Qualification Accredited

Oxford Cambridge and RSA

A LEVEL

Exemplar Candidate Work

GEOGRAPHY

H481
For first teaching in 2016

H481/04/05 Summer 2018 examination series
Independent Investigation exemplar 2 – The water cycle

Version 1

Contents

Introduction

These exemplar answers have been chosen from the summer 2018 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to approach the assessment but do illustrate how the mark scheme has been applied.

Please always refer to the specification https://www.ocr.org.uk/Images/223012-specification-accredited-a-level-gce-geography-h481.pdf for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the June 2018 Examiners' report or Report to Centres available from Interchange https://interchange.ocr.org.uk/Home.mvc/Index

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.

Introducing the Independent Investigation

This A Level resource has been produced to support teachers and learners with the Independent Investigation. This resource includes a candidate's investigation from the 2018 submission as well as a commentary from the Principal Moderator. The mark recording sheet is incorporated to support teachers in understanding how the marking criteria has been applied.

This is one of four investigations which cover a variety of topic contexts, including Coastal Landscape Systems, Earth's Life Support Systems and Changing Spaces; Making Places. The Independent Investigations can be related to any area of the specification

These investigations have been marked and moderated by centres which is reflected in the mark recording sheets. The specification explains that marking should be a 'best fit' principle. The extent to which the work meets all of the requirements of a level descriptor will determine its placement within that level (page 58). All of the investigations include mark recording sheets that have been annotated by the centres, this ensures an evidence base for marking and helps support moderation as it is clear why the candidate has been awarded the mark.

To support teachers with the Non-Exam Assessment (NEA) component, each centre will receive a Moderators Report which will focus on three key areas of feedback – administration of the NEA, interpretation of the marking criteria and feedback on the moderated sample. This centre specific feedback can be used in conjunction with the Examiners Report for 2018 (https://interchange.ocr.org.uk/Downloads/ER_H481_04_05_June_2018.pdf).

A Level non-exam assessment (NEA) forms

For the purpose of marking (internal) and moderation (internal and external), the following three documents must be included with each candidate's work:

- Independent investigation proposal form – this must be signed by the teacher
- Mark recording sheet
- Candidate record form and centre declaration – signed by the candidate and teacher.

All of these documents can be found on the A Level geography page within *Assessment* and *Forms*.

https://www.ocr.org.uk/qualifications/as-and-a-level/geography-h081-h481-from-2016/assessment/

We have a number of resources and CPD materials to support the Independent investigation and these include:

Support resources:

- Independent Investigation outcomes – Autumn 2018 (https://www.ocr.org.uk/Images/521840-independent-investigation-outcomes-autumn-2018.pdf).
- Joint Exam Board – Frequently Asked Questions (https://www.ocr.org.uk/Images/386111-a-level-geography-independent-investigation-faq-s.pdf)
- Guide to developing titles and completing the proposal form (https://www.ocr.org.uk/Images/396138-a-level-geography-independent-investigation-guide-to-developing-titles-and-completing-the-proposal-form.pdf)
- A student's guide to the Independent Investigation (https://www.ocr.org.uk/Images/390518-independent-investigation-student-guide.pdf)

CPD

- Developing a deeper understanding of the A Level Independent Investigation (https://www.cpdhub.ocr.org.uk/DesktopDefault.aspx?e=fjefcbdbhgnidcpindncdphpabihkmpcehicklnfcaaglpdcik)
- Tackling the Independent Investigation (https://www.cpdhub.ocr.org.uk/DesktopDefaultaspx?e=fjefcbdbhgnidcpindncdphpabihkmpcehicklnfcaaagonojd)
- Independent Investigation Feedback and Effective Marking (https://www.cpdhub.ocr.org.uk/DesktopDefault.aspx?e=fjefcbdbhgnidcpindncdphpabihkmpcehicklnfcaagloljcm)

If you need any further support or advice then please don't hesitate to get in touch with the Geography Subject Advisor geography@ocr.org.uk

Independent Investigation marking commentary

Proposal Form – general comments

- The form has been fully completed and contains evidence of the candidate's own ideas to make the investigation independent.
- The location looks appropriate as are the links to the specification.
- The focus is clear and achievable; scale seems appropriate and manageable.
- The data collection seems appropriate, although the design is not particularly clear in the "Investigation focus" section. "Planned methodology" does give some other ideas, including the sampling strategy.
- Secondary map data is mentioned, although this might not be at the correct scale for this kind of investigation. Concepts and models could have usefully been referred to in the planning document.

Marking Comments – the centre has used evidence from the marking criteria in order to provide full "Teachers Comments". These would have been very useful during the process of moderation for the purpose of trying to agree marks. In this particular piece of work there is no evidence provided of internal standardisation having taken place.

Section 1: Planning, purpose and introduction. (Level 3 - 6 marks)

- The introduction shows good evidence of selection of an independent topic, which the candidate has provided a context and purpose for their investigation. The candidate also refers to the secondary data that will be used to support the investigation.
- A series of maps locate the Oldham location and in most instances this is precise and uses-geolocation technology in the form of digital maps (although no grid references are present). There are other large scale location maps in the methodology.
- The candidate refers to geographical theory (pages 1-2), so this provides evidence of individual literature research (e.g. water cycle model). A bibliography is provided.
- Justification and contextualisation again is explicit, giving a clear signal of L3 on this criterion. The use of a smaller-scale, more localised model, concept or idea could have been beneficial. This could have come from a more thorough literature review to help frame the investigation more effectively.

Section 2: Data, information collection methods and sampling framework. (Level 3 - 7 marks)

- The candidate has used a range which are appropriate to the focus. They have broken the discussion down into readable sections containing comments on both equipment and methodology.
- Description of the methodologies is clear, detailed and personalisation is explicit. The use of a pilot survey could have been beneficial in terms of practicing techniques, e.g. interception, to see whether any modifications of approach were needed.
- Design and especially sample size has been given some thought and this is characteristic of L3. There is still opportunity to justify locations, sampling procedures etc more fully.
- This section contains a clear discussion of the ethical considerations by using the MAGIC website. Ethical considerations can be considered at any point in the investigation and given credit.

Section 3: Data presentation techniques. (Level 3 - 9 marks)

- There is appropriate and selective presentation of the most influential data collected directly related to the investigation.
- The techniques used are very well selected, technically accurate and graphs produced with care in most instances. The use of box and whisker plots (vegetation and interception) helps lead the reader usefully into analysis.
- The range of data presentation techniques is appropriate and well selected, with good knowledge and understanding of the relevant techniques for representing results plainly to other readers. Tables of data and soil photographs are also clear and add to the evidence of analysis.
- Graphs would be improved if they carried individual figure numbers as they could be better integrated into the analysis.

Section 4: Data analysis and explanation. (Level 3 - 14 marks)

- Data and information collected is analysed and interpreted in a relevant manner, with evidence of independence, demonstrating the knowledge and understanding of the techniques appropriate for analysing and explaining data and information.
- Statistical analysis and significance testing are present and well delivered, e.g. Spearman's Rank. Some of the data collected provided opportunities for some additional quantitative analysis, interquartile ranges which have been included.
- The analysis and explanation are relevant and attempt to link to the stated aims. The discussion is mostly analytical rather than descriptive.
- There is evidence of use of appropriate knowledge, theory and geographical concepts to help explain findings. A personalised spider diagram / mind map could have been a helpful addition to draw linkages together as part of the analysis.

Section 5: Conclusions and investigation evaluation. (Level 3 - 12 marks)

- There are clear conclusions offered linked to the aims / questions or hypotheses, communicated by means of extended writing.
- Attempts to draw on primary and secondary evidence (although secondary is implicit through the discussion). This could be better supported by refence to either the literature research or geographical theory, concepts or parallel studies.
- There is evidence that conducting the investigation extended geographical understanding with reference to the wider geographical context of the investigation, e.g. flood risk and storm hydrographs.
- Evaluation is detailed and wider ranging. There is also an evaluation of the overall success of the investigation in the context of anomalies and reliability. This leads to a discussion of how those might have affected the strength of conclusions.

Section 6: Overall quality and communication of written work. (Level 3 - 10 marks)

- There is a high standard of communication that is relevant to the geographic purpose of the investigation.
- Throughout arguments are clear, demonstrating a strong degree of independence. Although the work is somewhat long this has not distracted from its overall quality.
- Written work is well structured, logical, concise, and includes good presentation with text and figures and tables of data appropriately integrated.
- Sources and literature references are clear and well referenced by means of a bibliography
- Geographical terminology is technical, used appropriately, and written language errors are very rare.

Project work

OCR
Oxford Cambridge and RSA

Geography
A Level Geography Independent Investigation
Proposal Form

Session	June	Year	2	0	1	8

Centre Name		Centre Number	
Candidate Name		Candidate Number	

Investigation Title	How the title links to the specification content
How are hydrological processes in the River Medlock drainage basin affected by environmental factors?	It investigates hydrological processes in the drainage basin (which we learn about in the water cycle, earth/s Life Support Systems) and how they are affected by and affect the landscape.

Planned investigation hypothesis or question, investigation sub-questions, and the geographical area where the primary data collection will take place.

Question is the title (above), sub-questions:

(1) How does vegetation type affect amount of interception taking place?

(2) How is soil saturation affected by drainage basin relief?

I will be investigating in the source- Limb Brook Catchment area of the Medlock Drainage Basin in Oldham, Greater Manchester.

Investigation focus - indication of how the enquiry will address the investigation title and explore the theme in relation to the chosen geographical area.

I will investigate how the environmental factors of: vegetation type on Glodwick Lows, and relief along a slope from the top of Glodwick Lows to the Medlock, affect hydrological processes of interception, and infiltration / surface runoff / throughflow respectively, and will explore what these impacts mean for the Medlock Drainage basin as a whole.

Planned methodology – indication of qualitative and/or quantitative techniques including primary and, if relevant, secondary data collection techniques, indication of the planned sampling strategy or strategies.	Individual/ Group data collection (Delete as appropriate)

I will measure the effect of vegetation type on interception by collecting precipitation in containers outside of, and under, different types of vegetation, then measure the volumes to establish the proportion of rainfall intercepted by different types of plant. I will measure soil saturation by collecting & sealing soil samples along a slope, then merging them before and after overdrying to find out % of water making up the weight. I'll use secondary published map data to find slope gradient and categories of vegetation. I'll use stratified sampling to choose sites with different types of vegetation to measure them all, and to repeat samples, and I'll use stratified sampling along a transect to choose sites for soil samples.

Teacher approval for the investigation or details of any necessary amendments that need to be made before approval can be given.

Teacher Approval: (Yes/No)	Yes
Teacher signature	Date (DDMMYYYY)

GCW182 Revised November 2016

Oxford Cambridge and RSA Examinations

OCR
Oxford Cambridge and RSA

A Level Geography

OCR A Level Geography H481/04/05 Investigative Geography
Mark Recording Sheet

Please read the instructions printed at the end of this form. **One** of these sheets, suitably completed, should be attached to the assessed work of **each** candidate.

Component	**Investigative Geography**	**Unit Code**	**H481/04/05**	**Session**	June	**Year**	**2**	**0**	**1**	**8**
Centre Name				**Centre Number**						
Candidate Name				**Candidate Number**						
Investigation Title	**How are hydrological processes in the River Medlock drainage basin affected by environmental factors?**									

Mark scheme section	0 marks	Level 1	Level 2	Level 3	Level 4	Teacher Comment	Mark
Section 1: Planning, purpose and introduction. (8 marks)	0 marks	1-2 marks	3-5 marks	6-8 marks	n/a	**Level 3**	6
Section 2: Data, information collection methods and sampling framework. (7 marks)	0 marks	1-2 marks	3-4 marks	5-7 marks	n/a	**Level 3**	7
Section 3: Data presentation techniques. (9 marks)	0 marks	1-3 marks	4-6 marks	7-9 marks	n/a	**Level 3**	9
Section 4: Data analysis and explanation. (14 marks)	0 marks	1-3 marks	4-6 marks	7-10 marks	11-14 marks	**Level 3**	14
Section 5: Conclusions and investigation evaluation. (12 marks)	0 marks	1-3 marks	4-6 marks	7-9 marks	10-12 marks	**Level 3**	12
Section 6: Overall quality and communication of written work. (10 marks)	0 marks	1-3 marks	4-6 marks	7-10 marks	n/a	**Level 3**	10
						Total/60	**58**
						Please tick to indicate this work this been standardised internally	

URS669 Devised November 2016 **H481/URS**

Oxford Cambridge and RSA Examinations

Criteria				Teacher Comments
Section 1: Planning, purpose and introduction (8 marks).				Clear well focused plan with effective use of an aim. Appropriate hypotheses which are manageable and well linked to the purpose of the investigation Clear evidence of valid and individual research into the water cycle evident through the use of OCR textbook, NASA and other publications. Links to specification and reference to the hydrological cycle made with consideration of factors such as infiltration, interception, throughflow etc. Geographical terminology clearly defined and explained Clear justification of chosen location provided through description of areas. Clear location at a variety of scales but lacking geo located data, north arrows, scales.
0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-5 marks)**	**Level 3 (6-8 marks)**	
No response or no response worthy of credit.	• There is a partial or incomplete attempt to include a plan with aims or questions or hypotheses which are not clearly linked to the geographic purpose of the investigation. • The plan is based on an individual geographical topic or issue, within a research framework, but definitions are incomplete or absent. • There is no justification for the investigation provided in the introduction and no meaningful attempt to contextualise the fieldwork and research. • The location is unclear with few relevant or appropriate geo-spatial techniques. • There is limited evidence of research that supports the investigation through wider geographical links, comparisons, models or theory.	• There is a mostly clear plan, appropriately designed to include aims or questions or hypotheses linked to the geographic purpose of the investigation. • The plan is based on an individual geographical topic or issue, within a research framework, which is partially defined. • There is some justification for the investigation provided in the introduction and an attempt to contextualise the fieldwork and research. • The location is clear, using geo-spatial techniques, and at different scales. • There is some evidence of individual research that supports the investigation through an appropriate combination of wider geographical links, comparisons, models and theory.	• There is a clear, well focused plan, appropriately designed to include aims or questions or hypotheses linked to the geographic purpose of the investigation. • The plan is based on an individual geographical topic or issue, which is accurately and appropriately defined and within a research framework. • There is a justification for the investigation provided in the introduction and valid contextualisation of fieldwork and research. • The location is precise and geo-located, using geo-spatial techniques, at appropriately different scales. • There is clear evidence of valid and individual literature research that defines and contextualises the investigation through an appropriate combination of wider geographical links, comparisons, models and theory.	
[0]	[1 2]	[3 4 5]	[6 7 8]	Mark 6

