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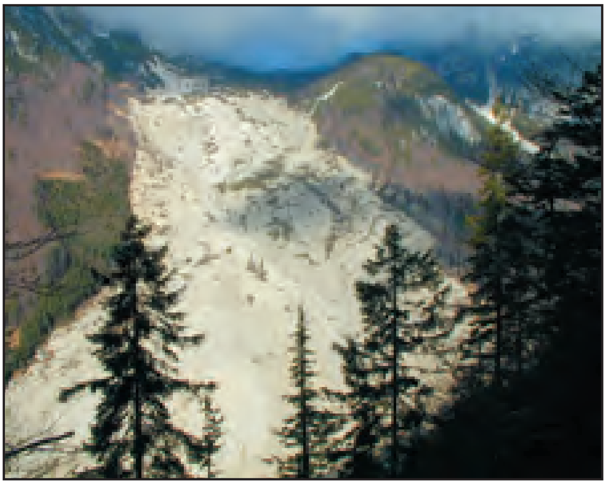
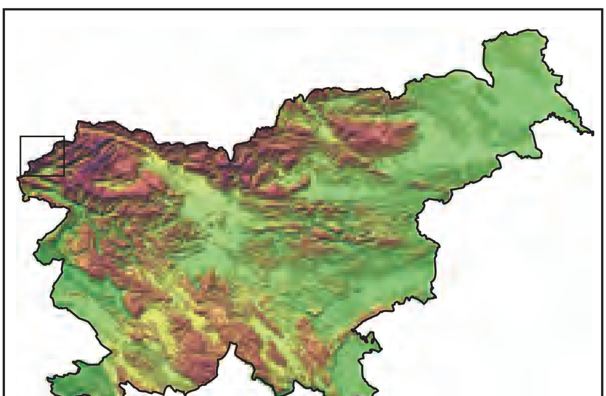
DELINEATION OF RISK AREA IN LOG POD MANGARTOM DUE TO DEBRIS FLOWS FROM THE STOŽE LANDSLIDE

DOLOČITEV OGROŽENEGA OBMOČJA V LOGU POD MANGARTOM ZARADI DROBIRSKIH TOKOV S PLAZU STOŽE

Matjaž Mikoš, Rok Fazarinc, Bojan Majes



View of the Stože landslide on December 6, 2000.
Pogled na plaz Stože 6. decembra 2000.



Delineation of risk area in Log pod Mangartom due to debris flows from the Stože landslide

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ABSTRACT: The paper shows in detail the case of delineation of risk area in the village of Log pod Mangartom in the Koritnica River valley due to possible debris flows that might in future be triggered on the Stože slope above the Mangart Mountain pasture. On the basis of field and laboratory investigations of the debris flow of November 17, 2000, that devastated the Koritnica River valley, the possible scenarios of triggering new debris flows on the Stože slope were investigated. For the determination of debris flow hazard area in the Koritnica River valley, the results of one- and two-dimensional modelling of selected debris flows of known magnitudes and different viscosities were applied. For the determination of risk area, the existing and the possible new infrastructures were taken into account, and the risk area was divided into 3 zones. The paper presents the expert bases summarised by the legislator in the relevant decree issued by the Government of the Republic of Slovenia on the conditions and limitations governing the construction in the debris-flow risk area of Log pod Mangartom. This regulation is the first of its kind in Slovenia.

KEYWORDS: slope mass movements, debris flows, hazard assessment, risk assessment, risk area, preventive protection, legislation, building conditions

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Contents

1 Introduction

In this paper, we present the expert bases and the content of the decree on conditions and limitations governing the construction in the area of Log pod Mangartom, which, following the catastrophic debris flow of November 17, 2000, remains threatened by possible new debris flows from the Stože slope above the Mangart Mountain pasture.

On November 17, 2000, the village of Log pod Mangartom was hit by a debris flow of the magnitude of 1.2 million m^3. The intervention of Civil Defense units during the event and in the days and weeks following this natural disaster (Ušeničnik 2000/2001) was immediately followed by the remediation of the devastated area (Majes 2000/2001). The remediation was firstly carried out under two special laws that were passed by the Parliament of the Republic of Slovenia (Zakon 2000; 2002a), providing for the intervention and other measures for the remediation of the area, the way of their execution and funding. The final remediation of the area is still under way and will be executed in line with the adopted detailed plan of national importance for the impacted area of the Stože landslide in the Bovec Municipality (Uredba 2003a). Parallel to the adoption of the detailed plan for the final remediation, expert bases were prepared and the legislator used them to pass the Decree on the conditions and limitations of construction in the area of Log pod Mangartom, threatened by the debris flow phenomenon (Uredba 2004). The decree was adopted in line with the Water Act (Zakon 2002b) and it is the final legal act, whose intention is to gradually ensure a higher level of preventive protection of Log pod Mangartom against the possible activity of new debris flows from the Stože landslide.

The practice of other Alpine countries shows that the designation of risk areas is especially critical in documents of spatial planning. From practical experiences we know that protection structures or protection (preventive) measures are often not enough to protect us against the hazard of slope mass movement activity, debris flows included (Mikoš 1997). So the rule of conduct should remain the same as in the past: land use should be adapted to natural conditions. This can be reached also in such a way that damage potential (vulnerability) in the space is decreasing, and this by adopting spatial-planning measures, which are supportive for long-term development (Komac, Zorn 2005). State-of-the-art review in Slovenia (Đurović and Mikoš 2004; Komac, Zorn 2005) shows that Slovenia lags behind other Alpine countries with regard to carrying out preventive protection in spatial planning.

In areas threatened by activity of natural geological phenomena, the hazard level of existing spatial use is reduced by structural-engineering measures, if this is the rational way and if the use cannot be abandoned. In the past, man fought for survival on his land and acted in harmony with natural laws. Nevertheless, he could not avoid all disasters, which also did not force him to move out of hazard areas. Such an example is the case of Log pod Mangartom, where the inhabitants have been confronted with threatening natural phenomena of floods, avalanches and land slides for centuries – an evacuation of inhabitants of such a large settlement along an important road connection has no meaning. Only partial reforming of the settlement is acceptable, where the most threatened objects are withdrawn, and the settlement develops in a more condensed form. Such a spatial orientation was the base for adoption of the »Decree on the conditions and limitations of construction in the area of Log pod Mangartom, threatened by the debris flow phenomenon« (Uredba 2004). The basic question in doing that was where to remove the existing infrastructure and where to plan the new one.

In the paper, firstly a short description of the event of November 2000 in Log pod Mangartom is given, which was the basis for the preparation of hazard assessment of the settlement due to the possible activity of new debris flows in future. In continuation, the selected scenarios of triggering the new debris flows on the Stože landslide are shown, followed by a compound presentation of the results of mathematical modelling for selected cases of the run-out areas of debris flows in Log pod Mangartom. A description of mathematical modelling is not presented, since it has been given in detail elsewhere (Četina et al. 2006). The paper ends with expert bases for the »Decree on the conditions and limitations of construction in the area of Log pod Mangartom, threatened by the debris flow phenomenon« (Uredba 2004), which, by incorporating a map of the risk area in Log pod Mangartom, became the basis of spatial planning.

2 Debris flow in Log pod Mangartom in November 2000

On November 17, 2000 a debris flow from the Stože slope in the torrential watershed of the Predelica Torrent devastated the valley of the Koritnica River, a typical narrow alpine valley in the west of Slovenia. It was

Figure 1: The debris-flow run-out area in Log pod Mangartom on November 28, 2000. The Predelica Torrent flows into the emerald Koritnica River.

the largest such phenomenon in the 20st century in Slovenia. More than 1 million m^3 of slid debris material from the Stože slope flowed as a wet debris flow along the narrow torrential gorge of the Predelica Torrent into the 4-km distant village of Log pod Mangartom and further along the Koritnica River valley (Zorn, Komac 2002).

Triggered in the channel of the Mangartski potok Torrent, the debris flow reached the village in few minutes, killed 7 inhabitants in their homes and destroyed or damaged 29 residential and farm buildings, covering almost 15 ha of arable land (Majes 2000/2001). Along with the unfavourable geological composition of the Stože slope (Majes 2000/2001; Petkovšek 2000/2001), a hydrological analysis of the event has shown that the main triggering factor of the November 2000 event was abundant and long-lasting rains in a relatively warm autumn without snow precipitation below 1800 m a. s. l. (Mikoš et al. 2002c; 2004a). In the rain gauge station in Log pod Mangartom in the 46 preceding days (before November 17, 2000) in total 1638.4 mm rainfall was registered (Table 1), which corresponds to a return period over 100 years. An essential difference between the event in Log pod Mangartom (maximum daily rainfall total of 174.0 mm, measured on October 12, 2000, with a return period of 2 years) and the occurrence of shallow soil slides should be stressed – the latter are triggered by intense short-term precipitation (Caine 1980; Crosta 1998; Komac 2005 – analysis using maximum daily precipitations with the return period of 100 years).

During the debris flow event on November 17, 2000, around 400,000 m^3 of debris material was deposited along the flowpath upstream of the Koritnica River valley bottom and around 700,000 m^3 on the valley bottom itself. Locally, the deposited debris depth reached 10 m. Log pod Mangartom was exposed to high waters of the Predelica Torrent and the Koritnica River, and to possible new debris flows. Therefore, in the spring of 2001 a preliminary design of temporary engineering measures was prepared, which should accelerate natural fluvial erosion processes and increase flood safety of Log pod Mangartom. The decision was based on the assessment that, by taking into account the triggering factors for the November 17, 2000 event, there was no imminent threat of a repeated debris flow in Log pod Mangartom. The basic guidance for the proposal of new arrangements of river channels in the area of Log pod Mangartom was to find an ecologically acceptable and financially executable solution that would ensure the safety of the settlement and infrastructure in the case of an active new debris flow triggered on the Stože slope of the same volume as was that of the November 17, 2000 debris flow. The assessment of the possible repeated debris flow from the Stože slope was based on geotechnical investigations of the Stože landslide, when the boreholes in the landslide hinterland above the landslide crown to the pass on the border with Italy confirmed the presence of around 3 million m^3 material that may fluidise and turn into a debris flow (Petkovšek 2002).

Table 1: A comparison between the measured precipitation (mm) in autumn 2000 in the rain gauge station in Log pod Mangartom and the statistically derived values (the reference period of measurements was 1961–1990), given for different return periods (Mikoš et al. 2002c; 2004a).

Values measured				
Precipitation [mm]	Period			
174.0	October 12, 2000 (1 day)			
481.6	November 11 – November 17, 2000 (7 days)			
1042.7	October 18 – November 17, 2000 (1 month)			
1638.4	October 3 – November 17, 2000 (46 days)			
1666.4	September 18 – November 17, 2000 (2 months)			
Statistically derived values				
Return	Duration			
period (years)	1 day	7 days	1 month	2 months
2 years	170	359	496	756
5 years	226	453	684	1018
10 years	263	515	808	1192
25 years	309	594	966	1411
50 years	344	652	1082	1574
100 years	378	710	1198	1735

At the same time, the arrangement of stream channels had to ensure flood safety against the 100-year flood (77 m^3/s for the Predelica Torrent, and 211 m^3/s for the Koritnica River; Mikoš et al. 2002a), where new channels had to be formed in locally over 10-m thick layer of debris deposits.

