

The fragment is taken from the Report on the Project Implemented by the Ministry of Emergency Situations, 2005.

Recommendations on Priority Measures for Ensuring Security of the Burial Ground (made by Mr. R. Yadoyan)

The burial ground was erroneously constructed on the head part of the landslide body. It implies that no geologist took part in the choice of the location of the burial ground. But if this is not so, then one may conclude that the instructions of the former “Agro-techniques” company of 1971 were underestimated, which is less possible, because the construction parameters of the burial ground met the requirements of the official instructions (a barbed wire fence, a gate with iron-concrete posts, construction of drains on both sides of the burial ground, 2m thick clayey cover, setting up a guardianship, etc).

It is worth mentioning that the location of a landslide was not mentioned on all maps available at that time.

The burial ground was constructed on the body of the active landslide, in the vicinity of the cottages that were built by the residents of Yerevan. These cottages are located in the first zone of a danger related to the consequences of the burial ground.

The summary of short-term field and laboratory investigations allowed suggesting the sequence /consistency of the following activities to be undertaken in order to ensure the security of the burial ground.

1. Concreting of the canal for derivation of waters of the mineral spring, all types of precipitation: natural and artificial waters; provision of permanent cleanness of the canal
2. Elimination of the swampy area located on the head part of the landslide; lifting of the soil cover
3. Construction of a 30m long waterproof wall barrier/wall fence (in the soil) at a distance of 10-15m
4. Enclosure of the burial ground; construction of a watertight wall barrier (length - 110m, width - 20m, the total length – $110+110+20+20=260$ running meters)
5. Construction of a watertight wall barrier in the direction of a tongue of the landslide, at distances of 50m and 100m, the length of each wall barrier – 50 m. Total length -100 running meters
6. Enforcement of the tongue of the landslide in order to prevent the flooding of the tongue by means of metal gabions, using the local cobble-stones and splinters of tufa. The length of gabion barrier is about 300 running meters, the width- 1.5 m, the height -2.5 m
7. Construction of a watertight cover of the burial ground with 20cm thick layer of sandy- polymeric – mineral mixture. The surface to be covered is $110 \times 20 = 2200 \text{ m}^2$ sq. m
8. Refilling and leveling of all cracks, clefts and gaps. By the approximate calculations it is 400 m^3 , out of which 100 m^3 is clayey-sandy-polymeric-mineral.
9. Provision of the integrity of the fence, cleanness of the concrete drains and firmness of all other constructions
10. Samplings, analyses, observation and monitoring of the velocity of the landslide and migration of the pesticides according to the methods available

The volume of security measures of the burial ground of the obsolete pesticides are the following:

1. The length of the concrete drain is 50m , the width is 0.5m, the drain is designed for the removal of the waters from the head part of the landslide
2. The volume of earth activity for the elimination of the swampy area makes 200 m^3 ; the soil of III category

3. The length of 3 waterproof wall barriers is $30+50+50=130\text{m}$, the depth is 2m, and the width is 0,7m. The total volume of the earthwork will make 182m^3 . To construct the barrier $130 \times 2 \times 0,7 = 52\text{ m}^3$ sand and $10,4\text{ m}^3$ of 10 % sandy-polymeric-mineral mixture is needed.
4. The volume of earthwork to enclose the burial ground will make $260 \times 2 \times 0,7 = 364\text{m}^3$. For this purpose $260 \times 2 = 520\text{m}^3$ sand and $10\% \times 104 = 10,4\text{ m}^3$ 10 % sandy-polymeric-mineral mixture is needed.
5. The volume of earthwork for the cover of the burial ground will be $2200 \times 0,5 = 1100\text{ m}^3$ (to remove 0,5 m clay layer and close again). The amount of sand will be $2200 \times 0,2 = 440\text{m}^3$, and of 10% sandy-polymeric-mineral mixture $440 \times 0,2 = 88\text{m}^3$
6. For the clefts of the landslide body 100m^3 of sand and 20m^3 of 10 % sandy-polymeric-mineral mixture will be needed. 1m^3 of sandy-polymeric-mineral mixture is estimated at a sum equivalent to 500 US dollars.
7. To investigate the whole landslide body; a geotechnical complex investigation of 10 ha is needed to be conducted: scale 1:500

Thus, the suggested measures should be viewed with regard to the following:

