

The Landslip Prevention and Mitigation Programme

Key Messages: The Geotechnical Engineering Office (GEO) has launched a Landslip Prevention and Mitigation Programme (LPMitP) to dovetail with the Landslip Preventive Measures Programme (LPMP) which was completed in 2010. The LPMitP aims to prevent landslide risk from increasing due to population growth, slope degradation and more frequent extreme weather events. The LPMitP is implemented on a rolling basis with the following annual output: (i) upgrade 150 government man-made slopes; (ii) conduct safety-screening studies for 100 private man-made slopes; and (iii) implement studies and necessary risk mitigation works for 30 natural hillside catchments.

Introduction

Government's concerted effort in the past 40 years has brought about substantial improvement in slope safety and a significant reduction in the number of landslide fatalities in the past couple of decades. Under the LPMP, which was completed in 2010, about 4 600 government man-made slopes were upgraded. Safety-screening studies for about 5 200 private man-made slopes were conducted and among them Dangerous Hillside (DH) Orders for about 2 600 potentially substandard slopes were issued to request private owners to investigate those slopes and carry out the necessary upgrading works. All the substandard pre-1977 man-made slopes affecting multi-storey buildings and roads with very heavy traffic, which posed the highest risk to life and hence deserved the highest priority for action, were upgraded under the LPMP. The overall landslide risk in Hong Kong has been substantially reduced to less than one-fourth of the risk level in 1977, reaching an "As Low As Reasonably Practicable" (ALARP) level¹ that is commensurate with the international best practice in risk management. The strategies of reducing landslide risk from man-made slopes in Hong Kong are outlined in Annex A.

However, upon completion of the LPMP in 2010, there were still remaining landslide risks that pose a hazard to the community. The majority of the remaining landslide risks came from about 18 000 substandard man-made slopes affecting existing development and about 2 700 natural hillside catchments with known hazards that are close to existing buildings and important transport corridors. If the investment in slope safety was not maintained, landslide risk would progressively increase with time due to population growth, slope degradation, and more frequent extreme weather events arising from climate change. In addition to risk-to-life, this would cause significant economic losses and social disruption as a result of road blockages and building evacuation due to landslides, thereby compromising public safety, sustainable development of society and Hong Kong's reputation as a modern smart city and tourist hub.

¹ The landslide risk cannot be completely eliminated, and the government needs to strike a balance between the level of risk and the cost. The "As Low As Reasonably Practicable" (ALARP) level means that the risk should be reduced as much as possible until the cost of any further risk mitigation measures is grossly disproportionate to the benefit gained based on the cost-benefit analysis.

The LPMitP, which has received support from the Legislative Council, was launched in 2010 to contain landslide risks in Hong Kong to within an as low as reasonably practicable level in the long term. The annual outputs of slope upgrading works for government man-made slopes, safety screening studies for private man-made slopes and risk mitigation works for natural hillside catchments from 2011 to 2021 under the implementation of LPMitP are shown in Annex B.

Man-made Slopes

Upon completion of the LPMP in 2010, there were about 18 000 substandard man-made slopes affecting existing development yet to be dealt with. These slopes include about 13 000 old (pre-1977) man-made slopes affecting residential structures in village areas including squatter dwellings, heavily used roads and footpaths, shelters, etc. and 5 000 “old technology” slopes, which were mostly formed or treated from 1977 to the late 1980s based on knowledge and technology at the time. The latter typically comprise slopes trimmed back to a less steep gradient without the provision of reinforcement or structural support (e.g. unsupported cuts). “Old technology” slopes are more prone to degradation and less robust than those treated with modern engineering technology (such as soil nails).

Government Slopes

All substandard government slopes are systematically upgraded to the current safety standards under the LPMitP. Potentially problematic man-made slopes that are at a more advanced state of degradation with signs of distress or past instabilities are identified for follow-up action in accordance with a risk-based priority ranking system. Besides slope safety, the GEO also accords high priority to slopes aesthetics. The GEO has pledged to landscape every slope to be upgraded under the LPMitP, with specialist input from landscape architects. Vegetation cover is used whenever possible in slope upgrading works. In general, hard surface cover, such as shotcrete, is only used as a last resort when other techniques have been thoroughly explored and found not practical. Even when the use of a hard cover is unavoidable on slope safety grounds, measures will be implemented to improve the appearance of slopes, e.g. use of planters, stone pitching, graphic design and colouring.

