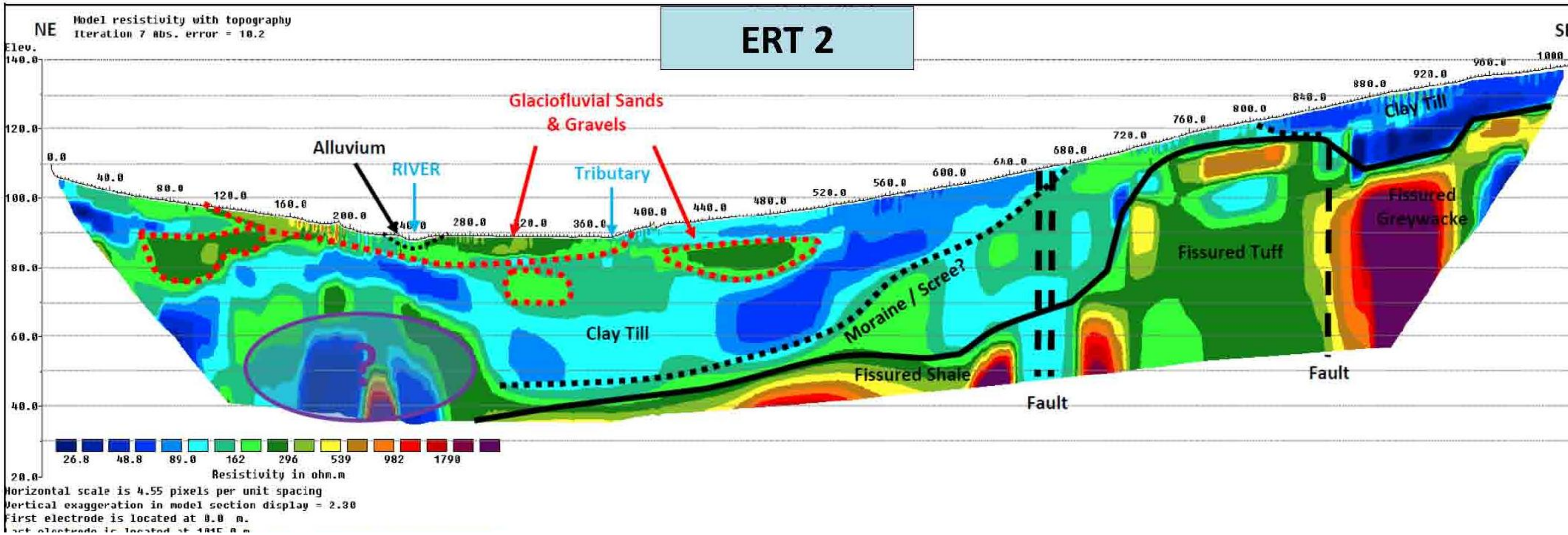


Figure 1.6


ERT 2
NE
SE
Model resistivity with topography
Iteration 7 Abs. error = 10.2
Glaciofluvial Sands & Gravels
Alluvium
RIVER
Tributary
Clay Till
Fissured Greywacke
Fissured Tuff
Moraine / Scree?
Clay Till
Fissured Shale
Fault
Fault
Resistivity in ohm.m
Horizontal scale is 4.55 pixels per unit spacing
Vertical exaggeration in model section display = 2.30
First electrode is located at 0.0 m.

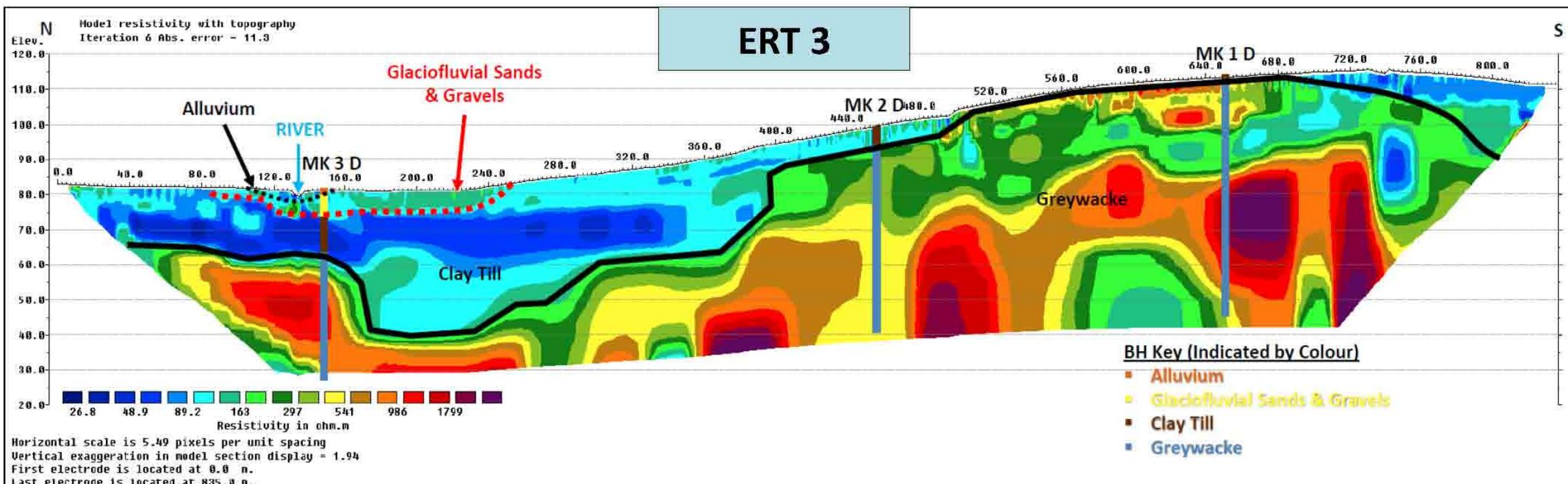

ERT 3
N
S
Model resistivity with topography
Iteration 6 Abs. error = 11.3
Glaciofluvial Sands & Gravels
Alluvium
RIVER
MK 3 D
MK 2 D
MK 1 D
Greywacke
Clay Till
BH Key (Indicated by Colour)
Alluvium
Glaciofluvial Sands & Gravels
Clay Till
Greywacke
Resistivity in ohm.m
Horizontal scale is 5.49 pixels per unit spacing
Vertical exaggeration in model section display = 1.94
First electrode is located at 0.0 m.
Last electrode is located at 835.0 m.

Figure 1.7

Microbiological Sampling

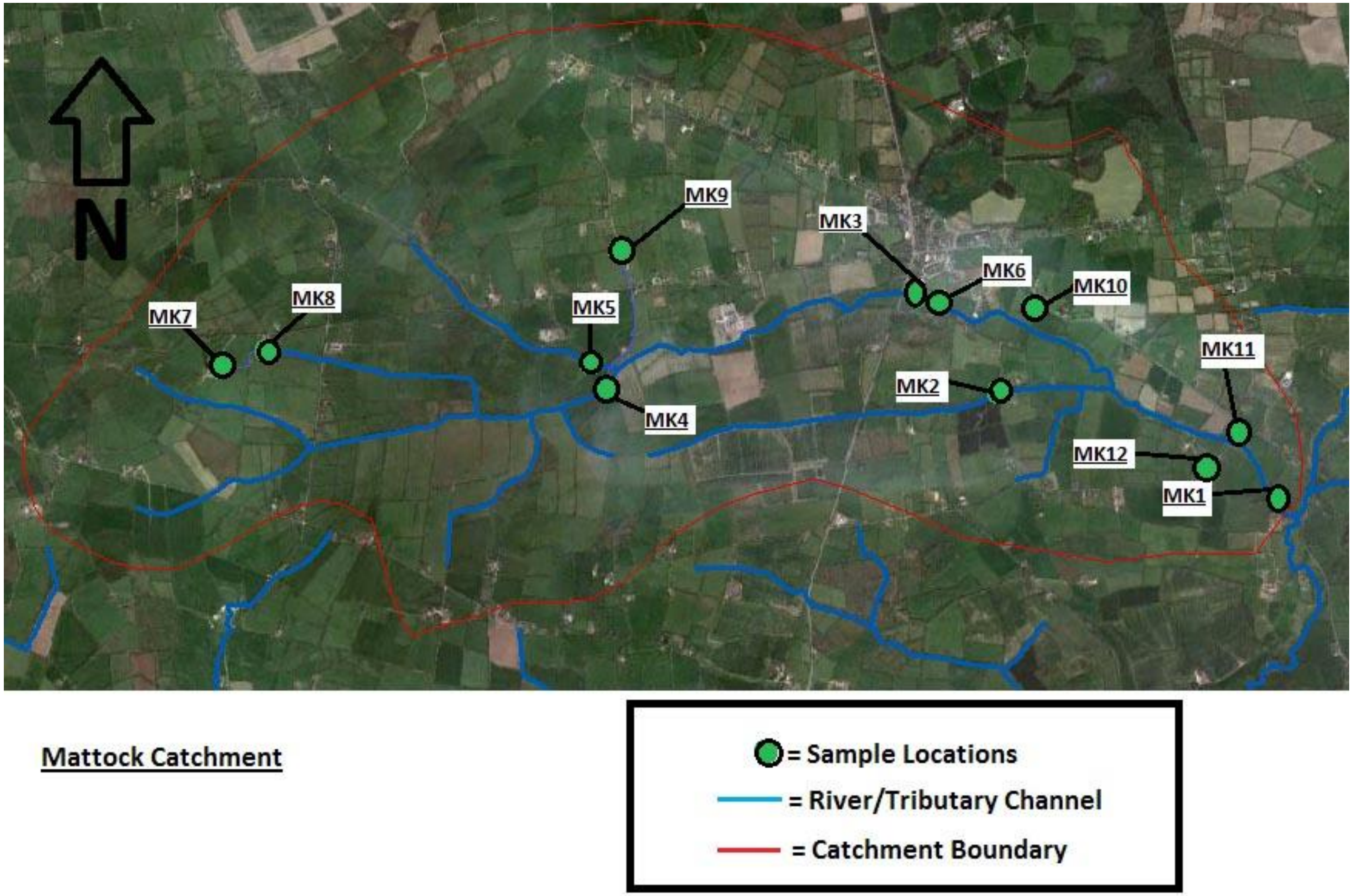
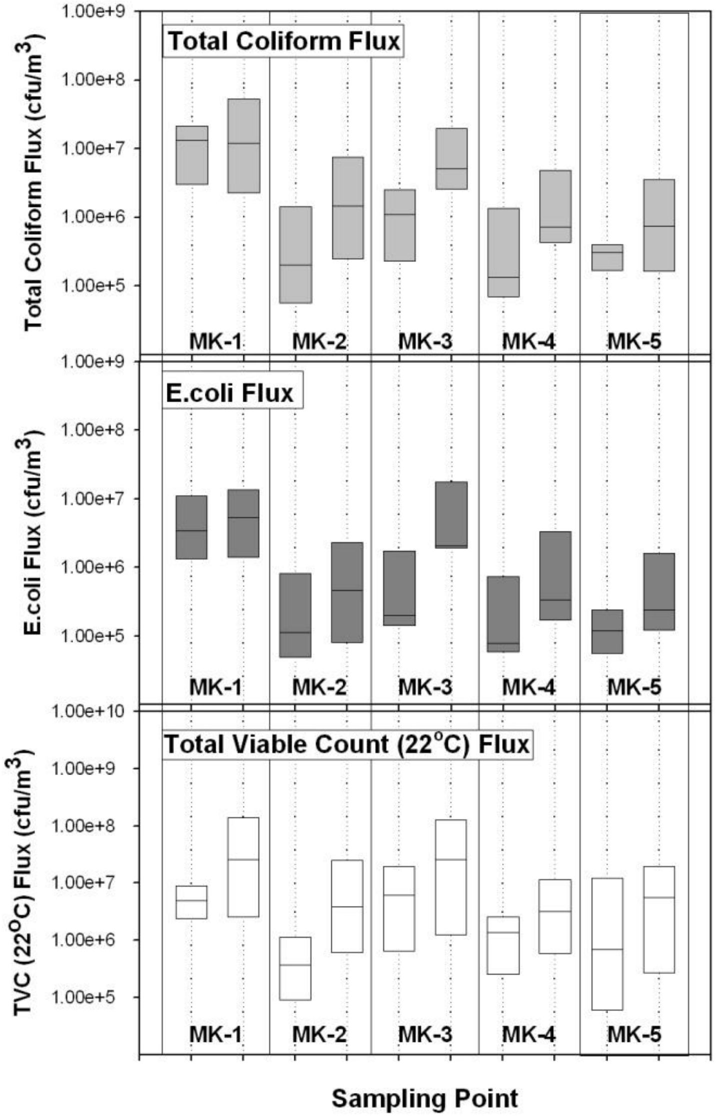


Figure 1.8

Base image: Google Earth

Microbiology Flux. Open vs Closed Season.