In the cross sections and in the longitudinal profile, the stream channels were formed using construction machinery in such a way that the maximum hydraulic conveyance was ensured and that there was no need for extensive mechanical removal of debris deposits. A solution that immediately after the natural disaster seemed attractive and the only possible one, namely the total and fast excavation of all deposits and their disposition in an artificial disposal site, found no expert support in procedures of the preparation of the remediation of the devastated area. The main obstacle was the lack of space in the Koritnica River valley, but also the wish for a natural appearance of the Predelica and the Koritnica, which flow in the Triglav National Park. The proposed engineering preliminary design proved to be very successful, since in 5 years after the event more than half of the deposited debris was washed away from the Koritnica River valley bottom by natural forces (Figure 2; after Mikoš and Fazarinc 2005).

The expert bases for engineering preliminary design of the arrangement were the results of an hydrologic analysis (Mikoš et al. 2004b), an analysis of granularity of debris flow samples (Figure 3), an assessment of sediment transport capacity in the flow sections of the Predelica and the Koritnica (Mikoš et al. 2004a), and the results of debris flow simulations using mathematical modelling (Četina et al. 2006).

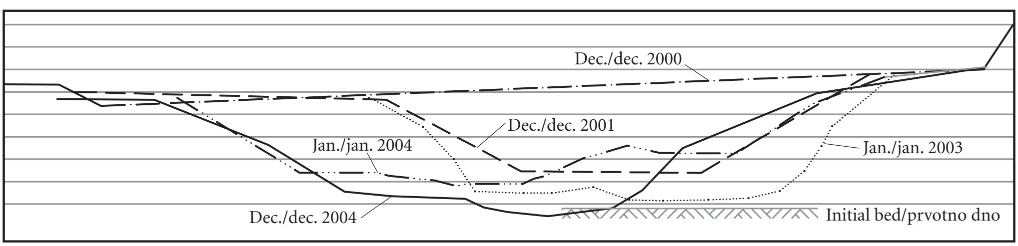

Figure 2: Temporal development of a typical cross section of the Koritnica River after the November 2000 debris flow (vertical step is 1 m) (Mikoš and Fazarinc 2005).

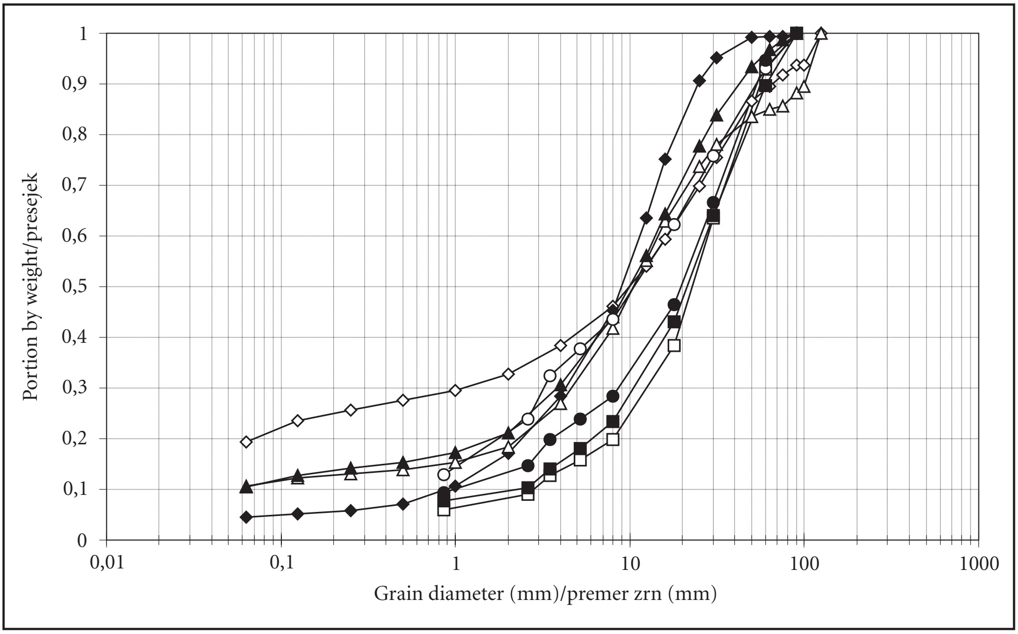

Figure 3: Grain-size distribution of debris flow samples in Log pod Mangartom (Mikoš et al. 2002a).

3 Modelling of the november 2000 debris flow

For debris flow hazard assessment frequently a combination of a one-dimensional model (description of debris flowpath from its source area along steep and/or narrow gorges) and a two-dimensional model (description of flowpath in the deposition area: on fans or in valley bottoms) (Mikoš et al. 2006) is used. Such practice proved to be adequate also in the case study of debris flow modelling in Log pod Mangartom. Different mathematical models were used: one-dimensional model (non-commercial model DEBRIS1D) and two two-dimensional models (commercial FLO-2D, non-commercial PCFLOW2D). Calibration and validation of all three models were executed using a comparison between the computed results and the field measurements after the November 2000 debris flow, and by the comparison of computed results of both two-dimensional models (Fazarinc 2002; Četina et al. 2006).

The simulations of debris flow of different characteristics triggered on the Stože slope using the geometry prior to the November 2000 debris flow (Četina et al. 2006) confirmed the maximum flow velocities of the debris flow front, which were estimated at over 10 m/s in the steep and narrow channel of the Predelica Torrent, and at 3 to 5 m/s in the River Koritnica channel of the open valley bottom (Mikoš 2000/2001; Fazarinc 2002). The devastating force of the debris flow in Log pod Mangartom was a consequence of high flow velocities of the debris front and the high debris flow density (2000–2200 kg/m^3). Therefore, from the preventive point of view, it is necessary to execute the construction of buildings and vulnerable engineering structures outside the debris-flow run-out area.

The main protection structures between the Stože landslide and Log pod Mangartom (two rock-fill dams, two reinforced concrete debris flow breakers), proposed in 2001, were later, in the procedure of adopting the detailed plan of national importance (Uredba 2003a), changed and so only the construction of one debris-flow breaker in the Predelica Torrent channel immediately upstream of Log pod Mangartom was proposed. The omission of the other initially proposed measures asked for the adaptation of the remaining measures, especially the forming of the Predelica Torrent channel in the area downstream of the debris-flow breaker to the confluence with the Koritnica River. The results of the calibrated two-dimensional mathematical model have shown that for the safety of Gorenji Log the excavation of the deposited debris from the Predelica Torrent channel all the way down to the old channel bottom

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Figure 4: Downstream view of the 11.5 m high debris-flow breaker, made of reinforced concrete, finished in winter 2005, approximately 150 m upstream of the prefabricated bridge in Gorenji Log, at the upstream edge of the narrow in the Predelica Torrent, September 29, 2005. The debris flow breaker reduces the debris-flow kinetic energy and retains debris-flow coarse fractions thus changing debris-flow rheological characteristics downstream of the breaker.

prior to November 17, 2000, is not enough. Therefore, the calibrated models of debris flows were used for the optimisation of the proposed preliminary design of arrangements of the Predelica Torrent and the Koritnica River channels (Fazarinc et al. 2006). The modelling took into account the possible interventions into the narrow bottle neck, that is to the narrow in the channel of the Predelica Torrent immediately upstream and in the cross section of the prefabricated bridge in Gorenji Log:

- Guiding wall on the right bank of the Predelica Torrent to prevent a debris-flow overspill to Gorenji Log;

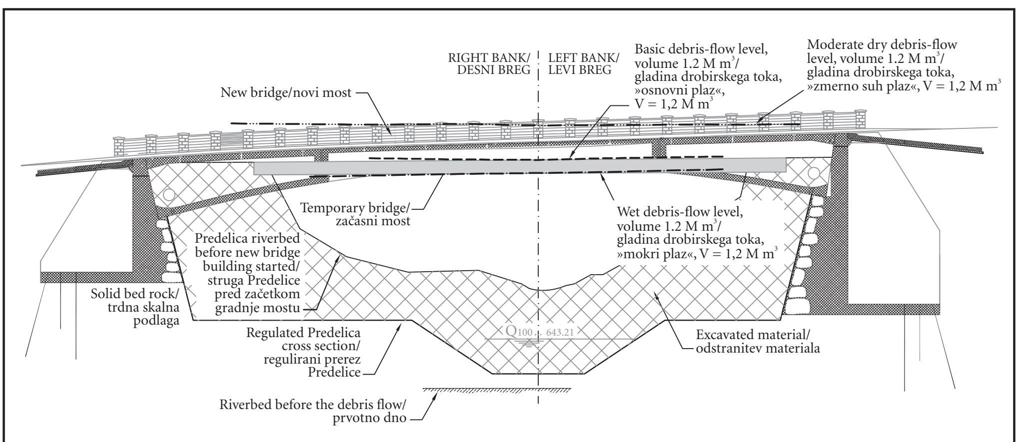

Figure 5: Cross section of the new reinforced concrete road bridge in Gorenji Log (upstream view). The computed debris-flow levels of different viscosities are also marked (after Fazarinc et al. 2006).

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Figure 6: A view of a new reinforced concrete road bridge in Gorenji Log on September 9, 2006 (upstream view, compare the executed bridge with the preliminary design on Figure 5).

- Widening and smoothing of a narrow cross section from the existing 24 to 28 m to a uniform width of 33 m, 40 m or 48 m, in order to lower the debris-flow levels and to improve the impact of the breaker on the debris flow (Figure 4).

In the area of the road bridge in Gorenji Log, the widening of the narrow to the uniform 40 m proved to be the optimal solution. Too large widening (even up to 48 m) would, due to a high debris-flow momentum in the curvature, increase the chance of overtopping the right bank. The solution with the widening of the narrow is advantageous to the construction of a large deflecting wall on the right bank, which was initially proposed as the ideal solution (Horvat 2000/2001), and which would, due to its height, make the new road bridge in this location difficult (Figure 6).

4 Determination of the debris-flow impacted area in Log pod Mangartom

Comparing the magnitude (total volume of 1.2 million m^3) of the debris flow from the Stože area of November 2000 with similar cases recorded in the Alps (van Steijn 1996), it can be listed in the group of events with »extremely high magnitude«. Despite the difficulties in determining the return periods from historical data only, we can, based on the comparison with other cases from the Alpine region, estimate the event of November 2000 in Log pod Mangartom as having a return period of several hundreds of years. This is supported by the classification for debris flow size proposed by Jakob (2005), putting the debris flow of Log pod Mangartom in class 5, i. e. debris flows which rarely develop bouldery front (high return period). The parameters used in class 5 of this 10-fold classification are:

- Debris-flow magnitude 10,000÷1,000,000 m^3 (Log pod Mangartom: 1,200,000 m^3);
- Peak discharge 1,500÷12,000 m^3/s (Log pod Mangartom: 7000÷8000 m^3/s, Fazarinc et al. 2006);
- Inundated area 4÷20 ha (Log pod Mangartom: 15 ha).

Such an estimate of the November 2000 debris-flow return period in Log pod Mangartom is supported by the estimate of debris-flow magnitudes triggered by precipitation in selected torrential areas of Slovenia (Sodnik and Mikoš 2006). The analysis has indicated that the event of Log pod Mangartom differs significantly from the estimated magnitudes of potential debris flows in other torrential areas in Slovenia under investigation.

