TBILISI DISASTER NEEDS ASSESSMENT 2015

FINAL DRAFT

2 September, 2015

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Foreword

During the night of 13-14 June 2015, heavy rainfall over the Vere River basin resulted in sudden, destructive flash floods which struck the Vake and Saburtalo neighbourhoods of Georgia's capital, Tbilisi, as well as other areas of the city along the right bank of the river Mtkvari. The Lisi, Tsodoreti, Napetvrebi, Bevreti, Tskhaldidi, Betania and Tskhneti areas around Tbilisi were also affected.

According to official government figures, the flooding killed 19 people (a further 3 are missing), displaced 67 families and directly affected around 700 people. The flooding also destroyed much of Tbilisi's zoo, killing most of the animals, and damaged around 40 roads, many homes and a variety of urban infrastructure and communication systems.

A large landslide which struck the right slope of the Vere River's drainage basin area near the village of Akhaldaba (about 10 km. west of Tbilisi) compounded the effects of the flooding by turning the waters into a torrent of mud and debris.

The Georgian government and Tbilisi's City Hall rapidly mobilized various units which immediately undertook rescue and relief operations to help those most urgently in need. Their efforts naturally focused upon the most badly affected areas.

On the 19th of June, a few days after the floods, Georgia's Ministry of Finance, representing the government, officially asked the country offices of the United Nations' Development Programme (UNDP) and the World Bank to support their efforts to quickly undertake a needs assessment which could serve as a basis for long-term recovery and prevention.

In response to this request, a team of national and international consultants from UNDP, the World Bank, the Global Facility for Disaster Reduction and Recovery (GFDRR) and the United States Department of Agriculture (USDA) joined Georgian government and Tbilisi City Hall experts to conduct the Tbilisi Disaster Needs Assessment. The assessment was led by the Georgian Ministry of Finance and was co-ordinated by Tbilisi's City Hall. The government identified the following sectors as a priority for the assessment: housing, transportation, water management, the zoo, and Disaster Risk Reduction (DRR) as a cross-cutting sector.

Initial findings on damage, losses and needs along with a series of recommendations for immediate, medium and long-term recovery were presented to the Minister of Finance, other government agencies and Tbilisi City Hall on the 15th of July. Feedback and government requests concerning this presentation have been included in this final version of the Tbilisi Disaster Needs Assessment.

Executive Summary

On the night of 13-14 June 2015, intense rainfall over the south-eastern part of the Vere River's drainage basin area compounded the continuous and heavy rainfall of the previous ten days, resulting in a flash flood which affected the Vake and Saburtalo neighbourhoods of Georgia's capital, Tbilisi, as well other areas along the right bank of the Mtkvari (Kura) river and various places outside the city. Approximately 100mm of rainfall fell over the Vere River drainage basin in only two hours, causing a flood whose peak flow has been estimated at ca. 468 cubic metres per second. Additionally, a large landslide of about 1 million cubic metres which struck near the village of Akhaldaba (about 10 km. west of Tbilisi) poured trees, rocks, soil and other debris down a hillside into the already overflowing floodwaters of the Vere River, transforming it into a massive torrent of mud and debris.

This disaster had devastating socio-economic consequences for Tbilisi: 19 people killed, 3 people missing, 67 families displaced, and around 700 people directly affected[1] overall. Indirectly, the disaster affected virtually the entire urban population of Tbilisi as a result of the physical and psychological impact it had on daily life. Besides the stress which many experienced during the disaster's aftermath, these events severely disrupted traffic flows within the city and caused high levels of congestion, much of which was still ongoing as this report was finalized. The floods were additionally responsible for the destruction of much of Tbilisi's zoo (killing most of its animals in the process) and damaged around 40 roads, many homes and several urban infrastructure and communications systems.

The economic impact was equally high: GEL 55.2 million (USD 24.3 million) in physical damage and GEL 9.62 million (USD 4.37 million) in financial losses. The government identified the following sectors as assessment priorities: housing, transportation, water management, the zoo, and Disaster Risk Reduction (DRR) as a cross-cutting sector.

Table 1. Value of damage and losses by sector (in millions)

Sector	Damage (GEL)	Damage (USD)	Losses (GEL)	Losses (USD)
Housing[1]	16.1	6.9	1.82	0.77
Transport	33.2	14.8	6.6	3
Zoo	3.2	1.4	1.2	0.6
Water & sanitation	2.7	1.2	0	0
TOTAL (est.)	**55.2**	**24.3**	**9.62**	**4.37**

The most affected sector was transportation, with most damage and losses observed in Tbilisi. The estimated cost of damage to transport was GEL 33.2 million; losses in this sector have been harder to assess given the short time-frame and limited data available, but have thus far (autumn 2015) been estimated at approximately GEL 6.6 million.

Recovery needs and recommendations by sector. One of the main goals of the Tbilisi Disaster Needs Assessment was to analyze various key sectors: these were housing, transportation, water management, the zoo, and DRR as a cross-cutting issue. The needs of each of these priority sectors are disaggregated by recommended measures to be taken in the immediate (0-3 months after the disaster), short (0-12 months) and medium to long (12-36 months) terms. For detailed information, see Section 3.

1 'Directly affected' were those who suffered damage to their houses and property.

Table 2: Total needs per sector (in millions)		
Sector	**Total (GEL)**	**Total (USD)**
Housing	50	21
Transport	76	33.5
Water Management	4.41	1.9
Zoo	137.6	61.6
TOTAL	**268**	**118**

Efforts to strengthen a disaster risk reduction system at the level of Tbilisi Municipality should include work to 1) improve understanding of disaster risk; 2) to improve disaster risk governance in order to better manage disaster risk; 3) to invest in disaster risk reduction for resilience; and 4) to increase preparedness in order to improve the effectiveness of disaster response and to "build back better" during post-disaster recovery, rehabilitation and reconstruction stages. For more detailed information, see Section 4.

SECTION I: THE DISASTER

Description of the disaster

On the night of 13-14 June 2015, intense rainfall over the south-eastern part of the Vere River's drainage basin area compounded the continuous and heavy rainfall of the previous ten days, resulting in a flash flood which struck the Vake and Saburtalo neighbourhoods of Georgia's capital, Tbilisi, as well as other areas of the city along the right bank of the river Mtkvari. The Lisi, Tsodoreti, Napetvrebi, Bevreti, Tskaldidi, Betania and Tskhneti areas around Tbilisi were also affected.

According to official government figures, the flooding killed 19 people (a further 3 are missing), displaced 67 families and directly affected around 700 people. The flooding also destroyed much of Tbilisi's zoo, killing most of the animals, and damaged around 40 roads, many homes and a variety of urban infrastructure and communication systems.

These events severely disrupted traffic flows within the city and caused high levels of congestion, much of which was still ongoing as this report was finalized. Several landslides also occurred, including a powerful one on the right slope of the Vere River's drainage basin near the village of Akhaldaba (about 10 km. west of Tbilisi) which destroyed the road connection between the two and turned the floodwaters which poured through the city into a destructive torrent of mud and debris.

Hydrology of the Vere River

According to Georgia's National Environment Agency (NEA), the Vere River springs at an elevation of 1,670m on the eastern slope of the Trialeti mountain range, close to Mt Didgori. It finally joins the Mtkvari (Kura) river in Tbilisi at a point on its right bank 0.5km downstream from the Queen Tamara bridge, at an altitude of 390m.

Figure 1: Vere River data.

Length: 38 km.
Overall water fall: 1,280 m.
Average incline: 0.034% Basin area: 194 km^2
Ave. basin elevation: 1,060 m

The normal annual rate of flow of the river ranges between 0.26 to 1.22 cubic metres per second. The maximum rate of flow (48.3 m^3/s) typically occurs in spring or early summer, whereas minimum flow in summer and winter ranges between 0.001 to 0.16 m^3/s. The Vere River's "100-year flood" rate of flow is 240 m^3/s.[2] On the 4th of July 1960, the Vere River saw a catastrophic spate, with rates of flow reaching 259 m^3/s (exceeding "100-year flood" rates), and peak rates of flow of 153 m^3/s and 155.3 m^3/s were reported in 1972 and on the 4th of June 2015 (a few days before the 13 June disaster).

During the 75 days which preceded the 13 June disaster, rain gauge stations in Tbilisi recorded 60% of the city's average annual rainfall. The ground was thus already saturated when the storm hit, and the resulting landslides and flooding caused many causalities and considerable damage to assets and property both in the upper drainage basin as well as within the Vere River corridor which runs through Tbilisi.

Table 3: Recorded flood flows by year

Year	m^3/s	Date
2015	468	13-14 June
2015	155	04 June
2012	153	12 May
2009	133	17 June
2002	67	30 June
1992	117	21 June
1960	259	04 July
1963	140	03 August

2 A "100-year flood" is a flood of such magnitude that there is only a 1 per cent chance of it happening in a given year.