Criteria				Teacher Comments
Section 2: Data, information collection methods and sampling framework (7 marks).				
0 marks	**Level 1 (1-2 marks)**	**Level 2 (3-4 marks)**	**Level 3 (5-7 marks)**	
No response or no response worthy of credit. [0]	• There is limited knowledge and understanding of data collection methodologies which are sometimes appropriate but lack explanation. • There is little or no evidence of personalised methodologies and approaches to observe and record primary data and phenomena in the field and/or incorporate secondary data and/or evidence, collected individually or in groups. • There is little or no evidence of the ability to collect and use digital, geo-located data. • The data design framework (sampling, frequency, range and location choice) is weak or absent and with no relevant justification. • Makes no attempt to address or understand the ethical and socio-political dimensions of the methodologies chosen. [1 2]	• There is some knowledge and understanding of a range of data collection methodologies, including quantitative and/or qualitative approaches, which are partially justified with some limitations outlined, mostly appropriate to the investigation with some explanation. • There is limited evidence of personalised methodologies and approaches to observe and record primary data and phenomena in the field and to incorporate secondary data and/or evidence, collected individually or in groups. • There is limited evidence of the ability to collect and use digital, geo-located data. • The data design framework (sampling, frequency, range and location choice) is mostly appropriate but with limited justification. • Attempts to address and show an understanding of the ethical and socio-political dimensions of the methodologies chosen. [3 4]	• There is good knowledge and understanding of a range of data collection methodologies, including suitable quantitative and/or qualitative approaches, which are justified with limitations outlined, appropriate to the investigation and explained in detail. • There is clear evidence of personalised methodologies and approaches to observe and record primary data and phenomena in the field and to incorporate secondary data and/or evidence, collected individually or in groups. • There is clear evidence of the ability to collect and use digital, geo-located data. • The data design framework (sampling, frequency, range and location choice) is appropriate, coherent and justified. • Addresses and shows an understanding of the ethical and socio-political dimensions of the methodologies chosen. [5 6 7]	**Good knowledge and understanding of a range of data collection methodologies including both quantitative and qualitative approaches.** **Effective use of both primary (interception/soil satuation/photographs) and secondary data (environmental agency, OS maps)** **Approaches are appropriate to the investigation and explained in detail-they clearly link to each hypothesis. Clear justification and limitations exist for each approach.** **The data design framework such as sampling is appropriate and unique to each approach. Justified in relation to other sampling strategies** **Use of geo located data-altitude.** **Addresses and shows an understanding of the ethical and socio-political dimensions of the methodologies** Mark 7

Criteria				Teacher Comments
Section 3: Data presentation techniques (9 marks).				**Evidence of selective data relevant to the investigation.** **A variety of data presentation techniques, both simple and sophisticated are present for example-bar graphs, line graphs, scatter graphs & error bars** **Geo location used in terms of location coordinates and altitude using an app on mobile phone** **Knowledge and understanding of a range of relevant techniques for presenting results.**
0 marks	**Level 1 (1-3 marks)**	**Level 2 (4-6 marks)**	**Level 3 (7-9 marks)**	
No response or no response worthy of credit. [0]	• There is no evidence of selective presentation of the most influential data collected directly related to the investigation. • The range of data presentation methods is poorly selected, with limited knowledge and understanding of the relevant techniques for representing results. • There is no attempt to balance the simple and more sophisticated data representation methods, relevant to the topic. [1 2 3]	• There is some selective presentation of the most influential data collected directly related to the investigation. • The range of data presentation methods is mostly well selected, with some knowledge and understanding of the relevant techniques for representing results. • There is an attempt to balance the simple and more sophisticated data representation methods, relevant to the topic. [4 5 6]	• There is appropriate and selective presentation of the most influential data collected directly related to the investigation. • The range of data presentation techniques is appropriate and well selected, with good knowledge and understanding of the relevant techniques for representing results clearly. • There is an appropriate balance of simple and more sophisticated data representation methods, relevant to the topic. [7 8 9]	Mark 9

Criteria					Teacher Comments
Section 4: Data analysis and explanation (14 marks).					
0 marks	**Level 1 (1-3 marks)**	**Level 2 (4-6 marks)**	**Level 3 (7-10 marks)**	**Level 3 (11-14 marks)**	
No response or no response worthy of credit.	• There is limited evidence of relevant independent analysis and interpretation of data and information. • When appropriate to the topic, statistical analysis and significance testing are absent or largely irrelevant to both the data and topic of investigation. • When appropriate to the topic, qualitative and non-numerical analysis techniques are absent or largely irrelevant to the overall purpose of the investigation. • The analysis and explanation show a poor or irrelevant link to the stated aims or questions or hypotheses. • There are limited or no element of appropriate knowledge, theory and geographical concepts to help explain findings.	• Data and information collected is analysed and interpreted in a relevant manner, with evidence of independence, demonstrating partial knowledge and understanding of the techniques appropriate for analysing and explaining data and information. • When appropriate to the topic, statistical analysis and significance testing are attempted when appropriate but with limited accuracy for both the data and topic of investigation. • When appropriate to the topic, qualitative and non-numerical analysis techniques are used but with limited success in relation to the overall purpose of the investigation. • The analysis and explanation show only a partial link to the stated aims or questions or hypotheses. • There is some attempt to use appropriate knowledge, theory and geographical concepts to help explain findings.	• Data and information collected is analysed and interpreted in a relevant manner, with evidence of independence, demonstrating the knowledge and understanding of the techniques appropriate for analysing and explaining data and information. • When appropriate to the topic, statistical analysis and significance testing are used with some accuracy for both the data and topic of investigation. • When appropriate to the topic, qualitative and non-numerical analysis techniques are developed and used to support explanations and findings from data and information collected. • The analysis and explanation link to the stated aims or questions or hypotheses. • There is use of appropriate knowledge, theory and geographical concepts to help explain findings.	• Data and information collected is analysed and interpreted in an effective and coherent manner, with evidence of independence, demonstrating the knowledge and understanding of the techniques appropriate for analysing and explaining data and information. • When appropriate to the topic, statistical analysis and significance testing are used accurately and proficiently for both the data and topic of investigation. • When appropriate to the topic, qualitative and non-numerical analysis techniques are successfully and individually developed and used to support explanations and findings from data and information collected. • The analysis and explanation are relevant and link effectively to the stated aims or questions or hypotheses. • There is effective use of appropriate knowledge, theory and geographical concepts to help explain findings.	**Good knowledge and understanding of the techniques appropriate for analysing and explaining data-e.g. line of best fit, statistical testing** **Statistical analysis and significance testing are used accurately and proficiently for both data and topic of investigation-spearman's rank for gradient and soil saturation and chi squared** **Analysis and explanation are relevant and clearly link to the 2 hypotheses and therefore the overall aim of the investigation.** **There is effective use of appropriate knowledge, theory and geographical concepts to help explain findings**
[0]	[1 2 3]	[4 5 6]	[7 8 9 10]	[11 12 13 14]	Mark 14

URS669 Devised November 2016 **H481/URS**

Oxford Cambridge and RSA Examinations

Criteria					Teacher Comments
Section 5: Conclusions and investigation evaluation (12 marks).					Clear, accurate and thorough conclusions linked to the aims or questions or hypotheses, communicated by means of extended writing Draws effectively on primary and secondary evidence, and where appropriate, theory to provide a very well-argued case and shape conclusions There is convincing evidence that conducting the investigation extended geographical understanding with reference to the wider geographical context of the investigation Strong evaluation of the overall success of the investigation with reference to the reliability of data sources, data collection methods, accuracy of data collected and the extent to which it is representative, and the validity of the analysis and conclusions There is a thorough understanding of the ethical and socio political dimensions of field research and data presentation
0 marks	**Level 1 (1-3 marks)**	**Level 2 (4-6 marks)**	**Level 3 (7-9 marks)**	**Level 3 (10-12 marks)**	
No response or no response worthy of credit.	• Basic, often unsupported conclusions which have few links to the aims or questions or hypotheses. • Limited elements of primary and/or secondary evidence linked to arguments and conclusions. • There is no evidence that conducting an investigation extended geographical understanding with no reference to the wider geographical context of the investigation. • The evaluation is very limited to the identification of a few basic errors and problems. • There is no comment on the ethical and socio-political dimensions of field research and data presentation.	• There is a limited attempt to reach conclusions which are linked to the aims or questions or hypotheses, communicated by limited means of extended writing. • Elements of primary and secondary evidence and, where appropriate, theory link to the argument and conclusions. • There is limited evidence that conducting the investigation extended geographical understanding with limited reference to the wider reference to the wider geographical context of the investigation. • There is an evaluation of the investigation through reference to isolated aspects of the investigation. • There are basic comments on the ethical and socio-political dimensions of field research and data presentation.	• There are clear conclusions linked to the aims or questions or hypotheses, communicated by means of extended writing. • Draw on primary and secondary evidence and, where appropriate, theory to make a well-argued case and shape conclusions. • There is some evidence that conducting the investigation extended geographical understanding with reference to the wider geographical context of the investigation. • There is an evaluation of the overall success of the investigation with reference to the data sources, data collection methods, the accuracy of data collected and the extent to which it is representative, and validity of the analysis and conclusions. • There is a reasonable understanding of the ethical and socio-political dimensions of field research and data presentation.	• There are clear, accurate and thorough conclusions linked to the aims or questions or hypotheses, communicated by means of extended writing. • Draw effectively on primary and secondary evidence and, where appropriate, theory to provide a very well-argued case and shape conclusions. • There is convincing evidence that conducting the investigation extended geographical understanding with clear reference to the wider geographical context of the investigation. • There is a strong evaluation of the overall success of the investigation with reference to the reliability of data sources, data collection methods (including sampling), the accuracy of data collected and the extent to which it is representative, and the validity of the analysis and conclusions. • There is a thorough understanding of the ethical and socio-political dimensions of field research and data presentation.	
[0]	[1 2 3]	[4 5 6]	[7 8 9]	[10 11 12]	Mark 12

URS669 Devised November 2016 H481/URS

Oxford Cambridge and RSA Examinations

<table>
<tr><th colspan="4">Criteria</th><th>Teacher Comments</th></tr>
<tr><th colspan="4">Section 6: Overall quality and communication of written work (10 marks).</th><td rowspan="3">High standard of communication, relevant to the geographic purpose throughout.

Arguments are clear, demonstrating a strong degree of individuality.

Written work is well structured, logical, concise and includes good presentation with text and figures appropriately integrated.

Sources and literature references are clearly stated and accurately referenced throughout the investigation

Geographical terminology is technical, used appropriately, and written language errors are rare.</td></tr>
<tr><th>0 marks</th><th>Level 1 (1-3 marks)</th><th>Level 2 (4-6 marks)</th><th>Level 3 (7-10 marks)</th></tr>
<tr><td>No response or no response worthy of credit.

[0]</td><td>• There is basic communication that has limited relevance to the geographic purpose of the investigation.
• Arguments are absent or simplistic.
• The work is poorly or partially structured and lacks a logical order. Presentation is often poor with little attempt to integrate text and figures.
• Sources and literature references are mostly excluded from the investigation or not relevant.
• Geographical terminology isolated or absent and there are frequent written language errors.

[1 2 3]</td><td>• There is a variable standard of communication that has some relevance to the geographic purpose of the investigation.
• Arguments are present showing elements of individuality.
• Written work is generally well structured, logical, concise and presentation is adequate with text and figures mostly integrated.
• Sources and literature references are mostly referenced throughout the investigation.
• Geographical terminology is present, but there are some written language errors.

[4 5 6]</td><td>• There is a high standard of communication that is relevant to the geographic purpose of the investigation.
• Arguments are clear, demonstrating a strong degree of individuality.
• Written work is very well structured, logical, concise, and includes good presentation with text and figures appropriately integrated.
• Sources and literature references are clearly stated and accurately referenced throughout the investigation.
• Geographical terminology is technical, used appropriately, and written language errors are rare.

[7 8 9 10]</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Mark 10</td></tr>
</table>

Please note: This form may be updated on an annual basis. The current version of this form will be available on the OCR website (www.ocr.org.uk).

URS669 Devised November 2016 **H481/URS**

Oxford Cambridge and RSA Examinations

How are hydrological processes in the River Medlock drainage basin affected by environmental factors?

Geography Independent Investigation

Introduction:

The global hydrological cycle is the movement of Earth's water by different processes between stores in the atmosphere, hydrosphere, biosphere and geosphere. It's a closed system as water doesn't enter or exit the Earth's vicinity, but it's always in flux due to inputs and outputs of energy e.g. from the Sun, with water moving between stores which may grow or shrink over time.

It is the movement of water over the land, from precipitation back down to the oceans as freshwater, which allowed organisms to make the transition to terrestrial lifestyles and which still supports all life on land, as well as all human societies and modern ways of life.

This image has been removed due to copyright restrictions. Image shows: Model of the water cycle.
Similar examples can be found:

https://pmm.nasa.gov/education/articles/earth-observatory-water-cycle-overview

FIGURE 1: MODEL OF THE WATER CYCLE, ESTIMATING AMOUNTS OF WATER IN EACH STORE AT ANY GIVEN TIME (NASA, 2018)

The ocean's water stores make up 96.5% of all water on Earth at 1.338 billion km^3; in comparison, terrestrial stores of water are small, only 47,976,000 km^3 (in glaciers and ice, groundwater, lakes, wetlands, soil, rivers, and within living organisms, in order of size) (NASA, 2018). But the movement of water during the terrestrial section of the hydrological cycle has a definitive role in shaping almost all landscapes, by erosion and deposition and by supporting living organisms. The processes which transport water between terrestrial stores are themselves also affected by the landscapes they take place in.

Though the global hydrological cycle is a closed system with processes which can be broadly split into evaporation, precipitation, and the flow of water over land to the ocean, on a smaller scale there are more cycles and processes which take place within it.

This image has been removed due to copyright restrictions. Image shows: Model of the drainage basin system

FIGURE 2: MODEL OF THE DRAINAGE BASIN SYSTEM, (NASA, 2018)

A drainage basin is an area of land which has all the precipitation which falls in it drained by the same output (a river). They are open systems because they have inputs (precipitation), stores (snow, lakes, groundwater, soil, channel storage, wetlands, held on vegetation, within living organisms), and outputs (evaporation, river output into the sea) of matter, in this case water, as well as energy. Features of the drainage basin environment can affect the system's balance of inputs and outputs, and therefore the size of stores, which are all in flux by means of several processes taking place in drainage systems (Jackson, 2014) :

- Interception is when precipitation is caught by vegetation; this may slow down the water's fall or water may be stored on the plants' surfaces. The type of vegetation affects this process, with trees such as conifers (with small needle-like leaves and a large surface area) able to hold more water than large-leafed deciduous trees. Intercepted water may then move to the ground by stemflow.
- Infiltration is the movement of water from the surface down into the soil. The amount the ground can absorb and the speed at which this takes place is affected by the type of soil (large

particles such as pebbles and sand have lots of air spaces to allow percolation, whereas small particles such as clay do not allow water to infiltrate as quickly), the saturation of the soil (because of previous rainfall or existing water stores such as wetlands), and is also affected by biological factors as soil that is aeriated by digging animals or roots can take in more rain than packed soil.