In this respect, the question is raised what is the significance of the November 2000 event related to the preventive protection of the settlement in the future. In recent years, the Alpine region has adopted the approach to protect against the events (landslides, floods) not only with return period of 100 years, as has been the practice in torrential control since the beginning of its service in Slovenia in 1884 (Jesenovec 1995). In the case of extreme events recorded recently, the protection of the affected populated areas, after the remediation, takes place according to the same magnitude. This is true even if the return period of the extreme events is much higher than 100 years. The classification of flood-endangered areas adopted in Switzerland takes into consideration the return period of 300 years (BUWAL 1998).

In pursuit of sustainable development in the modern-day society the question of return period of an extreme event has been pushed into the background, bringing forward the probability of damage that exists within a certain period, that is, the question as to how dangerous a certain place is. The probability of occurrence of a dangerous event and its return period may have a numerical relationship if we proceed from a unified period of use. The equation is:

$$p = 1 - \left(1 - \frac{1}{T}\right)^n, \qquad (1)$$

T is the return period and p is the probability of an event having the return period T to occur during the period of selected land use n (e. g. 30 or 50 years). If we assume as the period of investigation n = 30 years (period of one generation), the probability of a 30-year event (T = 30 years) is p = 63.83%, 100-year event (T = 100 years) p = 26.03% and 300-year event (T = 300 years) p = 9.53%, respectively. The calculation of probability p in the period of use n clearly shows that in a relatively long return period of an extreme event (e. g. T = 300 years) the remaining risk p is not negligible (Table 2). This is the reason why, in modelling debris flow, we have used the scenario with a volume of 1.8 million m^3, besides the one with a volume of 1.2 million m^3. The aim was to reduce the residual risk for Log pod Mangartom, despite the high estimate of the return period of such an event (several 100 years). This would of course not be sensible if the geological survey had not revealed that there is still approximately 3 million m^3 of material available on the Stože landslide, which could fluidise into debris flow.

Table 2: Calculation of residual risk p for occurrence of a dangerous event with a known return period T for the case of period of use n = 50 years.

Return period T	Residual risk p for n = 30 years	Residual risk p for n = 50 years
1 to 30 years	100% do 63.83%	100% do 81.64%
30 to 100 years	63.83% do 26.03%	81.64% do 39.50%
100 to 300 years	26.03% do 9.53%	39.50% do 15.38%

The risk of the area of Log pod Mangartom from the Predelica gorge above Gorenji Log up to the inflow of the Kotlina into the Koritnica below Spodnji Log was based on calculation simulations of debris flow movement with the use of calibrated mathematical models, taking into consideration different scenarios. In simulating the debris flow movement, the scenario included a combination of different volumes of the activated debris flow, rheological characteristics of the debris material, and the existing and planned geometry of the water courses (Fazarinc 2002; Četina et al. 2006).

The calculation considered different rheological characteristics of the debris flow:

- the debris flow has the same characteristics as the one of November, 17, 2000,
- the liquidized debris flow with lower values of viscosity and critical shear strength (characteristic of water with increased volume weight),
- moderately dry debris flow with higher values of viscosity and critical shear strength, as it was considered in the first debris flow of November, 15, 2000, which stopped in the Mangartski potok Torrent.

Ribičič (2000/2001) regarded this antecedent event as the first phase of the catastrophic debris flow of November, 17, 2000.

In the calculation we considered the geometry where the appropriate design project (VGI 2002) for the area of the Koritnica River and the Predelica Torrent to the bridge in Gorenji Log was followed. In regulating the Predelica in the area of the bridge, the excavation to the old torrent prior to the landslide of November 17, 2000, was considered. From the prefabricated bridge to the reinforced concrete debris-flow breaker we took into account the expansion of the Predelica narrow to an average width of 40 m. Besides, in the simulations in the area of Gorenji Log on the left bank above the bridge, the right bank below the bridge and in the area of Spodnji Log we considered low walls or dams preventing the spill of debris flow in urban areas of Gorenji and Spodnji Log. In the area of the bridge in Gorenji Log we considered the planned position and height of the piers of the new bridge and rise of the terrain in the right bank above the bridge.

The delineation of the run-out area of the debris flow head for each of the selected three debris-flow volumes was determined as the outer envelope of the least-favourable results of simulations according to the selection of rheological characteristics of debris material and the two-dimensional computer simulation programs.

The debris flow risk zoning by way of delineation of run-out areas applies to 4 areas:

- Area I – area with the run-out area similar to the November 17, 2000 event (debris flow magnitude is 1.2 million m^3). This area is an area under direct threat with high level of risk, with devastating consequences, due to the higher probability of occurrence. No development of residential or non-residential buildings is permitted on the area. The building of infrastructures is permitted subject to special conditions. In Figure 7, this area is shown as an area of high risk.
- Area II – this area includes the debris flow area of magnitude of 1.8 million m^3 (increased volume of debris flow due to the decreased residual risk), where the depth of the simulated debris flow is more than 1 m. The area is under indirect medium debris flow risk, since damage to buildings in the area can occur. The probability of occurrence of such an event is smaller than compared to an event with a volume of 1.2 million m^3. The existing construction in the area in retained. Reconstructions and adaptations are possible, however, the construction of new residential buildings is prohibited. Additional indirect measures help to reduce the indirect threat in the area. In Figure 7, this area is shown as medium debris flow risk.
- Area III – this area includes the debris flow area of magnitude of 1.8 million m^3, where the depth of the simulated debris flow is less than 1 m. This area is still considered as area under indirect debris-flow risk, however the risk is lower, since there is no damage to buildings if these were built following special conditions. In Figure 7, this area is classified as the area of the residual risk.
- Area IV – this area is outside the run-out area of a debris flow with a magnitude of 1.8 million m^3 and within the run-out area of a debris flow with a magnitude of 3 million m^3. The area is relatively safe of debris flows. Construction is not subject to special restrictions related to debris-flow risk. However, these area may be under threat of other dangerous natural phenomena, such as snow avalanches, earthquakes, landslips and rockfalls. When preparing local planning documents (municipal spatial plan) the risk has to be defined in terms of probability and location, which is the basis for any further building conditions. In Figure 7, this area is included under the area of the residual risk (in the Decree (Uredba 2004) called areas of low risk).

For definition of area under risk related to the construction of buildings and other activities in space, areas I–III are sufficient. Area IV was determined for planning of protection and rescue in case of direct threat, so that the Civil Defense may plan the retreat direction of population and technical equipment for absolutely safe areas.

5 General guidelines for land use planning related to debris-flow risk

The Waters Act (Zakon 2002b), Article 83, discusses 4 classes of risk areas and foresees a methodology of defining risk areas and the ways of classification of land into risk classes (expert bases are prepared – Mikoš et al. 2004c). Since this methodology had not been accepted the approach to risk area definition in Log pod Mangartom had to be a novel one. The expert basis for the Decree of the Government of RS was related only to the case of debris flow threat from the Stože area, but other kinds of dangerous phenomena, defining the risk areas under the Waters Act (Zakon 2002b), were not considered.

In making the risk map of Log pod Mangartom we considered the practice of other alpine countries, which use a 3-fold classification of debris flow areas (Petraschek and Kienholz 2003). Accordingly, the debris flow risk from the Stože area over the village of Log pod Mangartom was classified into three levels:

- area of high risk (area I),
- area of medium risk (area II), and
- area of residual risk (areas III and IV).

The areas are shown in the debris flow risk map of Log pod Mangartom (Figure 7). This was the basis for the map in the same scale, which is part of the Decree (Uredba 2004), where the areas under different risk areas are graphically shown (Uredba 2004). In the Decree the area of the residual risk is named as low risk area.

Table 3: General guidelines for ban on construction and for building conditions in Log pod Mangartom in the catchment area of the Stože debris flow.

A – High risk area (red zone)
Prohibited building of all residential and vulnerable buildings, which are intended for permanent stay of persons under the Construction Act. The construction of auxiliary buildings (such as garages, auxiliary farm buildings, animal shelters, drinking troughs, hay sheds) should be avoided, if possible. The building of roads is permitted, taking into account the debris flow action. Underground public and electricity lines should be planned and built. There are no restrictions for parks and green areas for recreation. Sports constructions, such as tennis courts, football courts and track grounds, are permitted. Camping sites are permitted if they do not include buildings, except toilet and bathroom facilities, and if they are open between 1 May and 1 October.
B – Medium risk area (blue zone)
The construction of new residential buildings, expansions and renovations of the existing buildings and vulnerable buildings is permitted under special building conditions. In general, for new residential buildings in the blue zone, the following building conditions apply: The ground-plan of the building should be positioned in such a way that it functions as braking wedge; its location should be on banked-up/consolidated terrain, with a raised entrance, hidden from the debris flow direction, and it should have no openings in the underground garage; The wall of the building facing the debris flow action, should be adequately designed and dimensioned (e. g. reinforced concrete) to impact action of the debris mass components and to its afflux pressure. The inner distribution of spaces in the building should consider the direction of debris flow action. The construction of vulnerable buildings is prohibited in the blue zone. The building of roads is permitted, taking into account the debris flow action. Underground public and electricity lines should be planned and built. There are no restrictions for agricultural land use. There are no restrictions for parks and green areas for recreation. Sports constructions, such as tennis courts, football courts and track grounds, are permitted. There are no restrictions for camping sites.
C – Area of residual risk (hatched yellow-white zone)
Similar to the blue zone, general building conditions apply for residential and vulnerable buildings, with the recommendation to prevent large material damage during rare extreme events. Consideration of these general building conditions is left to the investor. There are no special building restrictions. There are no restrictions for agricultural land use. There are no restrictions for parks and green areas for recreation. Sports constructions, such as tennis courts, football courts and track grounds, are permitted. There are no restrictions for camping sites.

The expert bases included general guidelines (requirements and warnings for adapted land use) for each risk area, separately as general guidelines for issuing building permits for residential buildings, vulnerable buildings (hospitals; elderly homes; kindergartens; schools; restaurants; hotels and similar