Summary of the causes of the disaster

Continuous rainfall following a peak in precipitation on the 3rd of June 2015 saturated the ground in the Vere River's drainage basin, and culminated ten days later when a severe storm occurred: an estimated 100 mm. of additional rainfall fell over the drainage basin in just two hours, resulting in a flood whose peak rate of flow was estimated at ca. 468 m^3/s according to the NEA post-disaster hydrological study of the Vere River.[3]

A large landslide of about 1 million cubic metres in the Tskhneti/Kojori area—to which even more debris from several smaller landslides was added—swept trees, rocks and soil down the hills into the already overflowing floodwaters of the Vere River. This transformed the floodwaters into a massive flow of mud and debris, and ultimately caused a blockage over 10 metres deep of trees and debris at the mouth of the first tunnel in Tbilisi.[4]

The debris also rapidly obstructed several bridges, forcing the flow to break the river's banks and to shift left, washing a large lorry into the river which compounded the blockage at the entrance to the first tunnel. Owing to the debris, the large trees and the lorry, the flow through the tunnel was severely restricted. The blockage then accumulated further debris and suspended materials, resulting in the waters to rise over 5 metres above the top of the tunnel entrance and the flooding of the lower part of Svanidze Street as well as that of the riverbanks upstream.

This rise in water levels subsequently created sufficient pressure to blow the blockage through the tunnel, causing a loud explosion and a sudden increase in sediment flowing through the tunnel. The force of the sediment-filled flow of water swept away the riverbanks, the Amirejibi Highway[5] and everything else in its path—including houses, businesses and schools. By the time the flow reached the final tunnel, the floodwaters filled the area of Mziuri Park and Tbilisi Zoo, where they deposited an overwhelming amount of sediment and debris.

Figure 2. Sediment flows

Response to the disaster

The Georgian government and Tbilisi's City Hall rapidly mobilized various units which immediately undertook rescue and relief operations to help those most urgently in need. Their efforts naturally focused upon the most badly affected areas, including Svanidze Street and along the Amirejibi Highway up to the junction of the Vere and the Mtkvari (Kura) rivers.

Georgia's Prime Minister and Deputy Prime Minister as well as the Mayor of Tbilisi and his deputies were on the scene immediately. City Hall employees (including the Mayor) patrolled the streets to make sure everything was under control, ensuring rapid mobilization. Traffic police units closed streets immedi-

3 This rate of flow largely exceeded the 1958 flood of 300 m^3/s.

4 The size of the mouth of the first tunnel in Tbilisi is 72m2, and that of the following 7 tunnels is 54m2. These entrances were not large enough to channel the flow of water and debris.

5 This relatively new highway was built in 2008-2009.

ately while other police units tried to capture and contain the numerous animals which had escaped the destruction of the zoo. The evacuation of people from houses and cars had begun before the flash flooding, but some people had chosen to stay put, not realizing the seriousness of the danger they were facing. People displaced by the flooding were moved to various hotels and guest houses in the city within a few hours, and were provided with food, drinks, clothing and other essentials.

The government convened the first co-ordination meeting with the international community 48 hours after the disaster. Among those present were representatives of the Asian Development Bank (ADB), the German embassy, the European Bank for Reconstruction and Development (EBRD), the European Union (EU) Delegation to Georgia, the International Monetary Fund (IMF), the German "KfW" Development Bank, the Swedish International Development Co-operation Agency (SIDA), the United States Agency for International Development (USAID), UNICEF, the United Nations, the United Nations Development Programme (UNDP) and the World Bank (WB).

The government highlighted several priorities for the short, medium and long terms which would rely upon donor support. The first meeting of a dedicated working group, which brought together donors with representatives of Tbilisi City Hall and the Ministry of Finance, met at the World Bank's offices on the 18th of June to outline the work that to be carried out over the following weeks.

Identified priorities include:

Short-term priorities:

- Find missing people;
- Provide displaced people with essential supplies;
- Clean, restore and reopen main roads;
- Manage paralyzed flows of traffic in the city;
- Reinforce damaged structures;
- Save and temporarily house zoo animals;
- Introduce a Multi-Hazard Early Warning System (MHEWS)[6];
- Find permanent housing solutions for displaced people;
- Initiate an analysis of transportation systems; and
- Prepare terms of reference for an open competition to consider proposals submitted for development projects.

Medium-term priorities:

- Conduct a feasibility study and comprehensive and multidisciplinary safety, hydrological and environmental impact studies;
- Carry out hydrological and geological studies from the source of the river to the end point;
- Create a master action plan for the affected area;
- Draft a plan for road infrastructure repair, identifying which sections of road should be removed, maintained or changed;

6 See https://www.wmo.int/pages/prog/drr/projects/Thematic/MHEWS/MHEWS_en.html.

- Reinforce riverbanks with an emphasis on prevention;
- Carry out work to monitor and examine the main tunnel;
- Relocate and repopulate Tbilisi Zoo; and
- Implement proper public transportation.

Long-term priorities:

- Repair damaged infrastructure and damaged roads;
- Elaborate a master plan for long-term city planning and engineering projects;
- Plan two new recreational areas along the banks of the Vere River; and
- Install water filtration systems.

In addition, an intergovernmental commission[7] was established for disaster mitigation, for the study of the Vere ravine and its adjacent territories, and for the organization of repair works. More specifically, the commission's main goals are 1) to organize a study of the Vere River and its adjacent territories; 2) to co-ordinate a Multi-Hazard Early Warning System survey and ensure its introduction; 3) to ensure the safety of the population; 4) to promote a more resilient rebuilding of roads; and 5) to develop the Vere ravine as an integral space of the city.

Equally important is the need to mobilize funds to meet the needs of the city and affected individuals. Treasury accounts were created within the Tbilisi Municipality for donations in GEL and with the Ministry of Finance for donations from abroad. According to information supplied by the Ministry of Finance, the following donations had been received as of 17 July: City Hall and national government pooled GEL 14,157,659 from different parts of the City and government, who adjusted their own budgets in order to help with the flood disaster relief. Private donors contributed a further GEL 13,358,449. (Total: GEL 27,516,108 = USD ca. 12.2 million.)

City Hall has GEL 14 million ready to be spent. To date, GEL 8.5 million have been spent by the Improvements Department, focusing on public works that needed immediate attention, e.g. removing debris and reinforcing and reconstructing infrastructure in flooded areas. City Hall has also granted GEL 190,000 each to families[8] which lost family members during the disaster, as well as additional funding to cover their funeral costs.

Donors and international organizations such as the EU, UNDP, WB and USAID also rapidly mobilized substantial resources to help the government's efforts to provide immediate relief and to carry out a damage and needs assessment and planning for the recovery phase. A large number of civil society organizations also immediately mobilized to support rescue, relief and rebuilding efforts in the areas affected by the flood. The Georgian Red Cross Society took the lead in organizing these efforts together with pools of volunteers that were co-ordinated by Georgia's Emergency Management Agency (GEMA).

On the 19th of June, the Georgian government officially requested UNDP and WB support for its efforts to carry out a needs assessment that would provide a basis for long-term recovery and prevention. The assessment was conducted under the leadership of the Georgian Ministry of Finance and co-ordinated by Tbilisi's City Hall, and an assessment team made up of government and City Hall experts as well as international and local partners was established.[9] See team composition attached in Annex 2.

7 A full list of the commission's members is given in Annex 1.

8 These families have approached the government with their loss; others cannot do so because their family members are still missing.

9 A full list of the assessment team's members is given in Annex 2.

SECTION II: ESTIMATION OF DISASTER EFFECTS

Effects upon the population

The disaster directly impacted the lives of 67 families, whose houses or belongings or both were damaged by the floods. Indirectly, it affected virtually the entire population of Tbilisi (1.2 million inhabitants) as a result of the physical and psychological impact it had on their daily lives, notably through the constraints it is imposing on the flow of traffic in the city and as a result of the levels of stress it imposed during the aftermath. Various media sources sought to analyze how stress levels were increased by different consequences of the disaster, and identified:

- the population's realization that, given its particular geological and hydrological situation, the city is vulnerable to natural hazards that can translate into acute and deadly episodes, and the knowledge that such a disaster may happen again;[10]
- the insecurity the population feels as a result of knowing neither the location of the city's safest or riskiest areas nor what to do in case of disaster; and
- the fear caused by the dangerous zoo animals which ran loose following the disaster, culminating in the death of a man who was attacked by a tiger in a warehouse next to Heroes' Square.

Because of the strong emotional effects felt by the population, city and government officials are making strong efforts to recover from the floods and to take a more proactive stance towards the city's disaster risk management.

DESCRIPTION AND VALUATION OF DAMAGE AND LOSSES

Table 4. Value of damage and losses by sector (in millions)

Sector	Damage (GEL)	Damage (USD)	Losses (GEL)	Losses (USD)
Housing[2]	16.1	6.9	1.82	0.77
Transport	33.2	14.8	6.6	3
Zoo	3.2	1.4	1.2	0.6
Water & sanitation	2.7	1.2	0	0
TOTAL (est.)	**55.2**	**24.3**	**9.62**	**4.37**

Sector 1: Housing

The flash floods seriously damaged housing and land in 5 areas: Svanidze Street, the Tskhneti ravine, Upper Tskhneti, Akhaldaba, and Chikovani Street. Some houses were partially damaged and can be repaired, whereas some were completely destroyed and cannot be repaired. If a house is deemed more than 50 percent damaged, it is classified as fully destroyed.