Private Slopes

Under the LPMitP, private man-made slopes are selected for safety-screening studies. Where prima facie evidence is established that a private slope is dangerous or liable to become dangerous, a statutory DH Order will be served by the Buildings Department on the slope owners upon the recommendation of the GEO. The Order requires the owners to carry out investigation and the necessary upgrading works to the slope. A DH Order may also be issued following a landslide, or as a result of other stability concerns (e.g. observation of significant signs of distress) brought to the attention of the GEO.

Natural Hillside Catchments

In 2010, 2 700 natural hillside catchments with known history of failure and close to existing buildings and important transport corridors (i.e. vulnerable natural hillside catchments) were identified from interpretation of historical aerial photographs. These called for expanded efforts under the LPMitP to systematically combat the risk pursuant to the “react-to-known-hazard” approach. Unlike man-made slopes, it is often impractical, costly

and environmentally undesirable to carry out extensive slope stabilization works on natural hillsides. Instead, natural terrain landslide risk can be mitigated in a more cost effective manner through mitigation measures such as rigid and flexible debris barriers, which are commonly adopted in other countries.

A risk-based priority ranking system has been developed to select the most deserving natural hillside catchments for natural terrain hazard studies. Mitigation measures will be implemented to those hillside catchments confirmed to be posing known hazards to existing developments.

With advances in technology and understanding of the nature of natural terrain landslide risk and occurrence of recent landslides, new candidates of vulnerable natural hillside catchments are identified from time to time. At present, altogether about 3 300 vulnerable natural hillside catchments are included in the ranking system for systematic action under the LPMitP.

Landslide Investigation

Systematic investigation of landslides by the GEO improves the understanding of slope failures in Hong Kong, provides new ideas for reducing landslide risk and innovative design of slopes, and assists in the LPMitP by identifying areas for improved practice in slope design, construction and maintenance. Further information about systematic landslide investigation by the GEO can be found in GEO Information Note 02/2022 on Landslides Studies by the Geotechnical Engineering Office.

Progress

The number of man-made slopes upgraded and hillside catchments with landslip prevention and mitigation works completed under the LPMitP can be found in the report on Landslip Prevention and Mitigation Studies and Works Carried out by the Geotechnical Engineering Office, which is posted on the Civil Engineering and Development Department website (<https://www.cedd.gov.hk/eng/our-projects/landslip/index.html>). Information of individual man-made slopes and hillside catchments can be found in Hong Kong Slope Safety website (<http://hkss.cedd.gov.hk>).

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Annex A

Strategies of Reducing Landslide Risk from Man-Made Slopes in Hong Kong

Background

Before the establishment of the GEO in 1977, geotechnical input on site formation works was very limited. The rapid development of Hong Kong in the 1960s and early 1970s has brought about a large stock of potentially substandard man-made slopes. After the GEO was established, the Government made concerted efforts in dealing with those existing substandard man-made slopes that pose a high risk-to-life to the community under the LPM Programme, which was launched in 1977 and completed in 2010. The overall landslide risk in Hong Kong has been substantially reduced to less than one-fourth of the risk level in 1977. After that, the Government launched the LPMitP to contain landslide risk to within an as low as reasonably practicable level in the long term.

Reduction of Landslide Risk from Man-made Slopes

The following strategies have been adopted in reducing landslide risk from man-made slopes:

(i) Upgrading Substandard Government Slopes and Safety-screening of Private Slopes under the LPM/LPMit Programme

Up to 2010, the LPMP upgraded about 4 600 substandard Government slopes and completed safety-screening studies for about 5 200 private slopes. The safety-screening studies resulted in the issue of DH Orders for about 2 600 private slopes under the Buildings Ordinance to require the responsible private owners to undertake investigations and necessary upgrading works. The summary of the output under the LPMP is shown in Fig 1 to 2.

Under the LPMitP, the GEO will upgrade 150 government man-made slopes and conduct safety-screening studies for 100 private man-made slopes each year.

(ii) Preventive Maintenance of Government Slopes

Regular and proper maintenance reduces the rate of deterioration of slopes. In addition to regular maintenance, the responsible slope maintenance departments also carry out routine Engineer Inspections and preventive maintenance works to improve the stability of existing slopes effectively. The GEO provides assistance to the maintenance departments in setting priorities in their preventive maintenance works.

(iii) Upgrading Existing Substandard Government Slopes as Part of New Public Works Projects

Government departments adopt an integrated approach to government projects, road projects in particular, to ensure that existing substandard slopes affecting or affected by these projects are upgraded as part of the projects.

(iv) Geotechnical Control of New Man-made Slopes

The GEO exercises geotechnical control on new development works and checks the designs of all new slopes and retaining walls to ensure that they meet current safety standards.

