finalised. This process is a basic form of quality control and a form of validation if the peer reviewer has appropriate wide experience.

9.2.2 Formal validation

For more important advanced level mapping projects there can be a process of validation within the study. To do this the landslide inventory is randomly split in two groups: one for analysis and one for validation. The analysis is carried out in part of the study area (model) and tested in another part with different landslides. An alternative approach for advanced mapping projects is for an analysis to be carried out with landslides that have occurred in a certain period whilst validation is performed upon landslides that have occurred in a different period. Validation can also be carried out by this process after the mapping and land use planning scheme has been in place for some time. This is really only practical for high frequency landsliding because of the time frame required to gather performance data.

9.3 POTENTIAL EFFECTS OF CLIMATE CHANGE

There is a developing knowledge of climate change and the effects of this on rainfall and snowfall. It could be anticipated that for example a decreased frequency of high intensity rainfall might reduce the frequency of shallow landslides on steep hill slopes. However the science of prediction of the effects of climate change and the prediction of the frequency of landslides from rainfall is not sufficiently advanced at this time to warrant consideration of climate change when carrying out zoning studies.

Those involved in landslide zoning studies should keep informed of developments which might alter this conclusion.

10 APPLICATION OF LANDSLIDE ZONING FOR LAND USE PLANNING

10.1 GENERAL PRINCIPLES

These guidelines are for landslide susceptibility, hazard and risk zoning. Those who are considering the introduction of land use management controls for landsliding need to decide the type and level of zoning which they require based on the purpose of the zoning. This is detailed in Section 6. They may choose to stage the zoning and implementation of land use controls.

It should be recognised that it is not possible to delineate zoning boundaries accurately with regional and local zoning using small and medium scale zoning maps. This can only be done using local or site-specific zoning and large to detailed scale maps.

It is critical that the local governmental authority or other organization requiring the zoning, clearly and fully define the purpose and nature of any zoning study, understand the existing availability of potential input data, assess the implications for acquisition of new data and then define realistic goals for the zoning study taking into account, timeframes, budgets and resource limitations.

It should be noted that mapping will usually result in lines on a map delineating for example the landslide hazard zones based on contours and geomorphologic boundaries. However, for land use planning and zoning purposes the zone boundaries are often re-drawn to coincide with allotment boundaries for administrative reasons. This may lead to adoption of conservative boundaries and should be avoided where practical.

10.2 TYPICAL DEVELOPMENT CONTROLS APPLIED TO LANDSLIDE ZONING

Examples of the types of development controls which are applied to landslide zoning are:

- If zoning is by susceptibility the controls usually require geotechnical assessment of hazard and risk of the proposed development for zones determined as susceptible to landsliding whilst only minimal requirements (such as adherence to good hillside practice) in areas determined as very low susceptibility or not susceptible.
- If zoning is by hazard and the study has been done at an intermediate or advanced level it should be possible to delineate land use zones where: (a) Hazard is so low that no development controls are necessary; (b) Where some prescriptive controls such as limits to the heights of cuts and fills are necessary; (c) Where detailed geotechnical assessment of the hazard and risk is required before development can be approved and (d) Where the hazard is so high no development is possible.
- Where zoning is by life loss risk and the study has been done at an intermediate or advanced level, it should be possible to delineate land use zones where (a) Life loss risk is so low no development controls are necessary; (b) Where site specific assessment of the risk is required prior to approval of development and (c) Where the risk is so high that no development is possible.

In practice those considering landslide zoning for land use management would be well advised to seek advice from a Geotechnical Professional who is familiar with landslide zoning and risk management to provide advice in planning the landslide zoning study and applying the outcomes to land use planning.

10.3 NEED TO REVIEW AND UP-DATE LANDSLIDE ZONING

It should be recognised that there should be periodic reviews of landslide zoning because:

- The susceptibility, hazard and risk may be altered by development and land-use changes subsequent to the study.
- The state of knowledge of landsliding in the area will be improved with more detailed investigations carried out as part of the development.
- The elements at risk may change with time so landslide risk zoning should be reviewed to allow for this.
- Methods of landslide zoning are evolving so in combination with the factors listed above, improved zoning will be possible.

It is recommended that reviews be carried out at intervals no greater than about 10 years. In some cases more frequent reviews will be necessary.

11 HOW TO BRIEF AND SELECT A GEOTECHNICAL PROFESSIONAL TO UNDERTAKE A ZONING STUDY

11.1 PREPARING A BRIEF

The following are some matters which should be considered in preparing a brief for a landslide zoning study.

- Define the purpose of the zoning and how it will be used.
- Define the area to be zoned.
- Define what type of zoning is required: landslide susceptibility, hazard or risk.
- Define the level of zoning required and whether it will be staged.
- Identify the various stake holders and their interests.
- Describe what, if any, public consultation process will be required.
- State relevant legal and regulatory controls.
- Set out the documentation required for the results of the zoning, including details of what maps are required, map scales, and electronic formats and the supporting report describing the zoning processes, methods used, validation and limitations.
- Set a program for the study.
- Set a budget consistent with the scope and expectations of the study.
- Describe the peer review process which will apply.
- List the available data and the format it is in.
- Detail the expected method for the study.
- Define the terminology to be used to describe susceptibility, hazard and risk.

In so far as possible, this is best done in consultation with prospective consultants so there is a clear understanding of what is required.

11.2 SELECTING A CONSULTANT FOR THE ZONING

Landslide susceptibility, hazard and risk zoning is a science that should be done by well qualified geotechnical professionals who are experienced in mapping and who understand slope processes, risk assessment and geotechnical slope engineering. This will usually mean that a team of professionals will be needed including an engineering geologist, geomorphologist (for zoning of natural slopes where geomorphology mapping is required) and a geotechnical engineer. It should be noted that only a few engineering geologists and geotechnical engineers are experienced in geomorphologic mapping. It is essential that geotechnical engineers who understand the soil and rock mechanics of slope processes pre and post-failure are involved in the landslide susceptibility, hazard and risk assessments.

Consultants proposing to carry out landslide zoning should demonstrate they have personnel who will work on the project with the relevant skills and experience. It is not sufficient that a geotechnical company has done such studies because it is the personnel directly involved that are important.