According to the assessment, the properties (homes, plots of land and household goods) of 67 families were totally destroyed (17 families in Svanidze Street, 39 in the Tskhneti ravine area, 10 in Chikovani Street, and 1 in Akhaldaba). The total surface area of housing lost amounted to over 7,164 m^2, and the total value

10 Flooding episodes had already recently struck the city, but the last occurrence with comparable effects happened in the early 1960s and remained largely an old memory that only a fraction of the population shared.

of destroyed properties in the affected areas is estimated at around GEL 14.5 million. (This figure includes not only the value of housing but also that of the plots of land and other property within surveyed areas.)

The household goods of the 67 families were also entirely destroyed, and therefore, the city council decided to allocate between GEL 8,000 and 10,500 to each of the families according to the number of family members (see Annex 4).

Table 5: Damage and losses per area (in millions of GEL)			
Areas	**Destroyed houses and land**	**Household goods**	**Losses**
Svanidze Street	14.5[3]	.39	1.82[4]
Tskhneti ravine		.60	
Chikovani Street		.11	
Akhaldaba		.23	
Upper Tskhneti		.27	
Sub-total	**14.5**	**1.6**	**1.82**
TOTAL	**16.1**		

The floods also partially damaged the properties (total surface area: ca. 15,109 m^2) of approximately 93 families (22 in Svanidze Street, 21 in Tskhneti Ravine, 1 in Chikovani Street, 22 in Akhaldaba, and 27 in Upper Tskhneti). At the time of writing, figures for partial damage to homes were not available; the total value of damage to the housing sector may thus be higher once the assessment is complete.

The 67 families which completely lost their property are currently being temporarily sheltered in hotels or apartments or with relatives. For those families which have been put up in hotels, expenses will be met (to a maximum of GEL 220,000) by the Foundation of the President of Georgia and the Tbilisi Mayor's Reserve Fund.

Sector 2: Transport

Most of the damage and losses caused by the disaster are concentrated in Tbilisi. In the transportation sector, damage has been estimated at GEL 33.2 million; losses—which have been harder to assess due to the short time frame and to the limited availability of data—have thus far been estimated (up to autumn 2015) at around GEL 6.6 million.

Throughout the affected areas, damage to transport infrastructure assets were mainly caused by the following:

1. Erosion and other damage caused by flood waters and debris

Damage of this kind has been observed along segments of the Amirejibi Highway where it runs adjacent to or above the Vere River tunnels (see Figure 3).

Figure 3: Damage to the Amirejibi Highway close to Vere River tunnel no. 5

Figure 4: Damage to the gabion and concrete inlet protection walls of Vere River tunnel no. 5

This type of damage, caused by fast-flowing flood waters and debris, also affected the gabion or concrete protective walls of the Vere River tunnel inlets and outlets (see Figure 4).

In other locations the flooding seriously undermined natural slopes along the built-up part of the Vere River, destroying houses (see Figure 5) and threatening other residential buildings and their access roads.

Over forty roads (see Figure 6 for an example) in Tbilisi were also flooded with debris, resulting in various degrees of damage. Cleaning operations were underway at the time of writing and will be followed by further repair and retaining work.

Figure 5: Eroded riverbank downstream from Vere River tunnel no. 1

Figure 6: Svanidze Street flooded with debris

2. Landslides and localized slope collapse

During the night of 13 June significant landslide activity occurred within the Vere drainage basin. The Geology Department of the Georgian Ministry of Environment and Natural Resources Protection (MENRP) mapped 75 landslides in the Akhaldaba area. Approximately 7% of the lower drainage basin from the site of the Akhaldaba landslide downstream to Tbilisi was affected by landslides from this storm.

The largest landslide, near the village of Akhaldaba, affected around 32 hectares, displacing 1.3 km of ground to the junction with the Vere River and releasing around 1 million cubic metres of debris. It also destroyed around a section 600 metres long of the road to Akhaldaba (see Figure 7). This landslide was caused by extreme levels of rainfall, which resulted in high pore pressures in the landslide mass, which apparently fell in a translational “infinite slope” type of movement.

Other types of cut slope failures have also been observed along the Amirejibi Highway (see Figure 8)—and indeed on many other similar slopes in Tbilisi—where existing curtain netting protection is too weak to retain large blocks of rock and debris which could potentially fall into the Vere River. This is typical of sedimentary rocks such as the sandstone/siltstone flysch rock which predominates in Tbilisi.

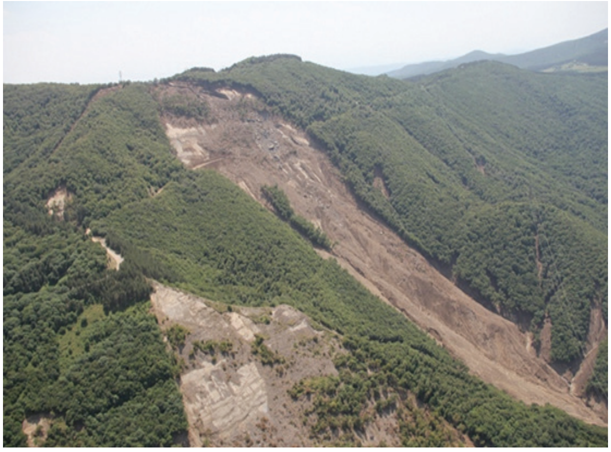

Figure 7: Akhaldaba landslide and destroyed road. The effects of an older large landslide are visible in the foreground.

Figure 8: Cut rock slope failure along the Amirejibi Highway. Stronger netting is required.

In these situations stronger and sufficiently anchored netting is required in order to retain potentially unstable blocks of rock in place.

Calculating the cost of damage and losses

The floods had an especially severe effect on roads, causing some to collapse and causing significant damage to other structures, and landslides obstructed many roads. The following are estimates of the damage to transport infrastructure caused by the disaster and of the losses or increases in vehicular operating costs which road users and companies incurred as a result of the unavailability of those transport assets which were totally or partially affected and incapable of operating.

The estimated value of the damage was based upon the cost of replacing affected transport assets to the same level of quality and efficiency as before the disaster.

Damage Assessment

The costs in Table 6 were estimated by separately analyzing each instance of damage before assessing replacement costs.

Table 6: Transport sector damage and losses (in millions)

Area		Damage (GEL)	Damage (USD)	Losses (GEL)	Losses (USD)
1	Chabua Amirejibi H'way	17	7.6	Not disaggregated	
2	Bagebi-Tskhneti road	2	0.9		
3	Other roads	8	3.6		
4	Tskhneti-Akhabada road	4	1.8		
5	Vere River course works	1	0.44		
6	Vehicles	1.2	0.5		
TOTAL		**33.2**	**14.8**	**6.6**	**2.9**

It is worth noting that the figures in this table include emergency expenditure that the government may have already incurred, as this cannot be separated from replacement cost because a share of the expenditure made immediately after the disaster includes both items. Also, the figures given in the table should not be interpreted as a definite assessment of damages because some of the existing damage is being observed over time. The degree to which light damage has deteriorated certain structures can often not be measured by direct observation but only by studying the structures over time or with certain tests.

In such cases, the initial damage assessment must be changed from "repair" to "reconstruction", with consequent cost increases. This may be the case of assets such as pavement, culverts, tunnels, etc. that could not be technically evaluated in detail during the evaluation period. Damage cost figures are therefore likely to be a low estimate.

According to information made available by insurance companies, 121 vehicles had been reported as having sustained an estimated GEL 1.2 million of damage due to the flooding as of 7 July 2015.

Estimated losses

The losses observed and quantified correspond to increases in travel time and higher operating costs incurred by road users when forced to lengthen their journeys because of impassable obstacles, e.g. roads collapsed or blocked by landslide debris.

The most serious damage to transportation in Tbilisi which the floods of the 13th of June caused was the partial collapse of the Amirejibi Highway—one of the major arteries between the city's Vake and Saburtalo neighbourhoods (see Figure 9). This has caused congestion elsewhere around the city, and has resulted in increased driver costs in terms of longer and slower trips between the western part of Tbilisi and the city centre.

Figure 9: A collapsed section of the Amirejibi Highway.

Svanidze Street was also closed and the road between the villages of Tskhneti and Betania was seriously damaged by the landslide. Although the main roads along the embankment of the Mtkvari (Kura) River and in the Heroes' Square area sustained damage, traffic was able to continue with only some restrictions (e.g. closed lanes or ramps).

A description of traffic conditions before the flood

The Amirejibi Highway is 3,450m long. As can be seen in Figure 10, there is only one access road to the highway between its two ends. Based on an estimated average speed of 60 km/h and the fact that the highway has neither junctions nor traffic lights, average travel time to drive from one end of the highway to another was 3.5 minutes.

Two major routes run parallel to the highway: Ilia Chavchavadze Avenue (to the south) and the Kazbegi/ Vaja Pshavela Avenue—Pekini Avenue axis (to the north). The length of the southern route is ca. 5 km. and the northern one ca. 4.5 km. Both have a speed limit of 50 km/h. There are 10 traffic lights on the southern route and 11 traffic lights on the northern route. According to these facts and to information supplied by Tbilisi City Hall, the average daytime travel times prior the flood were 13-14 minutes along the southern route and 15-16 minutes along the northern one.