- Throughflow is the movement of infiltrated water down the slope of a drainage basin through the soil; the speed of this is also affected by the type of soil, being faster through large particles such as pebbles slower through small packed particles like clay, and fastest by pipeflow through tunnels made by burrowing animals.
- Groundwater/baseflow is the movement of water through permeable rock, through the whole drainage basin or to the drainage channel respectively.
- Surface runoff is where water runs over the surface of the ground; it occurs when the soil is saturated or frozen and can't take in any more water by infiltration, and is therefore more likely to occur on ground types which take in less water by infiltration such as clay. The water experiences less friction over the surface than through the soil and so reaches the bottom of the basin faster than throughflow; it therefore causes steep storm hydrograph profiles and can lead to flash-flooding after heavy rain. The speed of this can also be affected by ground type, with vegetation such as grass creating friction.
- Channel flow is the movement of water down a drainage basin in river channels.
- Transpiration is the drawing up of water by plant roots from the soil and up the stem of the plant where it is lost by evaporation through the stomata of the leaves.

Environmental characteristics of drainage basins determine how much of each of these processes takes place, and therefore what happens to the water that enters a drainage basin. The major environmental factors which affect hydrological processes are (Michael Raw, 2016):

- Geology and soil type; the porosity of rock and the size of soil particles determines how fast water can enter them and flow through them downwards (percolation and infiltration) and horizontally (baseflow and throughflow). Different soils and rocks also have different capacities for storage as aquifers or soil water, and geologic features such as artesian aquifers can determine where springs or flooding may arise.
- Air temperature and wind speed; these affect how fast evaporation and evapotranspiration takes place by, heat by exciting water molecules, and wind by maintaining a steep water partial pressure gradient between surfaces and the air.
- Vegetation; the density and type of vegetation affect interception and evapotranspiration, with plants with large surface areas and indentations such as conifers and bromeliads intercepting a large proportion of precipitation. Water then evaporates from the large surface area; in the Amazon rainforest, 50% of all precipitation is returned to the atmosphere in this way (Michael Raw, 2016). They also draw water up from underground stores by capillary action and transpire this into the atmosphere.
- Relief; the gradient of slopes in a basin will affect what proportion of rainfall infiltrates into the ground and what moves as faster surface runoff to the drainage channel, with steeper slopes leaving less time for infiltration. The elevation of a basin including land features such as mountains affects how much precipitation falls in the first place, by forcing clouds higher into the atmosphere past their dew point, and also determines how likely the water table of a basin's aquifer is to rise and flood the surface.

Humans are both significantly affected by and significantly affect drainage basin processes; natural hazards such as flooding, drought, and landslides pose danger to human life and infrastructure, and as humans modify the environment they also change the hydrological aspects of the environment, such as deforestation reducing interception and evapotranspiration, the tarmacking of urban areas creating large swathes of impermeable ground and surface runoff, and overexploitation of aquifers leading to a falling water table and suffering ecosystem. (Gornitz, 1997) In some cases, such as removing naturally features such as vegetation on a river bank or slope, they can change the cycle in the area to an extent that hazards such as flooding are created.

I chose to focus on the geographical topic of drainage basin processes (within the wider topic of the hydrological cycle) for my independent investigation, and to carry out my investigation in my local area, because I was curious about the impacts of drainage basin processes on local physical landscapes, the impacts of these landscapes on the local water cycle, and about the potential interactions between these processes and humans in the area.

Specifically, I chose to focus on two hydrological components of my local drainage basin:

Interception is a significant part of the drainage basin hydrological cycle because it impacts other processes; it can reduce the amount of precipitation reaching the ground by storing it or slow its passage by drip-through, thereby potentially reducing surface runoff and increasing infiltration, which will could reduce the steepness of a channel's storm hydrograph and even reduce flooding. Water on the large surface area of vegetation is more likely to evaporate, thereby reducing precipitation reaching the ground and potentially contributing to precipitation itself in an area, for example half of precipitation in tropical rainforests in evaporated back into the atmosphere (Michael Raw, 2016), with interception by the extreme amounts of rainforest vegetation playing a large role. I would expect that either vegetation type, vegetation density, or vegetation variety in an area (due to differing levels of vegetation creating multiple layers of interception) would be the most important environmental factor in determining amounts of interception.

Soil saturation represents the hydrological store of soil storage, and is an important indicator of hydrological processes such as interception, infiltration, percolation, surface runoff, evapotranspiration and throughflow because it is determined by the amount of precipitation which reaches the ground, moves through the ground, and is extracted from the ground. I would therefore expect there to be a strong relationship between environmental factors including precipitation, vegetation type, soil type/geology, and ground relief and soil saturation, but also I would expect all these factors to work together so it may be hard to isolate relationships between saturation and a single variable.

Planning:

My aim is to investigate how different physical environmental conditions affect certain hydrological processes taking place in my drainage basin. Specifically, I will be asking the sub-questions:

- How does vegetation type affect the amount of interception taking place?
- How is soil saturation affected by drainage basin relief?

I hypothesize that there will be differences between the interception caused by different types of plant although I do not know how significant these differences will be, or what characteristics of/types of plant will turn out to cause the greatest and least amounts of interception.

I expect the outcome of my second sub-question to be that steeper areas of the slope have less sodden soil than flatter areas because they receive less water by infiltration because of increased surface runoff, and because they drain more down the drainage basin by throughflow in the soil.

Background information about the area I will be investigating:

My investigation is located in the Source-to-Lumb Brook catchment area of the River Medlock, East Oldham, Greater Manchester, North-West England. Specifically, I collected my data in the Glodwick Lows Nature Reseve and a portion of the Medlock valley.[1]

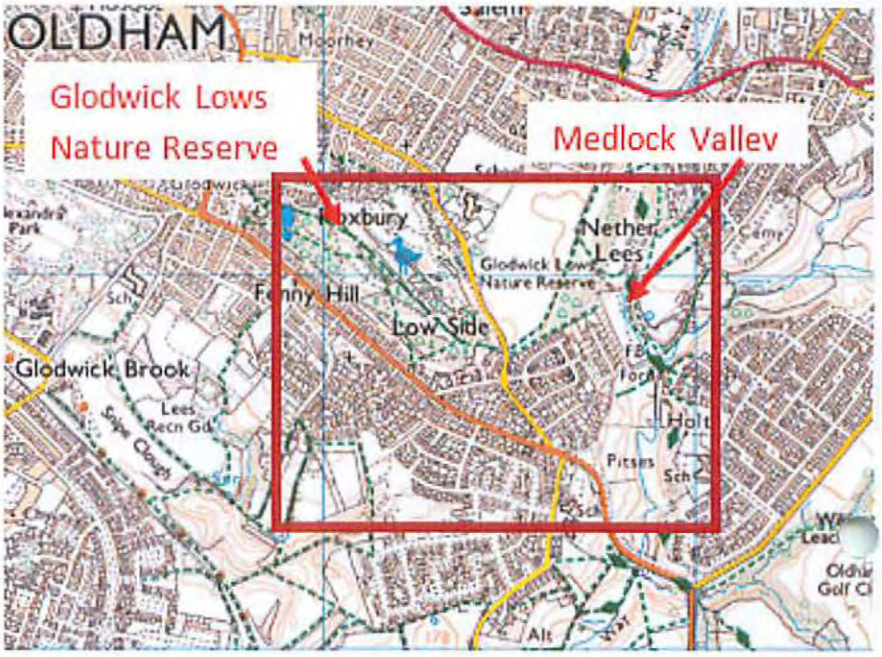
OS (c) Crown copyright 2018

Map data (c) Google

[1] Top maps sources from Google maps, bottom left the Environment Agency website, bottom right OS map supported by MAGIC GIS website

This image has been removed due to copyright restrictions.
Image shows:
Environment agency map of Oldham

FIGURE 3 ENVIRONMENT AGENCY MAP OF THE RIVER MEDLOCK'S FIRST CATCHMENT AREA, 'SOURCE TO LUMB BROOK'

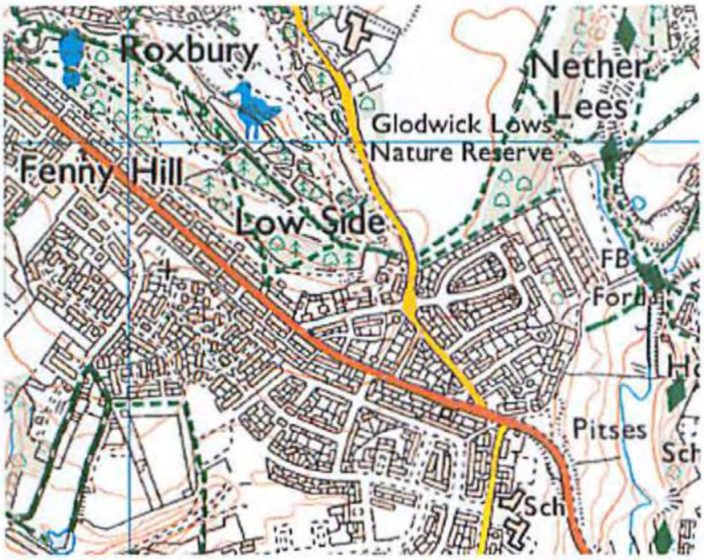


OS (c) Crown copyright 2018

Secondary data:

A justification for my choice to investigate the processes of interception and those of which soil saturation is an indicator (infiltration/overland flow, percolation, evapotranspiration) is that there is published secondary data available about my independent variables of vegetation type and drainage basin relief; factors of relief such as gradient and elevation are numerical and objective, increasing the likelihood of them being reliable, and though 'vegetation type' is categorical and somewhat qualitative, the secondary data will help me categorize vegetation types consistently, minimizing investigator bias.

Contour lines on the OS map were a good indication of basin relief, and OS maps are reliable published sources of information.

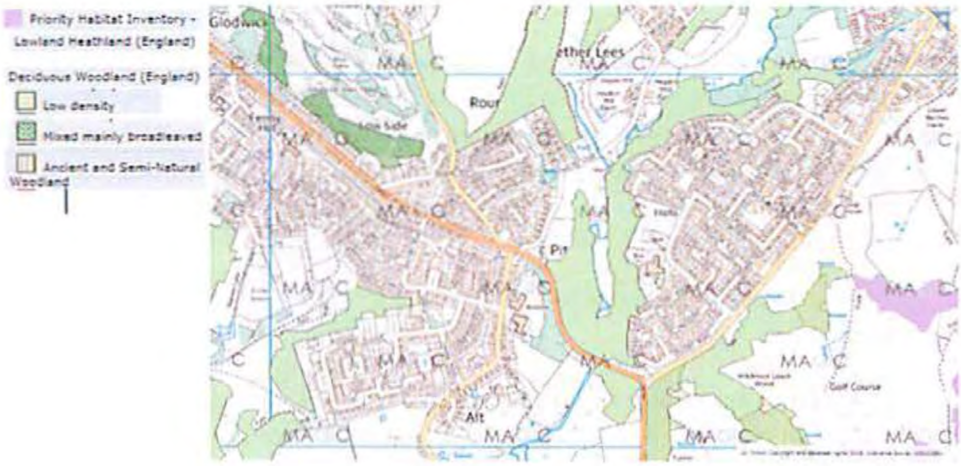


OS (c) Crown copyright 2018

The contour lines show that the bottom of this section of the drainage basin of the Medlock River runs along at 158m above sea level. The highest point of the slope which drains directly down to this is in the Glodwick Lows Nature Reserve at 207m, so I used this information to plan out the transect of my sampling.

I also used the Android app *Accurate Altitude* (by AR Labs) to geolocate co-ordinates of each of my sites.

The coloured OS map showed built up areas, rivers, cliffs, woods and open green areas in its, so told me where it would be possible to sample vegetation (as well as soil). To get more information about types of environment in the area I used a 'habitat type' overlay on the MAGIC map, which told me that there was various types of woodland plus some areas of heath nearby; these all have different soil compositions, average ground saturation, and vegetation types, so provide good opportunities for investigating different conditions.



OS (c) Crown copyright 2018

Method:

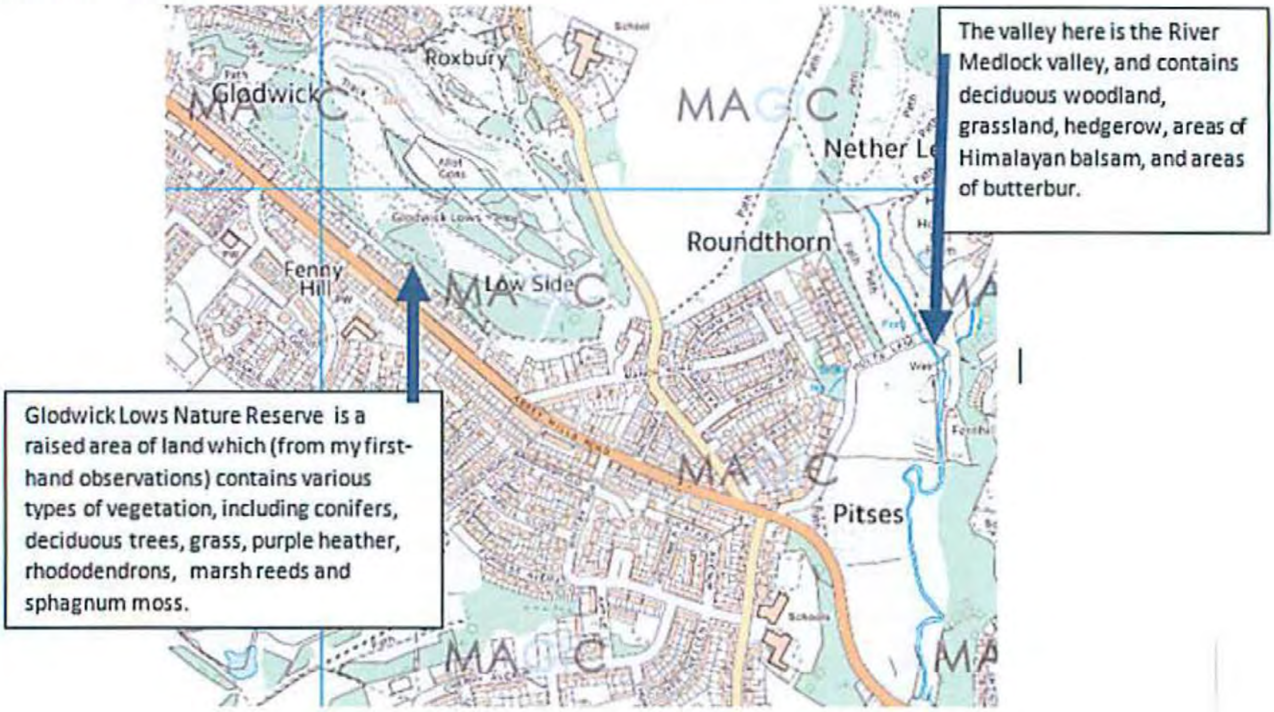
A reason I chose to investigate the specific processes of interception and involved in soil saturation is because they are easily and quantitatively measurable using simple equipment; this makes them good dependent variables in my investigation compared to other hydrological processes which would require more sophisticated equipment to measure (e.g. baseflow through deep rocks).

Question 1: How does vegetation affect the amount of interception taking place?

