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Professional Practice Guidelines for Geomorphologists

Version 1.5

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This guideline was developed by the PGO's Geomorphology Subcommittee

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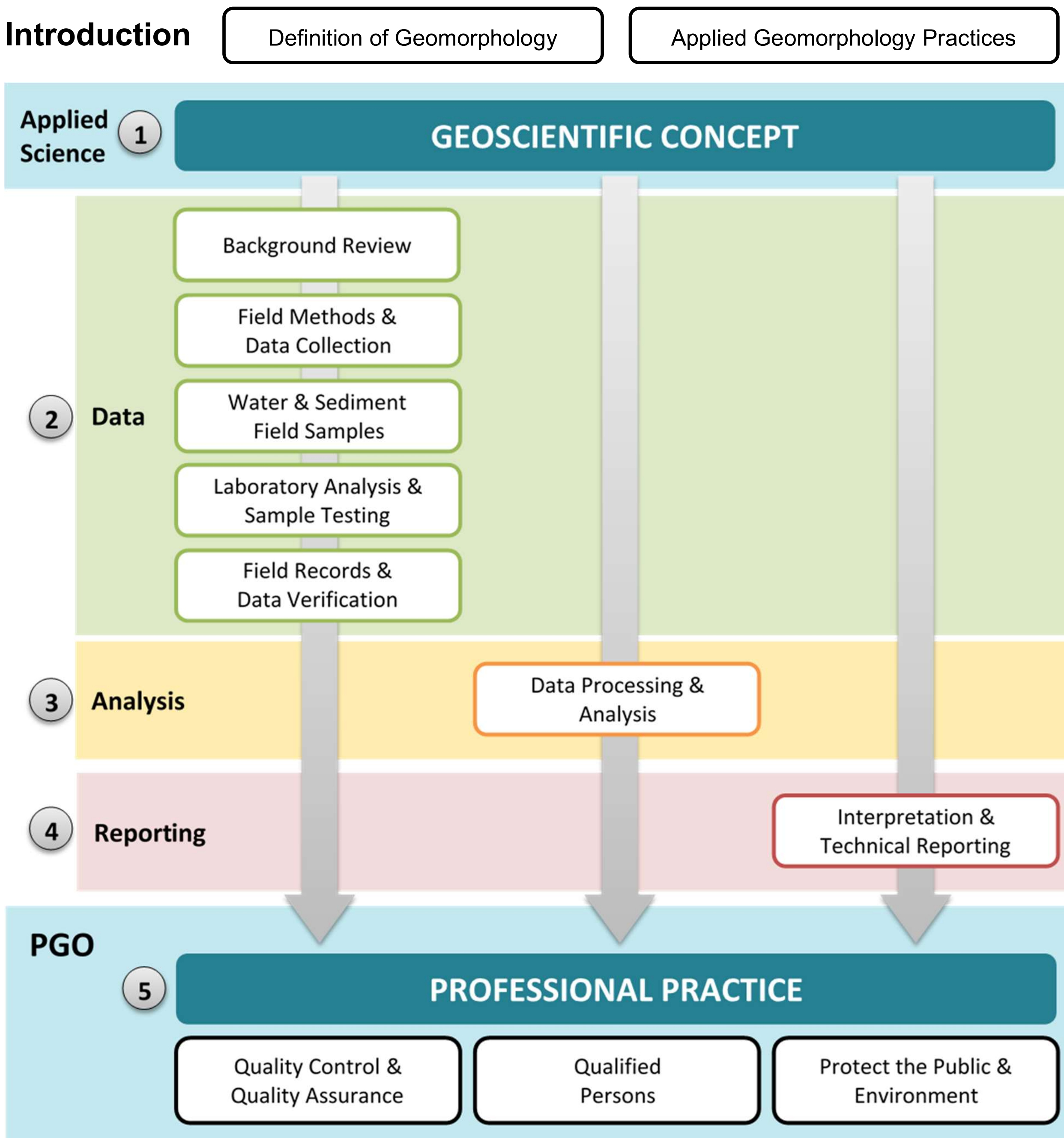
General Professional Practice Guidelines for Geomorphologists