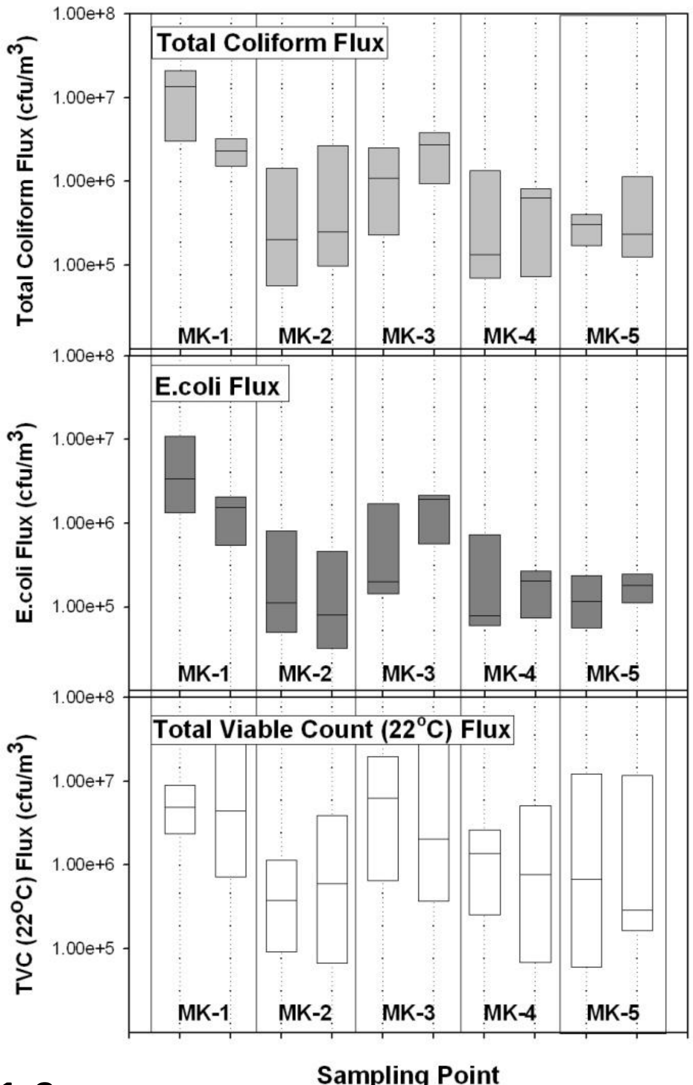


Figure 1.9

All Flow: Closed Season on left, Open Season on right

Low Flow: Closed Season on left, Open Season on right

Microbial Sources

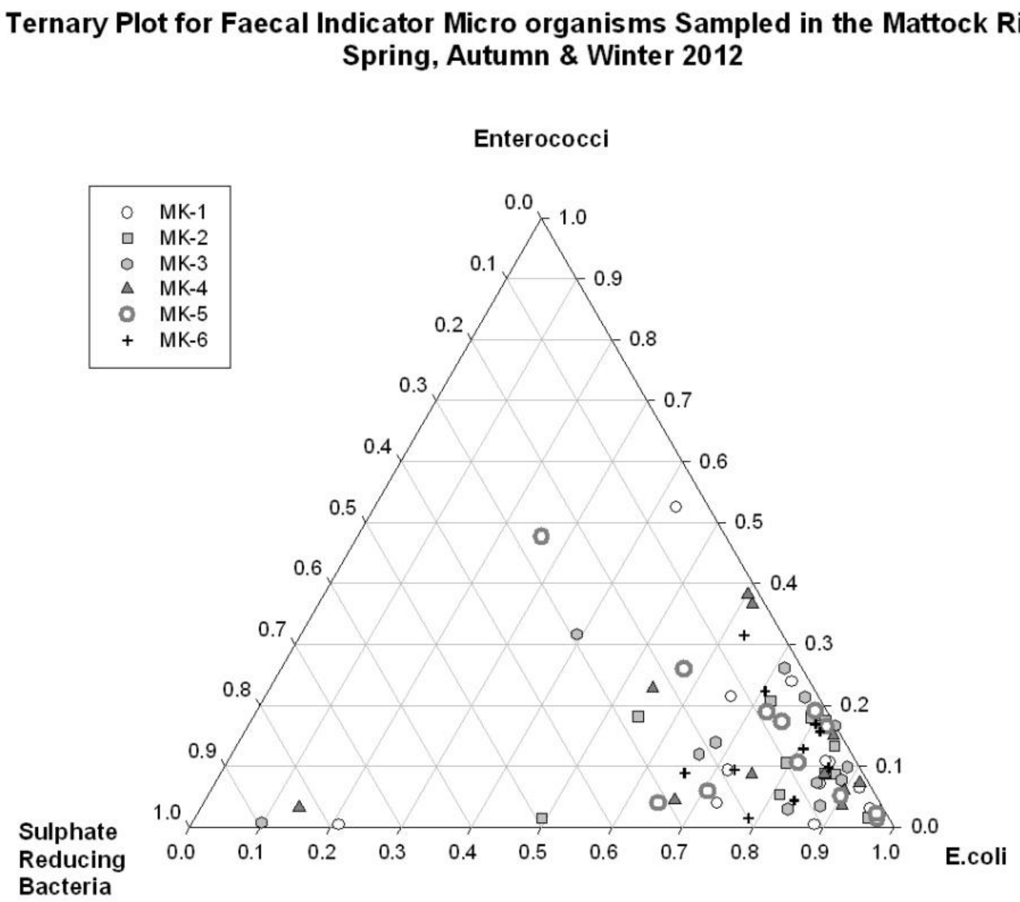


Figure 1.10

Stop 3: EPA Groundwater Monitoring Transect

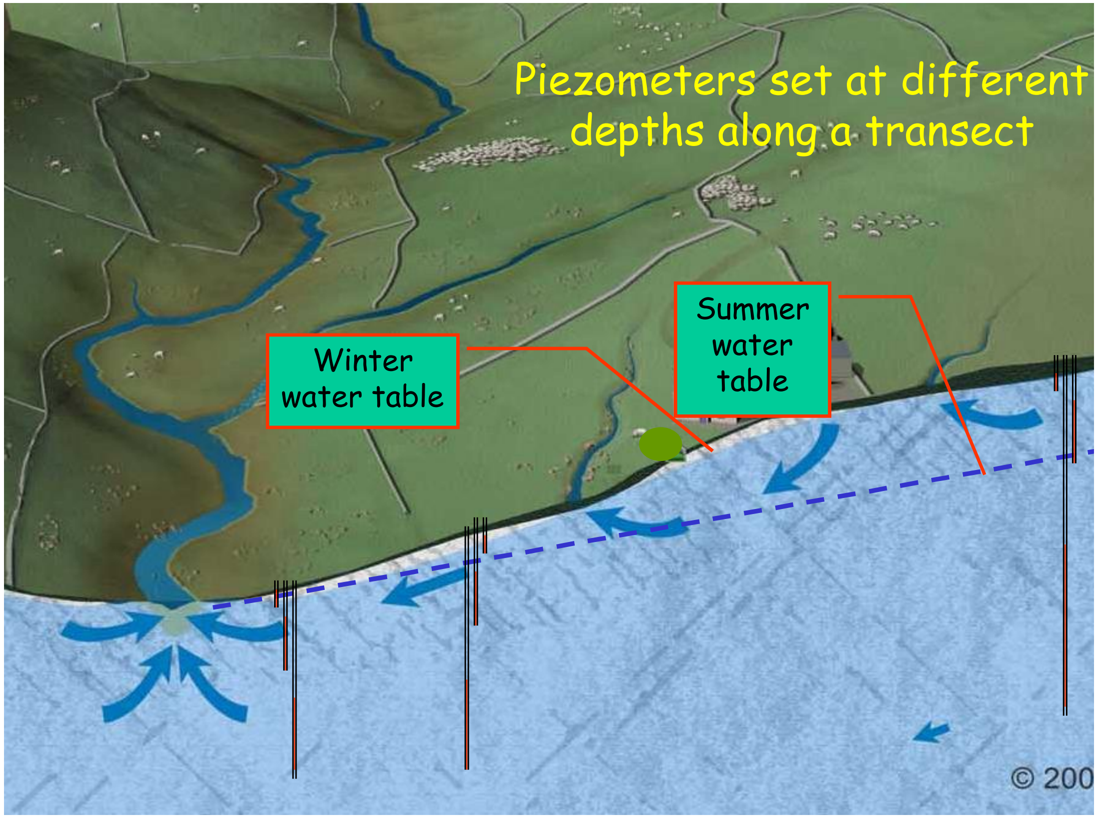
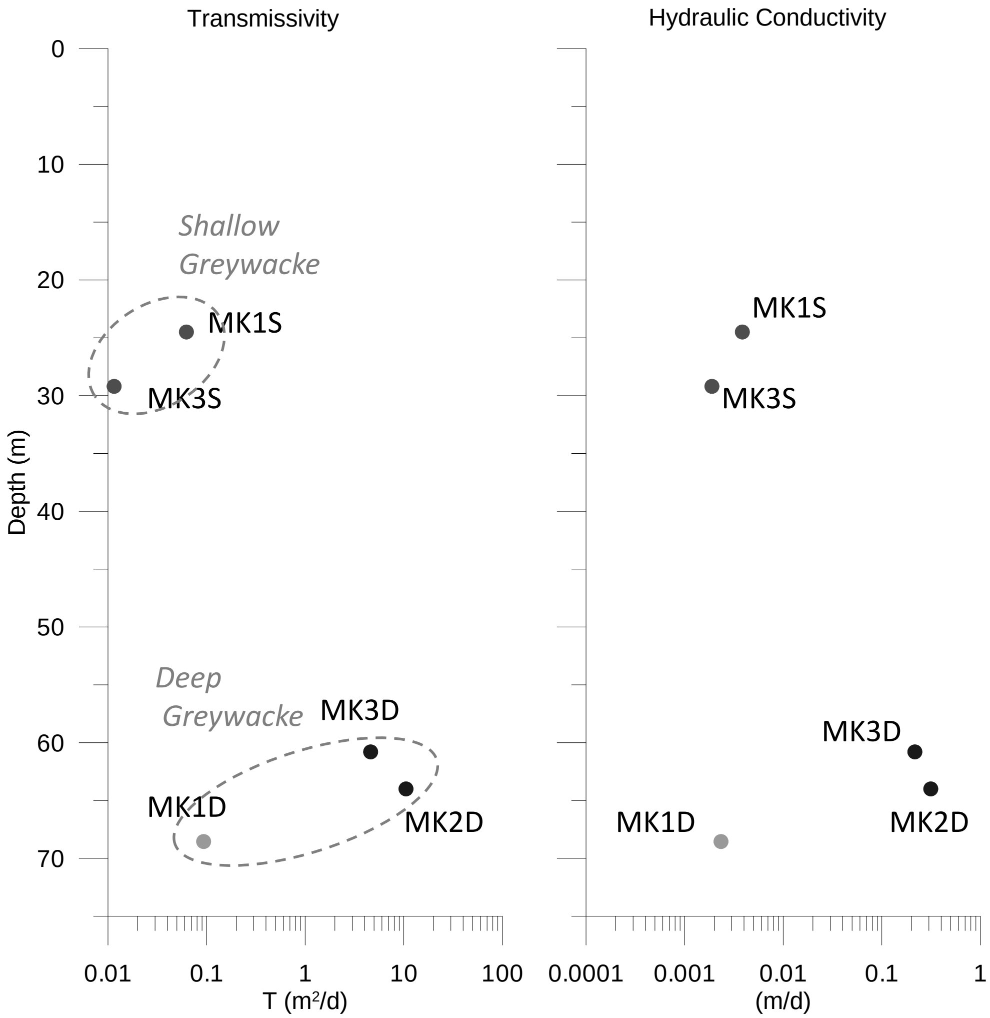


Figure 1.11

Image: WFD UKTAG

Mattock Catchment
Borehole Transmissivity



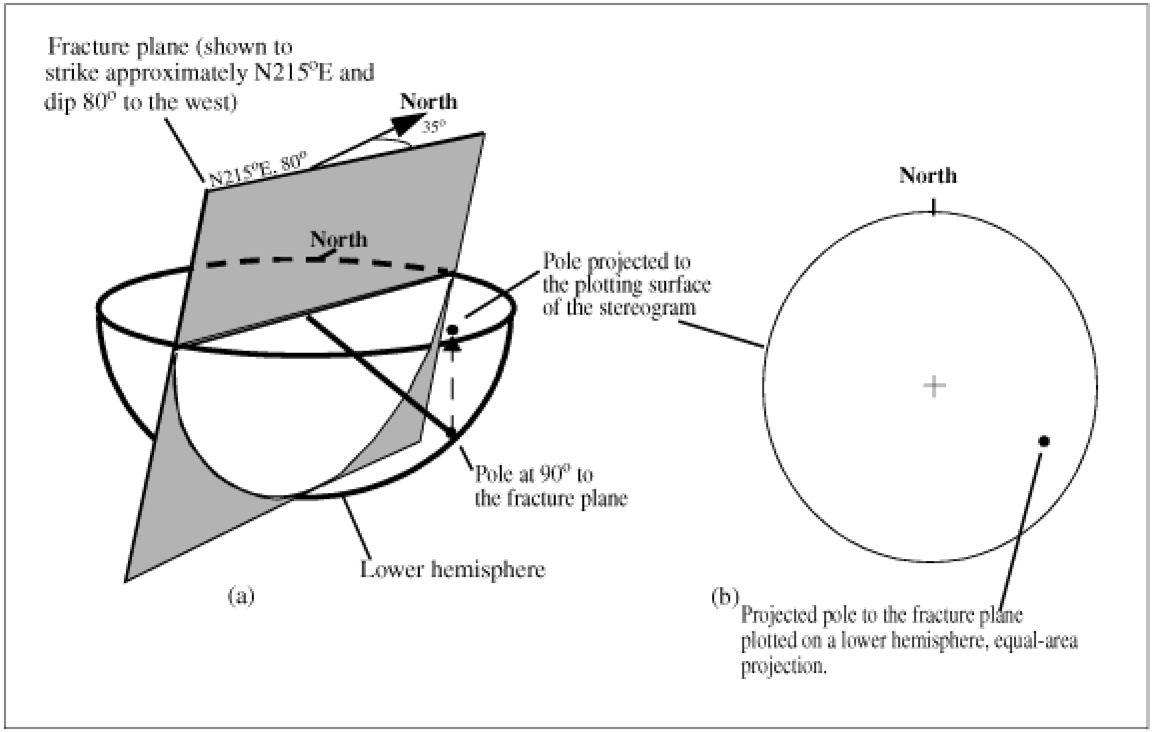
Theis and Theis Recovery
Drawdown Analysis

Hydraulic Conductivity?
Transmissivity/Saturated Length
For Fractured Rock???

Figure 1.12

Stereographic Projection

Planes and Poles to Planes

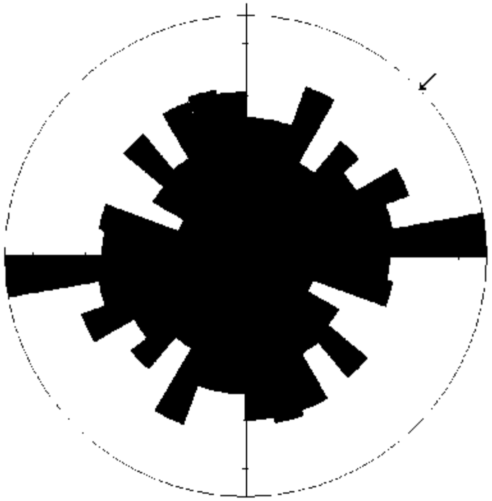


Source: USGS http://pubs.usgs.gov/of/2002/ofr02-279/

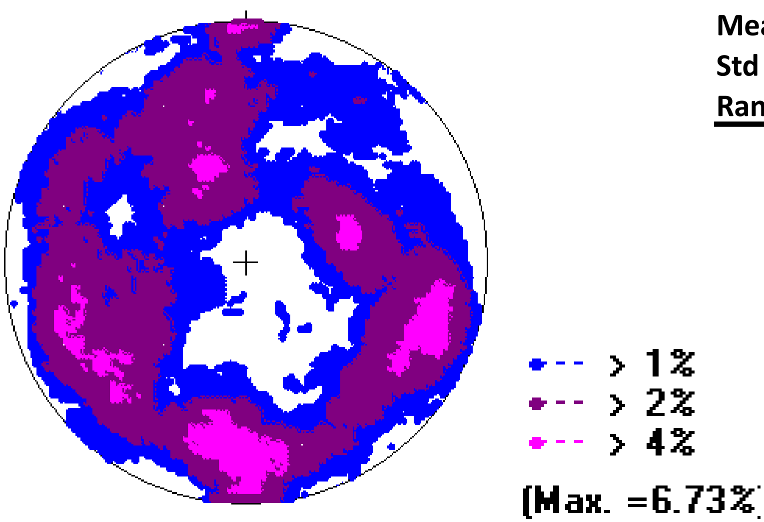
Figure 1.13

Figure 1.14

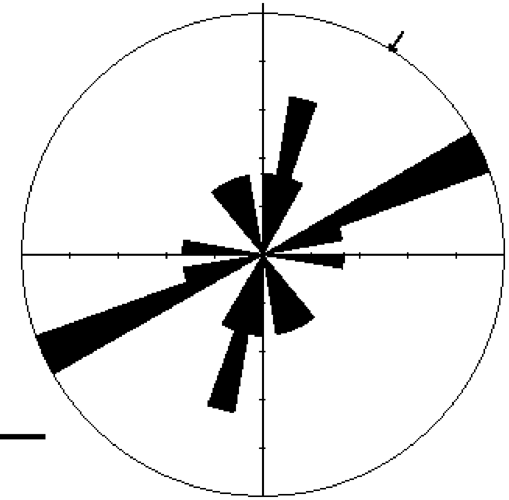
Mattock Fracture Data



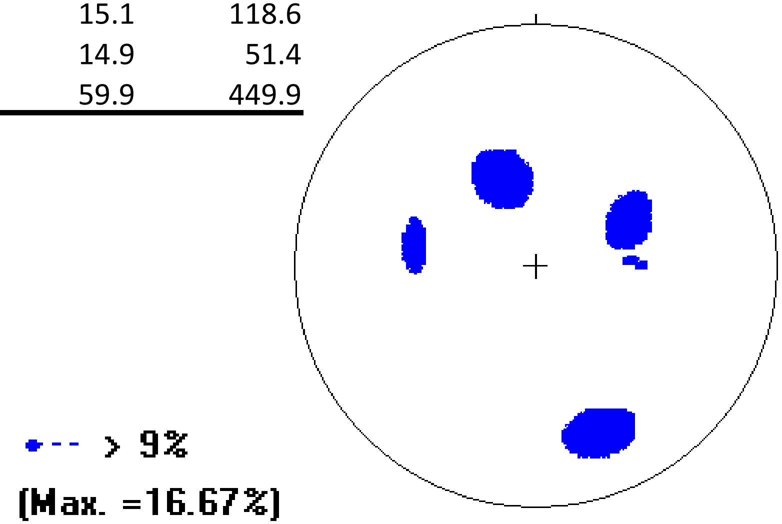
N = 520



Hydraulic Zones thickness	Shallow boreholes	Deep boreholes
Sample size	4	9
Mean (mm)	15.1	118.6
Std dev (mm)	14.9	51.4
Range (mm)	59.9	449.9



