CALIFORNIA DEPARTMENT OF CONSERVATION | CALIFORNIA GEOLOGICAL SURVEY
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Guidelines for Preparing Geological Reports for Regional-Scale Environmental and Resource Management Planning

The following guidelines were prepared by the Department of Conservation's California Geological Survey (CGS) in co-operation with the California State Mining and Geology Board and the Board for Professional Engineers, Land Surveyors, and Geologists. Note 52 was developed with input from representatives from more than a dozen governmental and professional organizations, universities, industry consultants and the environmental community. These guidelines may be used by California Professional Geologists (PGs) or Certified Engineering Geologists (CEGs) when preparing geologic maps and reports for regional-scale environmental and resource management planning documents, including the use of computer models in these studies.

Introduction

Geologic studies are used in a variety of regional-scale environmental and resource management planning documents including Program Environmental Impact Reports, General Plans, Safety Elements, Watershed Assessments, Sustained Yield Plans and Habitat Conservation Plans. Such studies may describe a region's geologic and geomorphic history, identify the location and depth of mineral and oil deposits, and show the location of active faults, landslides and other geologic hazards. Geologic maps and reports can be used in regional-scale environmental and resource management planning documents to assist geologists, engineers and land-use planners in making decisions that affect public health and safety, critical environmental habitats, water quality, uses of public lands, and help identify areas where more detailed geologic studies are needed. Geologic maps that accompany regional-scale environmental and resource management planning documents are generally done at a map scale of 1:12,000 or smaller. While this scale limits the accuracy of presentation, the mapped features should reflect conditions on the ground consistent with the map scale.

Purpose

The purpose of this note is to provide government and private geologists and other professionals general guidance on the preparation and use of geologic studies for use in regional-scale environmental and resource management planning documents. Because of the increased use of computer models with geographic information systems (GIS) for evaluating geologic hazards at a regional-scale, these guidelines also provide a general outline for documenting computer simulations. Conclusions and recommendations of geologic reports and maps for regional-scale environmental and resource management planning documents should be prepared so that they can be understood by both government agency reviewers and the public. These regional-scale geologic studies are not a substitute for site-specific investigations. Regional information can be incorporated into detailed studies provided the data are field checked, verified or revised based on new data. While the following guidelines suggest a format for geologic studies for use in regional-scale environmental and resource management planning documents, they do not include complete listings of techniques or topics, nor do they dictate that all elements of this note be used in every project. In many cases, portions of these guidelines may not be applicable to the study when a geologic hazard or issue is absent.

Geologic reports and maps prepared to assist in public decision making to comply with California statutes and regulation must be prepared by or under the direct supervision of a California PG practicing in his/her area(s) of expertise (Business and Professions Code, §§ 7800-7887, Chapter 12.5). Geologic reports and maps produced for projects where geologic factors affecting planning, design, construction and maintenance of civil engineering works should preferably be prepared by or under the direct supervision of a CEG. Geologic reports and maps produced for projects where the occurrence, distribution, quantity, quality and movement of ground water is of primary significance to the report's findings should preferably be prepared by or under the direct supervision of a Certified Hydrogeologist (CHG). If a report includes significant geophysical information, it should be co-signed by a California Professional Geophysicist, or the signed geophysical report may be appended to the geological report. Additional references for preparing and reviewing other types of geologic reports are included at the end of this note.

Geologic Studies for Regional-Scale Environmental and Resource Management Planning Documents

These guidelines suggest a format for preparing geologic studies for use in regional-scale environmental and resource management planning documents. They do not include complete listings of techniques or topics, nor do they dictate that all elements of this note be used in every project. The geologic data needed for each planning document may require that some of these guidelines be modified, or that additional geologic information be developed.