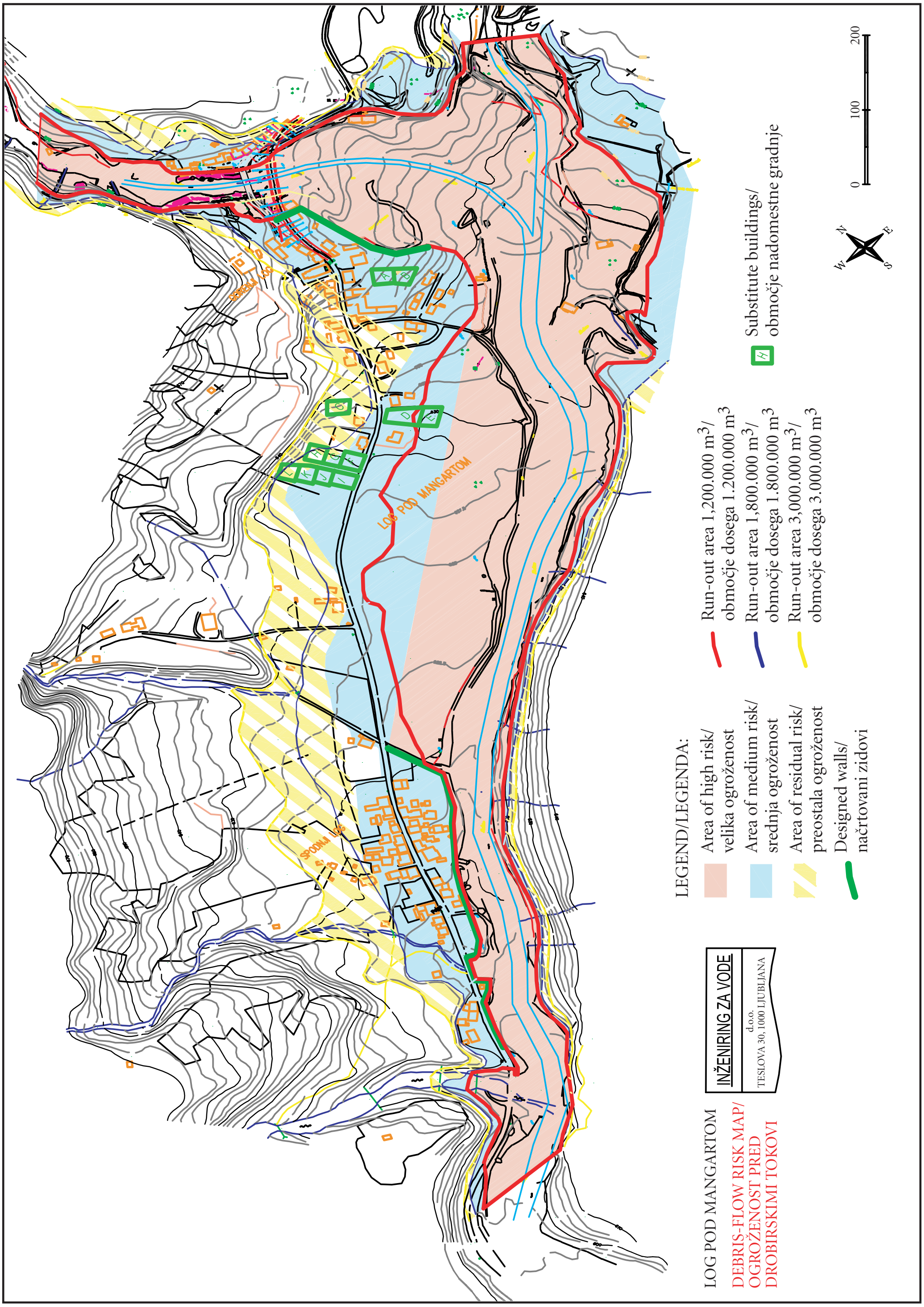

Figure 7: Debris flow risk map of Log Mangartom threatened by the Stože landslide, with run-out areas of debris flows shown, and classification into risk areas, originally given in a scale of 1 : 2000 (IZV 2004).

Figure 8: View of Gorenji Log with shown substitutional buildings under construction in 2006, September 9, 2006. The substitutional buildings are designated with arrows, built until 2006. Special construction conditions for single buildings (marked) are given in Table 4.

buildings for communities, which are hard to evacuate; storage of toxic substances; production sites with large storage of toxic sites and waste dumps) and infrastructures (urban supply and electricity lines), and for different kinds of land use, that is, for agricultural areas and leisure areas (Table 3).

For new buildings, expansions and renovations of the existing residential and vulnerable buildings, the preparation of detailed building conditions has been planned, in line and in the sense of the general guidelines. In this sense, the legislator proposed to prepare, within 1 year, detailed building conditions for the area of Log pod Mangartom for the planned locations of the building from the detailed plan (Uredba 2003a). These detailed conditions (Table 4) were prepared for locations of substitutional buildings, to be built in 2007 (Figure 8).

Table 4: An overview of special construction conditions for single substitutional buildings in Log pod Mangartom that were under construction in 2006. Buildings signs and their locations are given in Figure 9.

Building	Special construction conditions
A, B	Levee for preventing debris flow to overspill (detailed plan)
A, B, D, E, F, G, H, I, J, K, L	If the basement is planned it should be made of reinforced concrete and not brick or stone
A, B, D, E, F, G, H, I, J, K, L	A minimum level of the top of the basement and the building foundations is prescribed with regard to the building location
A, B, D, E, F, G, H, I, J, K, L	The building foundations should be made of reinforced concrete
D, E, F, G, H, I, J, K, L	Raising of the terrain with an adequate inclination for gravitational drainage
C	No special conditions

6 Conclusion

Table 5: Overview of construction conditions for buildings and civil engineering works in the area of Log pod Mangartom (Uredba 2004; Table 1, Annex 5) for areas of high (HR), medium (MR) and low risk (LR) (»+« – construction of buildings is permitted, »cp« – construction of buildings is permitted if the water consent is given in acquiring building permission, »–« construction is prohibited).

CC.SI	ITEM	HR	MR	LR
1	BUILDINGS			
11	Residential buildings			
111	One-dwelling buildings	–	cp	+
112	Two- and more dwelling buildings	–	cp	+
113	Residences for communities	–	–	cp
12	Non-residential buildings			
121	Hotels and similar buildings	–	cp	cp
122	Office buildings	–	cp	cp
12301	Wholesale and retail trade buildings	–	cp	cp
12303	service stations	–	–	cp
12304	buildings mainly used for other purposes	–	cp	+
1241	Communication buildings, stations, terminals and associated buildings	–	–	cp
1242	Garage buildings	–	cp	cp
1251	Industrial buildings	–	–	cp
1252	Reservoirs, silos and warehouses	–	cp	cp
1261	Public entertainment buildings	–	–	cp
1262	Museums and libraries	–	–	cp
1263	School, university and research buildings	–	–	cp
1264	Hospital or institutional care buildings	–	–	cp
1265	Sports halls	–	–	cp
12711	Farm buildings for agriculture farming	–	+	+
12712	Farm building for animals	–	+	+
12713	Storage buildings	–	cp	+
12714	Other non–residential buildings	–	cp	+
12721	Buildings used as places of worship and for religious activities	–	–	+
12722	Cemeteries and associated constructions	–	–	+
12730	Historic or protected monuments	+	+	+
12740	Other buildings not elsewhere classified	–	–	+
2	CIVIL ENGINEERING WORKS			
21	Transport infrastructures			
21110	Highways, streets and roads	cp	cp	cp
21120	Streets inside towns and villages, country roads and pathways, and forests tracks (excluding parkings)	cp	+	+
21120	Parkings	cp	cp	+
21410	Bridges and elevated highways	cp	cp	cp
21520	Dams and other waterworks	cp	cp	cp
22	Pipelines, communication and electricity lines			
22122	Pumping, filtering and catchment stations	cp	+	+
22130	Long-distance telecommunication lines	–	cp	+
22221	Local supply pipelines for potable and technological water	cp	+	+
22231	Local waste water pipelines	cp	cp	+
22232	Waste water treatment plants	cp	cp	+
22240	Local electricity and telecommunication cables	cp	cp	+
24	Other civil engineering works			
24110	Sports grounds	cp	cp	+
24120	Other sport and recreation constructions	cp	cp	+
24201	Military engineering works	–	–	+
24202	Constructions for the protection against harmful effects of water in endangered areas	cp	cp	cp
24203	Waste dumps	–	–	–
24204	Cemeteries	–	–	+
24205	Other civil engineering works not elsewhere classified	–	cp	cp

Note: description of types of buildings, given in the first column of the table, are in accordance with the unified Classification on Types of Construction (Uredba 2003b).

Based on the expert bases and on the Waters Act (Zakon 2002b) the Decree on the conditions and limitations of construction in the area of Log pod Mangrtom, threatened by the debris flow phenomenon (Uredba 2004) was adopted. This decree is the first of its kind in Slovenia.

Based on the Waters Act (Zakon 2002b) the Government of the Republic of Slovenia may define restrictions to land use in areas threatened by landslides, if such land use would pose a threat to people's lives and their belongings. In order to reduce the debris flow damage to an acceptable level, the area of Log pod Mangartom has undergone an objective assessment of the debris flow risk, which may present a threat to buildings in the vicinity of its flow, therefore, a special Decree (Uredba 2004) has defined building conditions and conditions of other land use in the immediate proximity of the potentially occurring debris flow.

Table 6: Construction conditions of basic (simple) buildings in the area of Log pod Mangartom (Uredba 2004; Table 2 in Annex 5) (see key to symbols in Table 5).

	Construction OF BASIC (SIMPLE) BUILDINGS	HR	MR	LR
1	Auxiliary buildings for own needs:			
	a) pool, woodshed, jutting roof, shed, summerhouse	+	+	+
	b) garage, conservatory, reservoir up to 5 m^3	–	+	+
2	Auxiliary infrastructures:			
	a) auxiliary roads, except road drainage and toll stations, auxiliary railway buildings, except railway lines drainage, auxiliary cable railways, auxiliary electric power distribution lines, except transformer stations, auxiliary telecommunication lines, auxiliary local pipelines and cables, except small waste water treatment plants and reservoirs of separately collected fractions of waste	–	+	+
	b) road drainage, toll station, except railway lines drainage, transformer stations, small waste water treatment plants, reservoirs of separately collected fractions of waste, auxiliary airport buildings and auxiliary border-crossing buildings	–	+	+
3	Auxiliary buildings for agriculture and forestry:			
	a) beehive, forest trail, forest road, forest educational road, skidding trail, forest cableway, field route	+	+	+
	b) granary, hay-rack, farm shed, barn, cesspit, cesspool up to 150 m^3, greenhouse, fish pond, silos	–	+	+
4	Temporary buildings for seasonal tourist services, events and storage	+	+	+
5	Training grounds for sports and out-door recreation:			
	a) grounds for sports and recreation, cycling trail, mountain trail, ski slope, foot trail, running course, runway	+	+	+
	b) pier, shooting range	–	+	+
6	Training grounds for military protection and relief exercise	–	–	cp
7	Monument	+	+	+
8	Urban equipment: roofed waiting area, public bicycle shed, public phone booth, advertising installation, boards, sculpture, spatial installation, multi-purpose stall/stand, makeshift sanitary unit and well	–	+	+

The restrictions from the Decree (Tables 5 and 6) have to be considered in any type of construction in areas under risk, whereby the protection against debris flow is divided into three levels, according to the magnitude of risk in the area, that is, into areas of high, medium, and low risk.

The detailed plan for the impacted area of the Stože landslide in the Bovec Municipality (Uredba 2003a) further defines the activities and buildings necessary for reduction of risk and setting-up of the appropriate infrastructure in the area of Log pod Mangartom (different water management measures, such as engineering works within the Stože landslide, debris flow breaker above Gorenji Log, expansion and deepening of the Predelica channel and making of low protection walls in Gorenji and Spodnji Log; traffic and bridging structures; waste dumps, urban supply and electricity lines in the area of Log pod Mangartom).

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Določitev ogroženega območja v Logu pod Mangartom zaradi drobirskih tokov s plazu Stože

UDK: 551.435.6(497.4Log pod Mangartom)
COBISS: 1.01

IZVLEČEK: Članek prikazuje primer določanja ogroženega območja v vasici Log pod Mangartom v dolini reke Koritnice zaradi delovanja možnih drobirskih tokov, ki se lahko v prihodnosti sprožijo na pobočju Stože nad Mangartsko planino. Na podlagi terenskih in laboratorijskih raziskav o drobirskem toku, ki je 17. 11. 2000 opustošil dolino reke Koritnice, smo določili možne scenarije proženja novih drobirskih tokov na pobočju Stože. Za določitev nevarnega območja v dolini reke Koritnice zaradi delovanja drobirskih tokov smo uporabili rezultate enodimenzijskega in dvodimenzijskega modeliranja izbranih drobirskih tokov znane magnitude in različne konsistence. Za določitev ogroženega območja smo upoštevali še obstoječo in možno novo infrastrukturo ter ogroženo območje razdelili v tri cone. Članek predstavlja strokovne podlage, ki jih je zakonodajalec povzel v ustrezni uredbi Vlade Republike Slovenije o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ogroženem zaradi pojava drobirskih tokov. Omenjena uredba je prvi tovrstni akt, sprejet v Republiki Sloveniji.