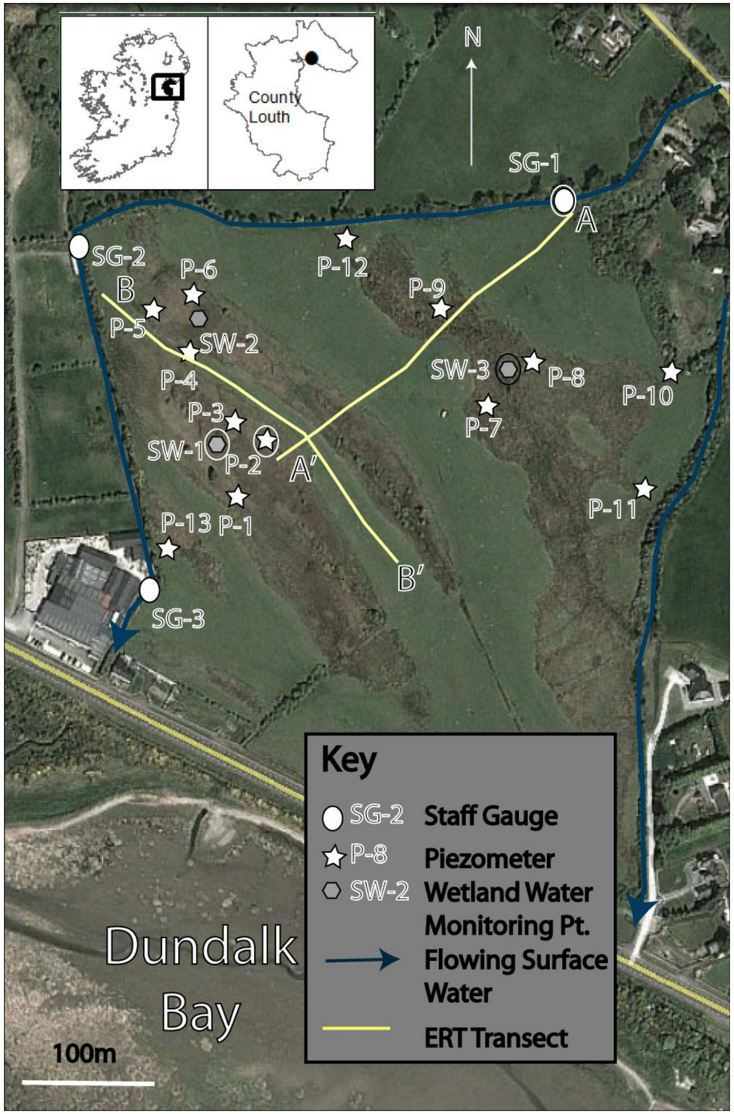
N = 12



Fracture orientations for all outcrop and borehole data in Mattock a) rose diagram b) Schmidt net (poles to fracture planes) density distribution plot

Hydraulically active fractures (HAF) and zones identified from tracer tests . a) rose diagram b) Schmidt net (poles to fracture planes) density distribution plot

Site 2: Rockmarshall Wetland, Co. Louth.



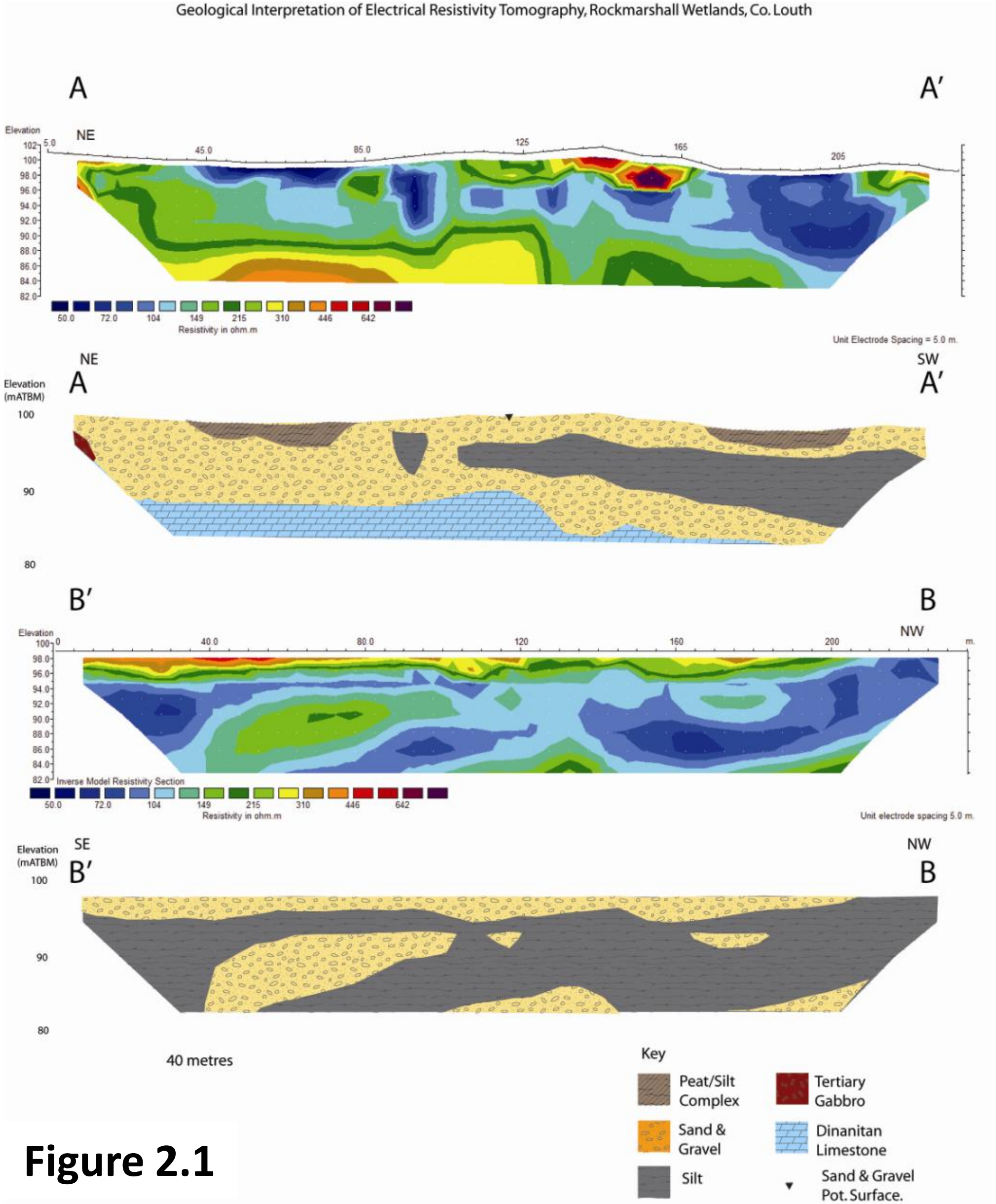


Figure 2.1

Base image: Google Earth

Nitrate Delivery

Notes:

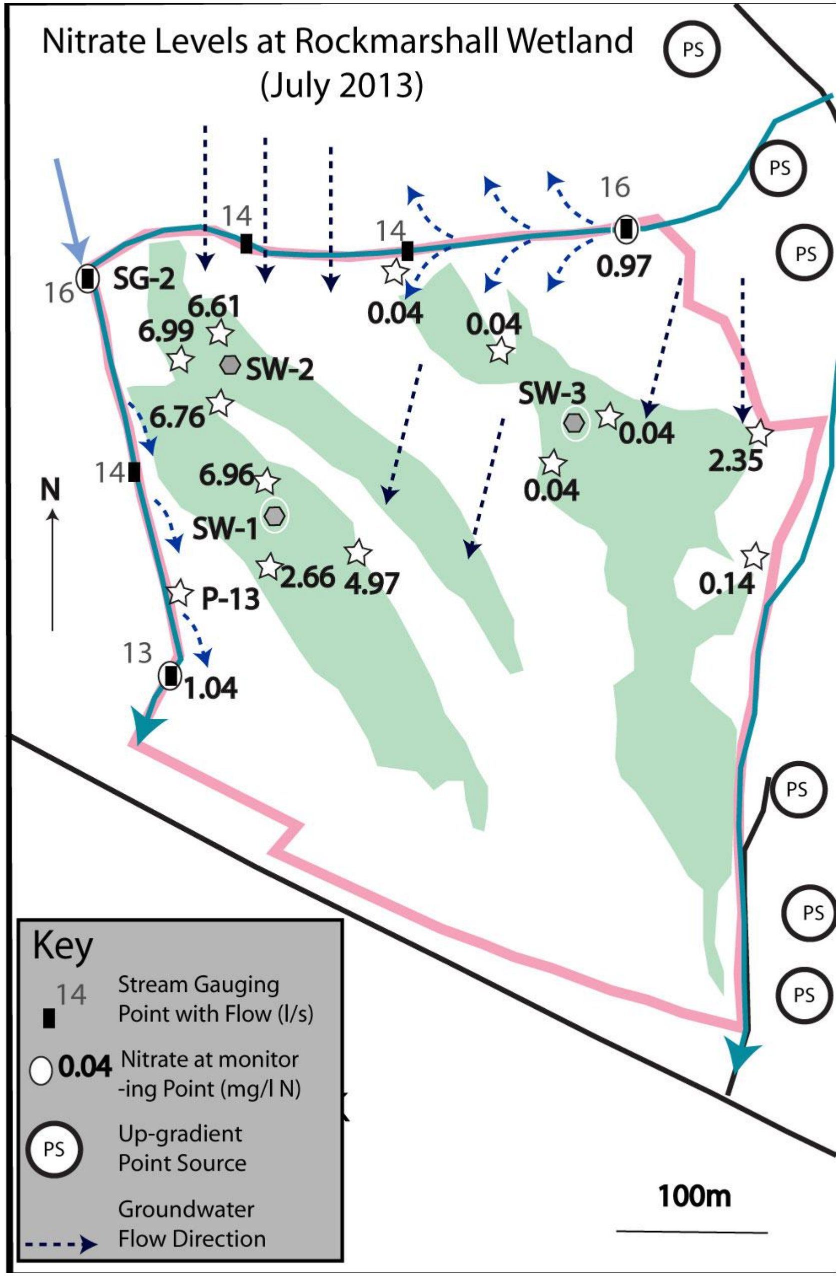


Figure 2.2

Schematic Illustration of Hydrogeological Regime at Rockmarshall, Co. Louth,

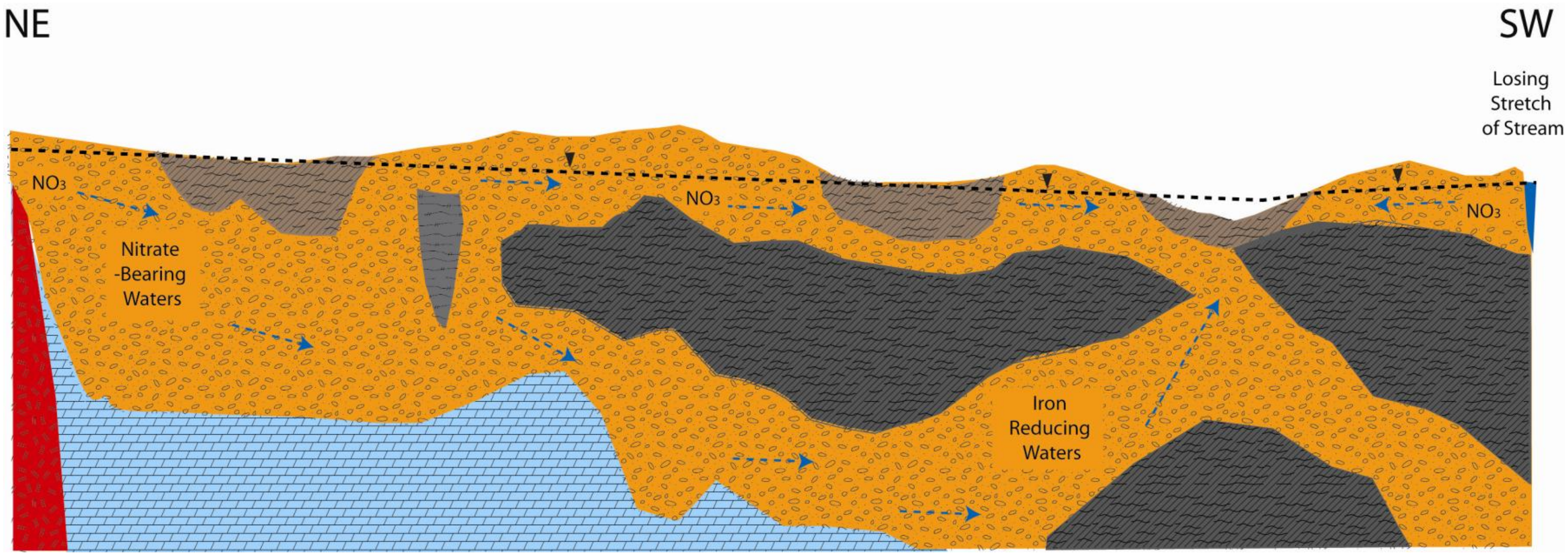


Figure 2.3

Site 3: Newry Granite

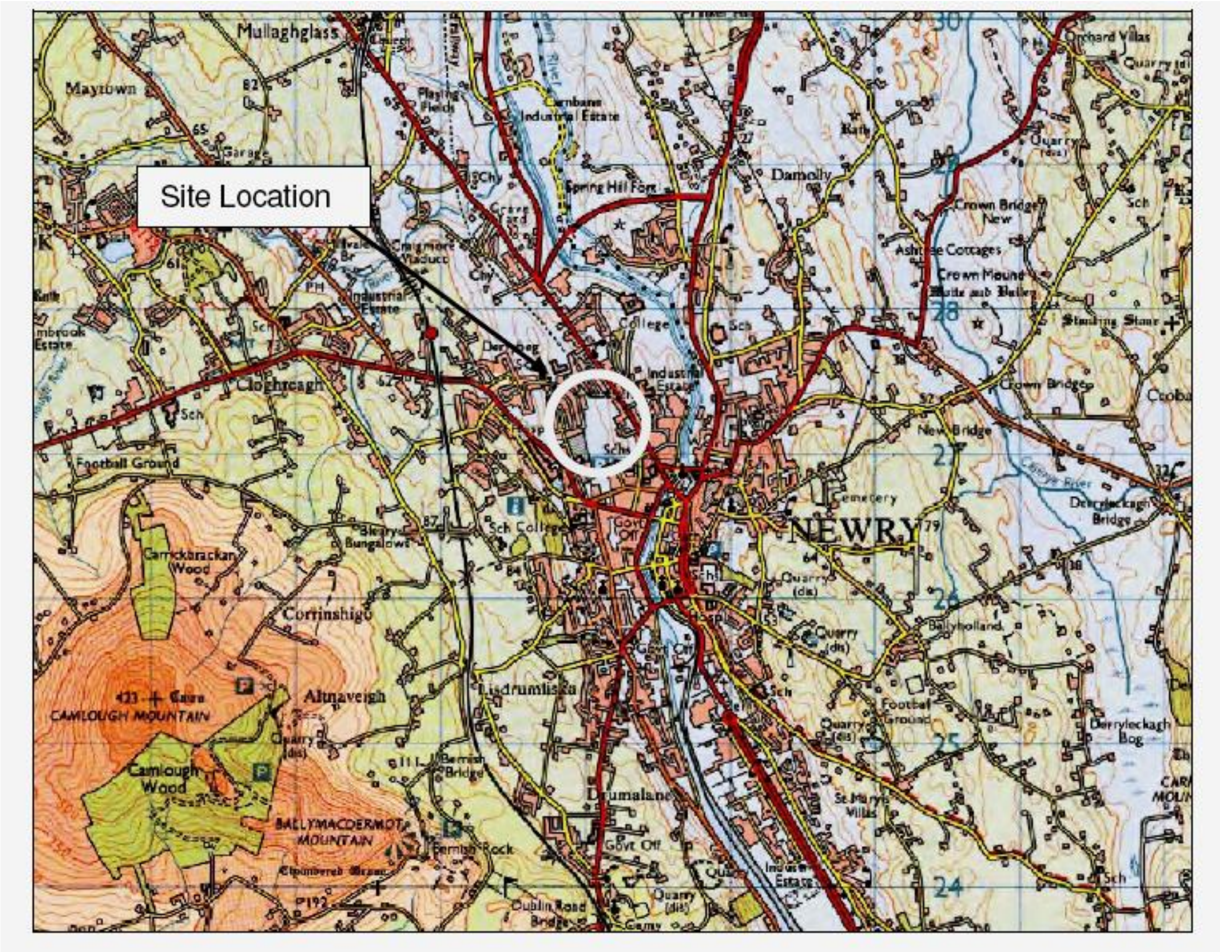


Figure 3.1

Base image: OSNI

Site Topography

Figure 3.2

Base image: Google Earth

Bedrock Geology

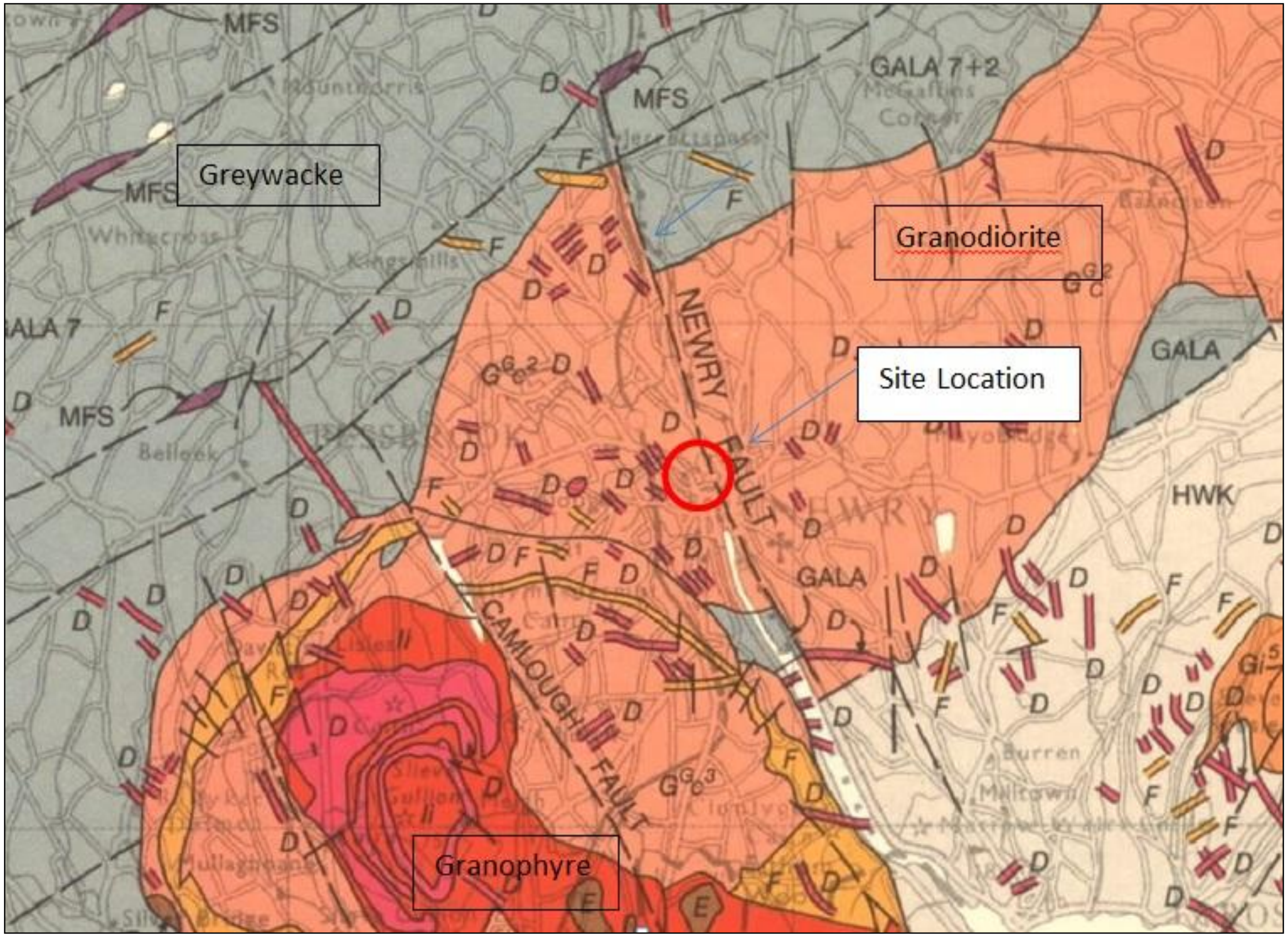


Figure 3.3

Base image: GSNI

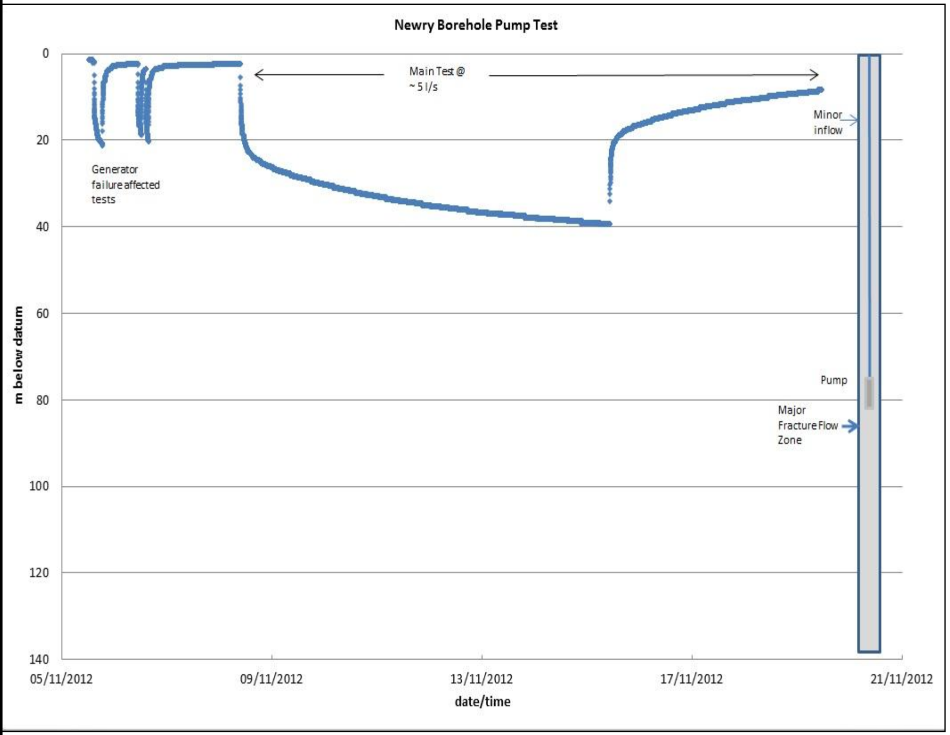
Borehole Locations

Figure 3.4

Base image: Google Earth

Constant Rate Test

Semi-log Plot Response



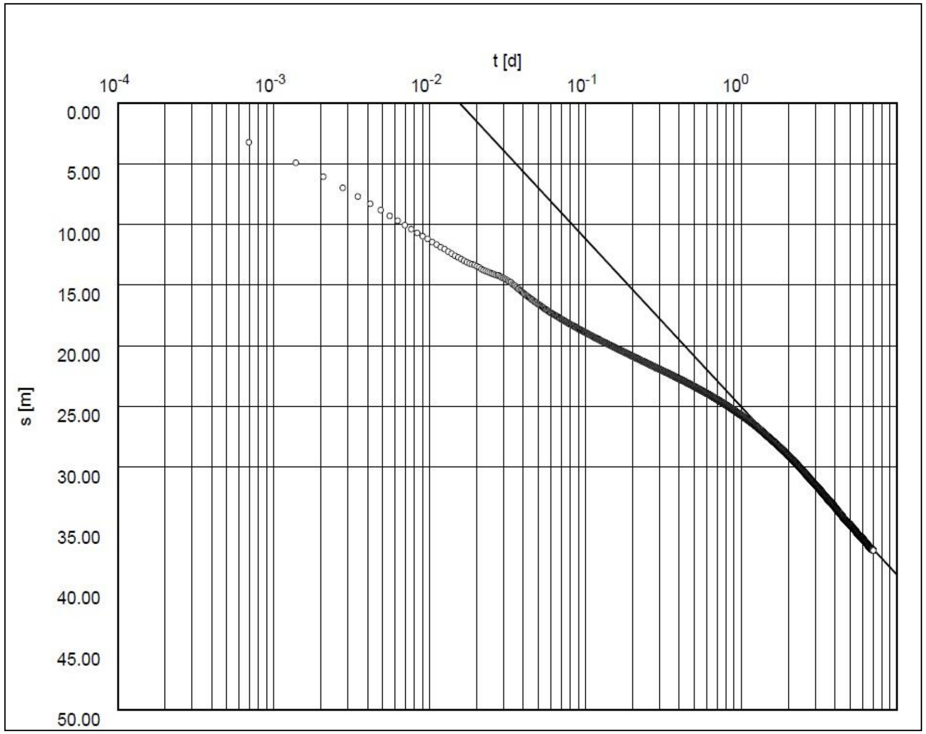


Figure 3.5

Image: McLorinan Consultants

Hydrochemistry

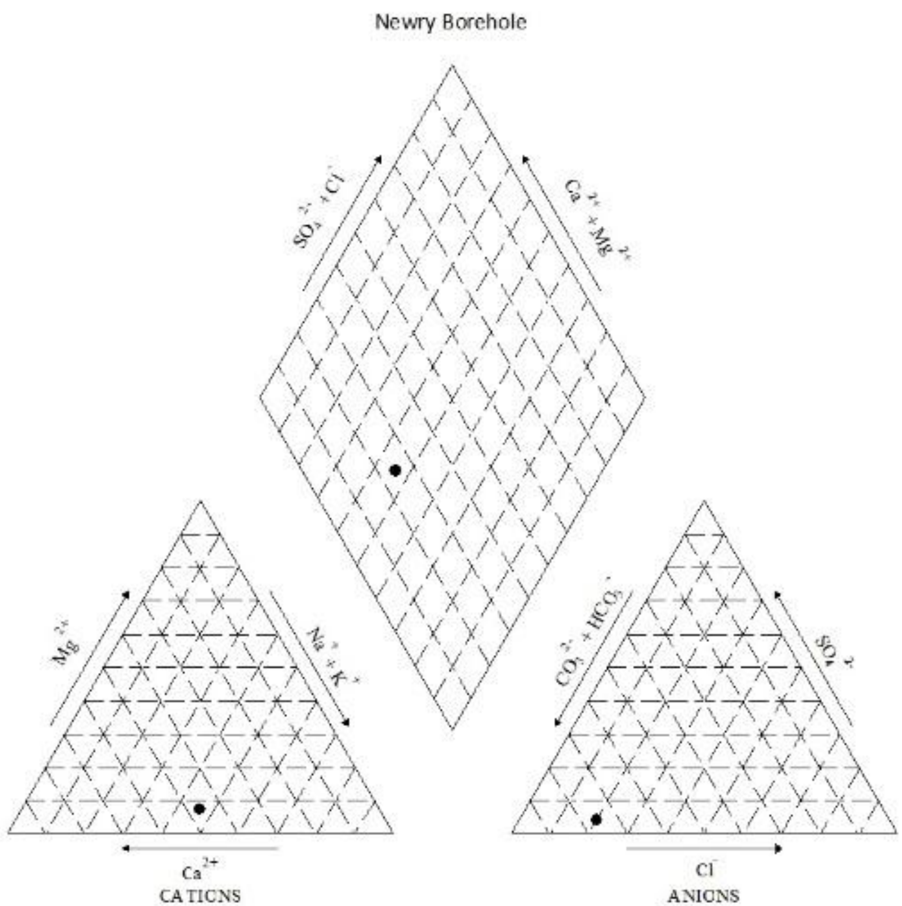


Figure 3.6

Image: McLorinan Consultants

Site 4: David Keir Building, Belfast.
Geophysical Logging of Boreholes

Temp and elect. Conductivity probe

Notes

Figure 4.1

Example of Suite of Geophysical Logs

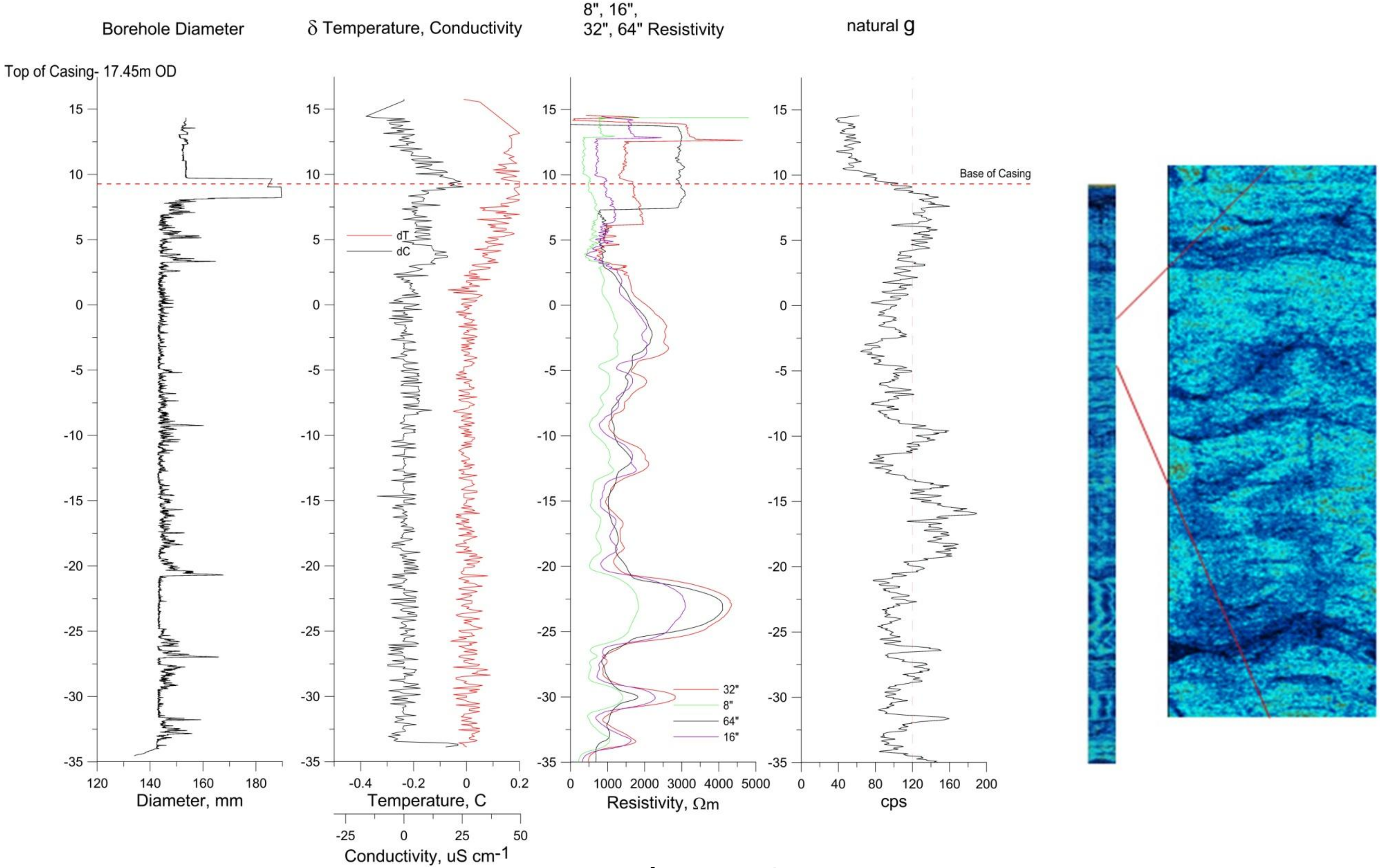
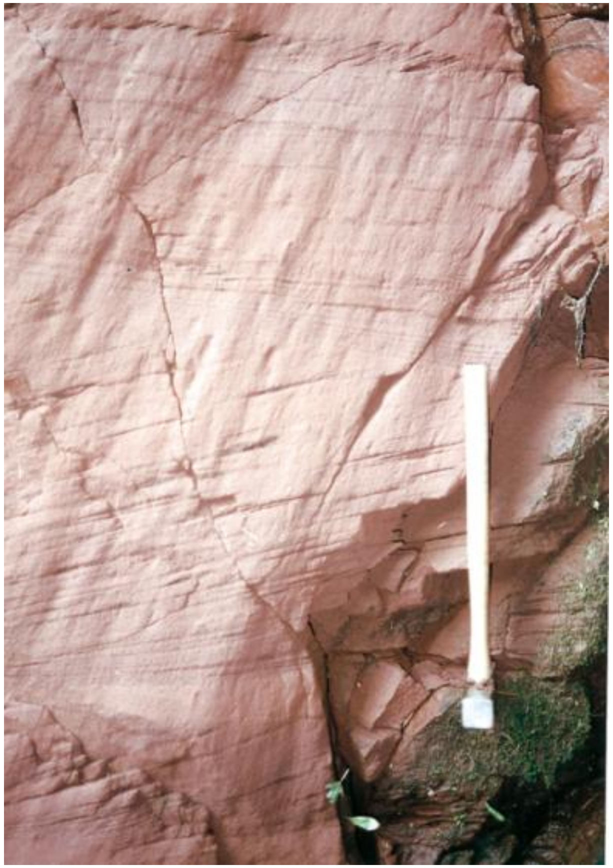