General Information

Project Description and Purpose

- describe the general project area and the type and scope of study
- discuss the purpose and objectives of the study and clearly delineate and list the limitations of the work and scope of the project data and results
- describe the general methods of analysis undertaken in the study
- acknowledge the contributions of others that provided data, funding, access, assistance and insight to the study
- provide an index map showing the general project location, including important rivers, roads and cultural features
- include the state, county, and other political boundaries relevant to the study area
- show boundaries of basins, watersheds, and sub-watersheds of the study area, as appropriate
- provide geographic and geologic names that might be used in a keyword search

Base Maps

- list the name of base maps, including the original scale of maps, date of last revision, map projection and datum
- reference the source and authors of base maps
- provide an index map showing the areas where previous mapping was utilized
- where previous mapping overlaps, discuss which maps were utilized and why they were selected
- list references for geologic and geomorphic maps from which data were compiled
- georeference maps and figures by showing coordinate system reference marks
- provide a bar scale on all figures and maps to facilitate accurate document reproduction

Aerial Photo and Digital Imagery

- name of vendor, company or agency that acquired imagery
- flight line and photo numbers, or digital file name and frame numbers
- date(s) of imagery
- scale of imagery
- percentage of cloud cover, as appropriate
- any unusual characteristics or interferences regarding the imagery, such as low sun angle, oblique, etc.
- wavelengths of digital bands available and analyzed
- corrections, filtering, or artificial shading changing the original imagery
- description of work flow and methods used to analyze imagery
- procedures and formulas used for any supervised or unsupervised classification of imagery
- provide plots of processed images and classification diagrams

Regional Geologic Setting

A description of the regional geologic setting of the project area is needed to guide the reader in understanding the geologic history of the area. Information and data that are the foundation for the present study should be discussed in some detail and properly referenced. Other geologic, technical and land use information that are of interest, but have lesser importance to the purpose of the study, should be noted and referenced.

Compilation of Geologic Data

- discuss and reference all geologic and geomorphic data used in the project
- discuss areas where reports overlap and the rational for selecting data that were and were not included in study
- provide the geologic name and description of each geologic unit in the study area, including prior names

- when available, provide engineering geologic properties of units and discuss the potential effect on results of regional-scale studies
- provide results of available field and laboratory testing for each geologic unit
- provide geographic coordinates for sample locations; if unavailable, then estimate locations and discuss spatial accuracy
- provide information on known geologic hazards in the study area and discuss where and how the study expands on the knowledge of geologic hazards (see Table)
- plot on project maps the locations where existing data were collected, reference data source and sample number
- provide map(s) of the known geologic hazards, such as landslides, faults, and liquefaction potential
- discuss and rank the significance of geologic hazards
- identify potential areas that are affected by geologic hazards
- define map symbology and describe changes made when transferring data to new map(s)

Compilation of Land Use Data

- discuss the general types of land use and provide maps, as appropriate
- provide a map showing locations where geologic hazards may impact land use
- document the source(s) of land use data (typically obtained from local planning departments, assessors, or other public agencies)

Compilation of Hydrologic Data

- provide a general discussion of the hydrologic setting of the study whenever the purpose of the study includes evaluating the impacts from precipitation, runoff, floods, ground water, surface erosion, mass wasting and sediment transport
- plot and/or tabulate rainfall intensity, frequency and duration data and reference the sources

TABLE: Geohazards that should be addressed in General Plans and considered in other environmental and resource management documents.

Earthquake Phenomena
- ground shaking
- landslides and rockfalls
- fault rupture and tectonic warping
- differential compaction and seismic settlement
- liquefaction
- tsunamis and seiches
- flooding due to dam or levee failure

Slope Instability
- landslides and mudflows
- snow and ice avalanches
- unstable cut and fill slopes
- trench wall stability problems

Foundation Instability
- collapsible (weak) soil
- expansive soil
- karst terrain
- lava tubes or caves
- abandoned mines or tunnels

Flooding Problems
- coastal storm flooding
- flooding of 100-year flood plains
- flooding along mountain streams
- flooding on alluvial fans
- possible collapse of dams or levees
- increased runoff from impervious surfaces

Volcanic Hazards
- lava flow
- ash fall
- volcanic explosion

Erosion & Sedimentation Problems
- coastal erosion:
  - bluff collapse
  - depletion of beaches
  - accretion of beaches
- streambank erosion
- erosion of graded areas
- sedimentation
- wind erosion
- dust storms

Land Subsidence
- extraction of groundwater, gas, oil, or geothermal energy
- hydrocompaction
- peat oxidation
- fault rupture