Summary of Key Points

- Professional geoscience services are required for a broad set of geomorphological programs
- Programs requiring the practice of a P.Geo. must be under their supervision
- The geomorphological work program requires consideration of geological, hydrological, and climatological settings and relevant spatial and temporal scales
- Development of the work program should be informed by background information and be appropriate for the geoscientific problem
- The P.Geo. supervising the geomorphological work should confirm that the work is undertaken by competent personnel
- The P.Geo. can use previous work, but must verify that it is based on sound science and ensure proper documentation within current work
- Quality control procedures are to be in place and documentation should be present to support the results
- Records must be kept for all work performed and must be consistent among different personnel
- Ongoing review of the work should be done to allow for possible changes to the program
- Data collection, analyses, and interpretation should be carried out in a careful and diligent manner, be informed by current scientific literature and pertinent guidance documents, and have reasonable explanations
- A report should be produced documenting the geomorphological work completed and assumptions made, and be presented in an appropriate manner
- All work must follow laws and regulations while respecting communities, as well as health and safety
- All geomorphological work is to be conducted in a safe, professional manner in accordance with applicable regulatory requirements and with due regard for the natural environment and the concerns of local communities

Structure of Guideline Document



Introduction

These guidelines have been prepared by Professional Geoscientists Ontario (PGO) to assist Professional Geoscientists (P.Geo.) in the planning and execution of geomorphological programs. These guidelines may also assist Professional Engineers (P.Eng.) who are qualified to practice professional geoscience in accordance with The Professional Geoscientist's Act, 2000.

Geomorphological programs that require the practice of professional geoscience must be conducted under the supervision[1] of a qualified P.Geo. who is responsible and accountable for the planning, execution and interpretation of all investigation activities. The P.Geo. must also be involved in the reporting, as well as implementation of quality assurance (QA) and quality control (QC) programs, so they shall have the relevant geomorphological training associated with their Professional designation.

These general practice guidelines have been developed to result in a consistent quality of work that will maintain public confidence and protect human health and safety and the natural environment with due regard for the PGO Code of Ethics Regulation (O.Reg. 69/01).

These professional practice guidelines are also recommended for use in the planning and execution of geomorphological programs where there is a regulatory provision for a Qualified Person (QP).

The P.Geo. may base the geomorphological program on such geoscientific premises and interpretation of existing information as the P.Geo. decides to be appropriate, based on relevant experience and professional judgement. In planning, implementing and supervising[1] geomorphological programs, the P.Geo. should ensure that the applied practices are generally accepted in the industry with reference to applicable technical guidelines, are in accordance with evolving best practices, and/or can reasonably be justified on scientific grounds.

These guidelines are not intended to inhibit the development or application of new approaches that are relevant to geomorphological work. These guidelines recognize that geomorphology is a discipline that is evolving along with new or innovative technologies and methodologies developed and employed by Professional Geoscientists.

Definition of Geomorphology as a Specialization in Geoscience

Applied geomorphology generally falls under the practice of geoscience[2], but as an interdisciplinary science shares some aspects with other disciplines including physics, biology and engineering. Geomorphology practice tends to fall within the Environmental Geoscience[3] stream of geoscience, but geomorphology training can also be covered under the Geology stream. To build on the definition of geomorphology[4] by Geoscientists Canada, the following definition provides a comprehensive basis for geomorphology as a geoscience:

Geomorphology: A specialization of geoscience that focuses on the interaction between geological processes[5] and landforms at the Earth's surface (and near-surface)—driven by the forces of gravity (colluvial), water (fluvial, coastal, lacustrine, marine, karst), ice (glacial, periglacial), and wind (aeolian)—including but not limited to weathering; erosion, transport, and deposition of sediment; hillslope instability and mass movement; and cold-climate permafrost processes. Geoscience practice in applied geomorphology addresses the short- and long-term risks to the public and environment due to natural geological processes and hazards at the Earth's surface produced by the interaction of the geosphere with other Earth systems including but not limited to the hydrosphere, atmosphere, biosphere, and human activities. Geomorphology contributes to a scientific understanding of Earth surface processes that informs sustainable environmental management decisions.

Applied Geomorphological Practices

Applied geomorphology practices that require professional geoscience services include, but are not limited to, the following activities:

G1. Landform Analysis – Landform analysis, mapping, modeling and classification, including surficial geology and terrain analysis.