Figure 4.2

Site 5: Scrabo Quarry, Sherwood Sandstone

Scrabo Quarry showing sandstone and igneous intrusions



Cross-bedding (GSNI)

Figure 5.1

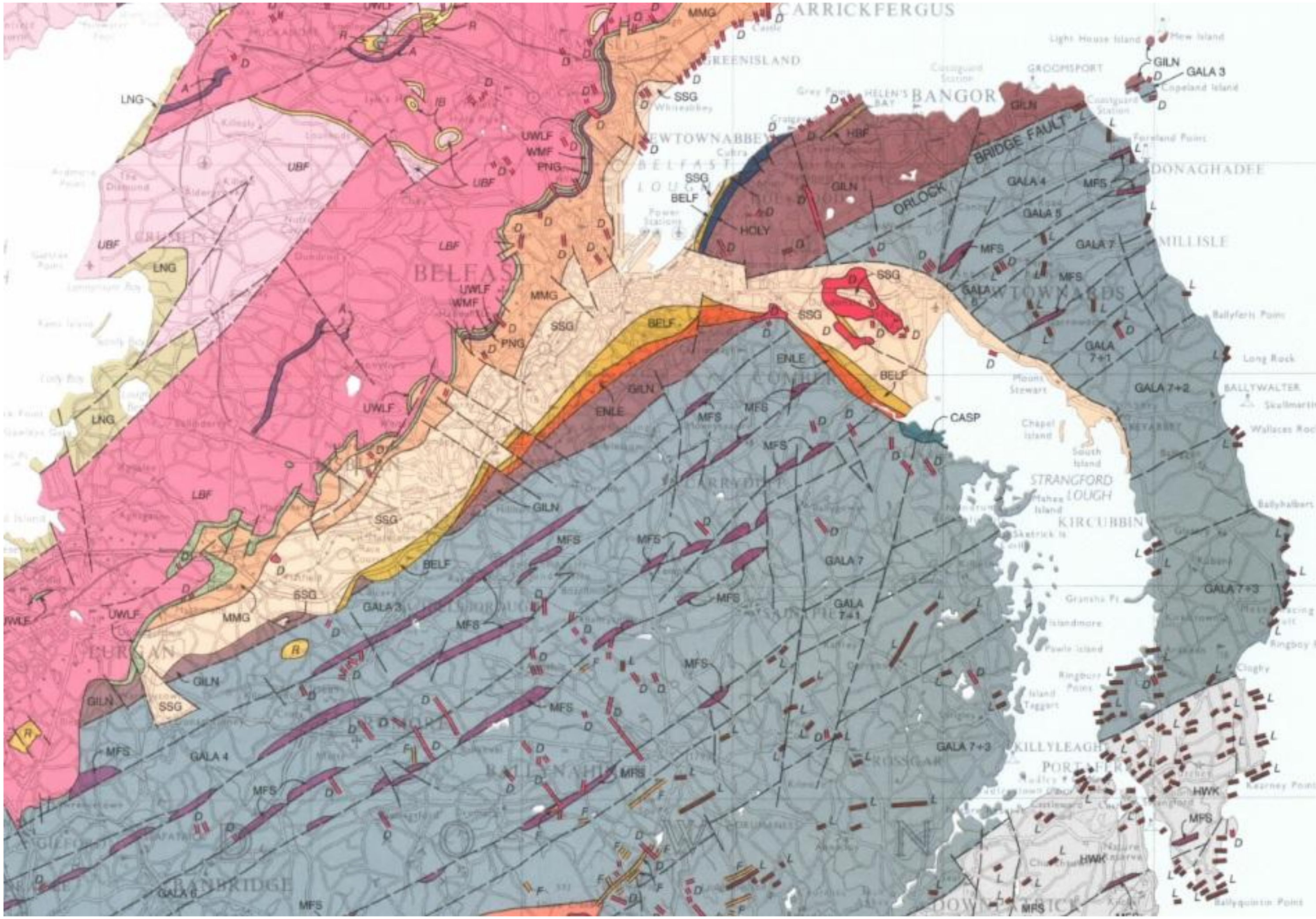
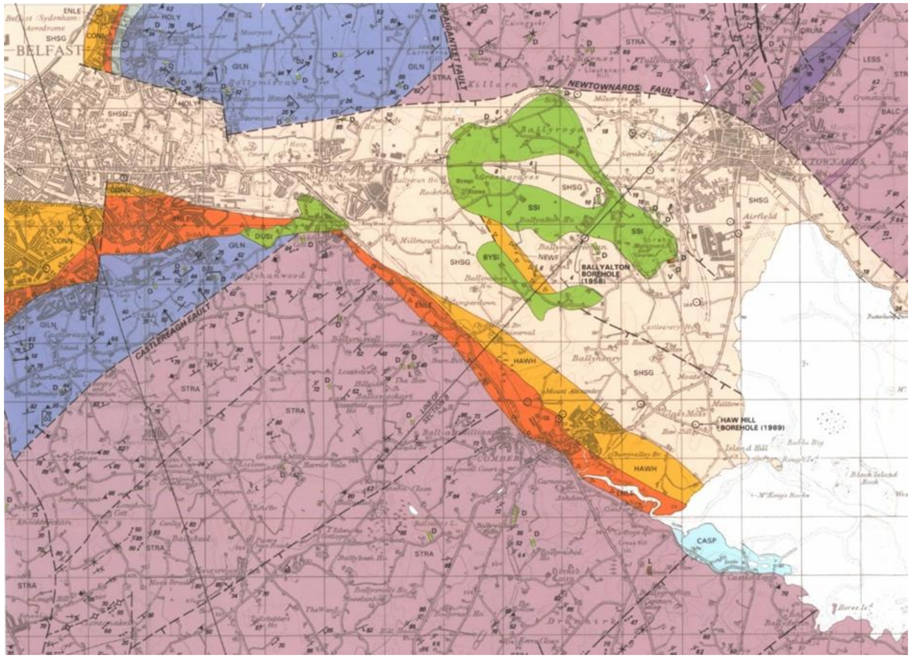
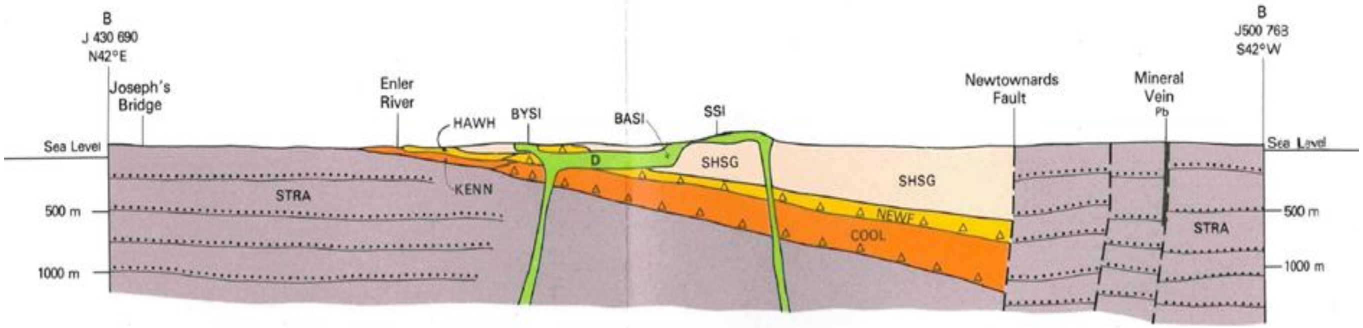


Figure 5.2

Base image: GSNI

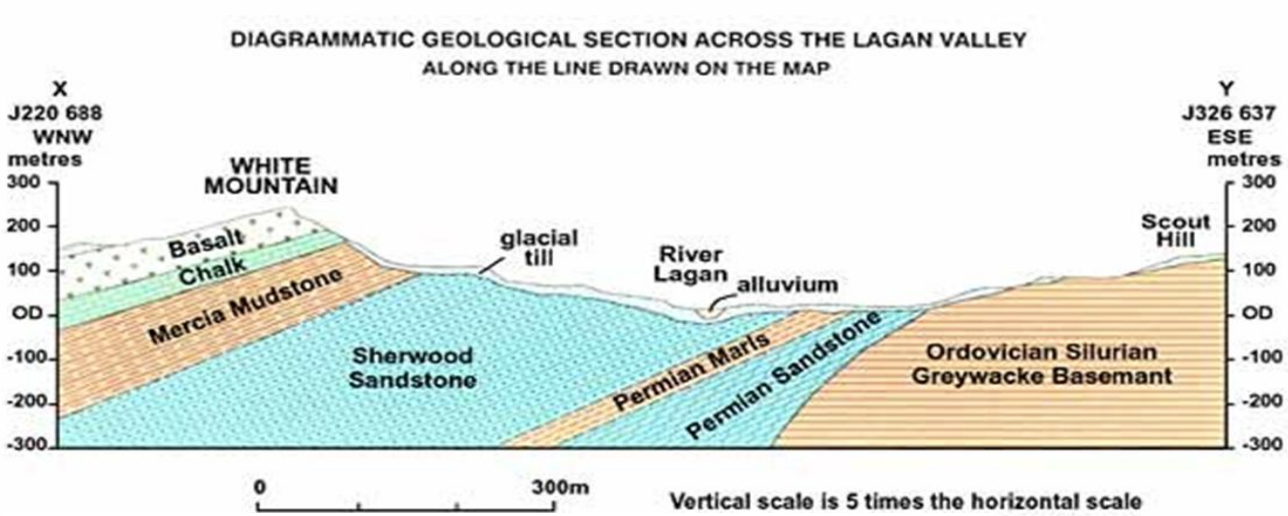
Newtownards Geology (GSNI Sheet 37 1:50 000)





Base image: GSNI

Figure 5.3



Cross Section Across the Lagan Valley

Base image: GSNI

W. A. Ross & Co., The Royal Belfast Ginger Ale and Aerated Water Works, Belfast.—No city in the United Kingdom has gained a more eminent reputation in connection with the manufacture of ginger ale and aërated waters generally than Belfast, and the fact is largely due to the great purity and fine quality of the waters of the artesian wells which exist in this neighbourhood. The enterprise of manufacturers has accomplished the rest, and an illustration of what has been done in raising the aërated water trade of Belfast to the highest level of perfection, is afforded by the establishment of Messrs. W. A. Ross & Co., one of Ireland's foremost firms in the important industry in question. This distinguished and ever-progressive house was founded in 1879 by Mr. W. A. Ross, who has been ably assisted from the first by his son. By energetic management and the exercise of untiring enterprise, the business has been developed to proportions of great magnitude and importance, and it is not too much to say that its fine productions are now known in almost all parts of the world. The Royal Belfast Ginger Ale and Aërated Water Works comprise a very extensive and substantial block of buildings, situated right over their artesian well, admirably arranged for the purposes of the immense and constantly increasing trade carried on. They are perfectly equipped in every respect, and in all our experience of well-organised and carefully conducted industrial establishments we have never seen a neater, cleaner, or more systematically appointed factory

Famous Bottled Water Industry

Figure 5.4

Site 6: Mount Stewart, Co. Down
Stop 1: (Temple of the Winds)

Catchment hydrology

Area	4.8 km^2
Rainfall	800 mm
Potential evapotranspiration	500 mm
Effective rainfall	325 mm
Median flow at catchment outlet	0.037 m^3/s [0.001 – 1.11 m^3/s] (Jan 2011-Jan 2013)
Runoff coefficient (Q/rainfall)	0.39* (*But some water escaping out of catchment)

Geological setting

Soils	Poorly drained gleys dominant, shallow well drained soils and brown earths between drumlins
Subsoils	Low permeability lwr Palaeozoic till in drumlins with numerous rocky outcrops in between. Peat in upper catchment. Sand/gravel alluvium in lower catchment
Bedrock	Silurian sediments
Vulnerability	Extreme to Low
Aquifers	Not classified. However likely to be Pl as per Mattock

Water Quality

Land use	82% intensive pasture 10% tillage
River	**NO_3:** Low (8 mg/l as NO_3) **MRP:** Very high MRP (0.34 mg/l as PO_4)
Groundwater	**NO_3:** Generally low at <2 mg/l NO3 in bedrock, <12 mg/l as NO_3 in alluvium and shallow bedrock. Up to 34 mg/l as NO_3 where borehole construction a possible issue. **MRP:** Low to high, often <LoD, average 0.04
Q-Value	Q2-Q3
WFD Status	Poor to Moderate

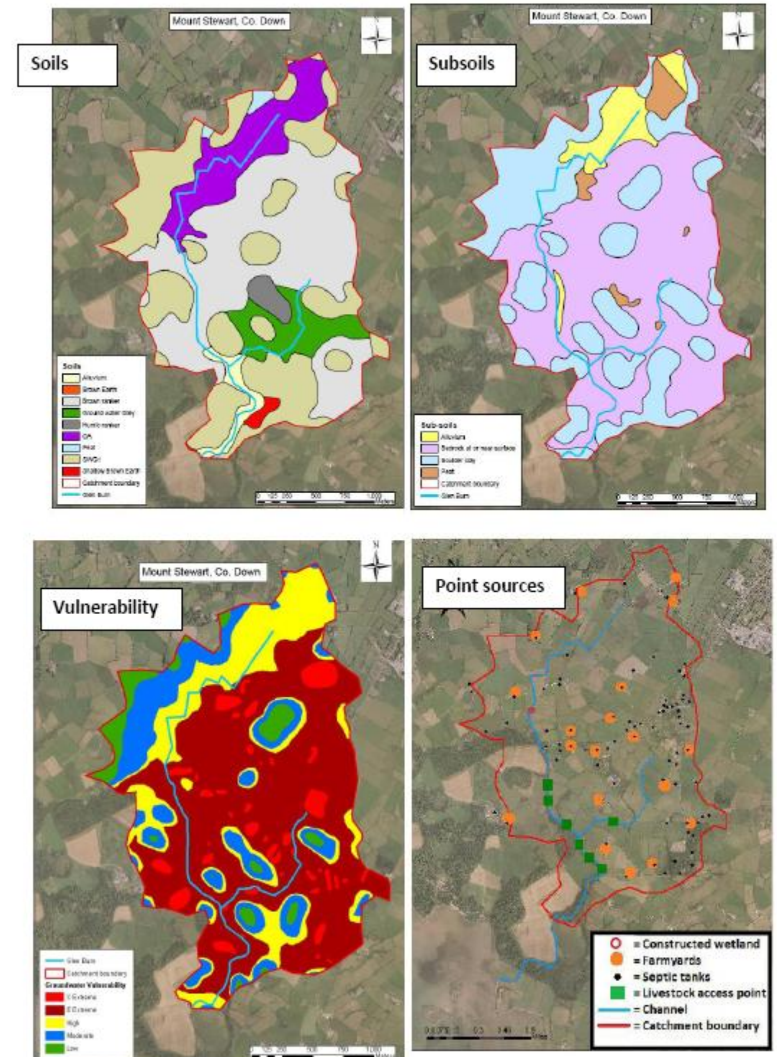


Figure 6.1 From Meredith, MSc, 2010

Mountstewart fieldsite with Geophysical Profiles and Monitoring locations (wells and surface water) indicated