Waste Disposal Problems
- change in groundwater level (raising or lowering)
- disposal of excavated material
- percolation of waste material

Water & Soil Pollution Problems
- pathogens in soils
- pollution from:
  - septic systems and waste disposal sites
  - underground storage tanks
  - industrial activities
  - runoff

- plot and/or tabulate existing data on stream flow in the watershed; include the peak flood flow frequency and reference the sources; if available include bankfull flow and other relevant flows
- summarize groundwater data; if available include groundwater contour maps, location of wells and springs, and identify gaining and losing reaches
- identify the locations of precipitation stations and river gages; include the identification number and the agency responsible for station maintenance and distribution of information
- provide more detailed statistical analysis and graphing of precipitation and stream flow data when the study is intended to provide a correlation between the area geology and hydrology
- briefly describe the methods of statistical analysis used for the study and provide references for more complete discussion of methodology
- discuss and map hydrogeologic hazards, such as areas of poor water quality

New Geologic Data

The purpose of a regional-scale geologic study is to develop a comprehensive geologic overview of an area through the process of compilation, synthesis and analysis of existing information. Often new data are needed to supplement existing data and to fill data gaps. If new geologic data are collected, document data collection and testing methods, sample locations, and provide detailed maps and cross sections that present the new information at scales appropriate for the study.

Purpose and Scope of New Data

- identify how and where new data modifies or adds to existing knowledge and mapping
- discuss critical issues addressed by the new data
- explain limitations of new data collection and mapping effort

Method(s) for Collecting New Data

- discuss the extent of office and field mapping data collection effort
- discuss the extent and method of field checking office mapping
- provide a map showing the number and location of field sample sites
- describe the method(s) for selecting type and location of field samples
- describe the method and results of field and/or laboratory testing
- provide estimate of spatial accuracy and precision of sample locations with a description of the method for determining locations
- use accepted geologic methods and symbols to map and reference standard methods, as appropriate
- if a non-standard method is used, append a detailed description of the methodology along with results of any calibration and validation studies
- use consistent units of measure and provide conversions for non-standard units
- discuss any restrictions on the collection and reporting of new data, such as access or confidentiality
- discuss aerial photo mapping and interpretation methods

Geologic Data

- when a geologic unit is unique to the study, describe the unit lithology, age, regional correlation, thickness, type location, and reasoning why the unit should be separated from those previously described
- describe geologic structures, contacts and discontinuities
- describe geomorphic features, structures and their relative age
- discuss where new data differ or add to existing knowledge and mapping
- provide a legend of geologic features and a description and age of mapped geologic units
- provide written and graphic logs of new data and images, as appropriate
- when temporal issues are important, differentiate mapped geologic features by time or order
- make recommendations for additional mapping and sampling to clarify findings or to fill in data gaps

Cross sections

- develop cross sections and other subsurface profiles and maps through areas that demonstrate regional geologic relationships
- when necessary to show critical geologic relationships, provide detailed profiles and maps
- show on map(s) field location(s) where detailed subsurface relationships are interpreted
- identify on sections and maps borehole logs used to construct profiles and subsurface maps

- use appropriate horizontal and vertical scaling to, as clearly as possible, illustrate geologic relationships

Concluding Section

- the concluding section of the report should provide a concise summary of the project's main findings and recommendations
- discuss presentation of maps, cross sections, figures, tables, and when used, formats of computerized databases and GIS maps and layers
- when appropriate, discuss potential impacts of geologic hazards on land uses
- for long reports, separate sections are needed for "Findings," "Conclusions," "Recommendations," "Additional Study Needs," etc.

Signature of Professional in Responsible Charge

The California Business and Professions Code requires that a PG, and/or CEG or CHG shall exercise and maintain responsible charge and shall certify geologic reports and must be working within his/her area of expertise. Inclusion of license numbers and/or official stamps shall be in accordance with the requirements of the licensing board, local government or other applicable regulatory requirements.

