Appendix F

GEOTECHNICAL REVIEW

GEOTECHNICAL REVIEW INTRODUCTION

Geotechnical review is an important part of City project review. Applications for master plan zoning, subdivision, use permit/grading permit, design review, or conditional certificates of compliance require geotechnical studies. If the site is rated 3 or 4 (most hazardous) on the General Plan Geoseismic or Slope Stability Maps, a Geotechnical Investigation Report will be required for projects to be deemed complete. If the site is rated 1 or 2, a preliminary Geologic Report will be required. A Geotechnical Investigation may also be required on a more stable site if the use is a defined "critical use" or if the site is downslope of possible debris flow avalanche areas.

Additionally, for use permits, subdivisions except lot line adjustments, design review permits and master plan zonings located on artificial fill or on land which has been used by businesses, the preliminary Geotechnical Report would include a preliminary hazardous materials evaluation. If the preliminary evaluation identifies evidence of hazardous materials, a Hazardous Waste Investigation Report will be required.

The contents of the Preliminary Geologic Report, the Geotechnical Investigation Report and Hazardous Waste Investigation Report are identified in the attached Geotechnical Review Matrix.

GEOTECHNICAL REVIEW MATRIX CONTENTS

EXPLANATION OF GEOTECHNICAL REVIEW MATRIX FOR SAN RAFAEL GENERAL PLAN 2000

The Geotechnical Review Matrix (Exhibit 1) summarizes the geotechnical requirements for various types of land use projects during different stages of government processing. The level of investigation for each project is related to public safety and the geologic risks associated with the site. Projects which have the greatest potential impact on public safety and that are proposed on lands with high geologic risk have the strictest requirements.

It is the intent of the matrix to help members of the community to plan and organize for projects presented to the City. It is also intended that the matrix will recognize a standard of practice pursued by geotechnical consultants. The main purpose of the matrix is to require a level of effort that is prudent and economically fair to developers and that adequately reduces the community's risks associated with geologic hazards. Another purpose of the matrix is to reduce the time needed by the City to make decisions by providing a means of objectively reviewing projects.

The governmental approval processes affecting land use projects are listed in the left-hand column of the matrix. The four land use categories listed across the top of the matrix are defined below:

Critical Use: Hospitals and related care centers, schools, auditoriums, churches and theaters, fire and police stations, transportation centers and facilities, major utilities, and communication facilities.

High Occupancy: Residential (single-family, apartments and PUDs); commercial (office buildings, restaurants and retail stores); and light and heavy manufacturing and assembling.

Low Occupancy: Warehouses, storage facilities and distribution centers.

Parks/Open-Space: Parks, marinas, and public and private open-space.

The relative slope stability and geo-seismic hazard zones are indicated by the numbers 1, 2, 3 and 4. The relative slope stability zones are based on the slope stability maps of San Rafael and other portions of eastern Marin County prepared by the California Division of Mines and Geology in 1976. The slope stability zones used by the California Division of Mines and Geology are defined as follows:

Zone 1 - The most stable category. This zone includes resistant rock that is either exposed or is covered only by shallow colluvium or soil. Also included in this zone are broad, relatively level areas along the tops of ridges or in valley bottoms that may be underlain by material that is quite weak (such as Franciscan melange and alluvium) but occupies a relatively stable position.

Zone 2 - Includes narrow ridge and spur crests that are underlain by relatively competent bedrock, but are flanked by steep, potentially unstable slopes.

Zone 3 - Areas where the steepness of the slopes approaches the stability limits of the underlying geological materials. Some landslide deposits that appear to have relatively more stable positions than those classified within Zone 4 are also shown here.

Zone 4 - The least stable category. This includes most landslide deposits in upslope areas, whether presently active or not, and slopes where there is substantial evidence of downslope creep of the surface materials. These areas should be considered naturally unstable, subject to potential failure even in the absence of man's activities and influences. Banks along deeply incised streams are also included in Zone 4.