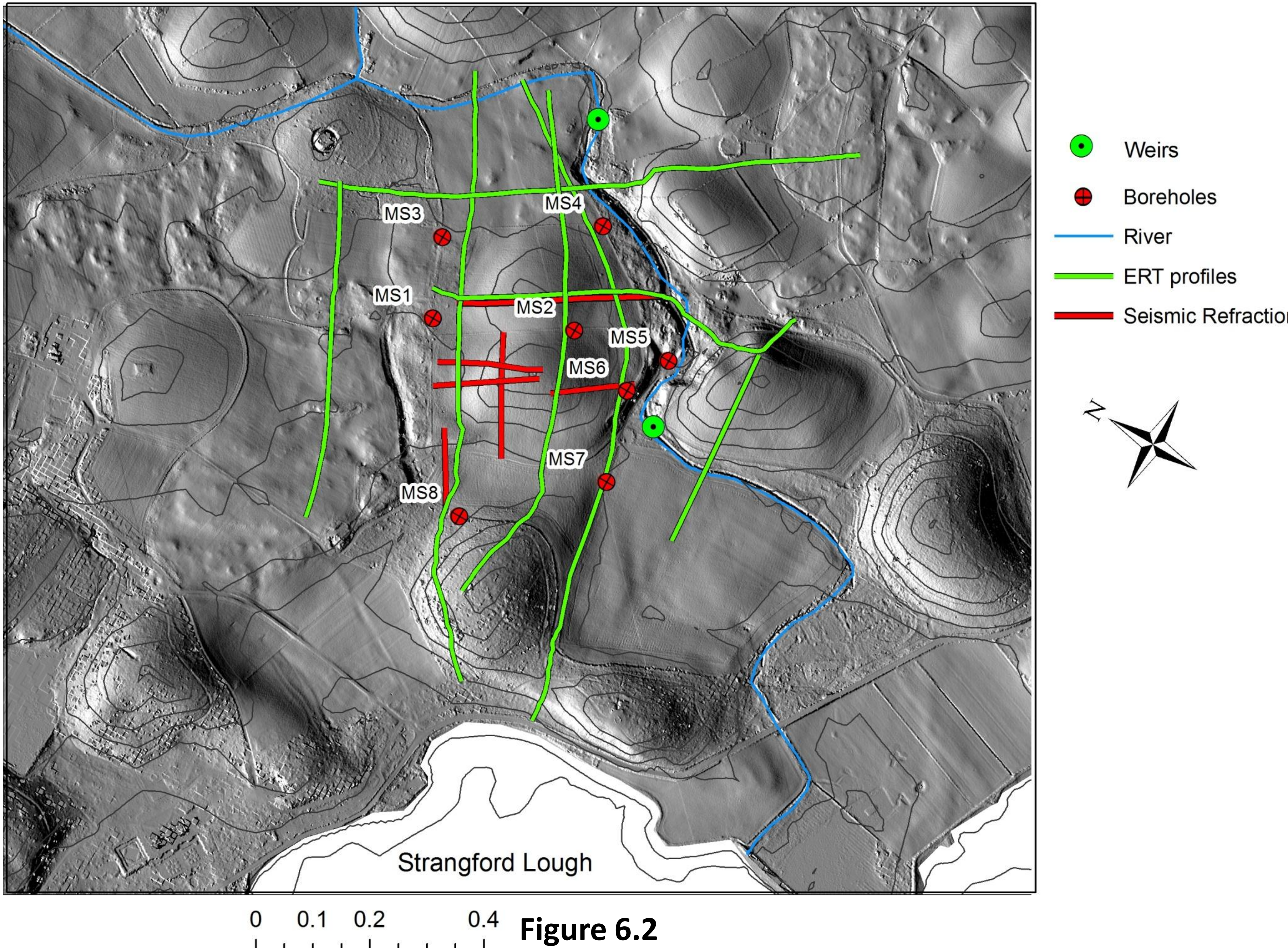


Figure 6.2

Greywacke exposure, Carrodore Quarry to NE of site

Site Geology (from 250k NI geology map)

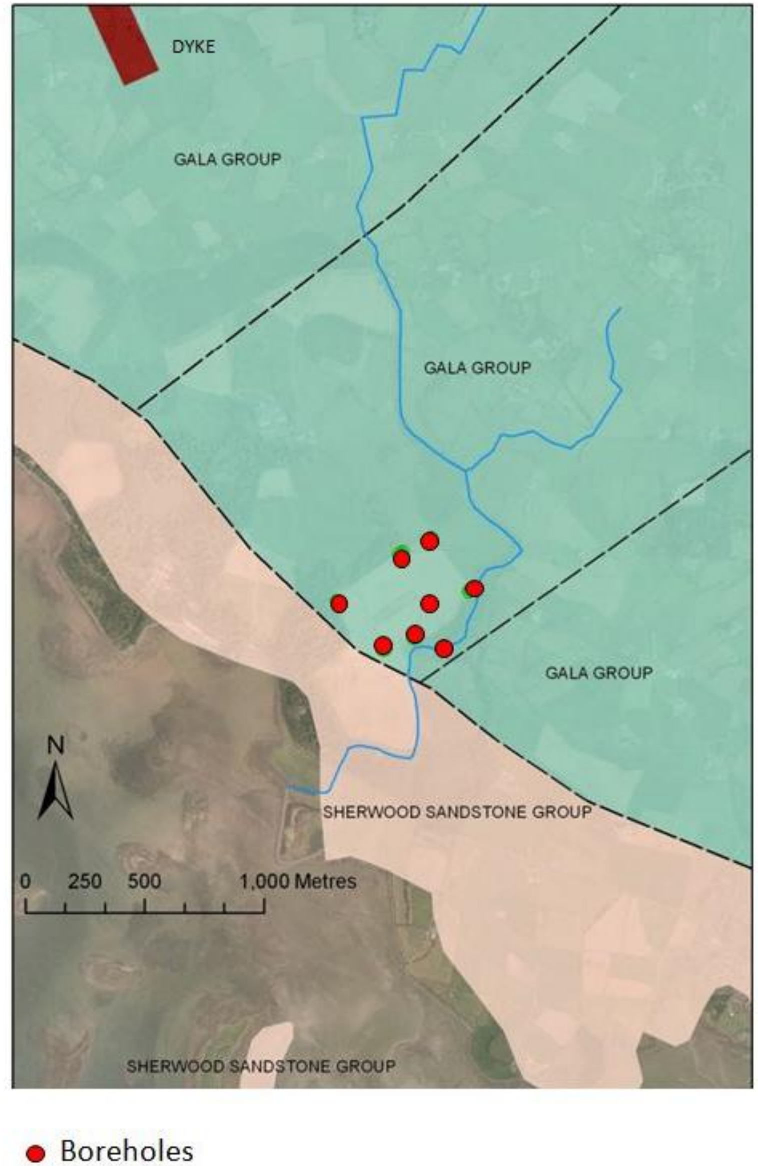


Figure 6.3

Seismic Refraction – Delineation of Drumlins

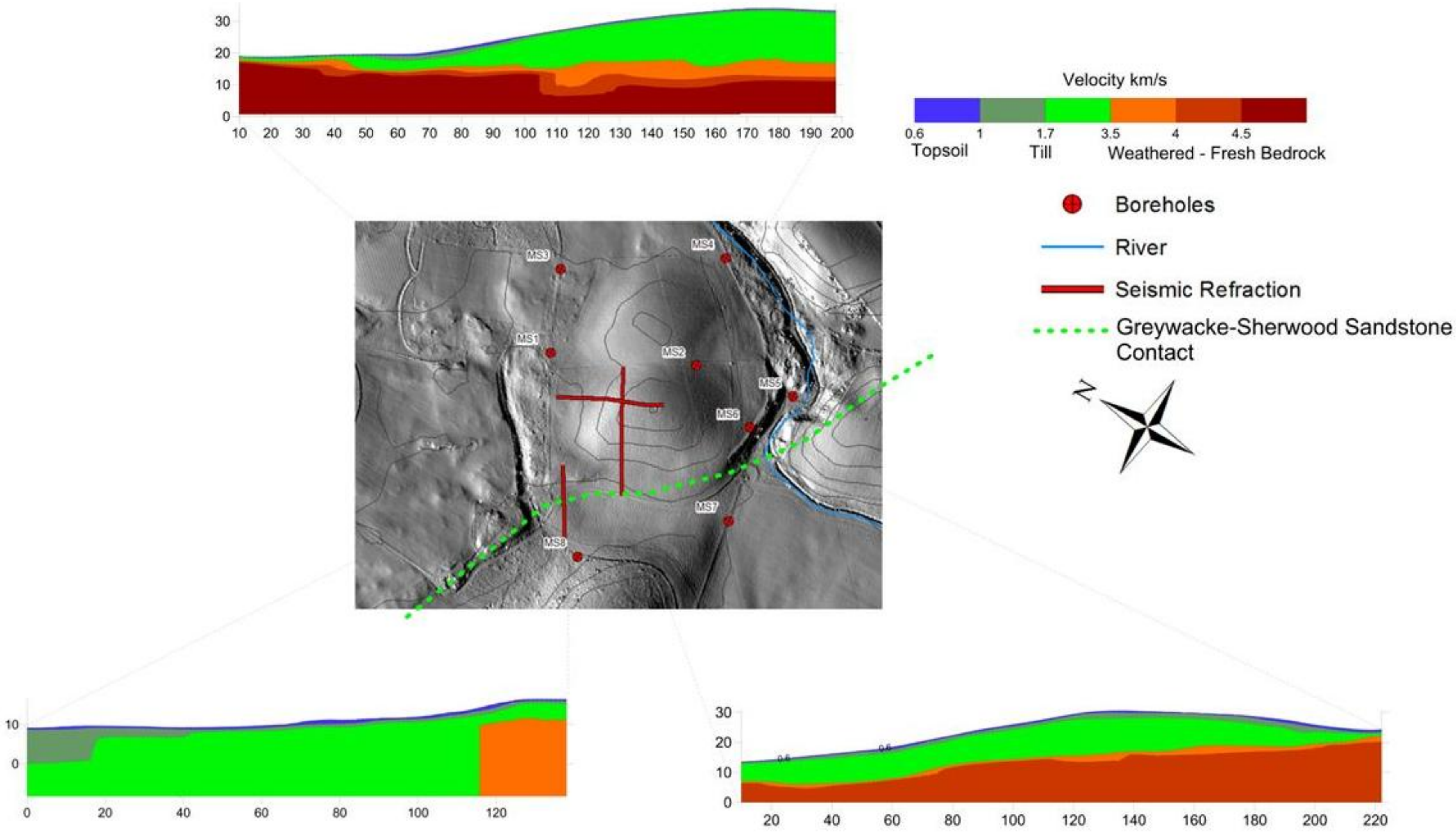
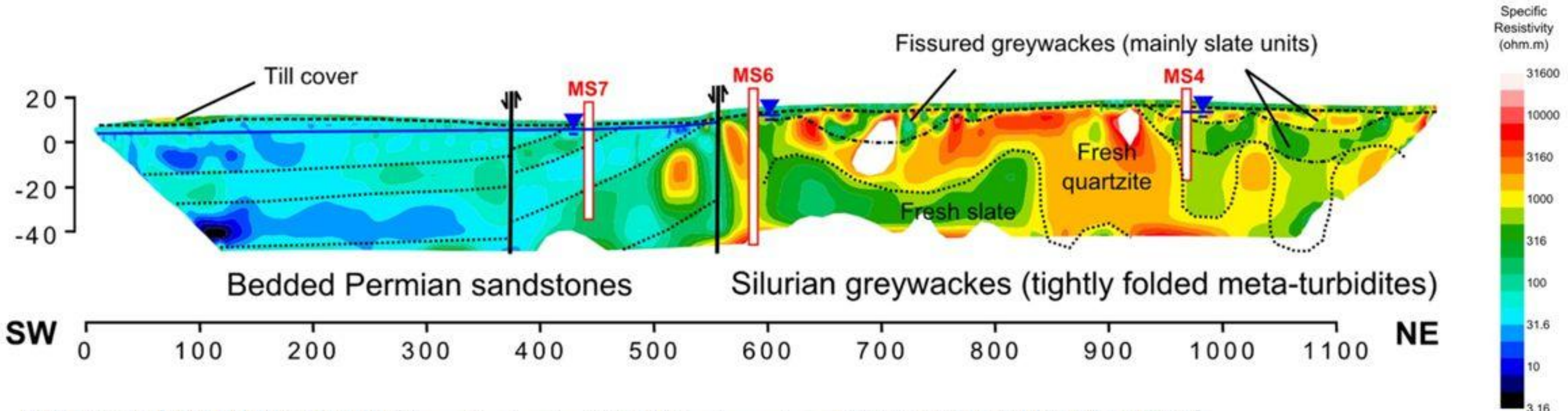
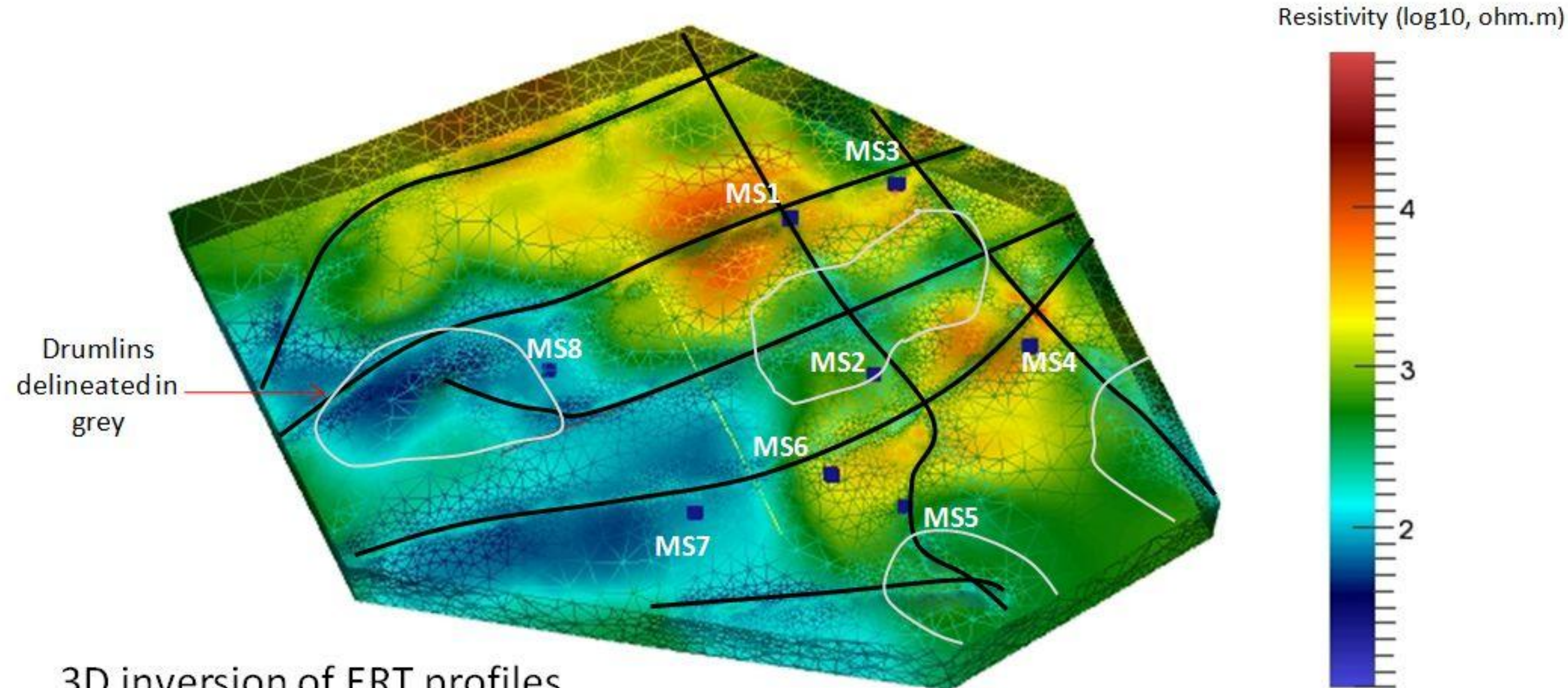