To investigate this I chose to measure the amounts of interception caused by different types of vegetation.

Sampling Framework: I chose 6 sites because this would give me enough data points to plug into statistical tests and get a valid result, from which I could draw a reliable conclusion, whilst still being manageable to sample by myself.

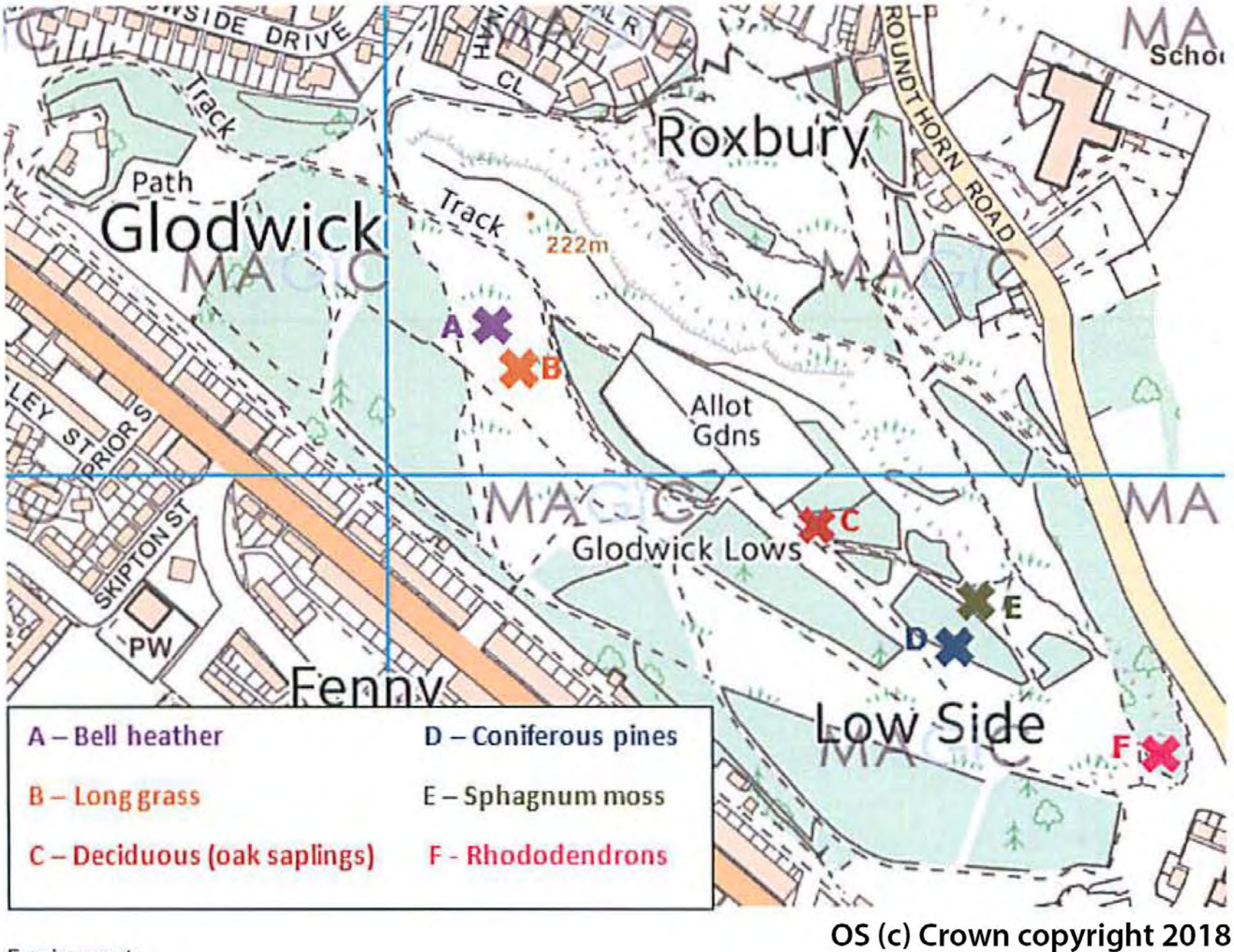
At each site I collected repeats by measuring the volume of water collected after rainfall events over several days; I then used these repeats to find mean percentage interceptions for each site, increasing the reliability of my data by decreasing the effects of any anomalous results. I also had 2 repeats for each vegetation type so that even if one cup was knocked over, data would still be being collected, and to calculate means.



OS (c) Crown copyright 2018

I chose my sites using stratified sampling, using both secondary data from the MAGIC map 'habitat type' overlay and the key of the OS map, and carrying out a degree of Discovery Fieldwork; I walked through the site I was going to be investigating (Glodwick Lows and the Medlock valley trial) and used observations and took photos of suitable potential sites (different types of plants, relatively easily accessible).

Stratified sampling was appropriate in this instance of data collection because I wanted to sample areas with different types of vegetation so I could analyse how these differences affect the rates of hydrological processes; random or systematic sampling, whilst they reduce bias and may be appropriate for measuring rates of a process throughout an area or along a transect, are not appropriate in this case because they would not guarantee that I obtain data from all these different vegetation-type categories. If I used these other sampling frameworks, I might end up with a lot of samples from similar conditions if those conditions took up the majority of an area, and these other sampling frameworks also remove the choice of choosing appropriate and accessible sampling sites e.g. not on private land, not tarmacked over.



Equipment:

Plastic cups, trowel, permanent marker, measuring cylinder.

Method:

First I checked when a rainfall event was due using the BBC's weather forecast.

Before this rain was due, I visited each of my sites, recording their geo-located coordinates using my phone, and wrote down the type of vegetation present and any other observations about the site.

Next I labelled my plastic cups using the permanent marker; for example, at site A I labelled the control 'A' and the 2 repeat cups to be placed under the vegetation a'1' and 'a2', at site B cups 'B', 'b1' and 'b2', and so on.

At site A I set the control ('A') cup out in the open nearby to record the total amount of precipitation, and placed my 'a1' and 'a2' underneath the vegetation itself to record what proportion of rainfall was intercepted by the plants. I repeated this at sites B, C, D, E, and F.

I stabilized the cups in the open or under tall vegetation such as bushes and trees against the wind by putting a small rock inside or burying them halfway using the trowel. In the case of the cups under short vegetation type (the moss) I pulled back a flap of the mat of vegetation, dug a hole for the cup and placed it in, then covered the opening back up.

I left the gauges during a rainfall event. Afterwards, I returned to the sites (in the same order I prepared them, to make sure the amount of time they had been collecting rain was as similar as possible), and used my measuring cylinder to find how many mls of water were in each of the cups (holding the cylinder level at eye-level to maximize the accuracy of my readings), and recorded this in my results table.

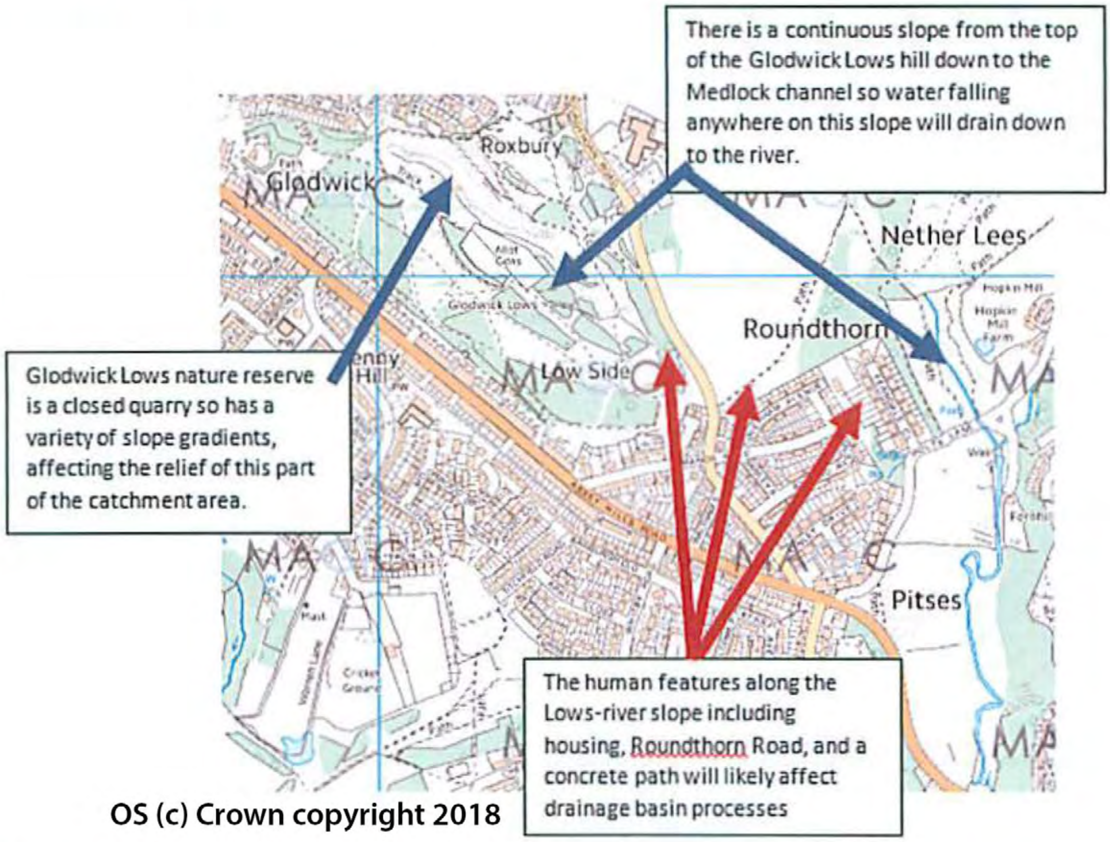
Finally I emptied the cups and put them back, and left them for several more lengths of time in the rain (the more repeats, the greater the reliability of my results). Each day I repeated my measurements and emptied the cups, and recorded the new volumes of water in each cup.

When I collected all my data I made sure to collect all my cups from my measurement sites.

Question 2: How is soil saturation affected by drainage basin relief?

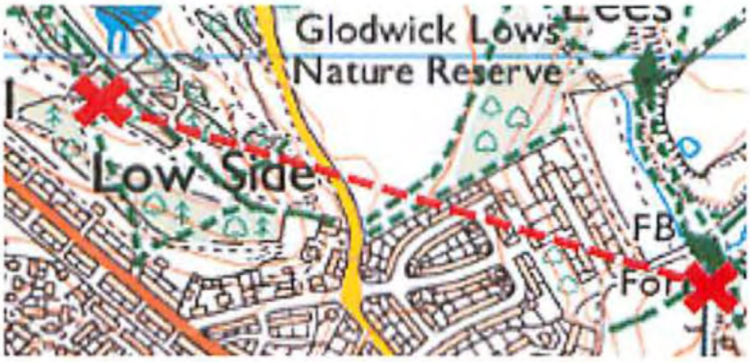
To investigate this I chose to measure the water content of soil and the gradient of the slope at different points along a drainage basin slope and see if there was any correlation.

Sampling framework:



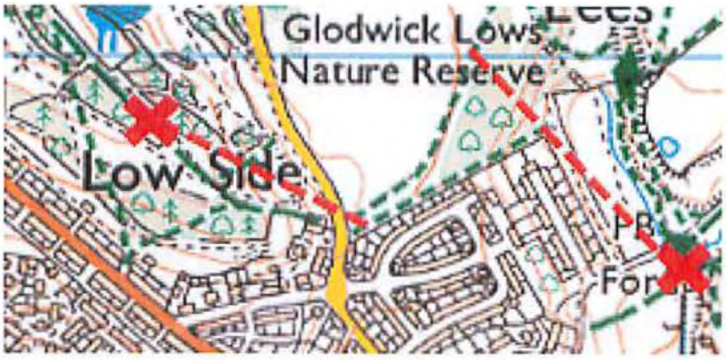
OS (c) Crown copyright 2018

To choose sites for my soil sampling, I drew a transect from the top of my slope on Glodwick Lows down to the stretch of river directly below.

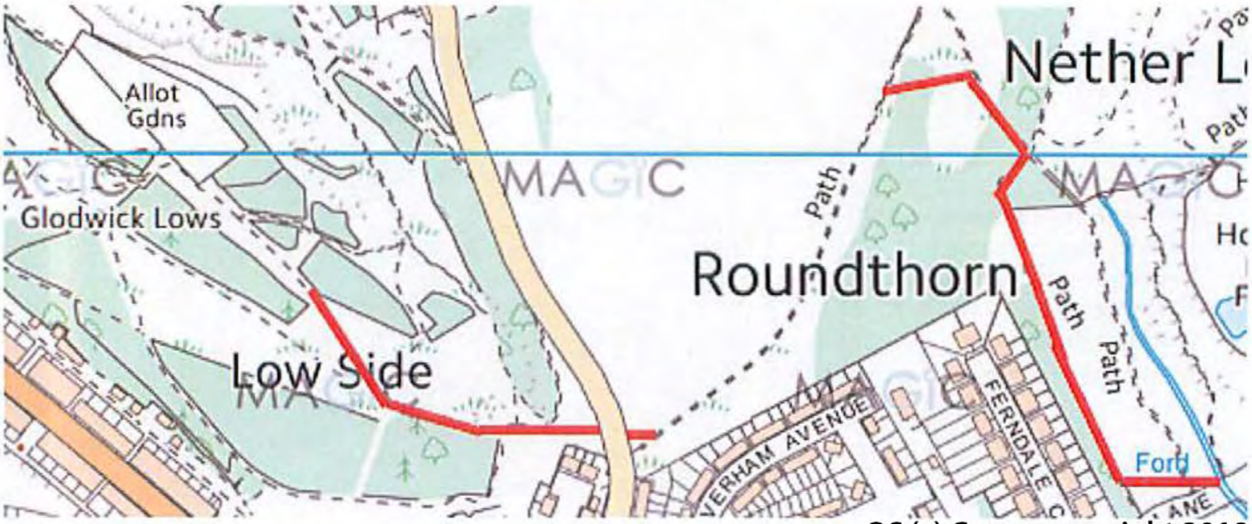


OS (c) Crown copyright 2018

However, since parts of this plotted transect were inaccessible e.g. built over, I used a strategy of convenience sampling to plot a transect along the accessible walkways which covered roughly the same elevations of the slope.



OS (c) Crown copyright 2018



OS (c) Crown copyright 2018

I then used systematic sampling to choose points along this transect to sample, by splitting the transect into 12 points equal distances apart.

Total length[2] of transect was 630m, /12 = approx. 53m so I sampled approx. 53 metres apart, as allowed by hazards such as the large road.

Systematic sampling in this way removes investigator bias and improves the reliability of data.

OS (c) Crown copyright 2018

Equipment:

[2] Measured using https://www.freemaptools.com/measure-distance.htm

Field: 12 small plastic sample cups, plastic food bags, elastic bands, trowel, marker, mobile phone

Lab: Electric scales, 12 evaporating dishes, spatula, oven trays, use of drying oven, labels, marker

Method:

Field:

I walked along my transect starting from the top of the slope. I used the geolocation app Accurate Altimeter by AR labs to pinpoint at which points I needed to take my samples.