These judgments are interpretive, and generally apply to large areas. Within each area conditions may range locally in detail through all stability categories. Hence, an area designated 1 may locally contain unmapped landslides, and an area designated 4 may locally contain relatively stable sites." Debris-avalanche landslides move rapidly downslope and may travel thousands of feet crossing over areas zoned 1 through 3 as well as Zone 4 areas. Areas in Zones 1 through 3 that may be affected by such landslides, in the judgment of a Certified Engineering Geologist, shall be downgraded to Zone 4 areas. In general, slope stability zones should be re-evaluated by a Certified Engineering Geologist during site-specific investigations. Based on such investigations, the City may upgrade or downgrade the mapped slope stability in some areas.

The relative geo-seismic hazard zones are based primarily on a rating system that assigns a geo-seismic hazard rating for each of the geologic units in the planning area. The system rates from 1 to 4 the geo-seismic hazard associated with each geologic unit shown on the California Division of Mines and Geology Maps of the San Rafael Vicinity prepared in 1976. Geologic units are defined on the State maps. Geo-seismic hazards include, but are not limited to, landslides, soil creep, expansive soil, seismic shaking, seismically induced ground failure, surface fault rupture, tsunamis, flooding, and high ground water table. Units rated as Zone 1 are the least hazardous. The hazard rating assigned to each geologic unit is derived from the work of the California Division of Mines and Geology. These ratings with some modifications are indicated on the following table and correspond to Figure F-1 at the end of this section:

GEOLOGIC UNIT	**GEOSEISMIC HAZARD ZONES**
Qaf (Fill) Fill is assumed to be 4. If investigation shows fill to be engineered, the fill will be assigned the number of the underlying geologic unit.	
Landslides	4
Qm (Bay mud)	4
Qa (Alluvium)	2
Qc (Colluvium)	Slope stability 1 or 2 = 2 Slope stability 3 or 4 = 4
Tv (Volcanic Rocks)	1
Ks (Arkosic Sandstone and Shale)	1
Kjs (Graywacke Sandstone and Shale)	1
Kjch (Chert)	1
Kjg (Basaltic Volcanic Rocks)	1
Kjsch (Metamorphic Rocks)	Slope Stability 1 or 2 = 2 Slope Stability 3 or 4 = 4
Fm (Franciscan Melange)	3
Fm (Creeping)	4

The capital letters A through D in each geologic risk zone column of the Matrix indicate the levels of report required for a particular land use project in a specific risk zone at a particular stage of governmental process.

REPORT DOCUMENTATION GUIDELINES

This section provides guidelines for the content of various geotechnical reports submitted to the city at different stages of project review. The content of each level of report should include, but may not be limited to the items listed below. Since different physical conditions demand differing reports, the content indicated for each report should be flexible. The city, however, may not accept reports that omit content guidelines without the City's prior approval. Geologic reports shall be prepared by a Certified Engineering Geologist (CEG) and soil engineering reports shall be prepared by a Registered Geotechnical Engineer (RGE). When reports require input from both disciplines, the reports shall be jointly prepared by a CEG and a RGE. It is the City's policy to evaluate not only the development site and its effect on adjacent properties, but also adjacent properties that may affect the site.

A. PRELIMINARY GEOLOGIC REPORT

This report is intended as an overview of site conditions. Its purpose is to identify obvious geologic hazards and geotechnical problems and considerations, and to provide a preliminary assessment of the suitability of the site for the project. The level of effort may vary depending on the site conditions.

The study should include:

1. A review of the site history and previous geologic/soils maps, literature and reports.

2. Consultation with prior geotechnical investigators as judged necessary.

3. Interpretation of stereopaired aerial photographs as conditions warrant.

4. A field reconnaissance of the site and vicinity.

5. Subsurface exploration if judged necessary to assess unclear geologic conditions.

6. Review of the engineering aspects of the proposed site including size and type of structures, and magnitude and extent of grading.