Geologic Report Appendices

- provide tables, figures, logs and graphics of supporting data summarized or utilized in the main text, particularly new information not contained in another report
- provide a detailed discussion of non-standard methods for data analysis and testing; include calibration studies if applicable
- provide a list of technical references including listing image sets, files and databases
- provide other data as required by permitting agencies

Computer Models

When computer modeling is used in geologic studies, for example, in regional-scale environmental and resource management planning, it can aid the interpretation and prediction of behavior of complex systems. Modeling helps organize field data and allows evaluation of past events and estimates of future impacts. There are many types of computer models with application to geologic studies including analytical models, finite element and finite difference models, that evaluate a variety of geologic problems, such as slope stability, groundwater and surface water flow. More recently geologic models are combined with GIS to provide more rapid data entry and data management. Models should be used with caution, to prevent the tendency for the "model" solution to supersede the reality on the ground. It is important to remember that modeling may be only one component of a regional geologic study and not an end in itself.

The use of a model in geologic studies for regional-scale environmental and resource management planning documents requires that some information be provided on how the model was applied and what limitations affect the model output. The level of detail needed to document a modeling study varies with the intended use of the model results. The following is an outline of information that should be reported along with the results of the modeling. The computer modeling needs for each unique planning document may require that some of these guidelines be modified, or that additional information about the modeling effort be provided.

Introduction

- discuss the purpose and objectives of the modeling effort and how the results assist in understanding the regional problem
- discuss limitations of the data and model in meeting the project objectives
- discuss sources of the model data and the quality of the data
- provide a glossary of special terms, use existing terminology, and clearly define new terminology
- if applicable, discuss the base maps, data grids and digital elevation models (DEM) used; include their source(s) and spatial accuracy

Modeling Approach

Conceptual and Numerical Models

- discuss the reasons for selecting the model
- describe the conceptual model of the study area and the simplifying assumptions used to fit the geologic data to the model
- discuss the type of model used, the governing equations, and the numerical methods used
- if applicable, describe the geologic setting including the rationale for the modeled spatial distribution of geologic units
- provide a discussion of previous modeling research on the study area and/or other similar areas using the same or other models

- discuss and map the field data and location of samples used in the model calibration
- when available, reference technical papers and reports where the model(s) is validated and provide a summary of any validation studies
- provide a reference for where the model code or program, and user's manual can be obtained

Sensitivity Analysis

- demonstrate the model's sensitivity by varying parameters within the range of expected values
- discuss the selection of the range of the model parameters, initial conditions, and how calibration changed the initial assumptions

Model Calibration and Verification

- discuss the type and location of boundaries and their initial conditions, the size and type of grids, node spacing and types of internal sources and losses (sinks), and results of model calibration
- discuss the geologic units including their composition, stratigraphy, depositional environment, and the range of values for parameters used in the modeling study
- discuss how parameter values used in modeling are selected, whether collected from study area, from literature or from model calibration
- discuss the methods used to estimate parameters through model calibration or inverse modeling
- discuss how and where parameters estimated through model calibration differ with data collected in the field
- discuss the calibration procedures, calibration targets and calibration results
- discuss model verification using data not part of the calibration study

Predictions

- discuss the level of uncertainty in the prediction including the results of sensitivity analyses
- discuss model assumptions used in estimating future events

Model Limitations

- discuss the limitations imposed by the model's numerical solution on the application of the model results
- discuss the quality of the input data and the confidence in the values
- discuss the impacts that uncertainty or lack of data has on the model results
- when model is based on a DEM, discuss the impact of the DEM spacing and accuracy on the model results
- identify areas of uncertainty on a map

Summary and Conclusion

- provide a brief summary of the model results and how the results assist in solving regional problems
- discuss future data collection needs and recommend where changes in the model design and calibration might improve the results, including the relevant quality and quantity of improved results
- discuss issues not answered by the modeling study and make recommendations for future work
- plot on a map the locations of samples and field measurements used in modeling study and when data are sufficient, provide cross sections
- provide a generalized map(s) showing the model grid and values assigned to each node

Modeling Appendices

- document changes made to the computer code function and mathematics
- document the results of calibration and validation studies
- document field data and provide data logs
- provide the input data or reference to where the data are available
- provide a reference list of work cited

References

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California Geological Survey Note 49 – Guidelines for Evaluating the Hazard of Surface Fault Rupture, 1998. www.conservation.ca.gov/cgs/information/publications/cgs_notes/note-49/

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