At each point, used my trowel to take a soil sample from beside the trail and filled a small plastic cup, labelling each with a letter A-L with the marker to keep them in order. I then covered it with the waterproof plastic food bag and sealed it to be airtight by wrapping an elastic band around it, to prevent any loss of moisture and skewing of the results between this step and the next.

Lab:

I used the spatula to decant the soil samples into evaporating dishes, labelling each with a label of the letter A-L corresponding to the site I collected it.

I then used the electronic scales (first resetting the balance to 0 grams) to measure the weight of each sample of soil in its evaporating dish, and noted these down.

Then I placed the dishes on oven trays and put them in the drying oven, and set it to 105 degrees Celsius – this is hot enough to evaporate all water from the soil, but not hot enough to burn organic matter in the soil and therefore skew the resulting weights.

I left the samples to bake for 96 hours, and then returned and removed them from the oven.

I allowed the dishes to cool first and then reweighed the dishes and recorded these results. Finally, I emptied the dishes (washing and drying them thoroughly to remove all the sample) and weighed each evaporating dish.

I found the wet weight of the soil by subtracting the weight of the dish from the original weight (wet sample + dish). I found the change in weight (water content of the original soil sample in grams) by subtracting the dry weight with dish from the wet weight with dish.

Then I found the percentage soil saturation of each wet sample using the equation: change in weight/wet weight x 100.

Ethics: I used the MAGIC GIS layers to show areas where fieldwork might have the potential to cause damage, such as Sites of Special Scientific Importance, ancient woodlands, nature reserves and important sites for the conservation of vulnerable species in the area I was surverying.

This image has been removed due to copyright restrictions.
Image shows:
Map showing ancient and semi-natural woodland

I found a SSSI (an abandoned quarry face containing Permian river fossils) and some areas of ancient woodland (which are an important natural habitat), and so I made sure not to choose sites for invasive fieldwork in these areas e.g. no digging to put rain gauges in the quarry face, no damaging tree roots by digging or damaging trunks with stem-flow measurements in the ancient woodland.

Because my investigation involved leaving plastic cups out to measure the water I was very sure to label them all and secure them from blowing away, so I could be sure to collect them all afterwards to eliminate the risk of littering, because plastic litter pollutes the environment and can cause harm to wildlife which eats it.

Risk Assessment: The risk of injury when climbing slopes/on rough ground can be countered by wearing suitable footwear with good grip. I addressed any risk of being injured and unable to get home by bringing a mobile phone and telling someone the route I intend to follow and when I expected to return. Carrying out collection near rivers and bodies of water and near cliffs posed the risk of falling over the edge, which I will prevent by again wearing suitable footwear and not getting to close to the edges of the river or cliff.

Data Presentation: Vegetation and Interception

Rates of Interception:

I used my data collection tables to work out mean results, and the proportion of rain which was intercepted:

% interception = 100% - (volume in vegetation cup/volume in control cup x100)

Repeat 1: length 24 hours

Observations: Medium-heavy rain, wind knocked some cups over so I reburied more securely

Site, type of vegetation	Rainfall in the open (ml)	Volume of water in cup under vegetation				Mean % Intercepted
		Cup 1		Cup 2		
		ml	% intercepted	ml	% intercepted	
A – Bell heather	7	-	-	1	85.7	85.7
B – Long grass	6	0.5	91.7	1	83.3	87.5
C – Deciduous (small oaks)	6	3	50	3	50	50
D – Coniferous (large pine)	8	0	100	0	100	100
E – Sphagnum moss	8	-	-	0.5	93.75	93.75
F – Rhododendron bush	3	0	100	0	100	100

Repeat 2: 24 hours

Drizzly rain

Site, type of vegetation	Rainfall in the open (ml)	Volume of water in cup under vegetation				Mean % Intercepted
		Cup 1		Cup 2		
		ml	% intercepted	ml	% intercepted	
A – Bell heather	4	0	100	0	100	100
B – Long grass	3	1	66.7	2	33.3	50
C – Deciduous (small oaks)	2	1	50	1	50	50
D – Coniferous (large pine)	2	0	100	0	100	100
E – Sphagnum moss	2	0	100	0	100	100
F – Rhododendron bush	3	0	100	0	100	100

Repeat 3: 72 hours,

Heavy snow which then melted so I could then measure its liquid volume.

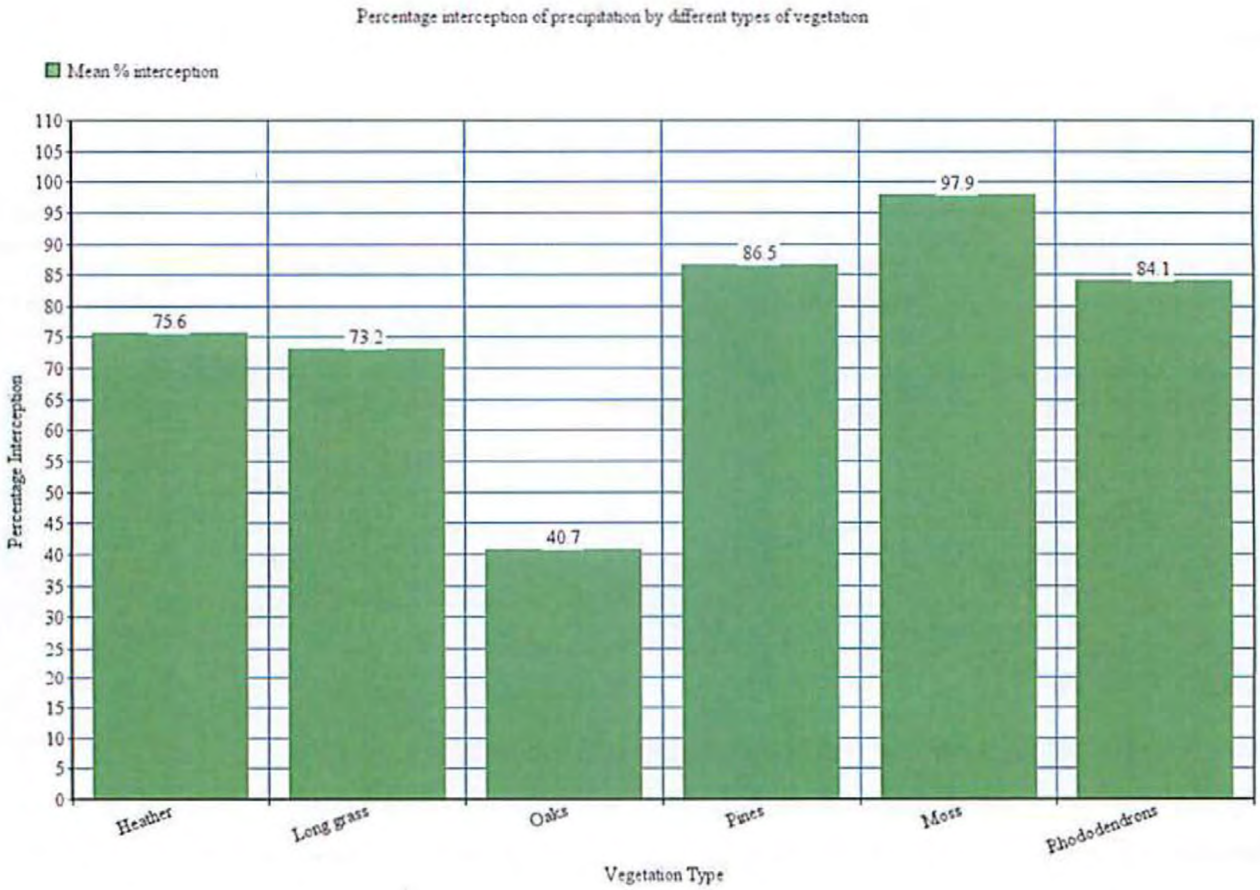
Site, type of vegetation		Volume of water in cup under vegetation	

	Rainfall in the open (ml)	Cup 1		Cup 2		Mean % Intercepted
		ml	% intercepted	ml	% intercepted	
A – Bell heather	50	27	46	32	36	41
B – Long grass	50	17	66	1	98	82
C – Deciduous (small oaks)	27	26	3.7	16	40.7	22.1
D – Coniferous (large pine)	21	16	23.8	1	95.2	59.5
E – Sphagnum moss	21	0	100	0	100	100
F – Rhododendron bush	44	7	84.1	35	20.5	52.3

Mean percentage of rainfall intercepted by each type of vegetation:

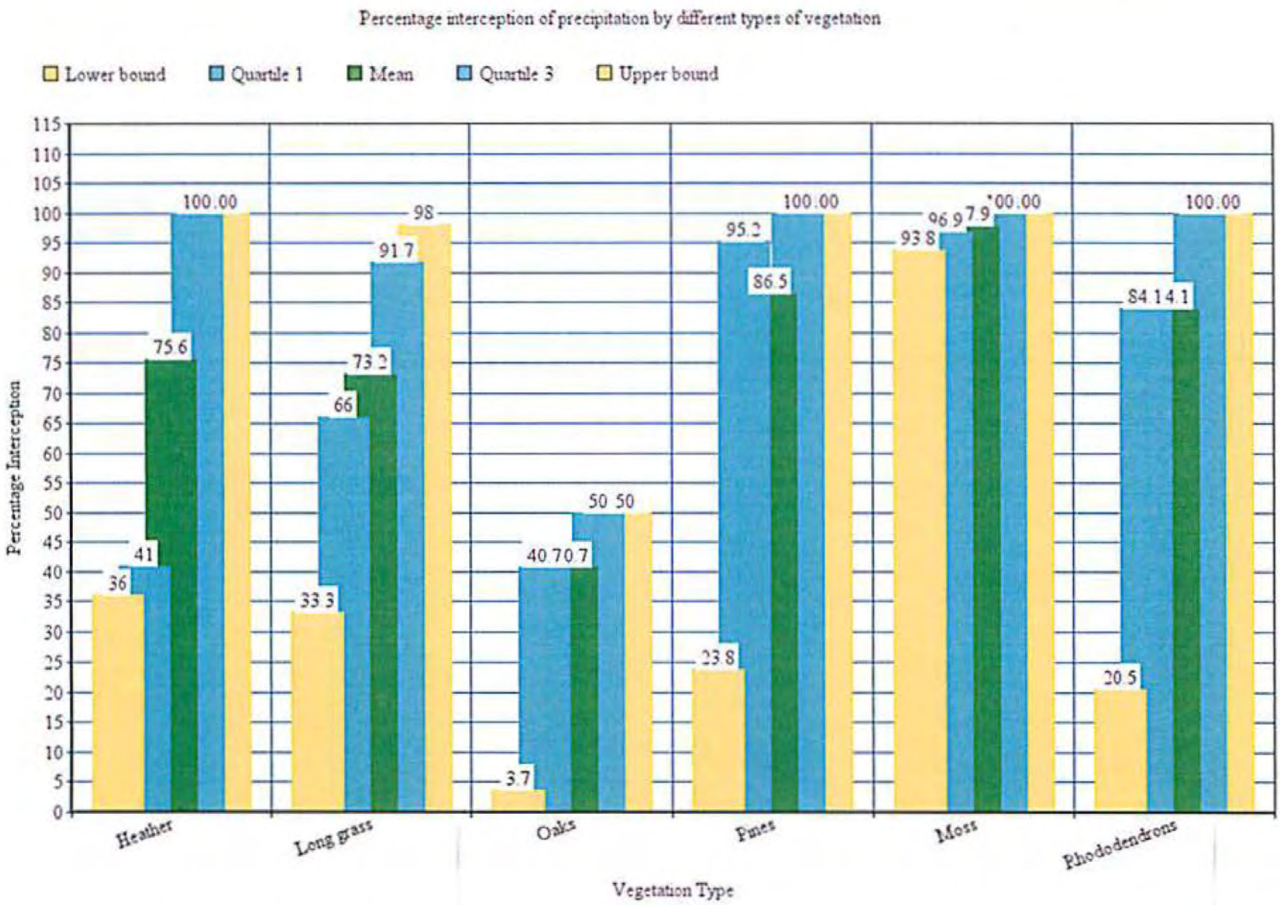
Repeat:	% interception of precipitation					
	Type of Vegetation					
	Heather	Grass	Oaks	Pines	Moss	Rhododendrons
1	85.7	87.5	50	100	93.75	100
2	100	50	50	100	100	100
3	41	82	22.1	59.5	100	52.3
Mean	75.6	73.2	40.7	86.5	97.9	84.1

The data can be represented as a bar chart, which is appropriate because the % intercepted dependent variable is numerical data whereas 'type of vegetation' is discontinuous, categorical data.

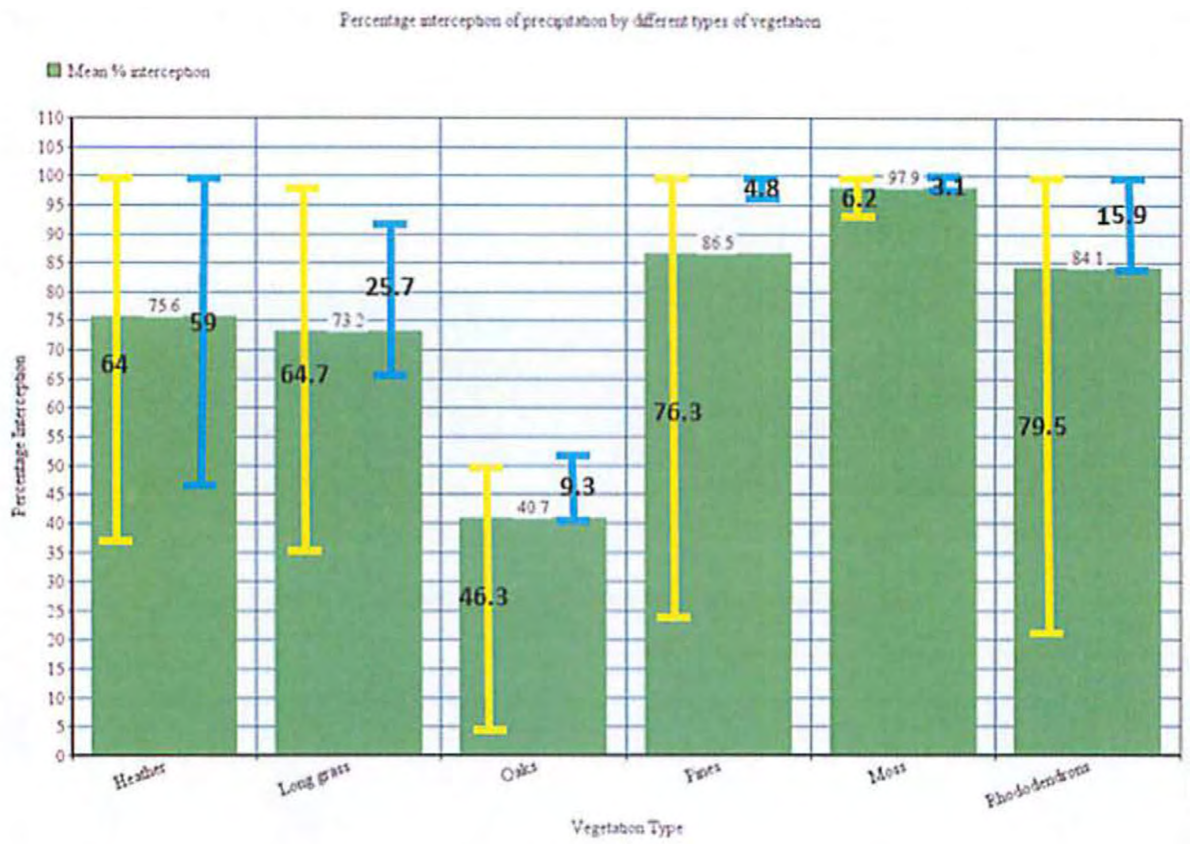


I also made a bar chart including my range, interquartile range, and mean of my raw data percentages to show the variability of each of my sets of data.