7. Review of historical land uses, nature of fill and site characteristics for evidence/potential of hazardous materials. (Refer to Exhibit F-1 at the end of this appendix for preliminary mapping of areas of concern).

8. Preparation of a written report which includes the following information:

    a) A description of the proposed project and its location.
    b) The general setting of the area being investigated including the location, size, history, topography, drainage and general soil/geologic conditions.
    c) A detailed geologic map of the site (exceptions are discussed under the heading Geologic Maps in the Report Documentation section).
    d) A discussion of Geologic hazards.
    e) The geotechnical feasibility of the proposed project, basic geotechnical problems, and generalized mitigation measures to be considered.
    f) A discussion of the engineering aspects of the site and proposed project. The discussion should address foundation types for proposed structures, retaining systems, grading considerations, stability of cut slopes and constructed embankments, settlement of the site and adjacent sites due to existing conditions, proposed construction, and proposed surface and subsurface drainage facilities.
    g) A bibliography of all references used.

B. GEOTECHNICAL INVESTIGATION REPORT

This report stage is intended to define the subsurface conditions, and provide geotechnical conclusions and recommendations for design and construction of the project. The investigation should include the scope of the Level A report as well as the following:

1. Subsurface exploration by test pits or borings. Representative disturbed and undisturbed samples should be taken for laboratory testing. Geophysical instrumentation may be used to provide supplemental information.

2. Laboratory testing of representative samples of soil and bedrock.

3. New (or revised) geologic mapping to reflect data obtained from the subsurface investigation.

4. Analysis of field and laboratory test results.

5. An evaluation of soil and geologic conditions and their effect on the proposed project.

6. A settlement analysis if the site is underlain by Bay Mud or other compressible soils; including assessment of site grades and settlement to account for 30-year elevation of +6 feet MSL or other criteria as determined by the City.

7. An evaluation of soils for liquefaction potential.

8. A site-specific assessment of seismic ground motion for critical use and high hazard zones, particularly Bay Mud sites.

9. A slope stability analysis for embankments constructed on Bay Mud, and for excavation in Bay Mud. A slope stability analysis may also be needed where unretained slopes steeper than 2:1 in soil or 1-1/2:1 in rock are planned or present.

10. Preparation of a written geotechnical investigation report which includes the following information:
    a) A description of the subsurface conditions encountered.
    b) Logs of subsurface explorations and laboratory test results.
    c) A revised geologic map (needed only if geologic conditions differ from the original map).
    d) Subsurface cross-sections, when appropriate.
    e) A discussion of potential geologic hazards and recommended mitigation measures.
    f) Geotechnical recommendations for design and construction of the project which include the following information when appropriate:
        i. foundation support of structures.
        ii. lateral pressures for retaining structures.
        iii. estimated settlement behavior including performance of structures, estimated final grades to achieve 30-year settlement elevations; and discussion of settlement on gravity flow utilities and subsurface drainage.
        iv. site grading including criteria for cut slopes and embankments on soft soils
        v. site dynamic response spectra.
        vi. pavement design criteria.
        vii. erosion control and winterization measures.
    g) Items recommended to be observed by geotechnical consultant during construction.

Prior to issuance of a building permit and start of construction, the geotechnical consultant should review the construction plans and submit a letter indicating conformance of the plans with the intent of the geotechnical report recommendations. Plan changes may be recommended before plans are approved and a construction permit is issued. Report and plan reviews are performed at the applicants expense.

C. CONSTRUCTION OBSERVATION REPORT

This report documents the geotechnical field observation and testing during construction. Interim or periodic progress reports may be required on larger projects. The report should include:

1. A description of the grading, foundation excavations, subsurface drainage, and hazard mitigation measures performed.

2. A summary of items observed and tested.

3. Unanticipated conditions encountered during grading or construction, and any field changes implemented that differ from the approved grading and construction plans.

4. A statement regarding the conformance or nonconformance of construction to the geotechnical recommendations, and any items not observed or tested during construction.