1. Construction of a concrete drain (1x0,5), length - 50 running meters
2. Earthwork of the head part - 200 m^3 , III category soil
3. Construction of 3 watertight barriers: the length of the earthwork is 130m, the depth is 2 m, the width is 0,7 or 182m^3 earthwork, soil of III and IV categories; sand - 52 m^3 ; polymeric-mineral mixture 10% - $10,4\text{m}^3$
4. Enclosure of the burial ground: 2 m deep drain, 260 running meters long, 0,7 m wide or 346 m^3 earthwork in soil of III and IV categories, sand - 104 m^3 ; 10% polymeric-mineral mixture - $20,8\text{ m}^3$
5. Cover of the burial ground: $2200 \times 0,5 = 1100\text{ m}^3$ earthwork in soil of III category, sand – $2200 \times 0,2 = 440\text{ m}^3$; 10% polymeric-mineral mixture - 88m^3
6. Refilling of the surface clefts in the III category soil; sand – 100 m^3 ; 10 % polymeric-mineral mixture - 20 m^3
7. Investigation of 10 ha area of the landslide body; scale - 1:500
8. Organization of monitoring

Conclusion

1. The burial ground is located in an active zone of a landslide, to the east of the dwelling places Vardashen and Jrashen of the city Yerevan
2. The landslide has become more active mainly because of technogeneious reasons which is explained by the fact that not long ago the water main, passing over the head part of the landslide locality, was exploited under the emergency/accidental conditions
3. The landslide tends to develop transversely
4. In the head part the landslide tends to move to the south-west, and in the end part to the west
5. The active landslide is a body with 1000m length, 100m width on average and more than 15m power/strength. The hypsometric height of the head part of the landslide is 1422m, in the tongue part – 1253m.

6. The surface waters of the slide of the landslide probably generate in the small ravine Shoraghbyur of Vardashen settlement, in the north-eastern part of the horticultural lands
7. Remainder of the concrete and metal posts of the surrounding of the burial ground has been found
8. The tongue of the landslide is more active and it is notable for multiple transverse clefts (0,1-1m); according to the geophysical activities it is predicted that the landslide will start to become active in the head part, where the boggy area is located.
9. According to the measurements the burial ground of the obsolete pesticides slid 10-12 running meters eastward during the last 20-25 years. The velocity of the landslide depended on the annual amount of precipitation and the impact of the water from the natural water spring which is located in the head part of the landslide; also it depended on the breakdowns of the water main passing through this territory.
10. The geophysical studies showed that the burial ground is located on the old, but currently very active landslide body. In the boundaries of the burial ground 2 surfaces of a slip are visible. The first slips that are not so deep are at a depth of 5-8m, the second slips are at a depth of 13-18m. The mentioned slips generated in the result of the hypsometric elevated landslide pressure
11. The cover of the burial ground is not concreted. The cover is sandy-clayey (0,75-1,0m) and clayey soil (1,2-1,5m). The mentioned data were confirmed by the data received in the result of boring activities at a small depth. After the completion of geophysical works, during the checking of the obtained data, as well as during the soil sampling from the depth of 1,7-1,8m, remnants of a polyethylene bag with residues of a gray-whitish paste of pesticides was taken out.
12. The main restoration works of the concrete drains and the fencing of the burial ground are over
13. It is proved that the danger comes only from the possible spread of the content of the burial ground, and that no other dangerous compounds were observed in the area. None of the heavy metals and the soluble compounds exceeded the maximum permissible concentrations and currently they are not dangerous.
14. The spread (migration) of pesticides towards the tongue of the landslide is mainly a superficial process and is caused mainly by the ablation and erosion, but taking into account the clefts of different sizes and a depth existing on the surface of the landslide, and also the filtration properties of the soil, it is very possible that the pesticides and their soluble compounds can easily penetrate into the landslide body (due to infiltration and mechanical movement), the surrounding area will get enriched with pesticide compounds and then due to a slip they will penetrate into the tongue of the landslide and the lower parts.
15. The active landslide, especially the tongue part is a big supplement to the development of negative phenomena of heavy showers in the ravine of Shoraghbyur of Vardashen settlement, as well to the development of other dangerous consequences.
16. The zones of danger are: 1) the area of horticultural plots of lands and the area of constructions, 2) the zones of the communities Vardashen and Erebouni.
17. The implementation of the suggested measures will allow to raise the level of security and ensure the preservation of vital norms
18. It is necessary to carry out a more detailed investigation of the active tongue of the landslide and to develop anti-landslide measures
19. To carry out monitoring in order to determine the velocity of the landslide and the degree of the possible migration of pesticides; to predict the increase of the volume and undertake preventive measures.