KLJUČNE BESEDE: pobočni masni premiki, drobirski tokovi, ocena nevarnosti, ocena ogroženosti, ogroženo območje, preventivno varstvo, zakonodaja, pogoji gradnje

Uredništvo je prejelo prispevek 11. septembra 2006.

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Vsebina

1 Uvod

V članku predstavljamo strokovne podlage in vsebino uredbe o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ki je po katastrofalnem drobirskem toku 17. 11. 2000 še naprej ogrožen zaradi morebitnih novih drobirskih tokov s pobočja Stož nad Mangartsko planino.

Vasico Log pod Mangartom je 17. 11. 2000 prizadel drobirski tok z magnitudo 1,2 milijona m^3. Posredovanju enot Civilne zaščite ob dogodku in v dnevih ter tednih po tej naravni nesreči (Ušeničnik 2000/2001) je takoj sledila sanacija opustošenega območja (Majes 2000/2001). Sanacija se je najprej izvajala po dveh posebnih zakonih, ki ju je sprejel Državni zbor RS (Zakon 2000; 2002a), v katerih so bili določeni interventni in drugi ukrepi za sanacijo območja ter način njihove izvedbe in financiranje. Dokončna sanacija območja še ni končana in se bo izvedla skladno s sprejetim lokacijskim načrtom za vplivno območje plazu Stože v občini Bovec (Uredba 2003a). Vzporedno s sprejemanjem lokacijskega načrta za dokončno sanacijo smo pripravili strokovne podlage, zakonodajalec pa je na tej podlagi sprejel »Uredbo o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ogroženem zaradi pojava drobirskih tokov« (Uredba 2004). Omenjena uredba je bila sprejeta v skladu z Zakonom o vodah (Zakon 2002b) in je končni pravni akt, katerega namen je postopno zagotavljanje višje stopnje preventivnega varstva Loga pod Mangartom pred možnim delovanjem novih drobirskih tokov s plazu Stože.

Tudi iz prakse drugih alpskih držav sledi, da je poglavitni namen razglasitve nekega območja za ogroženo območje prav uporaba takega dokumenta v postopkih prostorskega načrtovanja. Iz praktičnih izkušenj vemo, da se pred nevarnostjo delovanja pobočnih masnih premikov, kamor uvrščamo drobirske tokove, pogosto ni možno varovati samo z varstvenimi (gradbenimi) objekti ali varnostnimi (preventivnimi) ukrepi (Mikoš 1997). Tako naj vseeno še naprej velja že v preteklosti prakticirana maksima: rabe prostora se morajo prilagoditi naravnim danostim. To je možno doseči tudi tako, da se zmanjšuje škodni potencial (ranljivost) v prostoru, in sicer s pomočjo prostorsko-načrtovalskih ukrepov, ki podpirajo trajnostni razvoj (Komac, Zorn 2005). Pregled stanja v Sloveniji (Đurović, Mikoš 2004; Komac, Zorn 2005) kaže, da Slovenija pri uresničevanju preventivnega varstva pri rabi prostora zaostaja za drugimi alpskimi državami.

Na nevarnih območjih zaradi delovanja naravnih geoloških pojavov zmanjšujemo raven tveganja za obstoječo rabo prostora s pomočjo gradbeno-tehniških ukrepov, če je to racionalno in se taka raba ne more opustiti. Že v preteklosti se je človek boril za preživetje na svoji zemlji in je ravnal v sozvočju z naravnimi zakonitostmi. Kljub temu ni mogel preprečiti vseh nesreč, ki ga tudi niso odvrnile, da bi se izselil iz nevarnih območij. Prav za tak primer gre v Logu pod Mangartom, kjer prebivalci že stoletja kljubujejo nevarnim naravnim pojavom poplav in plazov ter zato razselitev tako velikega naselja ob pomembni cestni povezavi nima nobenega smisla. Sprejemljivo je le delno preoblikovanje naselja, kjer se najbolj ogroženi objekti umaknejo in se naselje razvija v bolj strnjeni obliki. Taka prostorska usmeritev je bila podlaga za sprejem »Uredbe o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ogroženem zaradi pojava drobirskih tokov« (Uredba 2004). Osnovno vprašanje pri tem je bilo, kam bomo umaknili obstoječo infrastrukturo in kje načrtovali novo.

V prispevku najprej na kratko opisujemo dogodek novembra 2000 v Logu pod Mangartom, ki je bil osnova za izdelavo ocene nevarnosti naselja zaradi možnega delovanja novih drobirskih tokov v prihodnosti. V nadaljevanju opisujemo izbrane scenarije nastanka možnih novih drobirskih tokov na plazu Stože in strnjeno prikažemo rezultate matematičnega modeliranja za izbrane primere razlivanja drobirskega toka v Logu pod Mangartom. Opisa matematičnega modeliranja ne podajamo, saj smo ga podrobno prikazali že v drugih prispevkih. Prispevek zaključujemo s strokovnimi osnovami za omenjeno »Uredbo o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ogroženem zaradi pojava drobirskih tokov« (Uredba 2004), ki je s prikazom ogroženega območja v Logu pod Mangartom postala osnova za prostorsko načrtovanje.

2 Drobirski tok v Logu pod Mangartom novembra 2000

Drobirski tok s pobočja Stože v hudourniškem območju Predelice je 17. 11. 2000 razdejal dolino reke Koritnice, značilne ozke alpske doline v zahodni Sloveniji. Šlo je za največji tovrstni pojav v 20. stoletju v Sloveniji. Prek 1 milijon m^3 splazelega drobirskega materiala je iz območja plazu Stože kot mokri drobirski tok steklo skozi ozko hudourniško dolino Predelice v 4 km oddaljeno vasico Log pod Mangartom in naprej po dolini reke Koritnice (Zorn, Komac 2002).

Drobirski tok je iz struge Mangartskega potoka dosegel vasico v nekaj minutah, usmrtil sedem prebivalcev v njihovih domovih, uničil ali poškodoval 29 stanovanjskih in gospodarskih stavb ter prekril skoraj 15 ha kmetijskih površin (Majes 2000/2001). Ob neugodni geološki sestavi tal na pobočju Stože (Majes 2000/2001; Petkovšek 2000/2001) je hidrološka analiza dogodka pokazala, da je bil glavni sprožilni dejavnik dogodka v novembru 2000 obilno in dolgotrajno deževje v relativno topli jeseni brez snežnih padavin pod 1800 m n. m. (Mikoš in ostali 2002c; 2004a). Tako je bilo v padavinski postaji Log pod Mangartom izmerjeno v 46 dneh pred dogodkom (pred 17. 11. 2000) skupaj 1638,4 mm padavin (preglednica 1), kar ustreza povratni dobi prek 100 let. Tu velja omeniti bistveno razliko med dogodkom v Logu pod Mangartom (maksimalna dnevna padavina 174,0 mm, izmerjena 12. 10. 2000, s povratno dobo 2 let) in pojavljanjem plitvih zemljinskih plazov, ki jih sprožajo intenzivne kratkotrajne padavine (Caine 1980; Crosta 1998; Komac 2005 – analiza ob uporabi maksimalnih dnevnih padavin s povratno dobo 100 let).

Slika 1: Razlivanje drobirskega toka v Logu pod Mangartom 28. novembra 2000. Pritok hudournika Predelica v smaragdno Koritnico.
Glej angleški del prispevka.

Preglednica 1: Primerjava med merjenimi padavinami (mm) jeseni 2000 na padavinski postaji Log pod Mangartom in statističnimi vrednostmi (referenčno obdobje meritev 1961–1990), podanimi za različne povratne dobe (Mikoš in ostali 2002c; 2004a).

merjene vrednosti				
padavine (mm)	obdobje			
174,0	12. 10. 2000 (1 dan)			
481,6	11. 11.–17. 11. 2000 (7 dni)			
1042,7	18. 10.–17. 11. 2000 (1 mesec)			
1638,4	03. 10.–17. 11. 2000 (46 dni)			
1666,4	18. 09.–17. 11. 2000 (2 meseca)			
statistične vrednosti				
povratna		trajanje		
doba (leta)	1 dan	7 dni	1 mesec	2 meseca
2 leti	170	359	496	756
5 let	226	453	684	1018
10 let	263	515	808	1192
25 let	309	594	966	1411
50 let	344	652	1082	1574
100 let	378	710	1198	1735

V času drobirskega toka 17. 11. 2000, se je okoli 400.000 m^3 drobirskega materiala odložilo vzdolž toka gorvodno od dolinskega dna reke Koritnice in okoli 700.000 m^3 na samem dolinskem dnu. Mestoma je debelina odloženega drobirja dosegla 10 m. Log pod Mangartom je bil izpostavljen visokim vodam Predelice in Koritnice in morebitnim novim drobirskim tokovom. Zato je bila spomladi leta 2001 izdelana zasnova začasnih inženirskih ukrepov, ki naj bi pospeševali naravne rečne erozijske procese in povečevali poplavno varnost Loga pod Mangartom. Odločitev je temeljila na presoji, da glede na sprožilne dejavnike dogodka 17. 11. 2000 neposredne nevarnosti za ponovni drobirski tok v Logu pod Mangartom ni. Osnovno vodilo pri predlogu nove ureditve strug vodotokov na območju Loga pod Mangartom je bilo najti ekološko sprejemljivo in finančno izvedljivo rešitev, ki bi zagotavljala varnost naselja in infrastrukture v primeru delovanja novega drobirskega toka, splazelega s plazu Stože enake prostornine, kot jo je imel drobirski tok 17. 11. 2000. Presoja o možnem ponovnem drobirskem toku s plazu Stože je temeljila na geotehničnih raziskavah plazu Stože, ko so z vrtanjem zaledja plazu nad odlomnimi robovi do sedla na državni meji z Italijo potrdili prisotnost okoli treh milijonov m^3 materiala, ki se lahko utekočinijo in oblikujejo drobirski tok (Petkovšek 2002).

Obenem je morala ureditev strug vodotokov zagotoviti tudi poplavno varnost pred 100-letno visoko vodo (77 m^3/s za hudournik Predelico in 211 m^3/s za reko Koritnico; Mikoš in ostali 2002a), pri čemer je bilo treba nove struge oblikovati v lokalno do prek 10 m debelo plast odloženega drobirja.

Struge vodotokov so bile v prečnem prerezu in podolžnem profilu oblikovane z uporabo gradbene mehanizacije tako, da je bila zagotovljena maksimalna hidravlična prevodnost in ni bilo treba opraviti obsežnega mehanskega odstranjevanja drobirja. Rešitev, ki se je neposredno po naravni nesreči zdela mikavna in edina možna, namreč popoln in hiter odkop vseh odkladnin in njihovo deponiranje na umetni deponiji, ni našla ustrezne strokovne podpore v postopkih priprave sanacije opustošenega območja. Poglavitna ovira je bilo pomanjkanje ustreznega prostora v dolini Koritnice kakor tudi želja po čim bolj naravnem izgledu Predelice in Koritnice, ki tečeta v Triglavskem narodnem parku. Predlagana inženirska zasnova se je izkazala kot zelo uspešna, saj se je v petih letih po dogodku iz dolinskega dna reke Koritnice z naravnim spiranjem in odnašanjem odplavila že več kot polovica odloženega drobirja (slika 2; Mikoš, Fazarinc 2005).