D. GEOTECHNICAL REVIEW

Prior to acceptance, geotechnical reports are subject to review by the City of San Rafael Geotechnical Review Consultant. The reports are only reviewed for conformance with the geotechnical requirements of the general plan and this document. Additional work, including exploration, testing, and analysis may be recommended if judged necessary by the reviewer. The geotechnical review will usually require a response by the geotechnical consultants.

E. HAZARDOUS WASTE INVESTIGATION REPORT

This report shall be submitted for: sites where hazardous contamination is suspected or encountered, and for investigations of existing or proposed waste dumps sites.

Tasks should include the following:

1. Installation of ground water and/or vadose zone monitoring wells.

2. Laboratory analysis of fills, unconsolidated deposits, water samples and/or gas samples for hazardous waste contamination.

3. Periodic monitoring of gases and/or water samples.

4. Preparation of a written report which includes the following as judged necessary by the geotechnical consultant:
   a) Chemical analysis results of soil ground water, and/or gas samples. (Include values for normal or allowable ranges.)
   b) Boring logs with a description of subsurface materials.
   c) Subsurface permeability test results.
   d) Potentiometric map of ground water in site vicinity.
   e) A map showing the concentrations, lateral extent, and thickness of the contamination zone if ground contamination exists.
   f) A discussion about water supplies that may be affected by contaminated sites.
   g) Recommended mitigation measures for contaminated sites.
   h) Suitability assessment of existing or proposed waste dump sites.

REPORT DOCUMENTATION

Landslide Information

Landslides are one of the most common and serious geologic hazards that affect the San Rafael area, and therefore, should be given special attention by the geotechnical consultant.

A landslide is defined here as the downslope movement of soil and rock material en masse under the influence of gravity. Where landslides affect a site, the consultant should describe, as a minimum, the landslide geometry, mechanics of movement, amount of movement, age of movement, failure surface, ground water conditions, cause(s) of original movement, change in conditions since the last movement, and the degree of present and anticipated future stability. The landslides to be considered include not only landslides on a site, but landslides on adjacent properties that may affect a site. If it appears that a site is not affected by landslides, the consultant should make such a statement in his report.

The above information should be documented by existing literature and observations that may require detailed topographic and geologic mapping, interpretation of aerial photographs, subsurface exploration, sampling and laboratory testing of soil and bedrock, water table measurements, survey measurements to detect movement, slope stability analysis, and the preparation of subsurface cross-sections.

Conclusions and Recommendations

Since conclusions and recommendations are normally the most important portions of a report, they should be described in a separate section. The section should address the following: (1) the effects of the geologic conditions on the proposed land use (2) the effects of the proposed land use on future geologic processes, and (3) the effects of the geologic conditions and proposed land use on surrounding properties.

Geologic Maps

Geologic maps are required with geologic reports with two exceptions:

1. A geologic map may not be necessary for small parcels if the geologic conditions can be completely described in writing or with the aid of geologic sketches to the satisfaction of the City;

2. If a geologic map was included in a previous report a geologic map may be omitted from supplemental reports if the supplemental information does not change the original mapping of geologic conditions.

The base used for geologic maps should be the most recent and legible site plan submitted to the City, and it should be at a scale that is large enough to show pertinent geologic features. The base map should include but not be limited to a bar scale, a north arrow, the source and date, revision dates, the contour interval, and a legend of the engineering and geologic symbols used. If such information is available, the proposed construction areas and proposed grading indicated by contour lines should also be included on the base map.

The geologic map should be of sufficient detail to accurately depict the geologic conditions affecting the study area. The map should include (as is appropriate) geologic formations or other mappable lithologic units; geologic structures; and surficial features in accordance with generally accepted standards and nomenclature. The map should clearly show the geologic features necessary for a complete and accurate evaluation of the feasibility and design of the proposed development. The map should also include the locations of subsurface explorations and geologic sections, if applicable.

