

MESSAGE Final Comprehensive Exam: Review

This list is drawn from the stated learning objectives and syllabi of the MESSAGE required core curriculum: Hillslope Geomorphology, Engineering Geology, Fluvial Geomorphology, Introduction to GIS, Field Methods I and II, Professional Practice, and Technical Communication. The purpose of this list is to 1) document the breadth of skills and expertise that students acquire during MESSAGE, and 2) to provide a starting point for studying for the final comprehensive exam.

The comprehensive exam covers a broad base of course material to assess the knowledge and the professional capacity of students. It is meant to integrate the themes and skills outlined below to simulate the professional demands that an applied earth scientist will face in the workplace. This is an oral exam, in front of a panel of at least two MESSAGE faculty. An hour before the exam, the student is presented with two multi-part scenario questions, each representing a different area of the core curriculum. Students have an hour to prepare an oral response to both questions, using whatever materials the student has elected to include in a three-ring binder for this purpose. During the exam the student is asked to describe how to solve the stated problems or plan an appropriate investigation. The examiners will ask follow-up questions. The student may use a whiteboard, and the images provided in the questions can be projected, if required. In addition to the two questions, the student may also be asked to identify a soil sample using the Unified Soil Classification System.

Students are encouraged to prepare for this exam assembling a binder of reference materials for key topics. It will be helpful to review course notes, particularly class assignments and exams. Student-organized study sessions and practice exams are encouraged.

(1) Professional skills

Field

- Work in teams and individually to collect and interpret observations in the field
- Take effective field notes, site maps, outcrop sketches and photographs
- Efficiently transfer and store field data for analysis
- Produce clear and concise field reports
- Recognize and document limitations
- Recognize and describe domains

Scholarship

- Identify and locate the common sources of site information (geographic, geologic, topographic, environmental, hydrologic, subsurface, climate, land use, historical, imagery, utilities, hazards, and recent activity).
- Know how to cite the various types of sources.
- Identify the major conclusions, methods of investigation, and data in scientific publications and technical reports

- Be familiar with the historical context of core sub-disciplines and possess a working knowledge of the varied applications of these fields (hydrogeology, hillslope geomorphology, fluvial geomorphology, engineering geology, GIS)

Communication

- Recognize the purpose, structure and style of different forms of written technical communication (correspondence, reports, proposals, memos)
- Read and review and critique technical materials for content and editorial improvement
- Produce concise, informative and unbiased documents of different forms (correspondence, report, proposal, memos)
- Recognize the elements of and produce a clear and precise technical illustration (photo, map, graph, drawing, tables)
- Understand the fundamentals of and principles underlying effective geologic mapping
- Deliver an oral presentation, including effective use of visual aids.\
- Understand and employ proper attribution/citation; recognize and avoid plagiarism
- Network and make new professional connections
- Participate in professional societies
- Recognize the benefits of presenting technical/scientific work to an audience of peers and general audiences

Professionalism

- Practice effective and confident public speaking and interaction with associates
- Understand the role of geologists in management of public lands, transportation, environmental, forestry, habitat restoration, infrastructure, development, and other related fields.
- Understand the requirements for and pursue professional geologist licensing
- Understand topics of current concern in the practice of applied geosciences
- Understand and practice the geologists' code of conduct
- Recognize and understand ethical dilemmas
- Understand the difference between hazard and risk

(2) Fundamental Geologic Concepts

Landforms/Observables

- Recognize major landforms and deposits of continental glaciation, as expressed in the Puget Lowland
- Recognize landforms and deposits of alpine glaciers
- Recognize the variety and understand the distribution of coastal deposits
- Recognize the variety and understand the distribution of volcanic deposits in western Washington
- Distinguish among fluvial, glacial, and lahar deposits
- Characterize channel planform pattern (e.g., braided, meandering, anastomosing) from field or remote observations
- Identify and understand the major processes and characteristics of hillslopes

Geologic History

- Understand and describe the active tectonic setting of Cascadia, including the seismic source regions and earthquake hazards of and the Pacific Northwest
- Understand and describe the glacial history of the Pacific Northwest