Slika 2: Časovni razvoj značilnega prečnega prereza reke Koritnice po drobirskem toku novembra 2000 (navpična ločljivost je 1 m) (Mikoš, Fazarinc 2005).

Glej angleški del prispevka.

Slika 3: Zrnavostna krivulja vzorcev drobirskega toka v Logu pod Mangartom (Mikoš in ostali 2002a).

Glej angleški del prispevka.

Strokovne podlage za inženirsko zasnovo ureditve so bili rezultati hidrološke analize (Mikoš in ostali 2004b), analize zrnavostne sestave vzorcev drobirskega toka (slika 3), ocena premestitvene zmogljivosti za plavine v pretočnih prerezih Predelice in Koritnice (Mikoš in ostali 2004a), ter rezultati simulacij gibanja drobirskih tokov s pomočjo matematičnega modeliranja (Četina in ostali 2006).

3 Modeliranje drobirskega toka novembra 2000

Za ocenjevanje nevarnosti delovanja drobirskih tokov se pogosto uporablja kombinacija enodimenzijskega modela (opis potovanja drobirskega toka od območja izvora vzdolž strmih in/ali ozkih korit) in dvodimenzijskega modela (opis gibanja v območju odlaganja: vršaji ali dolinska dna) (Mikoš in ostali 2006). Taka praksa se je pokazala kot primerna tudi v primeru modeliranja drobirskega toka v Logu pod Mangartom. Uporabili smo različne matematične modele: enodimenzijski model (nekomercialni model DEBRIS1D) in dva dvodimenzijska modela (komercialni FLO-2D, nekomercialni PCFLOW2D). Umerjanje in verifikacijo vseh treh modelov smo izvedli na podlagi primerjave računskih rezultatov z rezultati terenskih meritev po drobirskem toku novembra 2000 ter na osnovi primerjave računskih rezultatov obeh dvodimenzijskih modelov (Fazarinc 2002; Četina in ostali 2006).

Simulacije gibanja drobirskega toka različnih lastnosti s pobočja Stože v geometrijskih pogojih novembra 2000 pred dogodkom 17. 11. 2000 (Četina in ostali 2006) so potrdile maksimalne hitrosti čela drobirskega toka, ki so bile ocenjene na več kot 10 m/s v strmem in ozkem koritu hudournika Predelica in na 3 do 5 m/s v odprtem dolinskem dnu v strugi reke Koritnice (Mikoš 2000/2001; Fazarinc 2002). Razdiralna sila drobirskega toka v Logu pod Mangartom je bila posledica visokih hitrosti gibanja čela in visoke gostote toka (2000–2200 kg/m^3). Zato je v preventivnem smislu nujna gradnja stavb in občutljivih inženirskih objektov zunaj dosega drobirskega toka.

Leta 2001 predlagani glavni varstveni objekti med plazom Stože in Logom pod Mangartom (dve zemeljski nasuti pregradi, dva armiranobetonska razbijača drobirskega toka) so bili kasneje v postopku sprejemanja lokacijskega načrta (Uredba 2003a) spremenjeni in tako je bila predlagana le gradnja tako imenovanega razbijača drobirskega toka v strugi Predelice tik nad Gorenjim Logom. Opustitev ostalih, prvotno predlaganih ukrepov je zahtevala prilagoditev drugih ukrepov, predvsem oblikovanja struge Predelice na območju pod razbijačem drobirskega toka do sotočja s Koritnico. Rezultati umerjenega dvodimenzijskega matematičnega modela so pokazali, da za varnost Gorenjega Loga ne zadošča zgolj odkop odloženega drobirja iz struge Predelice do starega dna pred 17. 11. 2000. Zato smo umerjene modele gibanja drobirskih tokov uporabili za optimizacijo predlagane zasnove ureditve strug Predelice in Koritnice (Fazarinc in ostali 2006). Modeliranje je kot možne ukrepe upošteval posege v ozko grlo, to je v ožino v strugi Predelice tik nad in ob montažnem mostu v Gorenjem Logu:

- usmerjevalni zid na desnem bregu Predelice za preprečitev prelitja drobirskega toka v Gorenji Log;
- razširitev in glajenje ozkega prečnega prereza iz obstoječih 24–28 m na enakomerno širino 33 m, 40 m oziroma 48 m, za znižanje gladin drobirskega toka in izboljšanje vpliva razbijača drobirskega toka (slika 4).

Slika 4: Pogled v smeri toka na 11,5 m visok razbijač drobirskega toka, zgrajen iz armiranega betona, dokončan pozimi leta 2005 približno 150 m gorvodno od začasnega mostu v Gorenjem Logu na gorvodnem robu ožine hudournika Predelica.
Glej angleški del prispevka.

Razbijač drobirskega toka zmanjša kinetično energijo drobirskega toka in zadrži grobe frakcije drobirskega toka ter tako spremeni reološke značilnosti toka pod razbijačem.

Slika 5: Prečni prerez novega armiranobetonskega cestnega mostu v Gorenjem Logu (pogled proti toku). Označene so tudi računske gladine drobirskih tokov različne konsistence (povzeto po Fazarinc in ostali 2006).
Glej angleški del prispevka.

Kot optimalna rešitev na območju montažnega cestnega mostu v Gorenjem Logu se je izkazala razširitev ožine na enakomernih 40 m. Prevelika razširitev (celo do 48 m) bi zaradi velikega momenta drobirskega toka v ovinku povečala možnost preplavitve desne brežine. Rešitev s širitvijo ožine je ugodnejša od izgradnje usmerjevalnega zidu na desnem bregu, ki je bil predlagan kot idealna rešitev (Horvat 2000/2001), vendar bi zaradi svoje višine zelo otežil novo premostitev na tem mestu (slika 6).

Slika 6: Pogled na novi armiranobetonski most v Gorenjem Logu 9. septembra 2006 (pogled proti toku, primerjaj izvedeni most z zasnovo na sliki 5).
Glej angleški del prispevka.

4 Določitev vplivnega območja delovanja drobirskih tokov v Logu pod Mangartom

Če primerjamo magnitudo (skupna prostornina 1,2 milijona m^3) drobirskega toka s pobočja Stože novembra 2000 s podobnimi primeri, dokumentiranimi v Alpah (van Steijn 1996), ga lahko uvrstimo v skupino dogodkov »zelo velike magnitude«. Čeprav povratne dobe tovrstnih pojavov iz zgodovinskih podatkov ni enostavno določiti, je možno v primerjavi s podatki iz alpskega prostora približno oceniti dogodek novembra 2000 v Logu pod Mangartom na dogodek s povratno dobo nekaj 100 let. Tako oceno potrjuje Jakobova (2005) klasifikacija drobirskih tokov, ki uvršča drobirski tok v Logu pod Mangartom v razred 5, v katerem so skalnati drobirski tokovi zelo redki (velika povratna doba). Razred 5 te klasifikacije, ki pozna velikostne razrede od 1 do 10, je določen z vrednostmi parametrov, kot sledi:
- magnituda drobirskega toka je 10.000÷1.000.000 m^3 (Log pod Mangartom: 1.200.000 m^3);
- maksimalni pretok drobirskega toka je 1.500÷12.000 m^3/s (Log pod Mangartom: 7.000÷8.000 m^3/s, Fazarinc in ostali 2006);

površina odkladnin drobirskega toka je 4÷20 ha (Log pod Mangartom: 15 ha).

Táko oceno povratne dobe dogodka novembra 2000 v Logu pod Mangartom potrjuje tudi ocena magnitud drobirskih tokov, sproženih ob padavinah, v izbranih hudourniških območjih v Sloveniji (Sodnik, Mikoš 2006). V tej analizi se je pokazalo, da dogodek v Logu pod Mangartom izrazito odstopa od ocenjenih magnitud potencialnih drobirskih tokov v drugih obravnavanih hudourniških območjih v Sloveniji.

Ob tem se zastavlja vprašanje, kakšen pomen ima dogodek novembra 2000 za preventivno varstvo tega naselja v prihodnosti. V zadnjih letih je začel v alpskem delu Evrope prevladovati pristop, da izbrano območje varujemo ne samo na dogodke (plazove, poplave) s povratno dobo 100 let, kar je bila praksa v hudourništvu od začetka delovanja te službe na slovenskih tleh leta 1884 (Jesenovec 1995). V primeru ekstremnih dogodkov, ki so zabeleženi v bližnji preteklosti, varujemo prizadeta naseljena območja po končani sanaciji na dogodke enake magnitude. To velja tudi, če je povratna doba ekstremnih dogodkov pogosto precej večja kot 100 let. V Švici sprejet način delitve ogroženih območij zaradi poplav upošteva tudi 300 letno povratno dobo (BUWAL 1998).

Vprašanje povratne dobe ekstremnega dogodka je v sodobnem svetu v želji po trajnostnem razvoju vse bolj postavljeno v ozadje, v ospredje pa se postavlja vprašanje, s kakšno verjetnostjo mora računati uporabnik prostora na škodo v času določenega obdobja rabe oziroma vprašanje, kako nevaren je nek kraj. Verjetnost nastopa nevarnega dogodka in njegova povratna doba se lahko številčno povežeta, v kolikor izhajamo iz enotnega obdobja rabe. Enačba se glasi:

$$p = 1 - \left(1 - \frac{1}{T}\right)^n, \qquad (1)$$

T je povratna doba in p je verjetnost nastopa nekega dogodka s povratno dobo T v obdobju rabe n. Če privzamemo kot čas obravnave n = 30 let (obdobje ene generacije), je verjetnost, da nastopi 30-letni dogodek (T = 30 let) enaka p = 63,83 %, za 100-letni dogodek (T = 100 let) enaka p = 26,03 % in za 300-letni dogodek (T = 300 let) je p = 9,53 %. Preračun verjetnosti nastopa p v obravnavanem obdobju rabe n jasno pokaže, da tudi pri relativno dolgi povratni dobi ekstremnega dogodka (npr. T = 300 let) preostali rizik p ni zanemarljiv (preglednica 2). To je tudi razlog, da smo za modeliranje drobirskega toka uporabili razen ponovitve toka s prostornino 1,2 milijona m^3 tudi scenarij s prostornino 1,8 milijona m^3 in sicer v želji zmanjšati preostali rizik za Log pod Mangartom kljub sicer ocenjeni visoki povratni dobi tovrstnega dogodka (nekaj 100 let). Seveda tega ne bi bilo smiselno storiti, če ne bi geološke raziskave pobočja Stože pokazale, da je na pobočju še vedno na razpolago okoli 3 milijone m^3 materiala, ki se lahko utekočini in steče v obliki drobirskega toka.