Geologic Sections, Subsurface Logs, and Tabulations

Subsurface explorations such as test borings, test pits, geophysical instrumentation, or ground water monitoring wells are needed to accurately identify subsurface conditions. When subsurface work is performed, the information obtained should be documented in reports by use of graphic logs and descriptions. Graphic representations of the logs may be omitted if the subsurface conditions can be described in writing in sufficient detail to satisfy the City.

To fully understand the soil and geologic relationships of subsurface explorations, it may be necessary to prepare a geologic section (subsurface profile) drawing across the site.

Laboratory test results should be included on logs or presented on a summary table. Where curves are plotted to analyze laboratory test results, the graphic representation of such curves should be presented in the geotechnical report.

GLOSSARY

bedrock - A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.

boring - A hole made while drilling, such as for oil or soil samples.

compaction - The densification of soil by means of mechanical manipulation.

contour line - A line connecting points of equal value (generally elevation) above or below some reference value such as a datum plane. Contour lines are commonly used to depict topographic or structural shapes.

cross-section - A diagram or drawing that shows geologic features transected by a given vertical plane.

debris avalanche - The very rapid and usually sudden sliding and flowage of incoherent, unsorted mixtures of soil and weathered bedrock.

dynamic response - A site specific assessment of seismic ground motions indicating the nature and severity of motions which can cause shaking of a structure. It is usually performed for critical use facilities and sites with potentially hazardous conditions such as bay mud, loose saturated sands, and sanitary landfill.

earthquake - Groups of elastic waves propagating in the earth, set up by a transient disturbance of the elastic equilibrium of a portion of the earth.

embankment - A linear structure, usually of earth or gravel, constructed so as to extend above the natural ground surface and designed to hold back water from overflowing a level tract of land, to retain water in a reservoir, tailings in a pond, or a stream in its channel, or to carry a roadway or railroad; e.g., a dike, seawall, or fill.

erosion - The wearing away of soil and rock as a result of the movement of wind, water, and/or soil.

expansive soil - A soil usually of clayey character, which changes volume with changes in moisture content. As the moisture of the soil increases, the soil swells or expands, as the moisture content decreases, the soil shrinks.

fault - a fracture in the earth's crust along which there has been displacement.

fill - Man-made deposits of soil and/or waste material.

formation - A persistent body of igneous, sedimentary, or metamorphic rock, having easily recognizable boundaries that can be traced in the field without recourse to detailed paleontologic or petrologic analysis, and large enough to be represented on a geologic map as a practical or convenient unit for mapping and description.

geophysical exploration - An indirect method of determining structure and composition of underground geological formations. The principle involved includes the use of electric, gravity, magnetic, seismic, or thermal instrumentation.

ground failure - A permanent differential ground movement capable of damaging or seriously endangering a structure.

groundwater level - The elevation of the water table or another potentiometric surface at a particular place or in a particular area, as represented by the level of water in wells or other natural or artificial openings or depressions communicating with the zone of saturation.

grading - The removal or placement of earth material by mechanical means during preparation of construction sites.

landslide - The downslope movement of soil and rock material en masse under the influence of gravity.

liquefaction - In cohesionless soil, the transformation from a solid to a liquid state as a result of increased pore pressure and reduced effective stress.

permeability - The property or capacity of a porous rock sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.

potentiometric surface - An imaginary surface representing the total head of ground water and defined by the level to which water will rise in a well. The water table is a particular potentiometric surface.

seismic shaking - Earthquake shaking.

settlement - The reduction of surface elevation due to the compressibility of underlying soils.

slope - An inclined ground surface, the inclination of which is expressed as a horizontal distance to a vertical distance. A 2:1 slope indicates distances of 2 horizontal to 1 vertical.

slope stability - The resistance of a natural or artificial slope or other inclined surface to failure by landsliding.

stereopaired - An overlapping pair of photographs that, when properly oriented and used with a stereoscope, gives a three-dimensional view of the area of overlap.

test pits or test trenches - subsurface excavations other than borings that are usually large enough for a man to enter for the purpose of visual observation, sampling, and mapping.