Figure 6.4



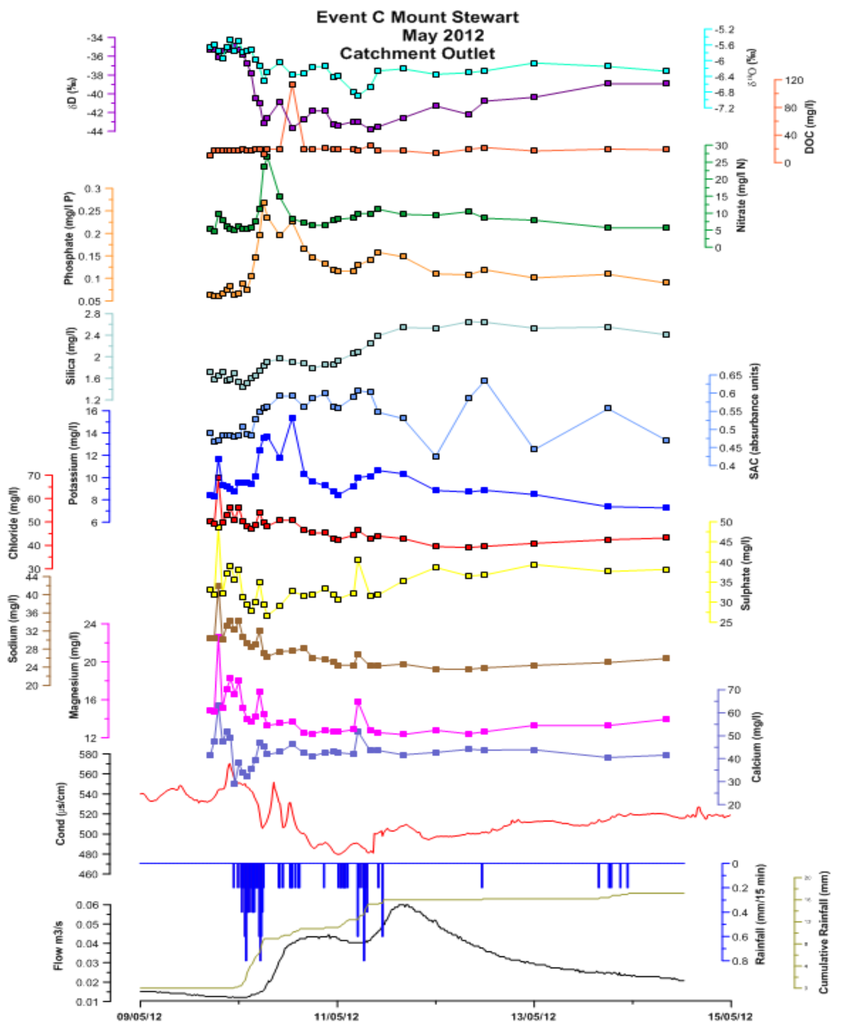
Interpreted 2D ERT inversion (*from Comte et al (2012) Hydrogeology, DOI 10.1007/s10040-012-0884-9*)

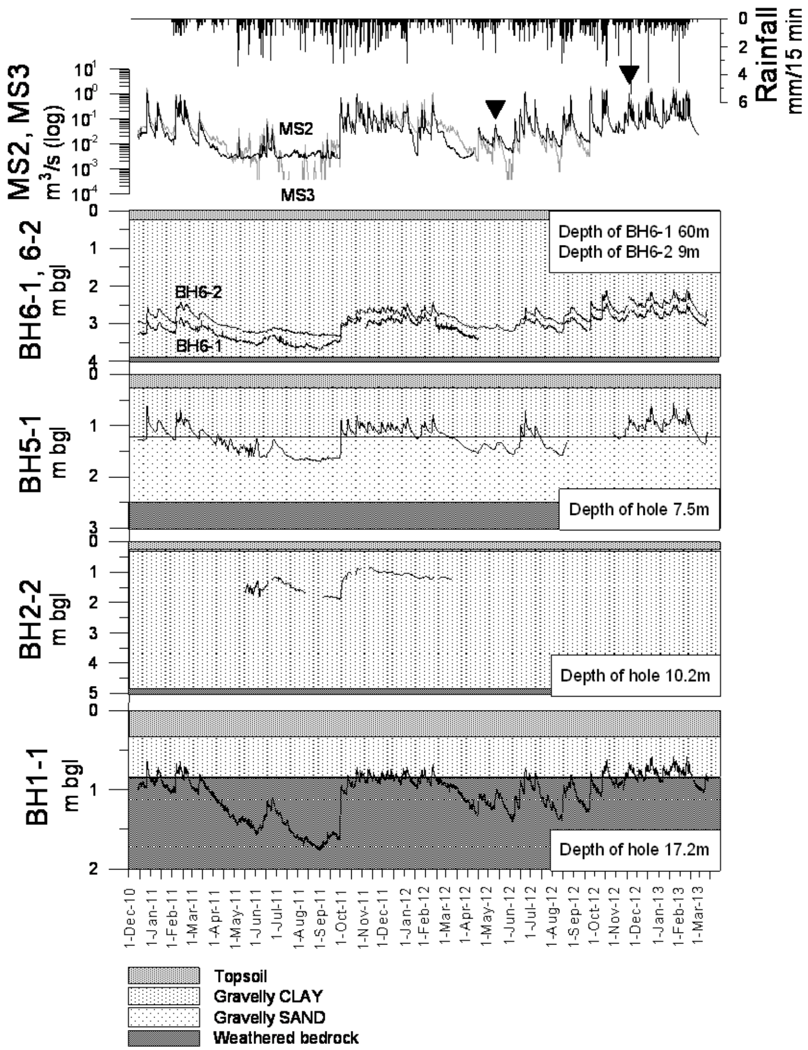


3D inversion of ERT profiles

Figure 6.5

Site 6: Mount Stewart, Co. Down
Stop 2:Catchment Outlet – MS-2



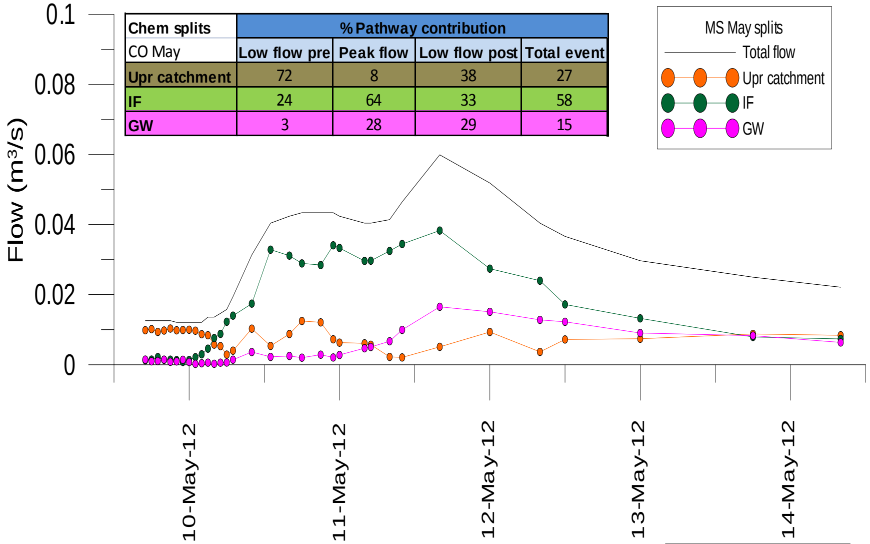


Event sampling is very informative. Spikes in some indicators prior to the rain = point source; first increase in NO3 and PO4 (and NH_4) = quickflow with point source contaminants e.g cattle access points; last peak increased interflow and shallow groundwater contribution.

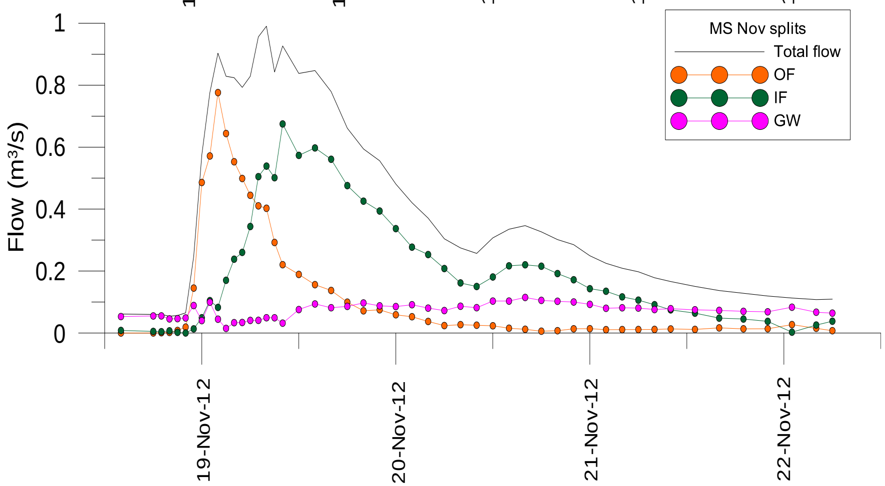
The catchment operates differently above and below a threshold that is related to groundwater levels.

Figure 6.6

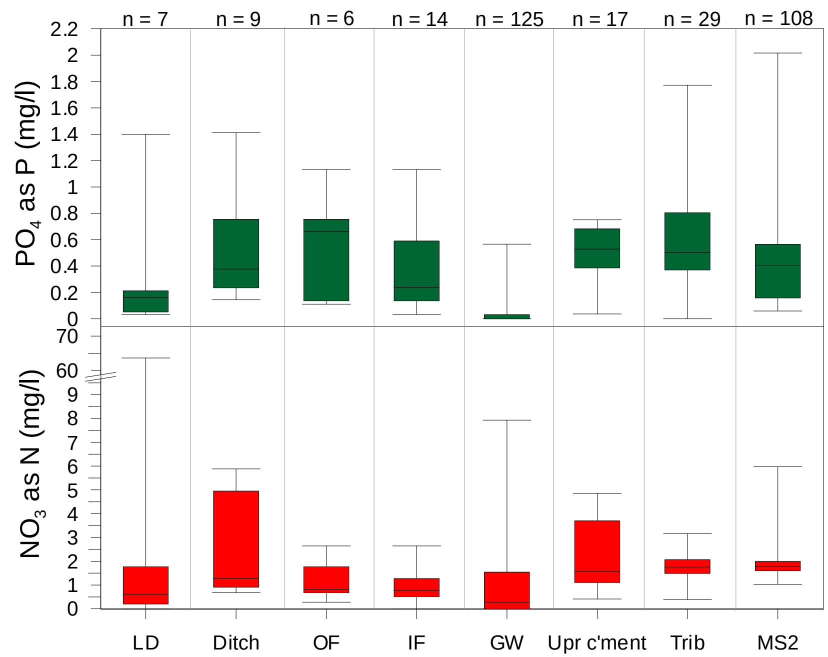
Pathways



Chem splits	% Pathway contribution			
CO May	Low flow pre	Peak flow	Low flow post	Total event
Upr catchment	72	8	38	27
IF	24	64	33	58
GW	3	28	29	15



Chem splits	% Pathway contribution			
CO Nov	Low flow pre	Peak flow	Low flow post	Total event
OF	0	41	7	25
IF	8	54	35	54
GW	92	5	59	21