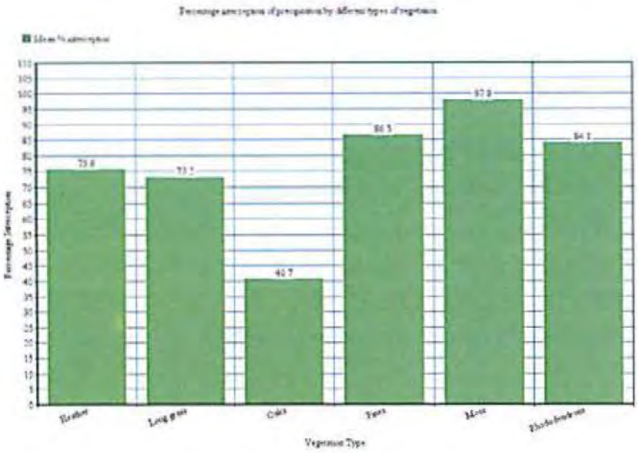
Vegetation:	Heather	Grass	Oak	Pine	Moss	Rhododendrons
Lower bound(%)	36	33.3	3.7	23.8	93.8	20.5
Lower quartile(%)	41	66	40.7	95.2	96.9	84.1
Mean (%)	75.6	73.2	40.7	86.5	97.9	84.1
Upper quartile(%)	100	91.7	50	100	100	100
Upper bound(%)	100	98	50	100	100	100

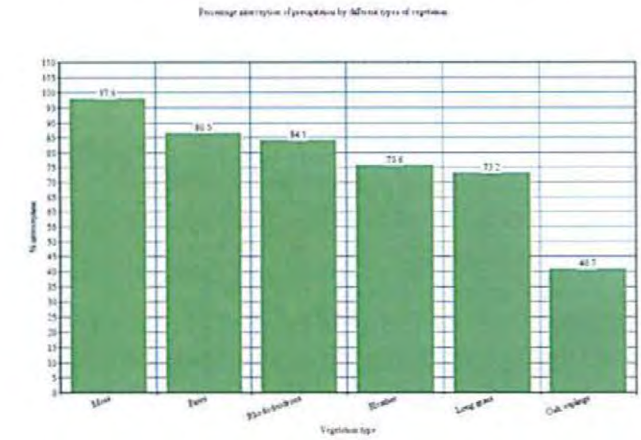


I then tried to make the range and inter-quartile range clearer by representing them as error bars around the mean value.


Percentage interception of precipitation by different types of vegetation
Mean % interception
Percentage Interception
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
75.6
73.2
40.7
86.5
97.9
84.1
64
59
64.7
25.7
46.3
9.3
76.3
4.8
6.2
3.1
79.5
15.9
Heather
Long grass
Oaks
Pines
Moss
Rhododendrons
Vegetation Type

Data Analysis: Vegetation and Interception





My bar graph shows that the vegetation with the highest ability to intercept precipitation is sphagnum moss, at an average of 97.9% interception. Following this are pine trees, 86.5% interception, rhododendron bushes, 84.1%, heather, 75.6%, long grasses, 73.2%, and finally the oak saplings at only 40.7%.

This result could be explained using the theory of how water is stored during interception; if I were asked to put these plants in order of surface area: volume ratio without measuring them it would be in almost the same order as their % interception rates.

Sphagnum moss is small and its surface is highly textured with spikes, giving it a larger surface area: volume ratio than other plants which is important because intercepted water is stored on the surface of a plant. Pine tree needles also have a large surface area due to their needles, which can hold water in the spaces between them due to its surface tension like a sponge.

The extreme result I collected for sphagnum moss are supported by research on the plant group, which says they can hold 'eight times their own weight in water' (ScottishWildlifeTrust, 2018).

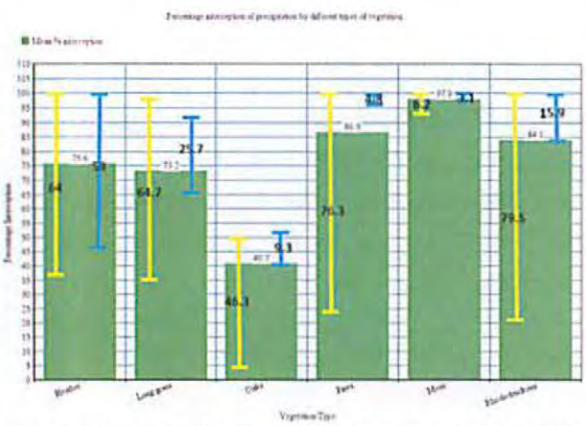
The density of vegetation also plays a role in its total surface area available to store intercepted water. For example, grass and heather are relatively low-growing and have less 'levels' of vegetation to catch water, whereas pine trees are very tall off the ground and pose a larger area for any water to drip through and more opportunities to be caught and stored, explaining its high interception rates.

This is where a problem with my data comes up; my investigation was carried out in winter, when many plants were in dead or dormant states.

Whereas sphagnum moss thrives in winter (ScottishWildlifeTrust, 2018), and pines and rhododendrons are evergreen, I recorded my observations that several of the sites' plants seemed to be deciduous, namely the oak saplings (which only had a few dried leaves on them), the long grass (which was still dense but dry and yellow), and the heather (which was dry and shrivelled); they had a decreased density and surface area.

This is very likely to mean that my data is not representative of interception rates in these areas for the whole year, especially summer when these deciduous plants come into leaf.

The ranges and interquartile ranges of my data varied dramatically, with the largest range of data being for the cups under the rhododendrons and the smallest range being under the sphagnum moss. This means that the rhododendrons had the outliers which were most different to their mean, and that the moss did not have any extreme outliers.



The moss also has the smallest interquartile range (3.1%) which suggests that these results are the most reliable as they've been replicated in repeats. Pine trees also had a small interquartile range (4.8%) despite a large range (76.3%) which means that despite a small amount of outliers, the pine data is reliable.

The interquartile ranges of the oaks, moss, and rhododendrons are all almost entirely above the mean as can be seen by the error bars having almost no overlap with the bars on the graph, which suggests that these means may have been dragged down by anomalously low results, and that if I continued collecting results to increase reliability, these means may not turn out to be representative.

The sites with the largest interquartile ranges are the heather and the grass, suggesting either that these mean results are not as reliable as some of the others and that if I carried out more repeats the interquartile range would grow smaller and the mean more accurate, *or* that there is genuinely more variability in the amount of rain which reaches the ground in these areas.

One explanation for there being different rates of interception on the different days of my investigation for the same sites is the different types of precipitation; as this was a geographical investigation I couldn't control this variable and whereas repeat 1 had medium-heavy rain, repeat 2 had drizzly rain and repeat 3 had heavy snow.

Theory says it isn't only the type of vegetation (its surface area and density) that affects interception, but also the type of precipitation, so this variability in type is likely to have significantly affected my results; whereas medium-heavy rain may fall straight downwards, small droplets of drizzle are likely to be blown by the wind and may not have fallen in the angle of the measuring cups. Small droplets fall with less force than larger droplets so I would hypothesize that interception for all the plants was relatively higher on the second day than on the first day.

Snow clumps in flakes and may stick to vegetation, forming a layer which itself intercepts more snow, which would likely have significantly affected my results. However I tried to counter this effect by waiting for the snow to melt and drip through the plant, however this may have resulted in a slight underestimate of volume as water may have been lost from the snow by sublimation and evaporation whilst it was melting before it reached the cup.

<u>Statistics:</u>

I used the Chi-Squared statistical test to investigate whether there was a significant difference between the rainfall (mm of water in the cup out in the open) of a site and the amount of water collected under the vegetation at that site. I did this to see if each site's observed rate of interception was statistically significant, and so I could then compare the sites' chi-squared values to see which had the most significant difference between mean rainfall in the open and mean rainfall under the plants – a.k.a., which one had the most statistically significant rate of interception.

The Chi^2 critical values are:

Chi-squared Test		
Table of critical values		
Degrees of freedom	p = 0.01	p = 0.05
1	6.64	3.84
2	9.21	5.99
3	11.35	7.81
4	13.28	9.49
5	15.09	11.07
6	16.81	12.59
7	18.48	14.07
8	20.09	15.51
9	21.67	16.92
10	23.21	18.31

[3]

I will have to use different degrees of freedom where there was unsuccessful data collection and less data points (e.g. the when some cups was knocked over on the first repeat).

My null hypothesis is that there is no significant difference for any site between the amount of rainfall collected in the open and the amount of rainfall collected under vegetation.

Site A, vegetation type: bell heather				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	7	1	-	-
		2	1	5.14
2	4	1	0	4
		2	0	4
3	50	1	27	10.58
		2	32	6.48
Chi-Squared value = $\Sigma(O-E)^2/E$ = 30.2 4 d.f., 30.2>13.28 the p=0.01 critical value Therefore there's a less than 1% probability of the difference between expected and observed values being down to chance, so the difference is highly significant and null hypothesis can be rejected.				

Site B, vegetation type: long grass				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	6	1	1	4.17
		2	1	4.17
2	3	1	1	1.33
		2	2	0.33
3	50	1	17	21.78
		2	1	48.02
Chi-Squared value = $\Sigma(O-E)^2/E$ = 79.8 5 d.f., 79.8 > 15.09 the p=0.01 critical value, so a less than 1% probability of the difference between expected and observed values being down to chance, so the difference is highly significant, null hypothesis can be rejected.				

[3] Critical values table from the Field Studies Council's Geographical Investigations Guide pdf (FSC, Open University, Geographical Association, 2016)

Site C, vegetation type: oak saplings				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	6	1	3	1.5
		2	3	1.5
2	2	1	1	0.5
		2	1	0.5
3	27	1	26	0.04
		2	16	4.48
Chi-Squared value = $\Sigma(O-E)^2/E = 8.52$ 5 d.f., 8.52 < 11.07 the critical value for p=0.05, therefore there's a greater than 5% chance of the difference between expected and observed values being down to chance, so the difference isn't significant, null hypothesis can't be rejected.				

Site D, vegetation type: pine trees				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	8	1	0	8
		2	0	8
2	2	1	0	2
		2	0	2
3	21	1	16	1.19
		2	1	19.05
Chi-Squared value = $\Sigma(O-E)^2/E = 40.24$ 5 d.f., 40.24 > 15.09 the critical value for p-=0.01 so there's a less than 1% probability of the difference between expected and observed values being down to chance, so the difference is highly significant, null hypothesis can be rejected.				

Site E, vegetation type: moss				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	8	1	-	-
		2	0.5	2.68
2	2	1	0	2
		2	0	2
3	21	1	1	19.04
		2	0	21
Chi-Squared value = $\Sigma(O-E)^2/E = 46.72$ 4 d.f., 46.72 > 13.28 the critical value for p=0.01, there's a less than 1% probability the difference between expected and observed values being down to chance, so the difference is highly significant, null hypothesis can be rejected.				

Site F, vegetation type: rhododendron bushes				
Repeat day:	(E) EXPECTED rain reaching ground (volume of water in the cup out in the open, ml)	Repeat Cup:	(O) OBSERVED rain reaching ground (volume of water in the cup under vegetation, ml)	$(O-E)^2/E$
1	3	1	0	3
		2	0	3
2	3	1	0	3
		2	0	3
3	44	1	7	31.11
		2	35	1.84
Chi-Squared value = $\Sigma(O-E)^2/E = 44.95$ This is greater than 15.09, the critical value for 5 degrees of freedom for p=0.01, Therefore there's only a 1% chance that the difference between expected and observed values is down to chance, so the difference is highly significant and the null hypothesis can be rejected.				

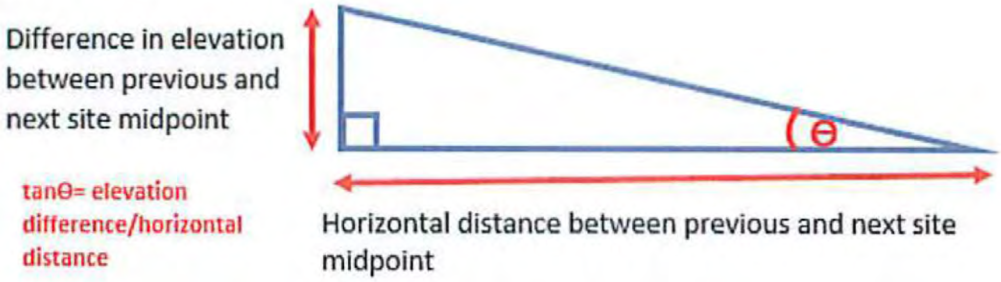
Vegetation type:	Grass	Moss	Rhododendrons	Pines	Heather	Oak
Degrees of Freedom:	5	4	5	5	4	5
Chi-squared value:	79.8	46.72	44.95	40.24	30.2	8.52
Significance:	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P>0.05

These statistical results support the patterns that my data representation shows; all differences are significant except the interception by the oak saplings, which is probably because it has lost much of its surface area/leaves because it's in a dormant winter state and therefore is not causing a statistically significant amount of interception.

The largest Chi-squared value actually for long grass, which suggests that there is the lowest probability that the observed difference between results in the open and under vegetation is down to chance, so despite its higher interquartile range this is the result I can most reliably say is not due to chance. Following this are the results for moss (46.72) and rhododendrons (44.95), but pines and heather also surpass the critical value for <1% probability of results being due to chance, so all these differences are highly significant.

Data Presentation: Soil Saturation

I worked out the average slope gradient of each point by calculating altitude change (m) between the midpoints between the sites, and then the horizontal distance between the sites (average 53m), and using trigonometry.