G2. Geomorphological Interpretation – Geomorphological data synthesis and interpretation of Earth surface landforms, processes, and functions, including historical analyses and environmental geomorphic assessments.

G3. Geomorphological Hazard Assessment – Geohazard mapping, modeling, and risk assessment, including due to erosion and flooding (fluvial, coastal, aeolian); hillslope (landslide, mass movement); karst; cold-climate periglacial and permafrost; tectonic, isostatic and seismic (Earth movement, earthquake) processes.

G4. Sediment Transport Analysis – Application of simplified and advanced sediment transport approaches, including fluvial, aeolian, and coastal systems. Sediment budgets, including sediment continuity and storage (residence times), landscape sediment cascades and sediment yields.

G5. Geostatistical Applications – Geostatistical applications for surface and near-surface geologic and environmental data; probabilistic models/modelling; geohazard risk assessment; and geospatial analyses.

G6. Geomorphic System Management, Hazard Mitigation, and Design – Geomorphology contributions to environmental, ecological, and water resource management; Environmental Assessment; watershed and stormwater management; river stabilization and stream restoration (e.g., natural channel design[6]); ecological habitat restoration; environmental and urban sustainability, identifying water resource system linkages to natural heritage systems.

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1. Geoscientific Concept

Fundamental to geoscience is visualizing and modeling the three-dimensional properties of Earth systems and the processes whereby materials move and change physically and chemically over time. For a given location or project, the geoscientific concept is a model developed from multidisciplinary knowledge and principles in Earth and environmental sciences, and from site-specific geoscientific data. Physical and chemical modeling of Earth systems at any scale often requires statistical methods of data collection, sampling, analysis, and interpretation to provide reliable representations of the geoscientific concept, and to accurately communicate the geological and environmental uncertainty.

The geoscientific concept on which the geomorphological work program is based, including the geological, hydrological, and climatological settings, and the relevant spatial and temporal scales, should be supported by relevant, program-specific data and a scientific approach. Established scientific knowledge, current scientific literature, and relevant technical practice guidelines should be referenced to clearly communicate the scientific basis. As data are gathered and interpreted, the program-specific geoscientific concept may be altered depending on the findings. The geoscientific concept provides the foundation for the geomorphological discussions concerning the program and should be presented in documents and reports.

Development of the geoscientific concept for geomorphology projects typically involves the application of one or more the following principles, which distinguish geomorphology from other related non-geoscience disciplines such as biology and engineering.

- **Geological Legacy:** Understanding the relevance of geologic legacy, both spatially and temporally, on modern geomorphic systems.
- **Earth Surface Systems:** Addressing the interactions of multiple Earth surface processes and geomorphic systems.
- **Landscape Scales:** Advocating the relevance of large spatial scales and long timescales in geomorphic systems to local environmental management practices and sustainability.
- **Geohazards:** Emphasizing the importance of infrequent and high magnitude events, in addition to gradual long-term processes, for managing future hazards and risks associated with geomorphic processes at or near the Earth's surface.
- **Geoscience Communication:** Advancing better communication of how geoscientific data are applied to address environmental uncertainty by improving geoscience applications through reliable datasets, geostatistical methods, probabilistic models, and accepted deterministic methods. Promoting evidence-based decisions with respect to geomorphic systems for long-term sustainable environmental management.

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2. Data

Background Review

Prior to the onset of data collection and processing, a thorough review of available background data should be undertaken to understand and refine the geoscientific concept. The background review is important to understanding geological legacy, defining appropriate spatial and temporal scales, and understanding the impacts of anthropogenic activities on modern Earth surface processes. The background data review should include, but not be limited to, historical and recent aerial imagery, topographic data, hydroclimatic data, geological mapping, and previously completed geoscience reports. The P.Geo. supervising the geomorphological work should confirm the data sources reviewed by themselves or supporting team members are appropriate and sufficient before proceeding to data collection and processing. Insight gained through the background review should inform the work program.

Field Methods & Data Collection

The P.Geo. supervising the geomorphological work should confirm that work by employees, consultants or contractors is undertaken by competent personnel and that appropriate QA/QC programs are practiced.