tsunami - A gravitational sea wave produced by any large-scale, short duration disturbance of the ocean floor, principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption and may pile up to heights of 30 m or more and cause much damage on entering shallow water along an exposed coast.

vadose zone - A subsurface zone containing water under pressure less than that of the atmosphere, including water held by capillarity; and containing air or gases generally under atmospheric pressure. This zone is limited above by the land surface and below by the surface of the zone of saturation.

unconsolidated material - (a) A sediment that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth; (b) soil material that is in a loosely aggregated form.

water table - groundwater level.

Exhibit HH:
GEOTECHNICAL REVIEW MATRIX

	SLOPE STABILITY & GEO-SEISMIC HAZARD ZONES 1, 2, 3 & 4															
	LAND USE CATEGORY (1)															
	CRITICAL				HIGH OCCUPANCY				LOW OCCUPANCY				PARKS/OPEN SPACE			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Rezoning, Master Plan	A	A	B/D	B/D	A	A	B/D	B/D	A	A	A	A	N/A	N/A	N/A	N/A
Subdivision – Tentative Map, Parcel Map, Conditional Certification of Compliance Design Review	B/D	B/D	B/D	B/D	B	B	B/D	B/D	A	A	B/D	B/D	A	A	B/D	B/D
Use Permit, Grading Permit, Building Permit	B/D	B/D	B/D	B/D	B	B	B/D	B/D	B	B	B/D	B/D	A	A	B/D	B/D
Occupancy Permit, Notice of Completion	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

Requirements for the following to be determined on a case-by-case basis, dependent upon the specificity of proposal:

- General Plan Amendment
- Annexation
- Rezoning-General
- Subdivision-Other
- Variance
- Open Space Acceptance
- Pre-Application Feasibility

(1) Land Use Categories
Critical Use: Hospitals and related care centers, schools, auditoriums, churches and theaters, fire and police stations, transportation centers and facilities, major utilities, and communication facilities.
High Occupancy: Residential (single-family, apartments and PUDs); commercial (office buildings, restaurants and retail stores); and light and heavy manufacturing and assembling.
Low Occupancy: Warehouses, storage facilities and distribution centers.
Park/Open Space: Parks, marinas, and public and private open-space.

Report type
A Preliminary Geologic Report
B Geotechnical Investigation Report
C Construction Observation Report
D Geotechnical Review

NOTES: (1) A hazardous waste investigation report (E) shall be submitted for sites where contamination is suspected, and for investigations of existing or proposed waste dumpsites.
(2) For Hillside lots with an average slope greater than 25%, refer to the Hillside Residential Guidelines Manual, Appendix C for Geotechnical/Hazardous soils review