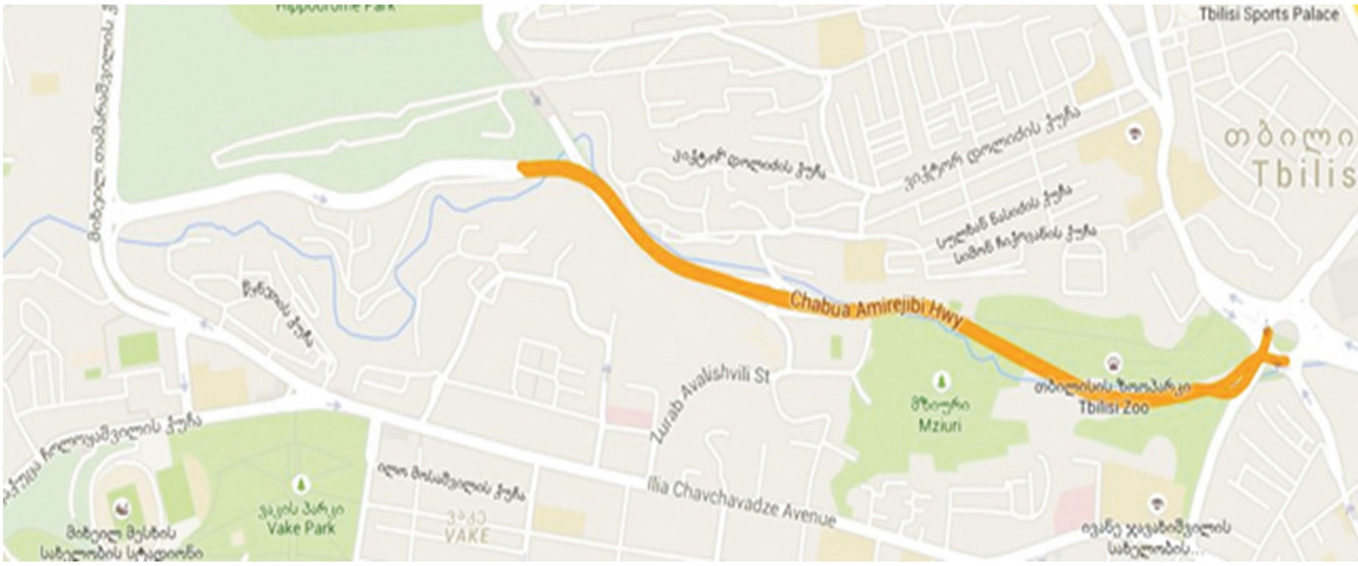

Figure 10: Map of the Amirejibi Highway. Source: Google Maps

Based on available traffic count data held by Tbilisi City Hall, the summary of traffic conditions prior to the flood is as follows:

Table 7: Summary of traffic conditions prior to the flooding of 13 June

Route	Length (km)	Traffic lights	Average travel time (minutes)	Average speed (km/h)	Daily traffic (vehicles/day)
Chabua Amirejibi H'wy	3.5	0	3.5	59	26,000
Chavchavadze Ave.	5	10	13.5	22	26,000
Kazbegi/Vaja Pshavela/ Pekini	4.5	11	15.5	18	25,000

Road user costs

During preparations for the East-West Highway Projects, the World Bank conducted a comprehensive analysis of the unit costs of vehicle operating costs (VOC) and time savings. VOCs are based upon road surface conditions. Based upon empirical experiments, 1) the overall condition of the surfaces of Tbilisi streets, including the Amirejibi Highway, is good, and 2) there is no significant difference between the conditions of individual streets. The additional VOCs caused by the flood are therefore solely the result of longer journey distances.

Secondly, longer journeys causes additional time costs for drivers and passengers. Based upon Georgia's average monthly income per capita in 2015[11], the working time cost per passenger or driver was assumed to be GEL 5.61 per hour. The cost of non-working time was assumed to be 70% less, i.e. GEL 1.68 per hour.

It should also be noted that alternative routes are congested due to diverted traffic from the Amirejibi Highway. Based upon empirical observations and some interviews with professional drivers, travel time during peak hours has doubled or even tripled due to this congestion.

Traffic impacts

Based upon information provided by Tbilisi City Hall, following the collapse of the Amirejibi Highway, 60% of the traffic which regularly used the highway was diverted to Chavchavadze Avenue (southern route) and 40% to the Kazbegi/Vaja Pshavela/Pekini (northern) route.

According to available and assumed data, the impact upon traffic has been roughly estimated as follows:

1. Additional time

- No. of vehicles using the southern route instead of the Amirejibi H'wy: 15,600 per day
- No. of vehicles using the northern route instead: 10,400 per day
- Additional time per vehicle using the southern route: 10 minutes
- Additional time per vehicle using the northern route: 12 minutes
- Additional time per day in total: 4,680 hours
- 20% extra time due to congestion of parallel routes: 936 hours/day

Total extra time per day: 5,616 hours

2. Extra vehicle operating costs

- No. of vehicles using the southern route instead of the Amirejibi H'wy: 15,600 per day
- No. of vehicles using the northern route instead: 10,400 per day
- Additional journey distance per vehicle using the southern route: 1.6 km.
- Additional journey distance per vehicle using the northern route: 1.1 km.

Total additional journey distance per day: 36,400 km.

By monetizing the extra VOCs, the closure of the Amirejibi Highway is resulting in roughly GEL 1.05 million in additional direct losses per month to road users. If, therefore, the Highway will be closed for 3 months, these losses will amount to GEL 3.15 million.

In addition to this calculation, several other issues need to be considered:

- Once the summer holiday season ends, traffic in areas affected by the flood will increase significantly. Tbilisi City Hall officials have estimated that the capacity of parallel routes will run out in autumn at the latest, causing serious traffic problems which are difficult to monetize.

11 Source: National Statistics Office of Georgia

- Given the fact that there are several affected streets not included in this calculation, and based upon empirical observations and interviews with professional drivers, the network of streets in which traffic is affected covers an area stretching from Old Tbilisi to the Vake and Saburtalo residential areas.

- Because there is currently no exact data for traffic this area, it has been conservatively estimated that **another GEL 1 million per month of additional losses** to road users should be added based upon congestion caused by the floods.

- Congested roads and temporary traffic arrangements (e.g. closed lanes, detours, etc.) have a worsening effect upon road safety. This impact has not been taken account in the calculation presented above. Based upon empirical observations, the number of traffic accidents in Tbilisi has already increased.

- Congested roads also increase vehicle emissions and contribute to air pollution in Tbilisi.

- The fact that the road to Akhaldaba remains impassable also leads to further losses.

In conclusion, the disaster has had an adverse financial impact upon road users estimated at around GEL 2.2 million per month, amounting to **GEL 6.6 million** by early autumn. It must be noted that **parallel routes are regulated by traffic lights and that these junctions may be totally congested in the autumn** once the summer holiday season is over. Traffic in Tbilisi will then increase, with unpredictable consequences in terms of additional losses.

Sector 3: The Zoo

The flash floods of 13 June devastated Tbilisi's Municipal Zoo. Three employees were killed[12], nearly 300 animals were drowned or later killed, and the Zoo itself sustained serious damage to buildings and enclosures.

Located at the bottom of the Vere River Ravine along the Amirejibi Highway, a few hundred metres before the Vere River flows into the Mtkvari (Kura) River, the Zoo became a floodplain of sorts during the flash floods. The flow of mud and debris swept over and flooded the Zoo's enclosures and facilities, killing many of its animals, and severely damaged several administrative and ancillary buildings.

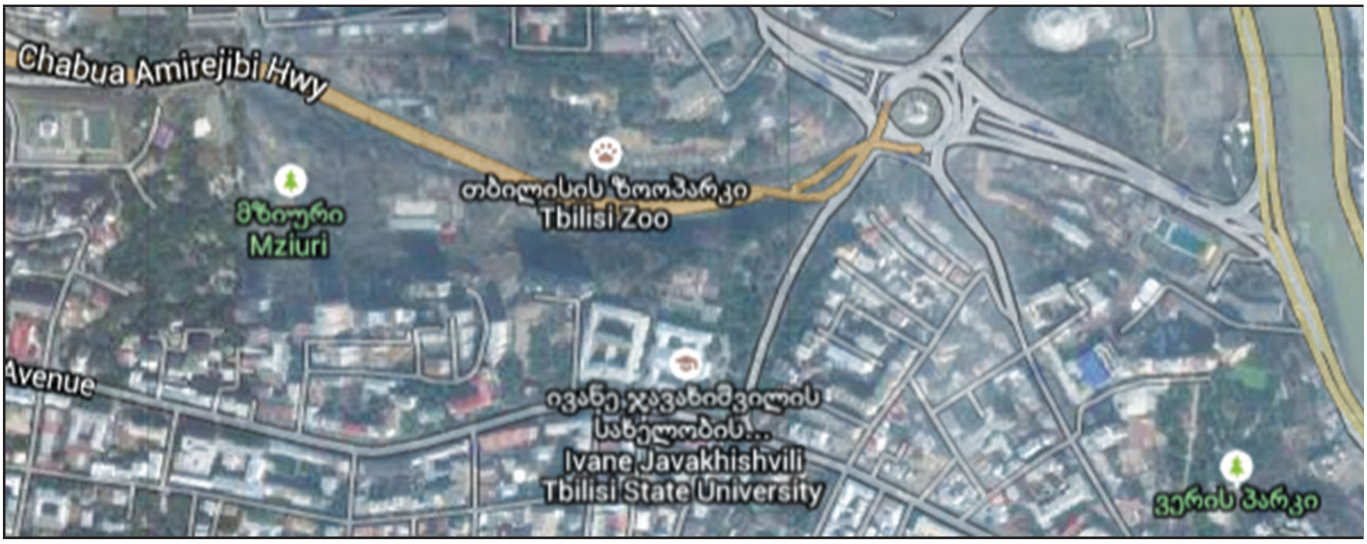

Figure 12. Map of current Tbilisi Zoo location

12 These three members of staff, who risked and ultimately gave their lives to stay and help the animals, reflect the dedication and commitment of the Zoo's employees.