*Theory**Hydrogeology*

- Learn the basic components of the hydrologic equation including precipitation, infiltration, run-off, evapotranspiration, recharge, discharge, and base flow
- Describe the basic concepts associated with aquifers and drawing geologic cross-sections to illustrate these ideas
- Know the connections among energy, pressure, and forces acting on groundwater
- Use Darcy's Law to calculate water fluxes and quantify permeameter properties
- Describe, distinguish, and use in quantitative calculations both hydraulic conductivity and permeability
- Describe the factors that control variations of hydraulic conductivity and permeability
- Describe the concepts of isotropy and homogeneity and the geologic factors that impact these concepts
- Describe the concept of aquifer elasticity and specific storage and undertaking quantitative analysis of aquifer properties
- Describe the connection between properties of geologic materials and the corresponding characteristics of an entire aquifer
- Adjust measured hydraulic heads to account for water with variable density
- Understand how Darcy's Law and conservation of water leads to the "diffusion equation" which provides a quantitative and qualitative framework for groundwater flow
- In the case of time varying flow, quantitatively determining characteristic lengths or times based on "scaling" of the diffusion equation
- Identify the appropriate boundary conditions of head and flux for various types of boundaries

Engineering Geology

- Understand the basic engineering properties of soil and rock
- Understand the differences among stress, strain, and rheology. Know the common constitutive equations that relate these quantities for elastic, plastic, and viscous materials.
- Understand the influences of groundwater on soil and rock
- Understand the impact of earthquake ground shaking on soil and rock
- Understand basic geologic hazards
- Understand basic geophysical techniques for investigating shallow subsurface
- Understand landslides, their causes and types
- Understand the importance of discontinuities in soil and rock

Hillslope Geomorphology

- Be familiar with properties of rock mass strength and hillslope weathering processes – physical and chemical
- Comprehend the basic factors controlling slope stability
- Derive the factor of safety equation assuming an infinite slope, understand the variables, and use this equation to assess slope stability
- Be aware of common hillslope geomorphic transport laws and governing equations
- Knowledge of other types of mass movements and extreme slope--failure events of bedrock and soil--mantled hillslopes, including debris flows, seismically--induced landslides, and rockfall processes
- Understand soil production and transport of mobile regolith geochemistry/morphology of soil covered hillslopes
- Understand important concepts in hillslope evolution such as threshold slopes and steady-state topography
- Understand concepts of hillslope hydrology, slope run-off erosion, sediment production, their temporal and spatial arrangement in the landscape, and connections between hillslope and fluvial systems

Fluvial Geomorphology

- Understand processes and controls on the initiation of channels and channel network development
- Understand fundamentals of open--channel flow in natural channels, including: the steady, uniform flow assumption; reach--average boundary shear stress; sources of roughness; shear stress partitioning; local shear stress and the vertical velocity profile for turbulent flow
- Understand the processes and mechanics of sediment transport and deposition
- Understand hydraulic, sedimentological, temporal, and spatial controls on the channel cross--section
- Understand interactions between river channels, fluvial wood, and riverine forests
- Understand processes and controls governing channel pattern and river-floodplain dynamics
- Understand processes of floodplain formation and the resulting landforms
- Know the uses and limitations of channel classification and the leading classification systems, including Montgomery and Buffington (1998)
- Understand erosion processes in bedrock river channels and the evolution of river longitudinal profiles and associated landforms
- Understand how channels adjust to changing climate and watershed conditions

Geographic Information Systems

- Understand the relevance of spatial dependence/patterns and issues of scale in any of the above phenomena, and how to apply principles of geospatial analysis to explore such dependencies

(3) Practical skills/application*Field/Lab**General field skills*

- Recognize and describe landforms such as: landslides and landslide deposits, terraces (river and marine), river bed forms and deposits, glacial moraines and glacial erosional features; coastal deposits
- Classify and describe unconsolidated materials using the Unified Soil Classification System
- Evaluate provenance of detrital grains, recognizing the common mineral grains found in sand.
- Use field sieves and use sieves in the lab to analyze grain size distributions in variety of deposits
- Use hand coring equipment in a variety of settings and materials and collect, describe, and characterize core samples of unconsolidated material
- Describe and sample stratigraphic sections in unconsolidated sediment, including creating a measured section
- Understand and establish survey monitoring points, including for long-term monitoring
- Survey geologic features and landforms (coastal landforms, stream cross sections, long profiles, hillslopes) with a variety of tools (hand level, autolevel, GPS, laser rangefinder, total station) and understand how these tools work