Site	Location coordinates degrees NW, from OS map	Altitude at previous site midpoint (m)	ϴ Slope gradient (degrees)
A	394287, 403913	208	5.7
B	394325, 403860	203	2.3
C	394387, 403831	201	6.8
D	394446, 403825	195	9.1
E	394504, 403826	187	8.0
		180	
F	394676, 404031	176	3.4
G	394731, 404027	173	5.7
H	394736, 403961	168	4.6
I	394753, 403915	164	5.7
J	394778, 403852	159	1.1
K	394802, 403803	158	0
L	394865, 403793	158	0
		158	

I used the results of weighing my soil before and after drying to calculate weight change and then plugged this into a calculation to work out what percentage of the initial weight was water (what the soil saturation was):

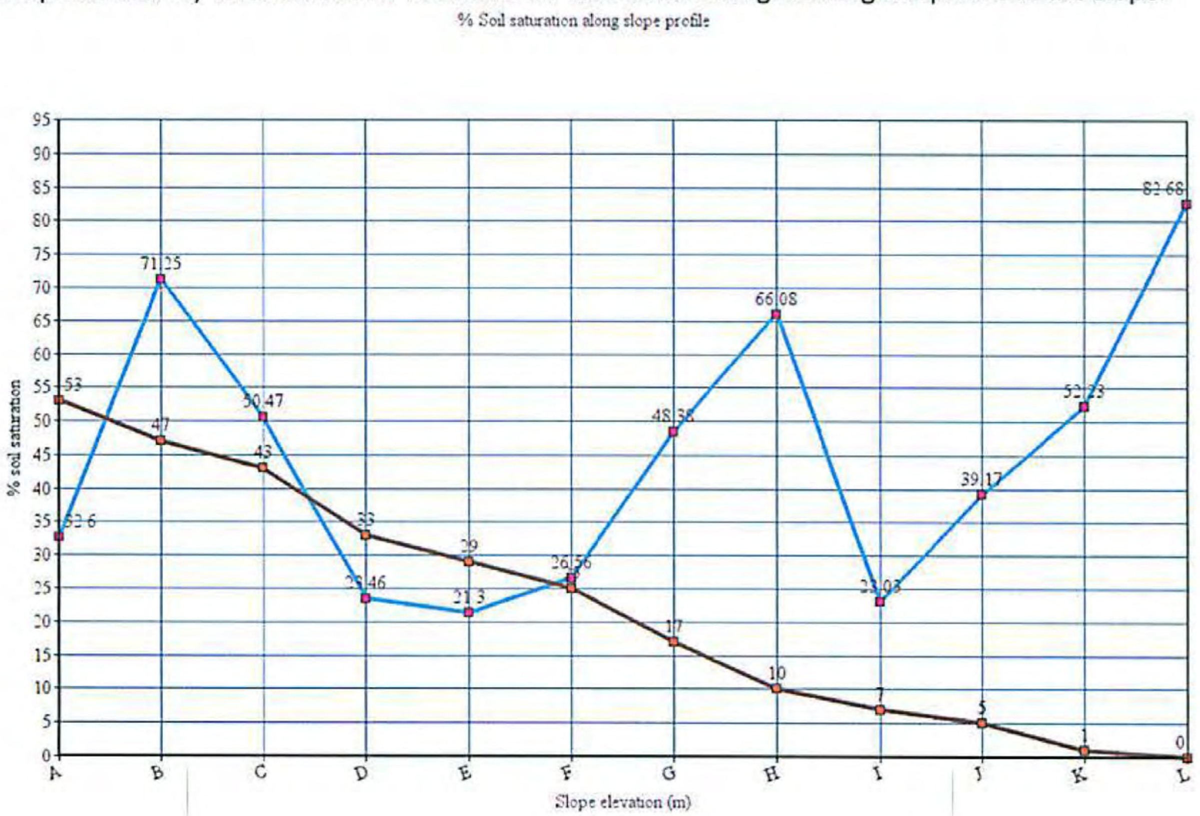
Change in weight = wet weight in dish – dry weight in dish

Wet weight = wet weight in dish – weight of dish

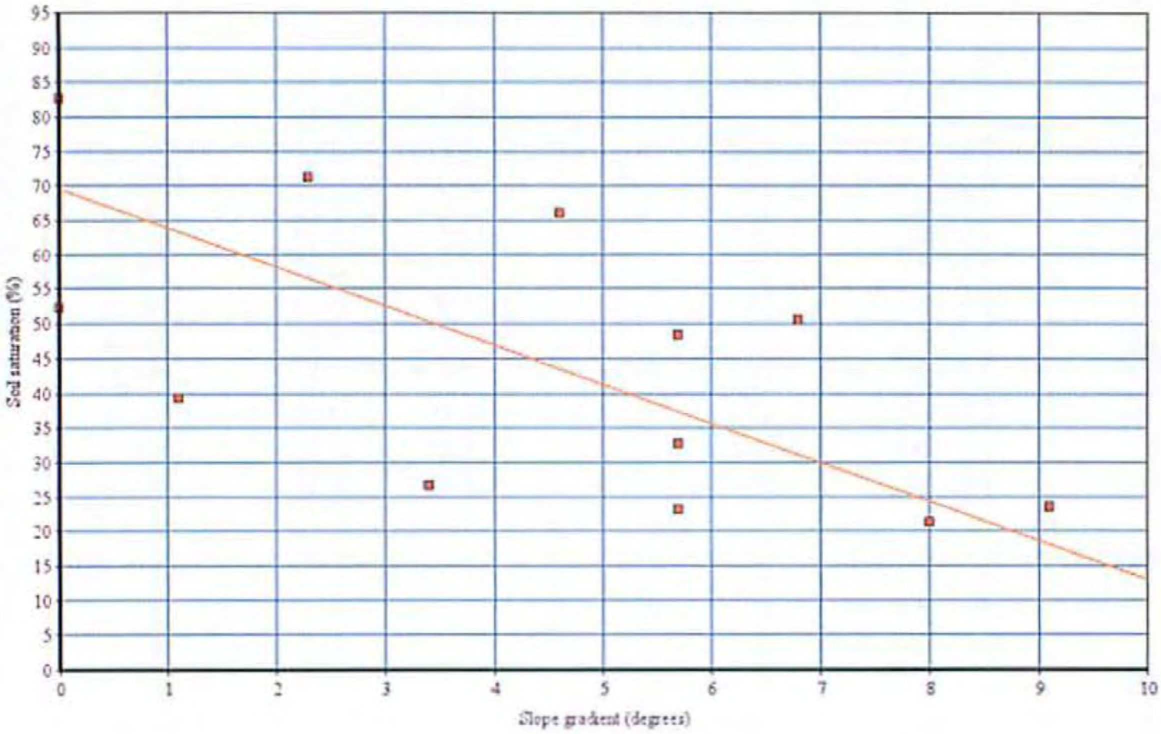
Change in weight / wet weight x 100 = % water saturation of wet sample

Site	Gradient of slope (degrees)	Weight of wet soil sample with dish (g)	Dried weight of soil sample with dish (g)	Weight of evaporating dish (g)	Weight change wet to dry (g)	Weight of wet soil (g)	% soil saturation of wet sample
A	5.7	103.73	90.26	62.41	13.47	41.32	32.60
B	2.3	96.84	83.16	77.64	13.68	19.20	71.25
C	6.8	83.42	67.41	51.70	16.01	31.72	50.47
D	9.1	89.11	80.76	52.75	8.35	36.36	23.46
E	8.0	91.60	84.01	55.97	7.59	35.63	21.30
F	3.4	89.95	79.92	52.18	10.03	37.77	26.56
G	5.7	83.97	70.41	55.94	13.56	28.03	48.38
H	4.6	91.75	69.99	58.82	21.76	32.93	66.08
I	5.7	88.01	80.12	53.75	7.89	34.26	23.03
J	1.1	86.97	73.55	52.71	13.42	34.26	39.17
K	0	101.87	80.30	60.76	21.57	41.11	52.23
L	0	86.47	67.99	64.12	18.48	22.35	82.68

I first represented my data with a line to show how saturation changed along the profile of the slope:



Then I created a scatter graph with my variables saturation and slope gradient to see if there was any obvious correlation between the two in my data.



There seemed to be a negative correlation between gradient steepness and amount of water in the soil, which my best fit line (orange) followed.

Data Analysis: Soil saturation

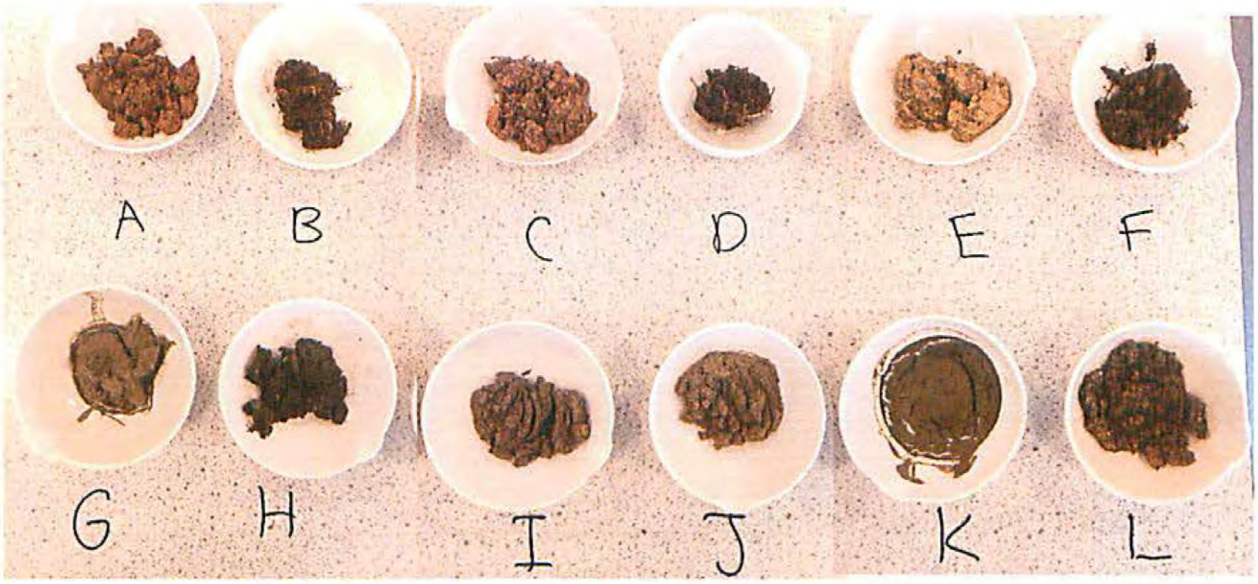
Some slight patterns can be seen by plotting the unprocessed data against a slope profile, for example at the bottom of the slope where the gradient becomes flat there is a spike in soil saturation.

But when the data's presented as a scatter graph there can be seen a clear trend in the data; a negative correlation between the steepness of a slope and how saturated the soil is.

This supports what one might expect; overall, steeper slopes cause any water on the surface to flow away as overland flow before it can infiltrate, and allow more water to drain down the slope as throughflow towards the drainage channel, and should therefore be expected to have lower soil saturations than soil in flatter areas.

However it is likely that along my transect slope gradient is not the only factor that changes; other factors which are likely to affect saturation are soil type, vegetation, and relief.

Areas that are more sheltered from driving precipitation will receive less precipitation and therefore have lower saturation. Areas with more vegetation or with certain types of vegetation will increase water drawn out of the ground by evapotranspiration (soil samples which I observed had particularly high densities of roots were sites B and D) and intercept precipitation (see the other question being investigated, e.g. plants with more surface area or absorbent capacity, higher density, or who are in leaf at a certain time of year, are more likely to increase interception).



Soil types which allow only slower rates of infiltration (e.g. they have small packed particles without many air gaps between them) are likely to decrease soil saturation because they have less capacity and because fallen rainwater remains on the surface longer during slow infiltration and has more chance to flow away overland. Several of my soil samples had noticeably high clay contents (samples A and C); clay is quite impermeable, so these sites' saturations are likely to have been most affected by the slow rates of infiltration and high rates of overland flow, and therefore should be expected to have lower soil saturations than steep slopes with more permeable soil (such as my sites G, I, and J, which contained lots of sand and pebbly particles). This theoretical effect may, however, by countered by the fact that soils which allow less infiltration also allow less throughflow, so they are likely to drain more slowly than steep slopes with more permeable soil (which are likely to drain quicker).

So steep slopes might have different effects on soil saturation dependant on the soil type and its capacity.

The data points on my scatter graph are off to either side of the best fit line, which meant there was not an absolute linear correlation in my data and that the correlation might be weak. This could be explained by the variability in these other environmental factors affecting soil saturation as well as slope gradient.

To test the actual strength of the correlation between gradient and saturation, I processed my data using the Spearman's rank stats test.

Statistics

I used the Spearman's rank statistical test to test how strong the correlation I could see in my data from my graph representation (a negative correlation between slope gradient and soil saturation) was, and whether it was statistically significant. It was possible to use this test because I collected 12 pairs of data, the minimum number for this test.

Spearman's Rank Correlation Test		
Table of critical values		
Number of pairs	p = 0.01	p = 0.05
12	0.727	0.587
13	0.703	0.560
14	0.679	0.538
15	0.654	0.521
16	0.635	0.503
17	0.618	0.488
18	0.600	0.472
19	0.584	0.460
20	0.570	0.447

[4]

My null hypothesis is that there's no statistically significant correlation between slope gradient and soil saturation.

Ranking table:

Gradient (degrees)	Rank 1	% soil saturation	Rank 2	Difference in ranks (D)	D squared
9.1	1	23.46	10	9	81
8.0	2	21.30	12	10	100
6.8	3	50.47	5	2	4
5.7	5	32.60	8	3	9
5.7	5	23.03	11	6	36
5.7	5	48.38	6	1	1
4.6	7	66.08	3	4	16
3.4	8	26.56	9	1	1
2.3	9	71.25	2	7	49
1.1	10	39.17	7	3	9
0	11.5	52.23	4	7.5	56.25
0	11.5	82.68	1	10.5	110.25
					Sum= 472.5

Spearman's rank correlation coefficient

$$= 1 - \frac{6\Sigma D^2}{n(n^2-1)}$$

D = difference between ranks
n = number of pairs of measurement

= 1 – (6x472.5)/(12x143)) = -0.6520979

This is a strong negative correlation coefficient, so despite the distance between the data points and the best fit line in the scatter graph the negative correlation between my variables is actually strong.

The Spearman's rank critical values for 12 pairs of data are 0.587 for p = 0.05 and 0.727 for p=0.01.

[4] Critical values table from the Field Studies Council's Geographical Investigations Guide pdf (FSC, Open University, Geographical Association, 2016)

My correlation coefficient of 0.652... is < 0.727 but > 0.587, which means that there is a more than 1% but less than 5% probability that the strong negative correlation observed is due to chance. This is a statistically significant result and means I can reject my null hypothesis and be sure of the negative correlation between slope gradient and soil saturation.

Conclusions and Evaluation

The two questions I was trying to answer were how vegetation type affects the amount of interception taking place, and how soil saturation is affected by drainage basin relief, to contribute to my overall investigation of how different environmental factors affect the hydrological cycle in a drainage basin.

My conclusions in reference to how type of vegetation affects amount of interception are that there are significant differences in the amounts of precipitation which different plant types intercept, with sphagnum moss showing the highest rates of interception of the six types I tested at a mean of 97.9% interception, followed by pine trees at 86.5%, rhododendron bushes at 84.1%, heather at 75.6%, long grasses at 73.2%, and finally oak saplings at 40.7%.