The animals[13] that were kept in the lower part of the Zoo near the river ravine itself suffered the heaviest casualties. Among them were some of the Zoo's most endangered, visited, valued and loved animals. The Zoo deplored the loss of 19 felines (tigers, lions and jaguars) as well as wolves, spotted and striped hyæna, brown bears, and over 100 exotic birds.

Figure 13. Destroyed Animal Enclosures

Buildings in the lower section of the Zoo were either partially damaged or completely destroyed by the floods. The damage noted in this section includes, but is not limited to, severe damage to the Zoo's utilities infrastructure (sewage, water, electricity and gas lines). Moreover, the main administrative building was half-submerged, resulting in the loss of all the administrative files—both electronic and on paper.[14]

Over 39 animal spaces—including night stalls, bedrooms, animal diet preparation and storage spaces—were completely destroyed. These infrastructure losses also included life support systems necessary to the provision of adequate care according to internationally recognized standards of animal welfare.

In order to quickly re-house displaced animals, many of the latter were relocated to unsuitable and unsustainable holding facilities in tight quarters with other animals. These new temporary holding facilities have led to above-average levels of stress among the animals, further reducing their ability to cope with unfamiliar surroundings and new cage mates.

Two of the brown bears have been kept in the city's animal shelter in small enclosures which will not be suitable for long. The Zoo's crocodile enclosures sustained damage which rendered them unsafe, so the crocodiles were moved to the former penguin pool (which needs serious repair) and the surviving penguins were moved to a smaller temporary enclosure that lacks the adequate life support system for them. More fatalities have been recorded among them following their relocation.

City Hall and army units moved quickly to clear the mud and debris from the devastated Zoo in order to begin the repairs that its infrastructure required, but a substantial amount of mud still remains within several buildings. The Zoo is expected to face additional costs to have this mud removed, which are accounted for in the "losses" column of Table 9 below.

In addition, the Zoo is expected to be closed or partially closed until the end of 2015 at least. It has partially reopened in mid- September of 2015. As the Zoo could have expected to make a profit of GEL 0.7 million during this period, this sum is also counted as a loss.

13 These animals included Amur tigers (Panthera tigris altaica), brown bears, jaguars, wolves and several species of primates.

14 Some animal records compiled in Tbilisi Zoo and now lost included quasi-irreplaceable historic data.

Figure 14: Community efforts to clear the mud and debris from the Zoo

The employees of the Zoo's ticket office are currently on paid leave and the Zoo's administration hopes it will still be able to pay them their salaries even if the Zoo remains closed for the next few months. Before the flood, the Zoo provided basic insurance packages for its animal keepers. The Zoo itself, however, did not have insurance to cover the damage to its infrastructure and animals.

For the families of the Zoo employees who were killed by the flood, the insurance company paid GEL 5,000 and Tbilisi City Hall an additional GEL 10,000 to each family.

Overall, it is estimated that the Zoo is facing GEL 3.2 million in damage and GEL 1.2 million in losses (the latter mainly due to the loss of entrance fees and rental incomes). If the Zoo is not reopened soon, losses will increase significantly (the current figure is based upon calculations through to the end of the year).

Table 9: Zoo damage and losses (in millions)

	Damage (GEL)	Damage (USD)	Losses (GEL)	Losses (USD)
Buildings and enclosures	1.5	0.7		
Animals	0.5	0.2		
Roads and utilities (sewage, water, gas, electricity)	0.7	0.3		
Other (equipment, attractions, etc.)	0.4	0.2		
Cost of removing mud and debris			0.5	0.2
Loss of entry fee income			0.7	0.3
TOTAL	**3.2**	**1.4**	**1.2**	**0.6**

Sector 4: Water management & drainage basin and river management

Total damage to the water supply and sewage sectors amounts to GEL 2.7 million, according to the Georgian Water and Power (GWP) company. No losses were reported.

The water supply system

No major water supply system was substantially affected by the floods. According to GWP, the floods slightly damaged a 400 mm. main pipe in the lower part of Svanidze Street; water services were interrupted but were reportedly repaired within hours of the disaster.

The 800 mm. high-pressure main water pipe (see Figure 11) located in the immediate flood zone along the new road in the Vere ravine had its insulation cover washed away by the floods, but was not directly affected. This pipe supplies water to the roughly 100,000 people living in the wider Heroes' Square area.

The total cost of the damage sustained by the water supply system amounts to GEL 0.5 million.

Figure 11. The 800 mm. high-pressure main water pipe

Sewage infrastructure

The wastewater collection system was substantially affected all along the flooded area. Tens of manholes were flooded and covered with silt. GWP actively worked on restoring the manholes and installed biofilters to damaged pipes leaking wastewater directly into the Vere River.

Total damage reported to sewage infrastructures and pipes amounts to GEL 2.2 million.

Culverts (tunnels) and river engineering works

As the Vere River approaches Tbilisi, it enters a series of tunnels which convey its waters through the city to flow into the Mtkvari (Kura) River. The first tunnel was built in 1958 and estimates of its design flow vary from 126 m^3/s under free flow conditions to a peak of 260 m^3/s under submerged flow conditions (i.e. when the tunnel entrance is submerged) and "100-year flood" flow rates.

The length of the original tunnel was 230 metres, but the tunnel was lengthened during recent work using Armtec corrugated steel pipe and pipe arches to form large-scale culverts. From the first tunnel to the Mtkvari (Kura) River, the river flows along its entire length through a succession of culverts that are numbered differently by different organizations, with the total number of sections varying from 6 to 8.

Although it has been reported that as-built drawings for the culvert system do not exist, the contractor who was responsible for the works possesses good quality CAD[15] drawings showing plans and sections of completed works. During the building of these additional culverts, specialist international consultants checked the carrying capacity of the closed sections under both free flow and submerged flow conditions.

Reports reflect the consultants' confidence that flows entering the first tunnel would pass through the system to the point of confluence with the Mtkvari (Kura) River. In addition, technical experts from Armtec—the Canadian company which manufactured and supplied the corrugated steel pipe—were present before and during its installation and were available to assess the suitability and carrying capacity of these large culverts. This does not, of course, necessarily mean that the operational aspects and durability of the tunnels were satisfactory: given the damage sustained during the floods, it is clear that a thorough design modelling of dynamic and static components should have been carried out and taken into account.[16]

Although the calculations carried out at that time are not yet available, an examination of the sites combined with discussions with Georgian hydraulic experts has confirmed that flows entering the first tunnel during normal flood conditions would have been able to continue through the whole covered network. The tunnels were designed to allow for some transported and suspended sediment, but certainly not to the extent that was required during the June 2015 floods. The debris blocking the first tunnel created very adverse water flows in the downstream sections when this blockage was suddenly pushed out by the high pressure that built up through the water backup.

The high velocity that resulted (>5 m/s) was powerful enough to transport large amounts of sediment and caused unfavourable and erosive flow conditions at each outlet and inlet down the course of the river to its confluence with the Mtkvari (Kura) River. More importantly, when the flow of water exited the closed sections of the river system, its velocity was reduced and its height increased, breaking the river's banks and forcing the river to seek out alternative routes (e.g. parks, roads, pedestrian tunnels, the zoo, etc.). Where there was no clear outlet, the flow rate rapidly decreased in velocity, depositing large amounts of sediment.

Table 8: Water management sector damage and losses (in millions)

Items	GEL	USD
Sewage infrastructure and pipes (around 6,000m)	2.2	1.01
Water supply infrastructure and pipes (around 2,400m)	0.5	0.23
TOTAL	**2.7**	**1.2**

The private sector

The floods also seriously damaged a meat processing plant, a cigarette repository and a dog shelter, and Tbilisi City Hall's Property Department is currently assessing the damage and losses the latter sustained as well as their needs. At the time of writing this report, however, this information was not available.