(v) Publicity and Education Campaigns

The GEO holds publicity and education campaigns to promote better understanding of the slope safety problems, to remind the public on precautionary measures during Landslip Warning, and to urge private owners to maintain their slopes. The Community Advisory & Education Section of the GEO also provides advisory services to assist private owners to fulfil their duties in maintaining their slopes properly and in the discharge of DH Orders.

No. of Government Man-made Slopes Upgraded under the LPM Programme

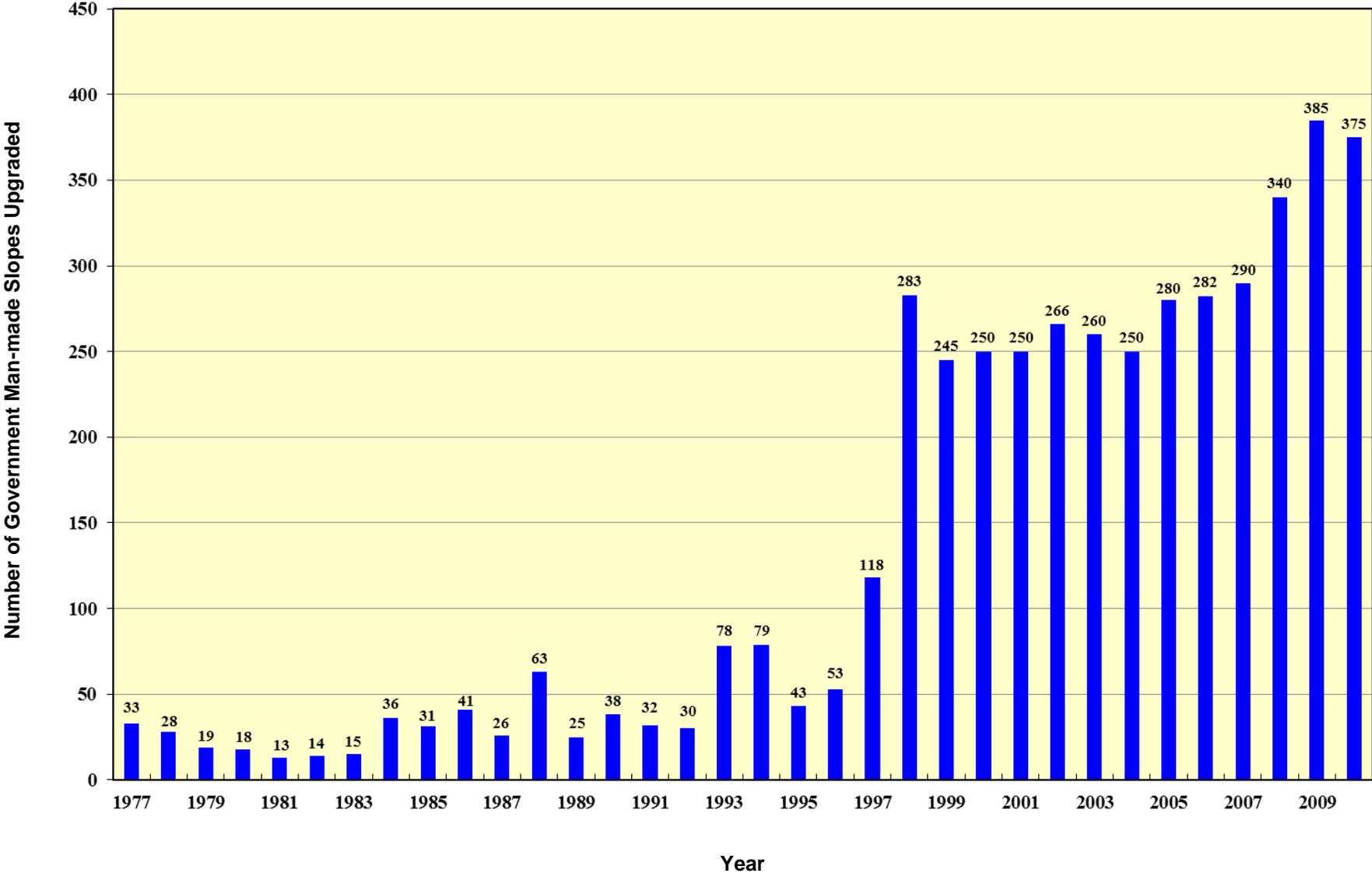


Fig. 1 - No. of Government Man-made Slopes Upgraded under the LPM Programme from 1977 to 2010