This supports the theory related to interception, that water is stored on the surface of plants and that therefore the plants with the largest proportional surface areas available to store water will intercept the greatest amounts, because sphagnum moss has a very large surface area due to a high degree of folding on its surface, and can consequently absorb eight times its own weight in water (ScottishWildlifeTrust, 2018). Pine trees can store and intercept more water because their clusters of small needles have a much larger surface area than broad-leaved trees and bushes and therefore act as sponges.

However, my chi-squared statistical test showed that of these, the greatest statistical significance can be assigned to the interception (difference between open rainfall and rainfall under vegetation) by the long grass, and moss after this; the reason that the sphagnum moss value, which had the smallest overall range of data and the smallest inter-quartile range (at 6.4% and 3.1% respectively) and can therefore be concluded to be the most reliable, isn't the most statistically significant is probably because (due to the fieldwork human error of me not securing cups from being blown over by the wind during the first repeat) there are only 5 data points to be used and therefore 4 statistical degrees of freedom, one less than the other results. The remaining order of chi-squared values was rhododendron, pine, heather, and lastly oak.

The only plant type which didn't give a statistically significant chi-squared result was the oak saplings; this supports the drastic difference between its low mean interception (40.7%) compared to all the other results which were between 73% and 98%.

I don't expect that the pattern I saw of oak tree, heather, and grass having the least effect on interception to be representative of these plants' interception rates all year round because these species were all noticeably dried out and dormant, because they're deciduous and I collected my data before spring began. The fact that the oaks had such an extremely low value can probably be attributed to the fact that they do not only dry out during its winter dormancy but also lose a large proportion of their surface area through leaf senescence, reducing the storage capacity of the plant and its ability to intercept rainfall.

I increased the reliability of my results by carrying out repeats (cups a and b at each site, plus carrying out 3 days of measurements) and calculating a mean. This means I am reasonably confident in drawing valid conclusions of which plant types intercept the most and least amounts from this data; however some of my sites have much larger ranges (suggests extreme/anomalous results) and interquartile ranges (suggests a large amount of variance around the mean; low precision can signal a lack of accuracy, though not always). For example, my heather site had the largest interquartile range (59%) and also had the second lowest chi-squared (30.2 because this also only had 4 degrees of freedom, though this is still a highly significant result); therefore, to be more confident in the mean I calculated for this site and the order of interception I concluded from that data, I would ideally perform more repeats.

Some of the variability could be due to other environmental conditions; in this case, factors which I didn't take into account when drawing my conclusions such as temperature and evaporation, and wind, but also the different types of precipitation I observed on each of my repeats (medium-heavy rain, light drizzly rain, and snow on the 3 repeats). Therefore it may be that different vegetation types react to different precipitation types differently. However I

However I'm still confident in drawing my conclusion of average rates of interception and the order of how much interception each vegetation type causes from my mean % infiltration results (figure 4) because the differences were supported by my stats test, although I am *more* confident that the means with smallest IQ ranges and/or most significant stats values are the most reliable (moss, pine) so if I was to extend or repeat this investigation I would focus on increasing the number of repeats to get more reliable means for the middle values so I could be sure of their interception rates and overall order.

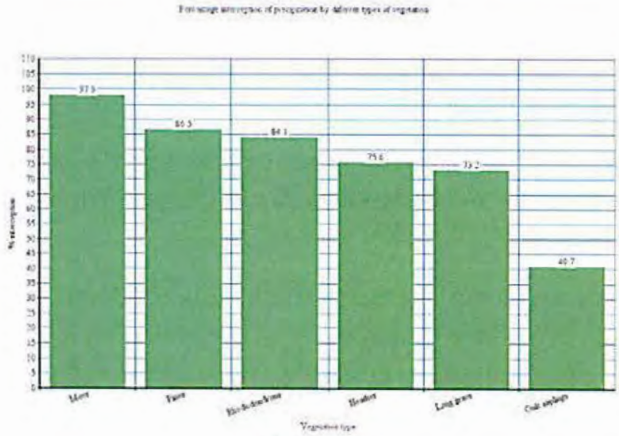


FIGURE 4

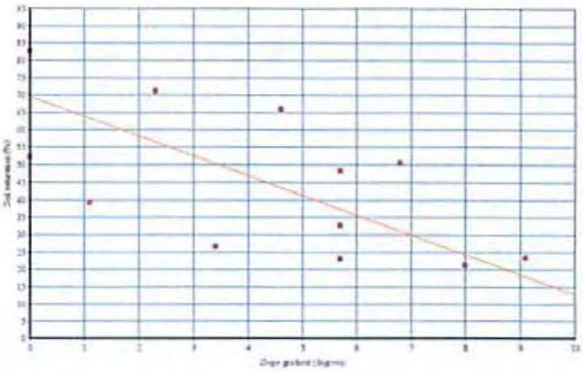
Therefore my results support my hypothesis drawn from theory, that there's a relationship between the characteristics of different plants (such as their surface area and density) and the amount of precipitation they intercept, and my conclusion can be that the different interception capacities of different types of plant have a significant effect on interception taking place in different part of the River Medlock drainage basin.

Possible sources of error in my method for this investigation could be human measurement errors on my part, though I tried to prevent this by following the same method for every site and tried to maximize the accuracy of my physical readings from my measuring cylinder by holding it level at eye-line. Also, a possible source of systematic sampling error could be a certain amount of evaporation occurring between the rain falling and me collecting the data; having uniform systematic error in this case, however, wouldn't be hugely harmful because I'm not measuring absolute values but rather proportions (percentages). There's also always the possibility of random sampling error, for example, an animal may have come and drunk from one of the cups without me knowing, skewing that data point down; the effect of this type of error can be reduced by performing repeats, however, which I did, collecting 6 data points and 3 controls for each site in all.

Overall, even though some of the means might become more accurate with further repeats and the results are only representative of the plants in winter, I feel confident in my conclusions that plants with a large enough surface area are causing significant interception in the Medlock basin, with some intercepting up to 100% of all rain during some rainfall events and that different vegetation types with different leaf densities and surface areas have a significantly different rates of interception to each other.

Using this conclusion it may be possible to inspect the vegetation in an area, for example the whole Source-Lumb Brook catchment area for the River Medlock, and, using either a mathematical method (area covered by a type of vegetation x (interception % x expected precipitation over that area)) or general trends, work out the expected amount of rainfall projected to reach the ground; this could help with modelling the hydrological cycle of a basin, work out the inputs into stores such as aquifers, and help project channel output and storm hydrographs.

In reference to my investigation of soil saturation and drainage basin profile, I used the Spearman's Rank statistical test to test the correlation between % soil saturation and the gradient of the slope. This showed that there was a statistically significant strong correlation between these two variables, so I can conclude that my hypothesis of this same relationship was correct. This was probably due to the differences in hydrological processes such as throughflow draining soil more significantly on steeper slopes, or infiltration into the soil versus overland flow over the surface.



However the relationship was not linear but was scattered around the mean as can be seen in my scatter graph.

Unlike with my interception fieldwork, I did not gather multiple repeats of each elevation due to limitations in oven space for drying the soil and the long amount of time (several days) it took to dry the soil to calculate water content. I tried to counter this by gathering 12 point of data, enough to be valid for a stats test, but even though there was a statistically significant negative correlation I could have increased the reliability of my conclusion by collecting a larger amount of data points at different sites in the drainage basin after the same rainfall event, and/or, at the same sites after different rainfall events.

Doing this would have given me a more representative-of-the-whole-basin idea of the relationship between soil saturation and slope gradient by allowing me to see any anomalous results and to calculate means for each gradient, or being able to put more values into my Spearman's rank to find a more statistically significant and therefore accurate correlation.

Finding a mean would have improved the validity of my conclusion about the strength of the relationship because it would have helped to exclude the effects of other environmental factors; using observations about my sites I know that some of them were under vegetation cover (e.g. the trees over sites F, H, I, J) which may have reduced soil saturation by intercepting rainfall and drawing up water by evapotranspiration (soil samples B and D had high root content, for example), and/or increased soil saturation by preventing sunlight reaching the ground and reducing evaporation from the soil.

My soil samples also showed a clear difference in soil type, and could be separated into high clay content (A,C,E), high organic matter content (B,D,F,H), and high sand/pebble content (G,I,J,K,L). Theory states that soil type and particle size is generally a very significant factor in soil saturation because the gaps between the particles determine the soil's water storage capacity, so I would expect that this observation along with the effects of vegetation work together to explain the looser correlation between my two factors in my data. It may even be that these are actually correlated to the slope gradient (due to differential rates of weathering or different positions on slopes due to strata with the different positions on a slope being linked to certain gradients), in which case simply increasing the number of repeats may not be enough to exclude the effects of these factors and additional sampling or statistical techniques would need to be used to isolate the effects of slope gradient on saturation.

Possible errors in affecting the reliability of my results and the validity of my conclusions could be measurement errors; for example, by measuring approximately 50m lengths of land to calculate gradient by trigonometry may have decreased the accuracy (been further from the actual gradient) of my sites, which I could have corrected by using a more accurate method of data collection such as a handheld clinometer and poles.

Overall, though I feel confident stating that there is a strong negative correlation between slope gradient and soil saturation, my results imply that there are other environmental factors contributing to determining relative soil saturation at different points along a drainage basin, namely soil type and vegetation, which is what I expected from my hypothesis. The fact that the negative correlation is statistically significant along my slope helps to answer how to soil saturation is affected by drainage basin relief; steeper slopes decrease soil saturation, probably by the mechanisms of decreasing the amount of rain which can infiltrate before flowing away over the surface, and by increasing drainage by throughflow through the soil.

But despite the effects of other environmental factors, the fact that the results of investigations into both of these factors yielded statistically significant results suggests to me that these are two of the most major factors in play in the drainage basin hydrological cycle in the catchment area I investigated.

As a final point, the two environmental factors I have investigated will clearly affect the processes I have assigned to the other; I've proven that vegetation type affects interception rates (in a pattern of positive correlation), and therefore I can conclude (as the amount of rain reaching the ground will have a direct impact on soil saturation) that vegetation type also affects soil saturation. Also, soil saturation will determine what types of vegetation (and therefore how much interception and evapotranspiration take place); somewhere with high saturation like a bog is actually the most likely to grow sphagnum moss, which was the type with the highest rates of interception that I measured (at almost 98%). Also, prominent other processes which I have theorized could have affected my results during this investigation are temperature (which affects precipitation type and rates of interception), and soil type (having significant effects on the movement of water through the soil by infiltration and throughflow).

So my conclusion, in answer to my investigative title, is that environmental factors affects hydrological processes to different degrees in different drainage basins depending on the profile (environmental characteristics) of that particular drainage basin, and that two of the most influential environmental factors in the Upper Medlock catchment area that I investigated are slope gradient and vegetation type.

I can reliably conclude this because I have found that they have statistically significant effects on soil saturation (which is a result of the balance of the drainage basin processes of infiltration, surface runoff, throughflow, and percolation and evaporation out of the soil in an area) and interception respectively.

Using this conclusion I could model the amounts of infiltration and throughflow occurring throughout a catchment area such as Source-Lumb Brook of a Medlock, however, before I did this I would want to make sure that my correlation coefficient (the relationship between slope and saturation) was more accurate and representative of the real world, which I could do by performing a lot more repeats in different parts of the basin to decrease the affect other environmental factors were having in the results. I would also want to gather data on these other factors before creating any kind of model or prediction; basin relief is certainly not the only factor affecting soil saturation, for example.

However an ethical concern of this would be that the sample sizes of my investigations were small, and therefore not likely to be representative and may lead to skewed conclusions. Another concern would be that there were non-systematic factors (such as choosing the precise spot to collect soil samples from at a site, or the precise spot to place rain gauges under the vegetation e.g. under different densities of leaves) which could allow investigator bias to influence the results, which could have lead to confirmation bias towards my hypotheses in my conclusions. This means that, in theory, a method and evaluation such as I've used would produce conclusions which would be unethical to apply to situations such as (for example) giving advice about building or development (e.g. where soil saturation is or isn't likely to cause subsidence of the foundations of a building), or modelling a drainage basin for the purposes of water collection for industrial use. For conclusions to be valid enough for these purposes, I would follow methods more like an organization such as the Environment Agency uses, with large survey teams and more accurate specialist equipment, which allows for large sample sizes and continuous repeats of investigations throughout the year/s and the production of reliable conclusions.

Bibliography:

(NASA, 2018) –

Earth Observatory Water Cycle Overview | Precipitation Education. 2018. *Earth Observatory Water Cycle Overview | Precipitation Education*. [ONLINE] Available at: https://pmm.nasa.gov/education/articles/earth-observatory-water-cycle-overview. [Accessed 23 March 2018].

The Water Cycle : Feature Articles. 2018. *The Water Cycle : Feature Articles*. [ONLINE] Available at: https://earthobservatory.nasa.gov/Features/Water/page2.php. [Accessed 23 March 2018].

(Michael Raw, 2016) –

Raw, M., 2016. *Ocr a Level Geography*. Hodder Education.

(Jackson, 2014) -

Alex Jackson. 2018. *Drainage Basins & The Hydrological Cycle*. [ONLINE] Available at: https://geographyas.info/rivers/drainage-basins-and-the-hydrological-cycle/. [Accessed 23 March 2018].

(Gornitz, 1997) –

Gornitz, V., C. Rosenzweig, and D. Hillel 1997. Effects of anthropogenic intervention in the land hydrologic cycle on global sea level rise. *Global Planet. Change* 14, 147-161.

(FSC, Open University, Geographical Association, 2016)

PDF - https://www.geography-fieldwork.org/media/.../geographical-investigations-hi-res.pdf

Field Studies Council Resources –

https://www.geography-fieldwork.org

The small print

We'd like to know your view on the resources we produce. By clicking on the 'Like' or 'Dislike' button you can help us to ensure that our resources work for you. When the email template pops up please add additional comments if you wish and then just click 'Send'. Thank you.

Whether you already offer OCR qualifications, are new to OCR, or are considering switching from your current provider/awarding organisation, you can request more information by completing the Expression of Interest form which can be found here: www.ocr.org.uk/expression-of-interest

OCR acknowledges the use of the following content:
Square down and Square up: alexwhite/Shutterstock.com; Page 19: Fig 1 - Map of Oldham, Map data (c) Google; Fig 2 - Map of Oldham, OS (c) Crown copyright 2018; Page 20: Maps of Oldham(Fig 1 and 2), OS (c) Crown copyright 2018; Page 21: Map, OS (c) Crown copyright 2018; Page 22, 23, 25: Maps of Glodwick, OS (c) Crown copyright 2018; Page 26: Maps of Low Side, OS (c) Crown copyright 2018.

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/

www.ocr.org.uk

OCR Customer Support Centre

General qualifications
Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk

OCR is part of Cambridge Assessment, a department of the University of Cambridge. *For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored.*

Cambridge Assessment

CERTIFIED ISO 9001

UKAS MANAGEMENT SYSTEMS 001