15 Computer-Aided Design

16 Because of the damage sustained, and despite satisfactory reports from consultants, the EMA does not consider the tunnels to have been sufficiently examined technically.

SECTION III: SECTORAL NEEDS AND RECOMMENDATIONS FOR RECOVERY

Introduction

Based on the terms of reference of the Tbilisi Disaster Needs Assessment, one of the main objectives of the exercise is to identify needs in all key sectors affected by the floods (transport, housing, water management and the Zoo) and work out indicative costs to serve as a basis for a Recovery and Reconstruction Framework.

The needs of each priority sector are disaggregated by recommended measures to be taken in the immediate (0-3 months after disaster), short (0-12 months after disaster) and medium to long (12-36 months after disaster) terms. Recommendations for disaster risk management as a cross-cutting issue are given in Section IV.

Table 10: Total needs by sector (in millions)

Sector	Needs (GEL)	Needs (USD)
Housing[5]	50	21
Transport	76	33.5
Water Management	4.33	1.86
Zoo	137.6	61.6
TOTAL	**268**	**118**

The recommendations listed below were either provided by relevant sector experts and country counterparts or discussed and agreed upon with them.

Housing

The well-being of people should always be the focus and the main concern before, during, and after a disaster. Hundreds of people were directly affected by the June 2015 floods and have to adjust their normal way of living until solutions are developed and implemented; many people even had to leave their homes with

Table 11: Housing sector needs (in millions)

Actions	Needs (GEL)	Needs (USD)
Technical assistance[6]	1	0.42
Compensation policy	25.3[7]	10.7
Plans implementation[8]	23.7[9]	10
Legal acquisition of land	TBD	
TOTAL[10]	**50**	**21**

1. Immediate measures

Technical assistance—Part of GEL 1 million budget

- Structural and multi-hazard risk assessments should be carried out in areas adjacent to the flooded area before construction or repairs begin.

- City Hall should consult households, especially vulnerable ones, when identifying alternative housing solutions, and link households with developers or with other kinds of information or advisory support (legal, etc.) that could ease the resettlement process. A grievance redress mechanism should be set up for individuals to communicate concerns and feedback.

Compensation policy—Part of GEL 20 million budget

Tbilisi City Hall has defined clear criteria for compensating owners and tenants whose homes and property were damaged by the flooding in its *Resolution No. 17-66 on the Approval of Rules for the Provision of Residence, the Cession of Real Estate Property Rights and the Provision of Other [Forms of] Monetary Assistance to the Families who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi*.

The following recommendations should ideally be included in the Compensation Policy Budget:

- The policy should consider compensating illegally built houses for the destruction of buildings and property.

- It should also provide for additional compensation for vulnerable households, e.g. households led by a female family member, households below the poverty line or including elderly or disabled members, etc.

Compensation Policy

According to Resolution No. 17-66 adopted by the City Municipality on 5 July 2015 (see Annex 4), affected families can choose between two options in order to be compensated for the loss of their property:

1. Cash compensation based upon the value of a selected amount of space based upon family size: Families with 1 or 2 members—45 m²; 3-4 family members—65 m²; 5-6 family members—90 m²; 7 or more—110 m².

2. A lump sum corresponding to the market value of the lost property as valued by the "Levan Samkharauli" National Forensics Bureau (NFB).

City Hall is responsible for the funding, management and payment of the two options, of which the maximum costs are listed below in Table 12. (Elements of the table are further detailed in Annex 4.)

Table 12: Breakdown of affected people and property

Area		No. of Families	No. of Family members	Living area (m^2)	Option 1 & 2 (millions of GEL)	Goods (GEL)
Svanidze Street	Destroyed	17	89	3,082	4.8	170,000
	Partially Damaged	22	106	6,583	3.1	220,000
Tskhneti Ravine	Destroyed	39	141	3,302	8.9	390,000
	Partially Damaged	21	97	2,929	1.4	210,000
Chikovani Street	Destroyed	10	38	643	2.7	100,000
	Partially Damaged	1	4	257	0.12	10,000
Akhalda-ba	Destroyed	1	5	137	0.21	10,000
	Partially Damaged	22	107	3,500	1.6	220,000
Upper Tskhneti	Destroyed	0	0	0	0	0
	Partially Damaged	27	109	1,840	0.87	270,000
TOTAL		**160**	**696**	**22,273**	**23,700,000**	**1,600,000**

The groups of families are categorized according to whether the market value of lost assets is greater or smaller than the value the Samkharauli NFB estimated for the same assets using USD 1,000 per square metre as a guideline. The compensation policy is based upon the calculation of an average of GEL 10,000 per household in compensation for lost property (household goods, etc.). Maximum costs correspond to the sum of the amounts paid out according to the option that is most favourable to the families.

The Resolution is intended to address the need for temporary shelters while permanent housing solutions are being consolidated. If, however, the families manage to use these funds to build in a zone considered safe for construction, then this could be used as a long-term solution. Assessments of high-risk zones are still ongoing to verify the feasibility of the latter approach.

Implement plans into projects—Part of GEL 19.35 million budget

- Once resettlement is complete, it is advised to establish a livelihood restoration monitoring system to ensure families are able to resume their lives. There should be facilitation and support to assist them.

2. Short-term measures

Technical assistance—Part of GEL 1 million budget

- High flood risk areas are being identified by the Ministry of Environment and Natural Resources Protection using a multi-hazard risk assessment.
- With this knowledge, several risk-sensitive development plans can be taken on within the first year after the disaster. However, they should be linked with Tbilisi Master plan/land usage plans.
    - 1) An action plan for alternative use of very high or high-risk areas.
    - 2) A comprehensive resettlement plan for very high or high-risk areas.
    - 3) Flood protection measures based upon technical analysis and data.
    - 4) Comprehensive permanent housing solutions.

Legal acquisition of land—To be discussed

- For affected households, City Hall should work on the legal acquisition of land to facilitate permanent housing solutions in disaster resilient areas.

Stakeholders working on these plans should keep long-term sustainable development and disaster resilience in mind, and should also consult technical experts to establish feasible actions that fit Tbilisi's specific urban, social, political and economic context.

It is also very important to maintain intensive consultations and a risk awareness campaign for persons living in areas identified as being at very high or high risk.

3. Medium and long-term measures

Implement plans into projects—Part of GEL 19.35 million budget

- Implement risk-informed plans discussed and agreed upon (i.e. relocation, urban development, etc.) in the short term, integrating the multi-hazard assessment into Tbilisi's long term urban development plan.
- Improve building permits as well as construction codes for stronger infrastructure that can withstand disaster risks. The Ministry of Economy and Sustainable Development is currently doing this.

Transportation

In addition to strengthening transport assets to prevent similar disasters in future, additional measures for flood and debris flow protection must be taken along the embankments of the Vere River. Priority should be given to a solution that will ensure the highest levels of safety and the lowest levels of risk. Possible solutions include designing or rebuilding roads in the same location following a detailed site investigation and monitoring and design methodology, or building new roads on a different alignment. Based on the table below, a sum of GEL 42 million for "Build Back Better" (BBB) is recommended on top of the estimated GEL 33.2 million it will cost to repair damage and restore assets to their original condition.

Table 13: Road damage and reconstruction costs (millions of GEL)			
Roads	Damage	BBB needs	**Reconstruction**
Chabua Amirejibi H'way	17	5	**= 22**
Bagebi-Tskhneti Road	2	5	**= 7**
Tbilisi roads affected by floods	8	12	**= 20**
Tskhneti-Akhaldaba Road	4	11	**= 15**
Protective works along the Vere River's embankments	1	9	**= 10**
TOTAL	33.2	42	**= 75.2**

Debris flow hazard measures

Based upon available data and reports, it appears that **the debris carried by the floods directly and indirectly caused the greatest number of casualties and the most damage**. Since unpredictable bad weather conditions and climate change may result in similar events in the future, the need to reduce this hazard is very important and urgent.

It is advisable that, following appropriate design preparation and based up on meteorological, geological and hydraulic data, the installation of debris barriers such as flexible high-strength steel nets (see Figure 15) will be considered in critical locations along the course of the Vere River and its tributaries.

Figure 15: High-capacity debris flow steel nets

The Amirejibi Highway

The Amirejibi Highway was partly constructed in available spaces along the banks of the Vere River. Overall, its ability to withstand damage during the floods was satisfactory; damage was limited to places where the highway crossed the Vere River and where the latter was channelled through concrete and metal tunnels.

Due to the impact of the Vere River's increased flow and to the erosion caused by debris, many of protective works were overwhelmed or simply washed away. When rebuilding, it would be advisable to:

- Increase the height and thickness of concrete or gabion walls protecting tunnel inlets and outlets;
- Increase the strength and protection of the highway's side slopes or walls to enable them to withstand the flows and velocities of the increased hydraulic design needs; and to
- Replace (where necessary and technically feasible) the existing Vere River tunnels with short span bridges, or to design and build diversion tunnels of appropriate diameter based upon hydraulic studies, geology and elevations.

These efforts should be undertaken in conjunction with work to strengthen tunnel capacity, and it should be noted that any such work should be carried out in consultation with flood prevention specialists.