Number of Safety-screening Studies Completed on Private Slopes

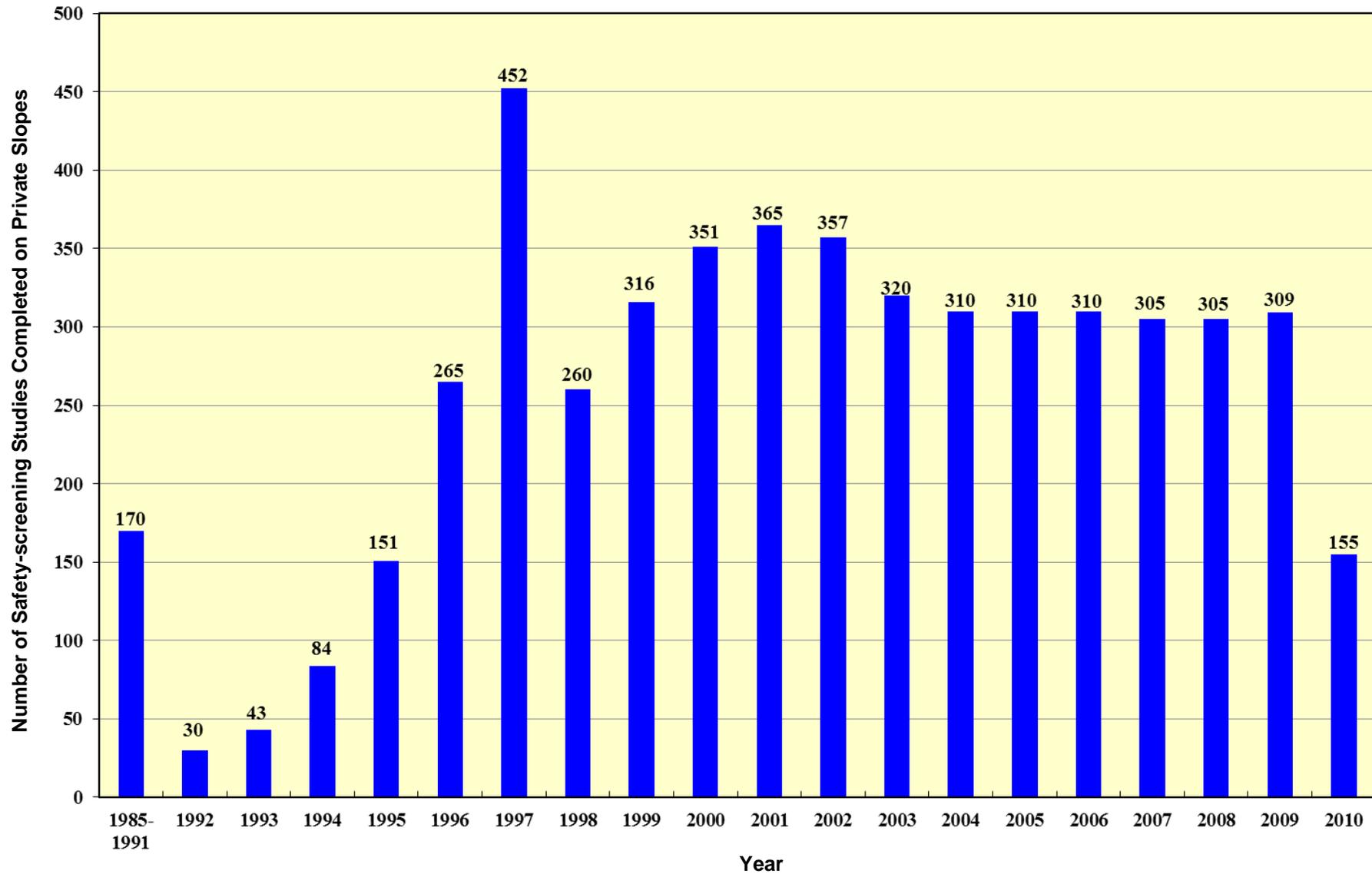


Fig. 2 - Number of Safety-screening Studies Completed on Private Slopes from 1985 to 2010