Preglednica 2: Izračun preostalega rizika p za nastop nevarnega dogodka z znano povratno dobo T za primer obdobja rabe n = 50 let.

povratna doba T	preostali rizik p za n = 30 let	preostali rizik p za n = 50 let
1 do 30 let	100 % do 63,83 %	100 % do 81,64 %
30 do 100 let	63,83 % do 26,03 %	81,64 % do 39,50 %
100 do 300 let	26,03 % do 9,53 %	39,50 % do 15,38 %

Ogroženost območja Loga pod Mangartom od soteske Predelice nad Gorenjim Logom do izliva Kotline v Koritnico pod Spodnjim Logom smo določili na podlagi računskih simulacij gibanja drobirskega toka z uporabo umerjenih matematičnih modelov in ob upoštevanju različnih scenarijev. Pri simulacijah gibanja drobirskega toka smo kot scenarij upoštevali kombinacijo različnih prostornin aktiviranega drobirskega toka, različnih reoloških lastnosti drobirskega materiala ter obstoječo in načrtovano geometrija ureditve vodotokov (Fazarinc 2002; Četina in ostali 2006).

V računu smo upoštevali različne reološke značilnosti drobirskega toka:

- drobirski tok ima enake značilnosti kot tok 17. 11. 2000,
- tekoči drobirski tok z nižjimi vrednostmi viskoznosti in mejne strižne trdnosti (značilnosti vode s povečano prostorninsko težo),
- zmerno suh drobirski tok z višjimi vrednostmi viskoznosti in mejne strižne trdnosti ter
- zelo suh drobirski tok z vrednostmi viskoznosti in mejne strižne trdnosti, kot so upoštevane pri prvem drobirskem toku, ki se je 15. 11. 2000 ustavil v strugi Mangartskega potoka. Ribičič (2000/2001) je ta predhodni dogodek ocenil kot prvo fazo katastrofalnega drobirskega toka 17. 11. 2000.

Pri računu smo upoštevali geometrijo, pri kateri smo za območje Koritnice in Predelice do mostu v Gorenjem Logu upoštevali ustrezni idejni projekt (VGI 2002). Pri ureditvi Predelice smo na območju mostu upoštevali izkop do starega dna hudournika pred plazom 17. 11. 2000. Od montažnega mostu do armiranobetonskega razbijača drobirskega toka smo upoštevali širitev ožine Predelice na povprečno širino 40 m. Poleg tega smo pri simulacijah na območju Gorenjega Loga na levem bregu nad mostom in desnem bregu pod mostom ter na območju Spodnjega Loga upoštevali nizke zidove ali nasipe, ki preprečujejo razlivanje drobirskega toka na urbana območja Gorenjega in Spodnjega Loga. Na območju mostu v Gorenjem Logu smo upoštevali načrtovano linijo in višino opornikov novega mostu ter zvišanje terena na desnem bregu nad mostom.

Linije dosega čela drobirskega toka za vsako od izbranih 3 prostornin smo določili kot zunanjo ovojnico najmanj ugodnih rezultatov simulacij glede na izbiro reoloških značilnosti drobirskega materiala in uporabljenih dveh dvodimenzijskih simulacijskih računalniških programov.

Coniranje ogroženega območja zaradi drobirskega toka s pomočjo linij dosega je podalo štiri območja:

- Območje I – območje določa doseg drobirskega toka pri ponovitvi dogodka 17. 11. 2000 (magnituda drobirskega toka je 1,2 milijona m^3). To območje predstavlja neposredno ogroženo območje velike stopnje ogroženosti, ker je pojav v tem območju rušilen in zaradi večje verjetnosti nastopa takega dogodka.

Znotraj tega območja ni možna gradnja stanovanjskih in drugih objektov. Pod posebnimi pogoji je dopustna gradnja infrastrukturnih objektov. To območje je na sliki 7 prikazano kot območje velike ogroženosti.

- Območje II – v območje je razvrščeno območje dosega drobirskega toka, ki bi nastal kot posledica drobirskega toka z magnitudo 1,8 milijona m^3 (povečana prostornina toka zaradi zmanjševanja preostalega rizika) in kjer je globina simuliranega drobirskega toka večja kot 1 m. Območje predstavlja posredno ogroženo območje srednje stopnje ogroženosti, ker lahko takšen pojav poškoduje objekte v tem območju. Verjetnost nastopa takšnega pojava je manjša v primerjavi s pojavom s prostornino 1,2 milijona m^3. Na tem območju se ohranja obstoječa pozidava. Možne so rekonstrukcije in adaptacije, izgradnja novih stanovanjskih objektov ni možna. Z dodatnimi posrednimi ukrepi je na tem območju možno zmanjšati posredno ogroženost. To območje je na sliki 7 prikazano kot območje srednje ogroženosti.
- Območje III – v to območje je razvrščeno območje dosega drobirskega toka, ki bi nastal kot posledica drobirskega toka s prostornino 1,8 milijona m^3 in kjer je globina simuliranega drobirskega toka manjša kot 1 m. To območje je še vedno razvrščeno v posredno ogroženo območje, vendar manjše stopnje ogroženosti, kjer pojav ob gradnji pod posebnimi pogoji ne poškoduje objektov. Na območju III je možna novogradnja z upoštevanjem posebnih pogojev. To območje je na sliki 7 razvrščeno v območje preostale ogroženosti.
- Območje IV – to je območje zunaj dosega drobirskega toka, ki bi nastal kot posledica drobirskega toka z magnitudo 1,8 milijona m^3 in znotraj dosega drobirskega toka z magnitudo 3 milijone m^3. Območje je realno varno območje pred drobirskimi tokovi. Pozidava je možna brez posebnih pogojev glede ogroženosti pred drobirskimi tokovi. Vendar lahko ta območja ogrožajo drugi nevarni naravni pojavi, kot na primer snežni plazovi, potresi, splazitve zemljin ali kamninski podori. Ob izdelavi lokalnih prostorskih aktov (občinskega reda) je treba nevarnost teh pojavov verjetnostno in prostorsko opredeliti in na tej osnovi predpisati morebitne dodatne pogoje gradnje. To območje je na sliki 7 razvrščeno v območje preostale ogroženosti v uredbi (Uredba 2004) poimenovano območje majhne ogroženosti).

Za potrebe določanja ogroženega območja v zvezi z gradnjo objektov in druge posege v prostor, zadoščajo območja od I do III. Območje IV je bilo določeno za potrebe načrtovanja zaščite in reševanja v primeru nastopa neposredne nevarnosti, da lahko Civilna zaščita načrtuje smer umika prebivalstva in tehnične opreme na absolutno varno območje.

5 Splošne smernice za načrtovanje rabe prostora z vidika ogroženosti pred drobirskimi tokovi

Zakon o vodah (Zakon 2002b), 83. člen, govori o štirih vrstah ogroženih območjih in predvideva pripravo metodologije za določanje ogroženih območij in način razvrščanja zemljišč v razrede ogroženosti (strokovne podlage so pripravljene – Mikoš in ostali 2004c). Ker ta metodologija še ni bila razvita, je bilo treba pristopiti k določitvi ogroženega območja v Logu pod Mangartom po še neprehojeni poti. Strokovna podlaga za uredbo Vlade RS se je nanašala le na primer ogroženosti zaradi delovanja drobirskega toka s pobočja Stož, ostale vrste nevarnih pojavov, ki opredeljujo ogrožena območja po Zakonu o vodah (Zakon 2002b), v tej strokovni podlagi niso bile upoštevane.

Pri izdelavi karte ogroženosti Loga pod Mangartom smo upoštevali prakso v alpskih državah, da se območja delovanja drobirskega toka razdelijo v 3 razrede (Petraschek, Kienholz 2003). Območje ogroženosti naselja Log pod Mangartom zaradi drobirskega toka s pobočja Stože smo razdelili v tri območja ogroženosti:

- območje velike ogroženosti (območje I),
- območje srednje ogroženosti (območje II) in
- območje preostale ogroženosti (območji III in IV).

Omenjena območja so prikazana na karti ogroženosti zaradi drobirskih tokov Loga pod Mangartom (slika 7). Na tej osnovi se je kot sestavni del uredbe (Uredba 2004) izdelala ustrezna karta v enakem merilu, kjer so grafično prikazane parcele, uvrščene v posamezno območje ogroženosti (Uredba 2004). Uredba je območje preostale ogroženosti poimenovala območje majhne ogroženosti.

Slika 7: Karta ogroženosti območja Loga pod Mangartom zaradi drobirskih tokov s plazu Stože z vrisanimi linijami dosega drobirskih tokov in delitvijo na območja ogroženosti, v originalu izdelana v natančnosti merila 1 : 2000 (IZV 2004).
Glej angleški del prispevka.

Strokovne podlage so tudi obsegale splošne usmeritve (različne zahteve ali opozorila za prilagojeno rabo) za vsako območje ogroženosti, in sicer posebej kot splošne smernice za izdajo gradbenih dovoljenj za stanovanjske objekte, občutljive objekte (bolnice; domovi za starejše občane; vrtci; šole; gostinski objekti; hoteli in podobni objekti, v katerih se zadržuje posebno veliko ljudi in jih je težko evakuirati; skladišča nevarnih snovi; proizvodna mesta z večjimi zalogami nevarnih snovi in deponije) in infrastrukturne naprave (razni komunalni in energetski vodi) ter za različne rabe prostora, in sicer za kmetijske površine in naprave za oddih (preglednica 3).

Preglednica 3: Splošne smernice za prepoved gradnje in za pogoje gradnje objektov v Logu pod Mangartom v vplivnem območju delovanja drobirskih tokov s plazu Stože.

A – območje velike ogroženosti (rdeča cona)
Prepovedana je gradnja vseh stanovanjskih in občutljivih objektov, ki se po Zakonu o graditvi objektov uvrščajo med stavbe in so namenjeni stalnemu zadrževanju oseb. Po možnosti naj se pomožni objekti (kot so garaže, pomožni gospodarski objekti, zavetja za živali, napajališča, seniki) ne gradijo. Gradnja prometnic je dovoljena ob upoštevanju delovanja drobirskega toka. Načrtuje in izvaja naj se podzemna gradnja komunalnih in energetskih vodov. Za rabo kmetijskih površin ni posebnih omejitev. Za parkovne in zelene površine, ki so namenjene oddihu, ni nobenih omejitev. Športne naprave kot npr. teniška ali nogometna igrišča ter atletske naprave so dovoljene. Šotorišča (kamping prostori) so dovoljena, če ne obsegajo zidanih objektov, razen sanitarij, ter če so odprti v času od 1. maja do 1. oktobra.
B – območje srednje ogroženosti (modra cona)
Dovoljuje se novogradnja stanovanjskih objektov ter razširitve in prezidave obstoječih stanovanjskih in občutljivih objektov samo ob upoštevanju posebnih pogojev gradnje. V splošnem veljajo za nove stanovanjske objekte v modri coni naslednji splošni gradbeni pogoji: Objekt naj bo po možnosti tlorisno lociran, da deluje na drobirski tok kot cepilni klin, postavljen naj bo na nasutem terenu, naj ima povišan vhod v objekt, lociran v zatišju glede na smer delovanja drobirskega toka, ter naj bo na strani delovanja drobirskega toka brez odprtin v kletni etaži; Stena objekta, ki je obrnjena v smeri delovanja drobirskega toka, naj bo ustrezno konstrukcijsko oblikovana in dimenzionirana (npr. armirani beton) na udarno delovanje posameznih komponent drobirske mase in na njen zajezni tlak. Notranja razporeditev prostorov v objektu naj upošteva smer delovanja drobirskega toka. V modri coni je prepovedana novogradnja občutljivih objektov. Gradnja prometnic je dovoljena ob upoštevanju delovanja drobirskega toka. Načrtuje in izvaja naj se podzemna gradnja komunalnih in energetskih vodov. Za rabo kmetijskih površin ni posebnih omejitev. Za parkovne in zelene površine, ki so namenjene oddihu, ni nobenih omejitev. Športne naprave kot npr. teniška ali nogometna igrišča ter atletske naprave so dovoljene. Za šotorišča (kamping prostori) ni omejitev.
C – območje preostale ogroženosti (šrafirana rumeno-bela cona)
Za nove stanovanjske in občutljive objekte so splošni gradbeni pogoji, ki veljajo v modri coni, le priporočilo, z namenom da bi preprečili večje materialne škode ob ekstremnih redkih dogodkih. Upoštevanje teh splošnih gradbenih pogojev je prepuščeno investitorju. Posebnih gradbenih pogojev ni. Za rabo kmetijskih površin ni posebnih omejitev. Za parkovne in zelene površine, ki so namenjene oddihu, ni nobenih omejitev. Športne naprave kot npr. teniška ali nogometna igrišča ter atletske naprave so dovoljene. Za šotorišča (kamping prostori) ni omejitev.