The geomorphological techniques and data collection method(s) selected by the P.Geo. should be appropriate to the objective(s) of the program, the geoscientific concept under consideration, the expected geomorphological phenomena and local conditions being investigated, and any applicable regulatory guidance or requirements. Data should also be collected in the field and through desktop analyses in accordance with applicable technical guidelines to the extent possible and appropriate.

All geomorphological work should be carried out in a careful and diligent manner using scientifically established practices that are designed and tested to ensure that the results are repeatable and reliable.

Professional judgement requires that the geomorphological program should be designed to address the spatial and temporal resolution requirements of the geoscientific problem. Further, the duration and frequency of the geomorphological investigations should be designed with the sampling methodology to provide sufficient, representative sample measurements or materials for interpretation and analysis.

All field investigations and monitoring programs using scientifically established data collection and sampling practices that are designed and tested to ensure that the results are representative and reliable.

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Water & Sediment Field Samples

Sample collection should follow applicable technical guidelines and/or best practices to ensure appropriate representation of site conditions with respect to sampling location, and spatial sampling distribution or density within a study area. Sample collection should also consider the timing and frequency of sample collection and, where relevant, the opportunity to collaborate with other disciplines.

Sample preparation, storage and delivery procedures should be appropriate to the materials being tested and the parameters being analysed.

All samples that are reduced or split should be processed in a manner such that the fraction analyzed or tested is as representative as reasonably possible of the whole sample and environmental medium being sampled. The sample volume should be sufficient to allow for verification, when necessary.

Sample storage and delivery should include chain of custody procedures to provide sample security. The method of transport for samples sent to a laboratory should be documented and done in a manner that maintains sample integrity.

Representative fractions of the material to be analyzed or tested should be retained for an appropriate period of time.

Laboratory Analysis and Testing

Chemical analysis and physical testing of samples must be done by a laboratory that is accredited or equivalently qualified for the particular methods to be employed and the materials to be analyzed or tested.

All analytical or test results should be supported by duly signed certificates or technical reports issued by the laboratory or testing facility and should be accompanied by a statement of the methods used and the laboratory QA/QC program results.

Field Records and Data Verification

Geomorphological field work, including planning, mapping, data collection, sampling, sample preparation, sample security and any physical and chemical testing, where relevant, should be accompanied by detailed record keeping. The record keeping should include information such as authorship of the record, a list of field staff, date of field work, a description of the procedures followed, the field conditions encountered, and other pertinent information obtained. A photographic record of the field program is also recommended.

Data should be properly recorded and documented at suitable spatial and temporal scales and with accuracy appropriate to the investigation. The study area and all data points should be accurately located with respect to known horizontal and vertical reference points.

Documentation of landform properties and composition should occur in the field, including a detailed quantitative and qualitative description such as stratigraphic logs, aspect, dimensions, observed form and variations, and inferred process, where relevant.

Whenever several persons carry out similar duties or when data have been collected by different persons over a period of time, care should be taken to verify that the quality and consistency of the data are maintained in accordance with the established QC/QA program.

3. Analysis

Data Processing and Analysis

Data processing and presentation should be appropriate to the type of data collected and the parameters being analysed. Likewise, the data analyses performed should be suitable for the data type and statistical relations being examined. For statistical analyses, results should be presented with an indication of uncertainty or significance—based on common scientific conventions—to provide context for the reliability of noted trends and/or correlations.

Data processing should be accompanied by a statement of the applied methods. Data should be duplicated and stored on a suitable media at separate and secure locations for an appropriate period of time.

Any simplification of data for presentation purposes should be clearly conveyed. Transparency regarding the selective omission or inclusion of any data, in analyses, should be provided.

4. Reporting

Interpretation and Technical Reporting

Comprehensive and on-going compilation, analysis and interpretation of all the geomorphological data, in the context of other pertinent data (e.g., background review, hydrology, geology), are important activities throughout the project. These activities should be undertaken to assess the results of the work, refine the geoscientific concept, and modify or recommend modification of the work program as appropriate. Changes in working hypotheses, objectives or work programs should be documented.

Analysis and interpretation of data to identify landforms, functions, and processes should remain current with emerging geomorphological, and other, scientific literature. This includes current scientific understandings of the interactions between landforms within the broader landscape at a range of spatial scales. Projection of processes to define geomorphological hazards and to identify risk should remain consistent with existing technical guidelines, be in accordance with evolving best practices, and be informed by current scientific literature, as relevant.