Engineering Geology field skills

- Understand and describe the various (index and engineering) laboratory and field tests for soil properties and interpret the results of those tests
- Describe and characterize bedrock materials, including measuring structures and sections
- Classify and describe rock masses for engineering purposes
- Understand and describe the various laboratory and field tests for rock and rock mass properties and interpret the results of those tests
- Understand and describe the investigative and monitoring methods commonly used in engineering geology
- Understand relevant properties of geomaterials for use in construction
- Understand different scales of site investigation and when each are appropriate
- Understand the limitations of site investigations

Hydrogeology field skills

- Design a groundwater monitoring well according to state criteria
- Collect a water sample from a monitoring well for chemical analyses
- Establish depth to water using electronic methods and prepare flow maps

Fluvial geomorphology field skills

- Field-identify the bankfull channel dimensions
- Use a Wolman pebble count or bulk subsurface sample method to characterize bed material and choose the method and stream location appropriate for the objective

- Measure streamflow using the velocity-area method and an acoustic doppler velocimeter (ADV), electromagnetic, or propeller (e.g., Price AA or mini) instrument
- Interpret floodplain history in the field from landforms, vegetation, and the sedimentary record
- Understand approaches to measuring bedload and suspended sediment transport
- Use a bedload transport rating curve and streamflow records to compute the effective discharge for bedload transport

Hillslope geomorphology field skills

- Understand the basics of landslide mechanics and morphologies, including field identification
- Create a field-developed cross section of a hillslope/landslide
- Know and recognize “Rule-Identified Landforms” relevant to forest practices

Analytical

General

- Identify and use appropriate units and significant figures in calculations

Hydrogeology

- Calculate annual aquifer recharge and discharge using stream hydrographs
- Critically evaluate regional groundwater sustainability issues on the basis of water budget arguments with reference to several current examples
- Quantitatively calculate heads and water fluxes in unconfined aquifers
- Calculate hydraulic gradients based on potentiometric surfaces
- Qualitatively estimate equipotential lines and flux lines using flownets
- Qualitatively and quantitatively estimate how flow lines are bent at interfaces between materials having different hydraulic conductivities

Geographic Information Systems

- Possess basic working knowledge of GIS software and data and gain a fundamental understanding of geospatial analysis principles and techniques
- Perform essential geospatial data manipulations (e.g., building & editing data sets), analyses and graphical presentation skills, particularly with respect to geologic data
- Know of key sources, method of collection, and uncertainties for geologic spatial data sets

Fluvial geomorphology

- Separate overland flow, interflow, and base flow components from stream hydrographs
- Calculate reach-averaged basal shear stress and local basal shear stress from field measurements
- Estimate Manning’s n from visual observations, field hydraulic measurements, “type” photographs, or bed-sediment grain size
- Use the Manning equation with field measurements to predict how flow depth and velocity vary with discharge at a cross section

- Use the Rouse number to predict whether a sediment particle is suspendable within a given flow
- Know the major types of bedload transport models and the conditions (e.g., sediment caliber, sediment concentration) under which they are most appropriately used
- Use the Shield's equation to compute the stability of river bed material
- Make a qualitative prediction of channel response to changes in the inputs of sediment or water or to changes in bank materials and bank vegetation

Hillslope geomorphology

- Possess knowledge of recent techniques in hillslope geomorphology and erosion rate assessment: numerical modeling, GIS, LiDAR, cosmogenic radionuclide applications
- Apply the Factor of Safety equation to a slope stability problem and state the assumptions used
- Apply the method of slices to a slope stability problem, and state the assumptions used

Engineering Geology

- Interpret and understand boring logs/sediment cores.
- Use well logs/sediment cores to produce a geologic cross section
- Plot and interpret inclinometer and other deformation monitoring data.
- Plot and interpret grain size distributions, including D10, D60 and uniformity coefficient.
- Understand and interpret Atterberg limits, including how they are measured in the lab.
- Plot lab test data on a Mohr diagram; construct a failure envelope and write an equation for the line; use the graph to determine the friction coefficient and cohesion for the material.
- Know and apply the Mohr-Coulomb equation, including pore pressure.
- Recognize the components of the Hoek-Brown strength envelope, and understand when the equation is used.
- Determine the geologic strength index (GSI) of a rock mass.
- Use a stereonet to evaluate the kinematics of potential failure of a jointed rock mass.