Za novogradnje ter razširitve in prezidave obstoječih stanovanjskih in občutljivih objektov se je skladno in smiselno s splošnimi smernicami predvidevala priprava podrobnejših gradbenih pogojev. V tem smislu je zakonodajalec predlagal v roku 1 leta pripraviti podrobnejše pogoje gradnje v območju Loga pod Mangartom za predvidene lokacije objektov iz ureditvenega načrta (Uredba 2003a). Omenjene podrobnejše pogoje (preglednica 4) smo pripravili za lokacije nadomestnih objektov, ki se dogradijo v letu 2007 (slika 8).

Slika 8: Pogled na Gorenji Log z vrisanimi nadomestnimi objekti v gradnji v letu 2006. S puščicami so označeni nadomestni objekti, zgrajeni do leta 2006. Posebni gradbeni pogoji za posamezne označene objekte so podani v preglednici 4.
Glej angleški del prispevka.

Preglednica 4: Pregled posebnih gradbenih pogojev za posamezne nadomestne gradnje v Logu pod Mangartom, ki so se izvajale leta 2006. Oznake objektov in njihova lokacija je vidna na sliki 9.

objekt	posebni gradbeni pogoji
A, B	nasip za preprečitev razlivanja drobirskega toka (lokacijski načrt)
A, B, D, E, F, G, H, I, J, K, L	morebitna klet mora biti armiranobetonska in ne zidana
A, B, D, E, F, G, H, I, J, K, L	predpisana je minimalna kota vrha kletne etaže oziroma temeljev objekta glede na lokacijo objekta
A, B, D, E, F, G, H, I, J, K, L	temelji objekta morajo biti armiranobetonski
D, E, F, G, H, I, J, K, L	nasipavanje terena z ustreznim naklonom za težnostno odvodnjavanje
C	ni posebnih pogojev

6 Sklep

Na temelju opisanih strokovnih podlag in Zakona o vodah (Zakon 2002b) je bila sprejeta »Uredba o pogojih in omejitvah gradnje na območju Loga pod Mangartom, ogroženega zaradi pojava drobirskih tokov« (Uredba 2004). To je prvi tovrstni akt sprejet v Republiki Sloveniji.

Vlada Republike Slovenije sme na podlagi Zakona o vodah (Zakon 2002b) določiti na plazljivih območjih omejitve rabe prostora, če so te rabe take, da bi bila zaradi nevarnosti delovanja zemeljskih plazov ogrožena življenja ljudi ali njihovo premoženje. Ker je na območju naselja Loga pod Mangartom objektivno določena nevarnost nastanka drobirskega toka, ki lahko ogrozi objekte, ki so v bližini struge njegovega toka, je posebna uredba (Uredba 2004) določila pogoje gradnje in druge rabe prostora v neposredni okolici struge morebitnega drobirskega toka z namenom, da se ogroženost zaradi posledic tega toka zmanjšajo na še sprejemljivo raven.

Preglednica 5: Pregled pogojev gradnje za stavbe in gradbene inženirske objekte na območju Loga pod Mangartom (Uredba 2004; tabela 1 v prilogi 5) za območje velike (VO), srednje (SO) in majhne ogroženosti (MO) (znaki pomenijo: »+« gradnja objektov je dovoljena, »pd« gradnja objekta je dovoljena, če je zanjo k projektnim rešitvam iz projekta za pridobitev gradbenega dovoljenja izdano vodno soglasje, »–« gradnja objekta je prepovedana).

CC.SI	objekt	VO	SO	MO
1	stavbe			
11	stanovanjske stavbe			
111	enostanovanjske stavbe	–	pd	+
112	večstanovanjske stavbe	–	pd	+
113	stanovanjske stavbe za posebne namene	–	–	pd
12	nestanovanjske stavbe			
121	gostinske stavbe	–	pd	pd
122	upravne in pisarniške stavbe	–	pd	pd
12301	trgovske stavbe	–	pd	pd
12303	bencinski servisi	–	–	pd
12304	stavbe za druge storitvene dejavnosti	–	pd	+
1241	postaje, terminali, stavbe za izvajanje elektronskih komunikacij ter z njimi povezane stavbe	–	–	pd
1242	garažne stavbe	–	pd	pd
1251	industrijske stavbe	–	–	pd
1252	rezervoarji, silosi, skladišča	–	pd	pd
1261	stavbe za kulturo in razvedrilo	–	–	pd
1262	muzeji in knjižnice	–	–	pd
1263	stavbe za izobraževanje in znanstvenoraziskovalno delo	–	–	pd
1264	stavbe za zdravstvo	–	–	pd
1265	športne dvorane	–	–	pd
12711	stavbe za rastlinsko pridelavo	–	+	+
12712	stavbe za rejo živali	–	+	+
12713	stavbe za spravilo pridelka	–	pd	+
12714	druge nestanovanjske kmetijske stavbe	–	pd	+
12721	stavbe za opravljanje verskih obredov	–	–	+
12722	pokopališke stavbe in spremljajoči objekti	–	–	+
12730	kulturni spomeniki	+	+	+
12740	druge nestanovanjske stavbe, ki niso uvrščene drugje	–	–	+

2	gradbeni inženirski objekti			
21	objekti transportne infrastrukture			
21110	avtoceste, hitre ceste, glavne ceste in regionalne ceste	pd	pd	pd
21120	lokalne ceste in javne poti, nekategorizirane ceste in gozdne ceste razen parkirišč	pd	+	+
21120	parkirišča	pd	pd	+
21410	mostovi in viadukti	pd	pd	pd
21520	pregrade in jezovi	pd	pd	pd
22	cevovodi, komunikacijska omrežja in elektroenergetski vodi			
22122	objekti za črpanje, filtriranje in zajem vode	pd	+	+
22130	prenosna komunikacijska omrežja	–	pd	+
22221	distribucijski cevovodi za pitno in tehnološko vodo	pd	+	+
22231	cevovodi za odpadno vodo	pd	pd	+
22232	čistilne naprave	pd	pd	+
22240	distribucijski elektroenergetski vodi in distribucijska komunikacijska omrežja	pd	pd	+
24	drugi gradbeni inženirski objekti			
24110	športna igrišča	pd	pd	+
24120	drugi gradbeni inženirski objekti za šport, rekreacijo in prosti čas	pd	pd	+
24201	vojaški objekti	–	–	+
24202	objekti za varstvo pred škodljivim delovanjem voda na ogroženih območjih	pd	pd	pd
24203	odlagališča odpadkov in objekti za predelavo nevarnih odpadkov	–	–	–
24204	pokopališča	–	–	+
24205	drugi gradbeni inženirski objekti, ki niso uvrščeni drugje	–	pd	pd

Opomba: nazivi vrst objektov, ki so navedeni v prvem stolpcu preglednice, so nazivi objektov v skladu z enotno klasifikacijo vrst objektov (Uredba 2003b).

Preglednica 6: Pregled pogojev gradnje enostavnih objektov na območju Loga pod Mangartom (Uredba 2004; tabela 2 v prilogi 5) (pomen znakov je enak kot v preglednici 5).

	gradnja enostavnih objektov	VO	SO	MO
1	Pomožni objekti za lastne potrebe:			
	a) bazen, drvarnica, nadstrešek, lopa, uta	+	+	+
	b) garaža, steklenjak, rezervoar do 5 m^3	–	+	+
2	Pomožni infrastrukturni objekti:			
	a) pomožni cestni objekti razen odvodnjavanja cest in cestninske postaje, pomožni železniški objekti razen odvodnjavanja železniških tirov, pomožni žičniški objekti, pomožni energetski objekti razen transformatorskih postaj, pomožni telekomunikacijski objekti, pomožni komunalni objekti razen malih tipskih čistilnih naprav in zbiralnic ločenih frakcij komunalnih odpadkov	–	+	+
	b) odvodnjavanje cest, cestninska postaja, odvodnjavanje železniških tirov, transformatorska postaja, tipska mala čistilna naprava, zbiralnica ločenih frakcij komunalnih odpadkov, pomožni letališki objekti in pomožni objekti na mejnih prehodih	–	+	+
3	Pomožni kmetijsko–gozdarski objekt:			
	a) čebelnjak, gozdna pot, gozdna cesta, gozdna učna pot, gozdna vlaka, gozdna žičnica, poljska pot	+	+	+
	b) kašča, kozolec, kmečka lopa, skedenj, gnojišče, gnojna jama do 150 m^3, rastlinjak, ribnik, silos	–	+	+
4	Začasni objekti, namenjeni sezonski turistični ponudbi, prireditvi in skladiščenju	+	+	+
5	Vadbeni objekti, namenjeni športu in rekreaciji na prostem:			
	a) igrišče za šport in rekreacijo na prostem, kolesarska steza, planinska pot, smučišče, sprehajalna pot, trim steza in vzletišče	+	+	+
	b) pomol in strelišče	–	+	+
6	Vadbeni objekti, namenjeni obrambnim vajam in vajam za zaščito, reševanje in pomoč	–	–	pd
7	Spominsko obeležje	+	+	+
8	Urbana oprema: nadkrita čakalnica, javna kolesarnica javna telefonska govorilnica, objekt za oglaševanje, transparent, skulptura in prostorska instalacija, večnamenski kiosk, montažna sanitarna enota in vodnjak	–	+	+

Omejitve iz uredbe (preglednici 5 in 6) je treba upoštevati pri vsaki gradnji na ogroženih območjih, pri čemer so ukrepi varstva pred posledicami drobirskega toka razvrščeni v tri stopnje glede na velikost ogroženosti na območju, in sicer na zemljišča na območju velike, srednje in majhne ogroženosti.

Lokacijski načrt za vplivno območje plazu Stože v občini Bovec (Uredba 2003a) nadalje opredeljuje ureditve in objekte, ki so nujni za zmanjšanje ogroženosti in za vzpostavitev ustreznega dokončnega stanja infrastrukture na območju Loga pod Mangartom (različni vodnogospodarski ukrepi, kot so ureditev območja plazu Stože, razbijač drobirskega toka nad Gorenjim Logom, širitev in poglabljanje struge Predelice ter izvedba nižjih varovalnih zidov v Gorenjem in Spodnjem Logu; izvedba prometnih, predvsem premostitvenih objektov; ureditev deponije ter komunalnih in energetskih vodov na območju Loga pod Mangartom).

7 Literatura

Glej angleški del prispevka.