Data interpretation should be based on all of the information collected and, if available, be supplemented by an analysis of pre-existing data. Technical reports should describe and document the interpretation, and discuss information that appears inconsistent with the selected interpretation. The adequacy of the collected data should be critically assessed for its ability to support any qualitative and quantitative conclusions that are reported. In addition, any known limitations of the geomorphological program with respect to the geoscientific methods or statistical uncertainties should be clearly communicated in technical reports.

Characterization, estimation, or delineation of landforms, geomorphological hazards, processes or functions can be fundamental steps in project development. The methodology used for characterization or delineation, and the associated uncertainties, should be documented.

The format and style of the technical report or geomorphological component of a larger report may vary depending upon the objectives and scope of the work program. However, all reports should document the program objectives and scope of work, the geoscientific concept and rationale for the investigative program, field and analytical methodology, results, assumptions and limitations, and conclusions or findings. Any changes in objectives and scope of work should be documented. The report should state whether recommendations are provided either in the report or under separate cover.

The results of the geomorphological program should be presented in a format that is appropriate to the study, analyses, and data. Site conditions and analytical results should be clearly presented and illustrated to convey meaning and to avoid ambiguity. This may apply to, but not be limited to, site photographs, aerial images, graphical and/or tabular presentation of data and/or results (e.g. cross-sections, plan views, profiles, 3-D images, temporal plots).

Where cost estimates are provided, the assumptions used in developing the cost estimate should be documented.

5. Professional Practice

Quality Control and Quality Assurance

Throughout the process of conducting geomorphological work, the P.Geo. should ensure that a quality assurance program is in place and that quality control and assurance measures are implemented. Likewise, the P.Geo. should ensure that supporting team members involved in the geomorphological work be aware of the QA/QC procedures.

The QC/QA program should confirm the validity of the data that are used in the production of technical material including reports, maps, tables, graphs, diagrams, and drawings. The data verification exercise should be documented, and the document(s) maintained with the project files.

Qualified Persons

The concept of a Qualified Person (QP) includes three important criteria: education, experience, and accountability. The education and experience must be relevant to the area practice. A QP is expected to be a licensed professional who is a member of a self-governing body, and as such is accountable for their professional work and must comply with a Code of Ethics or Practice. Further PGO recommendations on the QP concept can be found in the Final Report of the APGO Qualified Persons Task Force for the Environmental Geosciences (October 2000).

To protect the public and environment, the QP concept can be considered relevant to the professional practice of geomorphology. The practice of geomorphology is diverse, requiring the application of multiple principles of natural science as well as understanding and proper use of empirical formulae, which are often project- and site-specific. The understanding of the approaches to providing accurate data and credible geoscience reports is based on having a firm understanding of geoscience and related discipline principles founded in a strong academic base, relevant experience, ongoing professional development and the application of professional judgement. The ability to effectively apply professional judgement, in large part, is gained through relevant practical experience. Given the natural and scientific uncertainties inherent to the application of geomorphology—affecting analysis, interpretation, and reporting—relevant experience and professional judgement are critical factors in ensuring the successful conclusion of a project.

Further guidance is also recommended here for what constitutes appropriate supervision[1] of geomorphology work. For a P.Geo. (or P.Eng.) that is supervising geomorphology work, and taking professional responsibility for that work, it is expected that:

- The P.Geo. (or P.Eng.) should have a sound understanding of the area of geomorphology in which the work is completed, with relevant experience;

- The P.Geo. (or P.Eng.) should have the expertise and experience to be able to comment critically on different geomorphological approaches, observations, analyses, interpretations, and recommendations;
- Geoscientists-in-Training (G.I.T.) (or Engineers-in-Training (E.I.T.)) and technical staff completing geomorphology work should be supervised by a P.Geo. (or P.Eng.); and
- Direct supervision should occur through all project phases.

Protect the Public and Environment

The core mandate of professional geoscience regulation is *to the welfare of the public* including *the safeguarding of life, health, property and the environment* [*Professional Geoscientists Act*, SO 2000, c 13, s 2 (1)]. The duty of PGO is to *serve and protect the public interest* [*Professional Geoscientists Act*, SO 2000, c 13, s 28 (2)].