Landslides

The major landslips that affected transport assets should all be surveyed and analyzed to ascertain whether or not they can be stabilized; if not, alternative designs should be considered.

The risk of a catastrophic event once again damaging the road between Tskhneti and Akhaldaba is high, and the road is the only means of access to the village of Akhaldaba. Walkover surveys have revealed that the top and sides of the Akhaldaba landslide have large cracks and show signs of potential future slipping. The entire area will be highly unstable during the next instance of heavy rainfall: the loose soil and rock debris, once saturated, are particularly prone to sliding as many of the slopes below were over-steepened by the last event.

The Akhaldaba landslide should undergo a thorough geotechnical assessment to determine where the landslide is stable and where it is not. Various methods by which the landslide could be stabilized should be determined, especially before re-opening the Tskhneti Road, which has high rates of traffic flow. A careful site investigation should reveal if it will be safe to open the road with the landslide material still in place or if opening the road would require all or a portion of the material to be removed beforehand.

Alternative access routes should also be investigated, and the benefits and costs of opening the hazardous slide area to traffic or of improving the existing back road and providing an access point acceptable to the local community should be studied. A geotechnical survey would help decision-makers determine the best course of action with which to proceed.

Areas of cut slope failures

For the locations of cut slope failures such as those observed along the Amirejibi Highway (see Figure 6) and many other similar slopes in Tbilisi, where the existing curtain type of netting protection is not sufficient for retaining large size of falling rocks, steel netting of high tensile strength is required in combination with anchors at appropriate grids.

Table 14: Transport sector needs (in millions)[11]		
Recommendations	**Needs (GEL)**	**Needs (USD)**
Amirejibi Highway repairs	22	9.7
Protective works along the Vere River's embankments	10	4.4
Assessments and technical assistance	1	0.44
Bagebi-Tskhneti Road repairs	7	3.1
Repairs to other roads in Tbilisi	20	8.8
Akhaldaba Road repairs	15	6.6
TOTAL	**76**	**33.5**

Transportation: recommended measures by time frame

The recovery plan for the transport sector is probably the most important, as many of the other sectors rely upon it. Measures in **bold** are recommendations that should be emphasized and focused upon immediately. The recommendations are as follows:

1. Immediate measures

Amirejibi Highway repairs: GEL 22 million

- **Rehabilitate the Amirejibi Highway as soon as possible to reinstate normal traffic in the city and minimize high economic losses and citizens' discomfort before the expected traffic overload in September.** (Multi-hazard risk assessments should already commence to reduce the amount of risk during rehabilitation).

Protective works to the Vere River's embankments—Part of GEL 10 million budget

- **Design and install high-capacity debris flow fences in key locations along the course of the Vere River.**

Assessments and technical assistance—Part of GEL 1 million budget

- Calculate the capacity of parallel roads based upon the settings of their traffic light control systems. Alternative routes should be examined and communicated to road users accordingly.
- Landslide hazard mapping, and investigation and monitoring of the Vere River's drainage basin and tributaries—in progress.
- Strengthen a Multi-Hazard Early Warning System (MHEWS) together with community training and preparedness plans as well as regular emergency drills—in progress.
- Complete a land survey and mapping of the Vere River drainage basin using lidar.

Bagebi-Tskhneti Road repairs—GEL 7 million

- Rehabilitate the road between Bagebi and Tskhneti.

Repairing other roads in Tbilisi—GEL 20 million

- Repair damage to various other roads in Tbilisi.

2. Short-term measures

Protective works to the Vere River's embankments—Part of GEL 10 million budget

- Repair and protect built-up sections of the Vere River's banks and build retaining walls which consider the requirements of the river's rate of flow. In the meantime, identify and restrict development in unstable and flood-prone areas.

Assessments and technical assistance—Part of GEL 1 million budget

- Carry out a multi-hazard risk assessment of Tbilisi focusing on hydrological and geological risks.[17]

Akhaldaba Road repairs: GEL 15 million

- Design alternative solutions for the destroyed Akhaldaba Road.

3. Medium to long-term measures

Protective works to the Vere River's embankments—Part of GEL 10 million budget

- Reforesting slopes and creating a plan for land usage in the Vere River's upper drainage basin.

Assessments and technical assistance—Part of GEL 1 million budget

- Based upon the multi-hazard risk assessment:
    - Examine and analyze the cost and benefits of various alternatives for increasing the flood capacity of built-up sections of the Vere River; and
    - Design urban part of watershed and restore natural river system flow in conjunction with the required transport infrastructure repairs to serve the existing and future traffic needs of the flood-affected sections of the Amirejibi Highway.
- Survey, investigate and monitor large-scale landslides affecting the transport network.

Water management: Managing the river and its drainage basin

Water management interventions are essential not only to determine the design flood flows for any works within the drainage basin both upstream and within the city of Tbilisi, but also the works and measures required within the drainage basin to reduce the likelihood of similar catastrophic events occurring in the future.

Table 15: Water sector needs (in millions)

Recommendations	Needs (GEL)	Needs (USD)
Mitigation studies and works	1	0.46
Other river related items[12]	1.23	0.52
Inspecting dams, gabion walls and weirs	2.1	0.88
TOTAL	**4.33**	**1.86**

17 May overlap or be combined with the assessment recommended in the Housing Sector Recommendations.

1. Immediate measures

a. Ministerial responsibilities

Georgia's water resources are not managed by one single organization: mandates are instead shared by several agencies, including central government and local authorities. This matter must be addressed in order to ensure that environmental protection and water management issues are properly considered, that building along or close to rivers is properly regulated, and that enforcement does not fall between two or more organisations.

Although hydrological monitoring is carried out by the National Environmental Agency, the latter must be given more financial support to enable them to collect data more regularly and more widely. In addition, direct links between various institutions involved in water and risk management must be established and improved to the extent that such data can be available and utilised as part of the early warning strategy.

b. Physical planning and building control along and adjacent to the course of the Vere River

Existing regulations need to be reviewed and, where required, reinforced to ensure that they can be enforced, that unauthorized developments are immediately stopped and that the river's course is reinstated. Environmental Impact Assessments (EIA) should be mandatory and not 'selective and only implemented for projects financed by international institutions,' as has been reported.[18] An in-depth environmental policy is needed to ensure that the current gap between national and municipal authorities is bridged and that appropriate policies are included in all relevant documents for planning and building control.

Construction (new buildings, the renovation or rebuilding of old ones, infrastructure development, etc.) has been one of Tbilisi's most rapidly growing economic sectors during the past 15 years. A variety of Codes, Practices, Standards and Specifications have been used during this period, and this has effectively reduced quality control as many people involved do not understand the details and requirements of each one, whereas others take advantage of this knowledge gap.

Urban and peri-urban drainage and runoff must be covered in such documents along with the establishment of improved road designs within urban and rural areas. The latter must consider runoff design and storage to reduce flood peaks, as well as the safe disposal of storm runoffs both within the city and from highways to and within rural areas. This runoff exacerbates large river floods by creating unnecessary peaks to the flood hydrograph and concentrates flows in ravines, increasing the risk of erosion and subsequent landslides. Improvements must also include stricter requirements for road construction to ensure adequate attention is paid to the disposal of excavated material and to the control of runoffs emanating from the roads in order to reduce the probability of downslope scouring and the initiation of landslides.

c. Hydraulic modelling

To ensure that the sequence of events which occurred on 13 June is not repeated, the Vere River system's capacity "as-built" (i.e. both open and closed) to convey flood waters down to the Mtkvari (Kura) River needs to be determined immediately in order to identify all possible constraints. A proposed computer modelling of the river system will also determine the flood flows for different return periods and the river system's capacity "as-built" to carry these flows. The results will be used inter alia to identify and delineate areas prone to flooding, not only in terms of potential flood water height but also in terms of the probability. These results would also be essential inputs for efforts to work out the necessary types and heights of riverbank protections, the elevation of road infrastructure and similarly associated reconstruction work.

18 *GEO-Cities Tbilisi: An integrated environmental assessment of state and trends for Georgia's capital city*, United Nations Environment Programme (UNEP), December 2011.

The hydraulic modelling of the river proposed for the immediate future will determine not only flood flows through the tunnel system but also flood passage information[19] (e.g. flood elevations, flood return periods, flood risk zones, flood-prone area delineation, etc.) as well as establish criteria for the design and selection of check dams and debris collectors within the Vere drainage basin, covering not only the river's main stream but also its tributaries. It will also provide an assessment of sediment transport for at least the last 15 km. of the Vere River as it approaches Tbilisi. An outline of the requirements for this hydraulic modelling is presented in Annex B.

d. Rainfall and stream flow recording

With the destruction of the Tbilisi-Vere automatic recording station, the only such station within the drainage basin has gone. It is not only imperative that this station is replaced without delay, but it should be equipped with up-to-date automatic rainfall, stream flow and sediment monitoring and recording equipment linked to an appropriate office in Tbilisi. In addition, further such automatic total recording stations fitted with data loggers should be installed in key areas of the drainage basin, especially near where much of the peak flood and suspended material were thought to have originated. The data collected will be accessed directly as part of the proposed early warning system.

e. Early warning systems

Until recommended measures are taken and in place, Tbilisi remains vulnerable to extreme events within the Vere drainage basin such as those of 13 June. It is therefore imperative that mechanisms for risk mitigation are immediately introduced along with an early warning system and measures for civil protection suitable to prevent, above all, loss of life.