Annex B

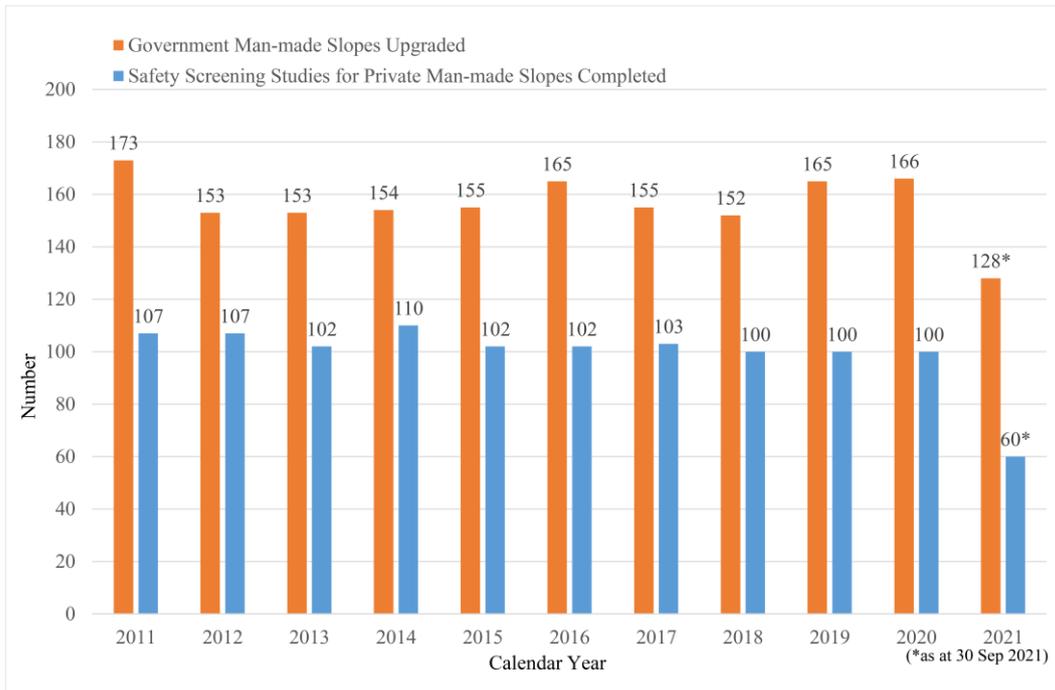


Fig. 3 – Annual Outputs of Upgrading Works for Government Man-made Slopes and Safety-screening Studies for Private Slopes under the LPMitP from 2011 to 2021

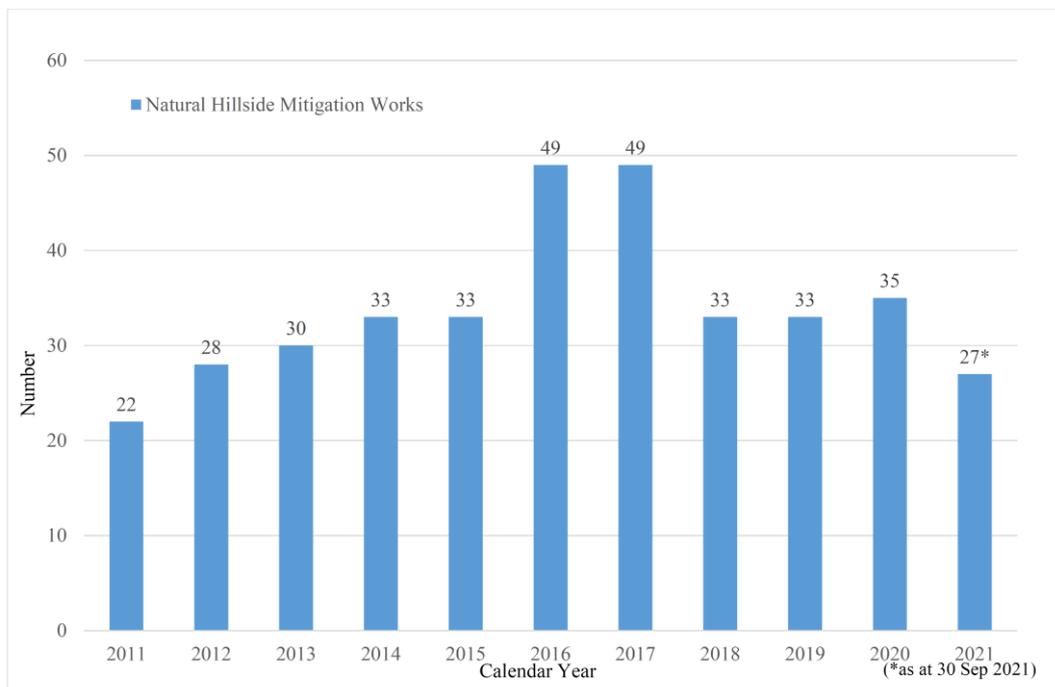


Fig. 4 – Annual Outputs of Natural Hillside Mitigation Works under the LPMitP from 2011 to 2021