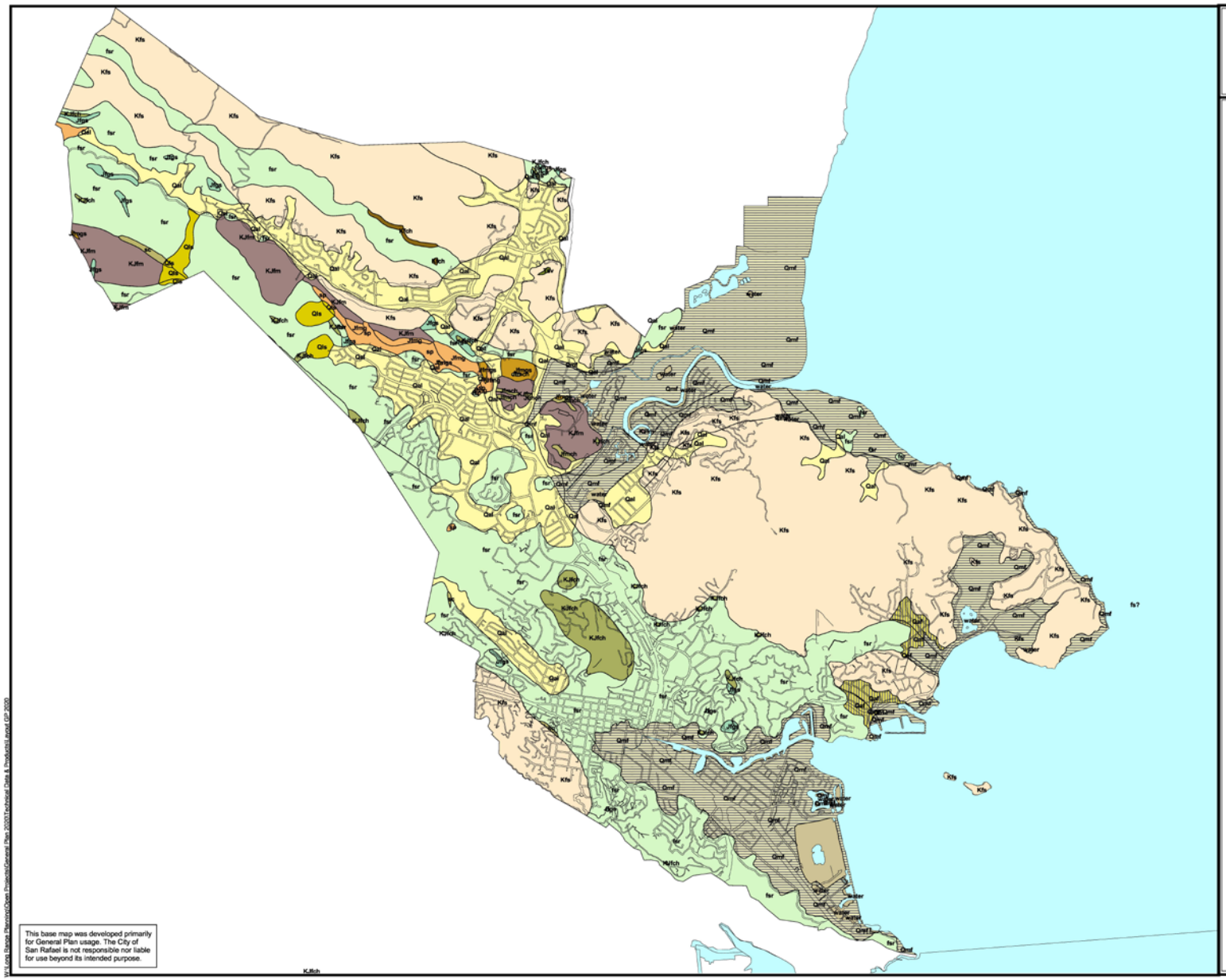

Exhibit F-1

Geology and Stability

Surficial Deposits

- Qaf — Artificial fill
- Qal — Alluvial deposits
- Qls — Landslide deposits
- Qmf — Artificial fill over marine and marsh deposits

Tertiary overlap sequence

- Tsv — Sonoma Volcanics

Franciscan Complex

- Jfgs — Greenstone
- Jfmch — Metachert
- Jfmgc — Metagreenstone and Chert
- Jfmgs — Metagreenstone
- KJfch — Chert
- KJfm — Metamorphic
- Kfch — Chert
- Kfs — Sandstone
- fsr — Melange
- sc — Silica-carbonate
- sp — Serpentinite

Source: USGS, 2000; map file MF2337

NOTE:
Spatial resolution of original map data is 1:62.500. This map is intended to be of general use to engineers and land-use planners. However, its small scale does not provide sufficient detail for site development purposes. In addition, this map does not take the place of fault-rupture hazard zones designated by the California State Geologist (Hart and Bryant, 1997). For a more complete depiction of landslide distribution, see Nilsen and others (1979), Ellen and others (1988; 1997), Pike(1997), and Wentworth and others (1997).

This base map was developed primarily for General Plan usage. The City of San Rafael is not responsible nor liable for use beyond its intended purpose.

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