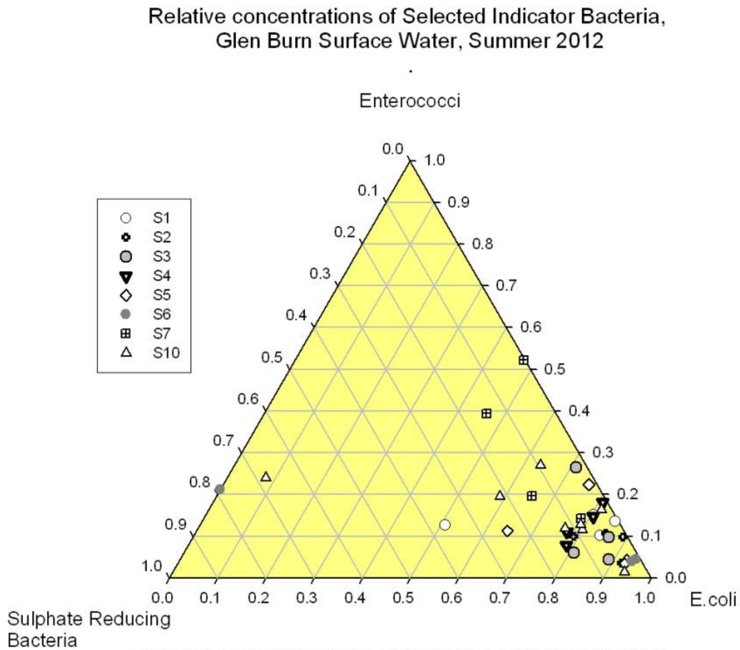


Nutrients in Pathways

Figure 6.7

Mount Stewart Microbiological Monitoring

Notes



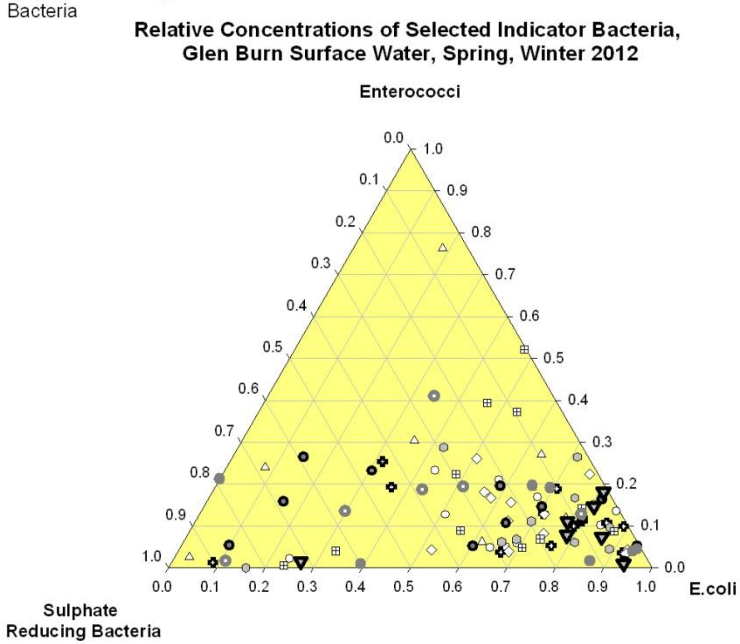
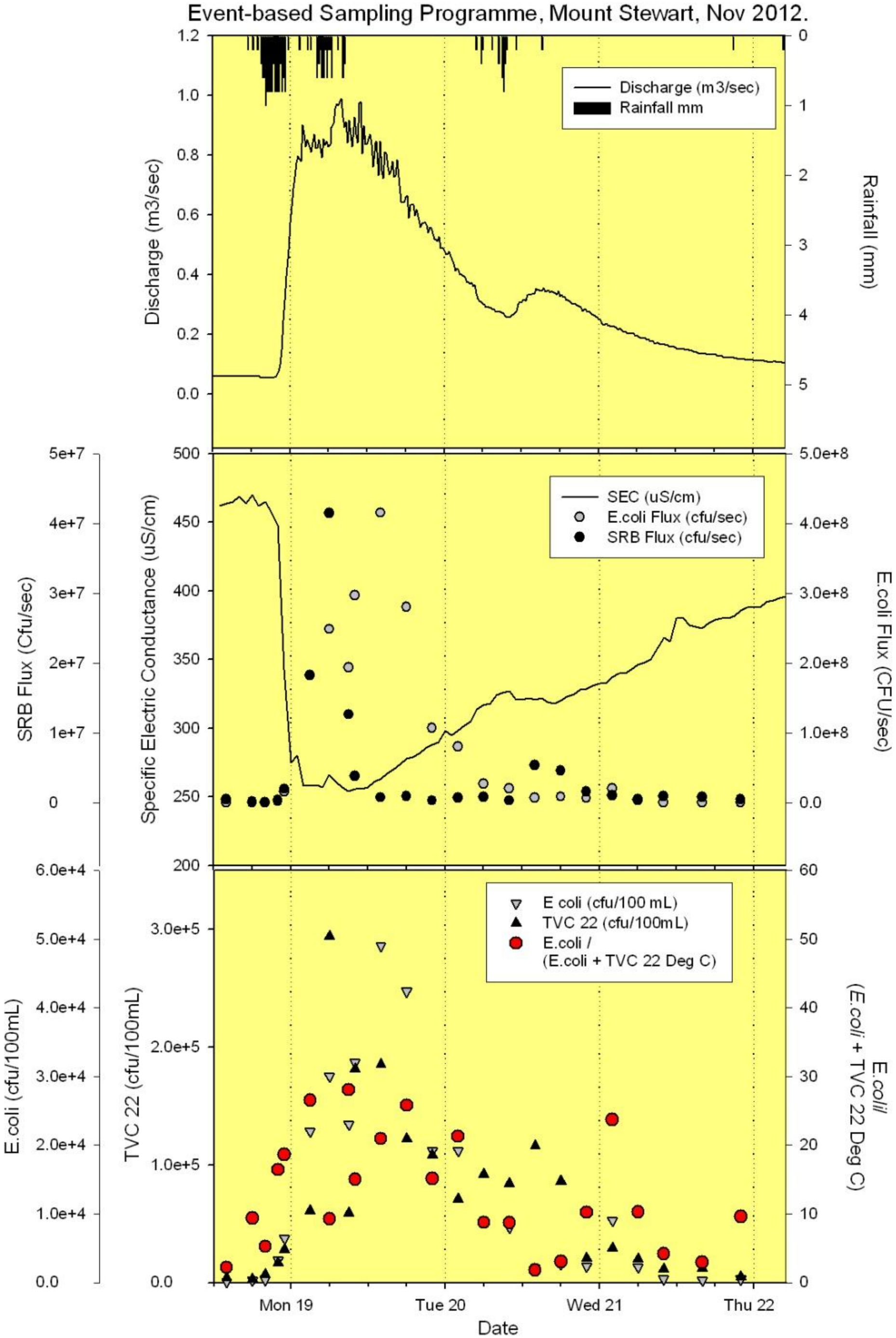


Figure 6.8

Event Microbiology



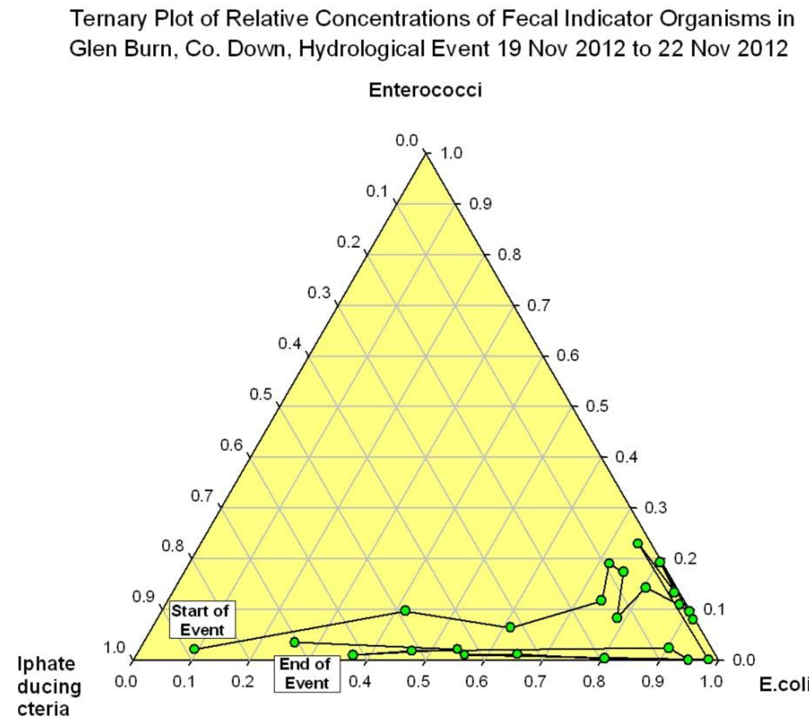
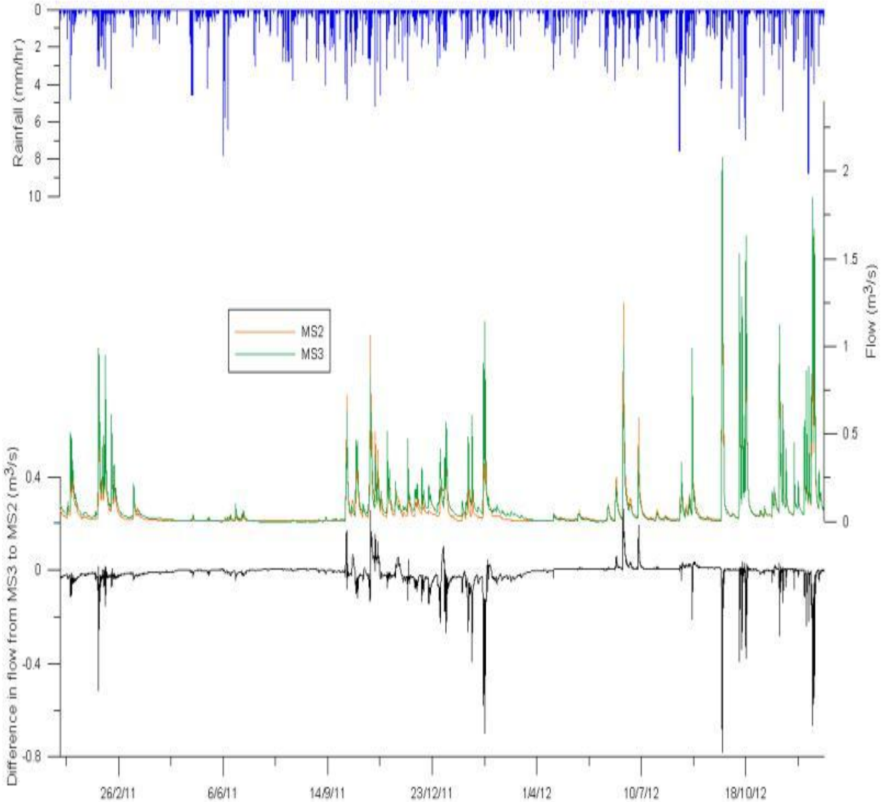


Figure 6.9

Site 6: Mount Stewart, Co. Down
Stop 3: Former Quarry



Flow at catchment outlet often less than flow up-gradient

Figure 6.10

Mt Stewart BHs Transmissivity

Theis and Theis Recovery Drawdown Analysis

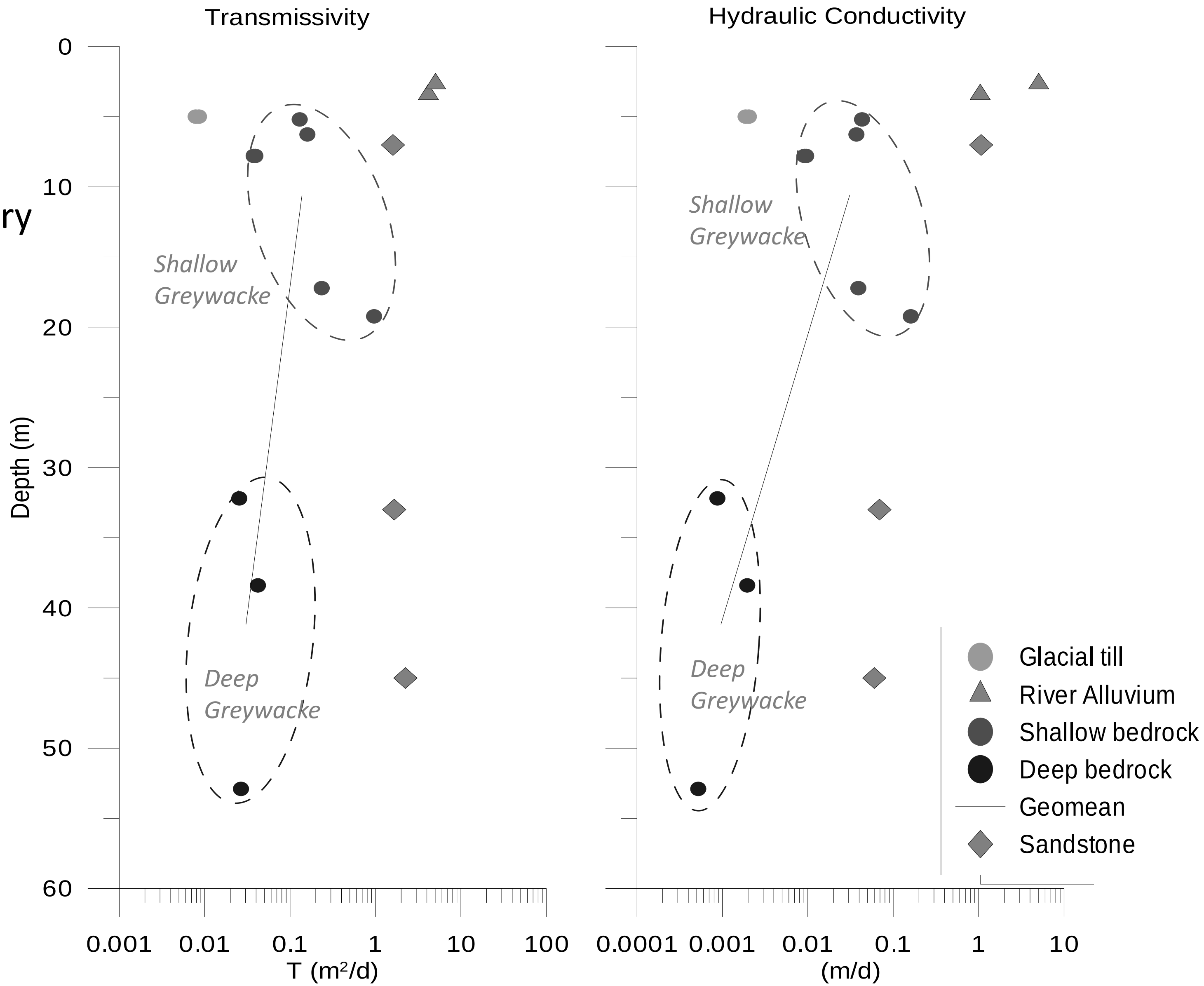
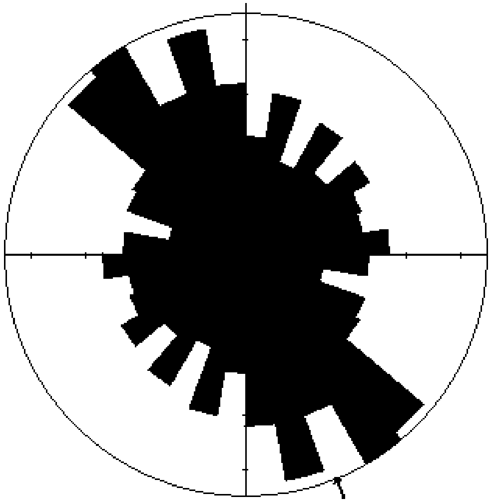
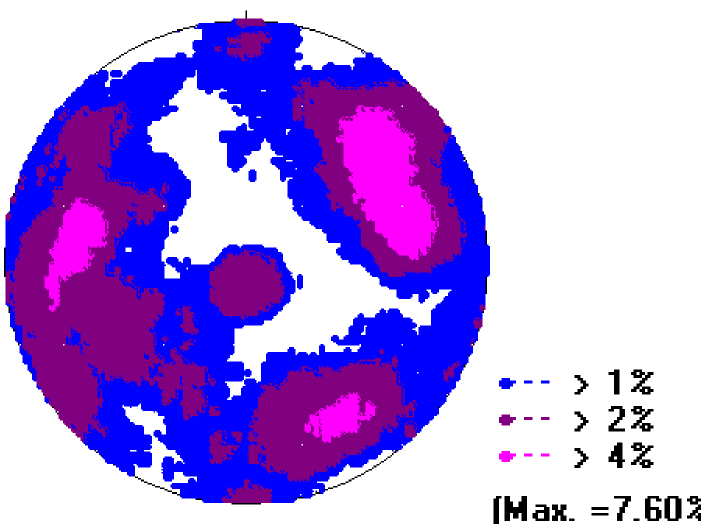


Figure 6.11

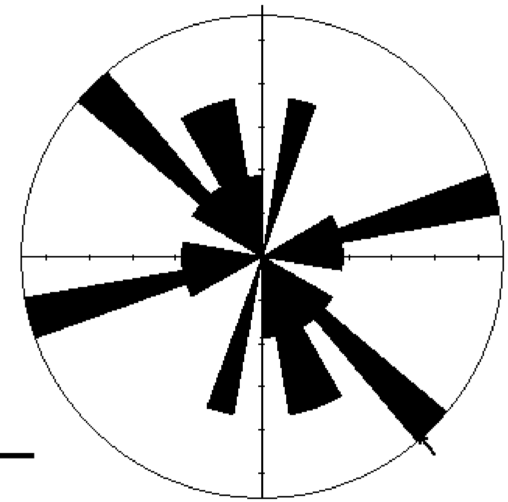
Mount Stewart Fracture Data



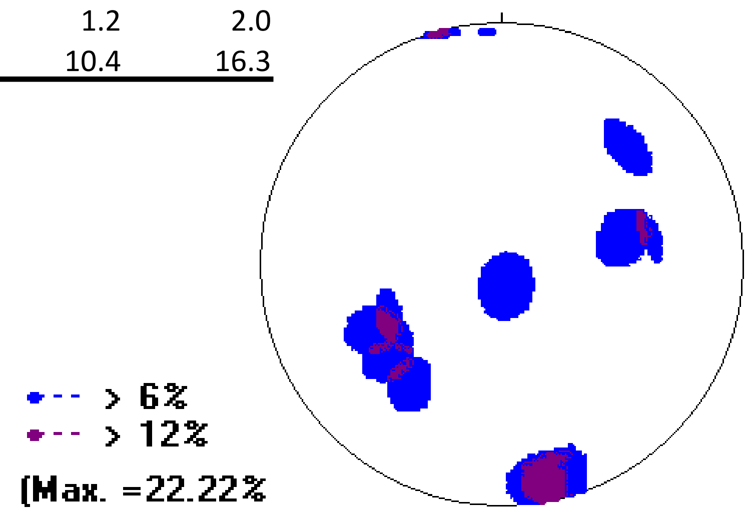
N = 658



HAF Apertures	Shallow boreholes	Deep boreholes
Sample size	13	8
Mean (mm)	2.9	5.4
Std dev (mm)	1.2	2.0
Range (mm)	10.4	16.3



N = 18



Fracture orientations for all local scale data in Mount Stewart
a) rose diagram b) Schmidt net (poles to fracture planes) density distribution plot

Hydraulically active fractures identified from tracer tests
a) rose diagram b) Schmidt net (poles to fracture planes) density distribution plot

Figure 6.12