All geomorphological work is to be conducted in a safe, professional manner in accordance with applicable regulatory requirements and with due regard for the natural environment and the concerns of local communities. This often includes communication and consultation with Indigenous People prior to engaging in field investigations to ensure no adverse impact to areas of cultural or heritage importance.

Generally accepted Health, Safety, Environment, and Community practices for the specific geomorphological sector should be followed when conducting field investigations to protect the geoscience professionals and public.

The P.Geo. has a duty to report any hazards that pose immediate risk to the public and/or environment to an applicable government or regulatory body.

Should field investigations result in the observation of potential environmental contamination, then the P.Geo. has a duty to report such findings to the relevant regulatory agency.

Should field investigations reveal items or remains of potential archaeological interest, then these must be reported to the Ministry of Heritage, Sport, Tourism and Culture.

All of the above professional responsibilities and requirements are to fulfill the primary duty of protecting the public and environment, and respecting Indigenous Peoples.

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Definitions

1. ***Supervision*** (of geomorphology work) involves direct engagement at all project stages in order to take technical and professional responsibility for the work. Thus, a supervisor should have the training, expertise, and experience necessary to practice geomorphology.

2. ***Geoscience*** (as per PGO definition update)**:** An individual practises professional geoscience when they apply the principles of Earth sciences, such as geology, geophysics, geochemistry or geomorphology, in a manner that affects or could affect the welfare of the public or that affects or could affect life, health or property, including the environment, including, without limiting the foregoing, sampling, analyzing, interpreting, reporting or providing an opinion on:

   (a) the discovery, development or management of oil, natural gas, metallic or non-metallic minerals, precious stones, water or other natural resources on the surface or in the subsurface of Earth;
   (b) the storage, management or disposal of waste materials or other materials; or
   (c) the discovery, development or management of geological processes and hazards at or below the Earth's surface produced by the interaction of the geosphere with other Earth systems, including but not limited to the hydrosphere, atmosphere, biosphere, and human impacts.

3. ***Environmental Geoscience*** (as defined by Geoscientists Canada) is a stream of geoscience education that is focused on the knowledge required to practice in the area of Earth science applied to the natural environment, in particular the near-surface environment and the interaction between the geosphere and the hydrosphere.

4. ***Geomorphology*** (introductory, as defined by Geoscientists Canada) studies processes and principles of landform development, with introduction to air photo interpretation. (Advanced): The examination of one or several geomorphic environments, including applied topics. Recognition and interpretation of sediments and landforms and the processes involved in their formation. In the case of applied geomorphology, to analyze problems caused by geomorphic processes pertinent to engineering or resource development.

5. ***Geological Processes****:* Broadly defined geology is the scientific study of Earth, and its history in the rock record. In relation to geomorphology, geological processes drive the rock cycle of the Earth's lithosphere, including the stages of weathering, erosion, and sedimentation at the Earth's surface.

6. ***Natural Channel Design (NCD)*** is a multidisciplinary approach to stream restoration typically involving engineers, biologists, and fluvial geomorphologists. NCD projects often attempt to integrate erosion protection (engineering stability) with habitat rehabilitation (ecological value). The distinct role of geomorphology in NCD is to restore natural channel forms and fluvial processes with consideration of alluvial sediment dynamics and continuity for long-term sustainability of the fluvial system. The degree to which natural processes must be constrained is generally proportional to the requirement for ongoing future maintenance of NCD projects; therefore, erosion hazard risks must be balanced with the natural infrastructure investment and life-cycle maintenance costs.

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PGO Professional Practice Committee	Review	1.2
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V1.1	03-Dec-2019	Draft Revised	PGO PP Guidelines Geomorphology 2019-12-03 draft V1-1	For Subcommittee Review
V1.2	16-Nov-2020	Draft Revised	PGO PP Guidelines Geomorphology 2020-11-16 draft V1-2	For PGO PPC Review
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V1.4	07-Mar-2021	Draft Revised	PGO PP Guidelines Geomorphology 2021-03-07 draft V1-4	For PGO Council Approval
V1.5	21-Mar-2021	Approved	PGO PP Guidelines Geomorphology 2021-03-21 V1-5 FINAL	Approved by PGO Council

Note: V1.1 and V1.2 were previously labelled as Rev. 1 and Version 2.0, respectively.