In general, an early warning system should be supported by guidance to be followed in case an imminent flash flood is predicted. This level of warning can be defined based upon an estimate of how much rainfall over a specified time in a small basin is needed to initiate flooding in small rivers, which usually have a drainage basin smaller than 200 km^2, as is the case of the Vere River's drainage basin. Once developed, this could form part of a system of:

- Modelling the flood threat (in particular flash flood) across the basin thanks to:
    - Stream-flow data;
    - Rainfall measured by rain gauges (real time), radar, satellite, etc.; and/or
    - Rainfall forecasts.

Initially, the early warning system could be based upon a simple operational framework, and could be improved in the short-term through monitoring using proven and more sophisticated means. Precursors to events should be monitored on a continuous basis, with the data analyzed to generate a forecast. Within the framework of an early warning, emergency committees will initiate actions as proposed in the emergency plans using real-time information available from automatic strategically placed measuring equipment in a linked telemetry network together with simple rain-gauges and river-level gauges.

Georgia's Ministry of Environment and Natural Resources Protection, through the National Environmental Agency, has begun work on the installation of automatic rainfall measuring equipment and hydrological stations in the Vere River Valley (apparently the precipitation-measuring equipment is already being installed). The early warning system will be supported mainly through the preparation of maps identifying the sectors of flooding in urban areas linked to significant return periods. Utilising these maps, an assessment

19 This is a high-priority need considering not only other mitigation proposals but also as damage repair and rebuilding has already been started and is ongoing without adequate or realistic hydraulic data.

will be carried out of the vulnerability of all structures and infrastructure and, above all, of the population likely to be affected by the event. This knowledge will permit the creation of a safety and action plan, initially linked to the weather alert mechanism. This would be used to order evacuations, in a relatively rapid and reliable manner, of all people determined to be at risk, giving priority to the most vulnerable persons and structures (e.g. children, the old and infirm, schools, hospitals, main roads, etc.). As part of the safety and action plan, assembly areas outside flood risks zones would be identified together with the number, types and location of appropriate evacuation transportation to implement these plans.

As a first stage in the alert process, one of the priority actions must be the removal of all vehicles from within flood-prone areas to safe parking areas outside risk zones. Such a safety and intervention plan should consider establishing a dedicated and efficient system for civil protection involving structured entities such as the army, local police, community leaders, etc., but also including those living in at-risk areas by assigning them tasks and intervention procedures.

Above all, it is essential that the concept and perception of the dangers caused by flooding need to be introduced and instilled among potential victims, and the behaviour to adopt during such events should be explained, focussing upon methods for evacuation. This will be possible through training and awareness at the level of neighbourhoods and especially in schools at all levels. These courses must be conducted using simple manuals that are easy to understand and read, and should be consolidated by annual (or more frequent) rehearsals with appropriate practical evacuation exercises carried out where considered necessary. Awareness should consider not only aspects related to the event but also be extended to include the concept of respect and annual maintenance of established structures.

f. Studies and data collection

There are no solutions to mitigating the risk of flooding if measures are not taken to prevent the arrival of transported and large amounts of suspended material in the last lower downstream sections of the Vere River past Tbilisi's city boundary and into potential blockage areas. It is therefore important to provide for studies and work to achieve this goal.

It is essential to augment the present state of knowledge of flooding and of the drainage basin to be able to accurately plan and implement suitable measures to mitigate future risks. This could be achieved through river embankment construction and protection along the Vere River and its major tributaries. It is therefore important to activate in the short term the following group of studies:

1) Drainage basin studies

These studies, which will be focused on obtaining a better understanding of the Vere drainage basin, will identify and design actions to mitigate the risk of events such as those that occurred in June 2015. Designs will be based upon the results of these studies and will lead directly to the construction of mitigation works.

A feasibility study and preliminary design should focus upon the last 10 km. of the main water course and upon a similar length in tributary valleys on the right bank. It is anticipated that the final design will follow directly on from completed studies to ensure the early implementation of the construction of selected structures for the embankment of the last 3 or 4 kilometres of the Vere River upstream from urban areas, and similarly in some of the closer tributaries on the right bank (see Annex D). This approach and methodology will be considered as a pilot project, with the results used to implement similar interventions in other similarly threatened valleys.

The studies and design may include:

- Lidar digital elevation models[20] (DEM) at 1m resolution and the preparation of the following thematic maps:
    - a map of contour lines (spacing 1m);
    - a geomorphologic map (1:5,000) thanks to aerial imagery;
    - a slope map (1:5,000);
    - an aspect map (1:5,000);
    - a hydrographical network map showing drainage basins;
    - a geological map (1:5,000); and
    - a landslide vulnerability map, possibly indicating type of movement and hazard level.

The combination of a geomorphological map, survey data (landslides) and DEM-derived geomorphic indexes (plan and profile curvature, convergence index, topographic wetness index, stream energy index) will enable the drawing of a susceptibility map which subdivides territory according to danger levels. The entire Vere River drainage basin (about 180 km^2) will be mapped with lidar.

2. Riverbank stability

Some of the open river sections between the existing tunnels and culverts in Tbilisi were badly damaged during the floods, especially those at the upper end of the system near the outlet from Tunnel 6 and the inlet to Tunnel 5 as described above (see Annex E, photographs 6 & 7). Although some work is ongoing in this area, the right riverbank is very unstable due to the number and size of the upslope buildings (see Annex E, photographs 13 & 14). It is therefore imperative that the following studies and investigations are initiated without delay:

(i) A geotechnical investigation[21] to characterize site lithology in order to realize geologic and geotechnical cross-sections of the riverbank. Investigations should extend to foundations and construction materials for each selected site, including:

- a detailed geological survey comprising a geomechanical survey of all possible outcrops;
- a geological survey of the footprint of the work being done, with particular attention paid to identifying outcrops of solid rock in the riverbed that are acting as a permanent hydraulic threshold;
- a geomechanical survey of the shoulders;
- at least 8 vertical boreholes with continuous coring, in-hole tests and sampling to suitable depths;
- trial pits along the central axis of the river, extended upstream, to investigate the presence of materials suitable for construction, with stratigraphy, samples collection and in situ tests;
- laboratory tests to be carried out on soil and rock samples taken from the boreholes and test pits, consisting of classification tests, mechanical tests, etc.

(ii) A detailed topographical survey to precisely determine the current status; this survey must be extended to the whole right riverbank between Tunnel 6 and the inlet to Tunnel 5.

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20 Lidar DEM will be extended to all the Vere Watershed (apparently a Lidar has been recently developed by a donor; we do not know the details of this study).

21 Details of geotechnical investigation and laboratory tests are given in Annex C.

(iii) Design studies that will include the designs of recommended works, to then be followed immediately by the construction of the same:

- Designs for slope stabilization which consider the geological and geotechnical parameters resulting from the investigation and the topography; a stability analysis under various conditions.
- Selecting sustainable engineering solutions for the complete stabilization of the slopes, the analysis to take into account seismic conditions. More sustainable design solutions would probably involve slope reshaping with the consequent loss of areas upon which houses have been built.
- Works for the restoration of safety.

g. Repairs to the tunnels and culverts damaged by the flooding

All of the river tunnels and culverts within city limits will need to be cleaned, to undergo a detailed structural analysis and repaired. It has been assumed that these aspects and their associated costs were taken into consideration when the damage to road infrastructure was being assessed, as almost all are directly related to the reinstatement of good transport links within the city.

2. Short to medium-term actions (12 to 36 Months)

h. Meeting appropriate norms regulating land usage

A significant lack of general norms regulating land usage was observed, and in relatively unstable areas such as this, the absence of such norms is one of the main contributory causes of its fragility. It is therefore essential to introduce new or improve existing land usage norms and criteria that will become part of a future long-term "Basin Plan" and will be in line with the Water Framework Directive.

i. River embankment works

A feasibility study and preliminary designs should be carried out along the last 10 km. of the main course of the Vere River and along a similar length of its right-bank tributaries. This stage will be shortly followed by the final design for the embankment of the last 3 to 4 kilometres of the Vere River before it enters urban areas, as well as for that of some of its closer tributaries on the right bank. (See Annex E, Figure 1).

j. Flood mitigation structures

Until the studies detailed above have been completed, only preliminary indications of actions can be given. The preliminary measures envisaged include the construction of low transverse works such as check dams (gabion weir structures) and debris flow barriers in order to:

- Decrease the riverbed gradient with consequent reductions in velocity, energy and peak flood flow;
- Confining the transported deposit erosion; and
- Trapping a large part of the transported load, including floating wood debris.

In the first analysis, a typology of structures corresponding to gabion-weir-type check dams (for typical configurations in similar contexts, see Annex E, photographs 17-28) is proposed as the most appropriate intervention, particularly considering the experience gained in Georgia. The number and size envisaged are:

- 10-14 check dams with a maximum height of 3 to 4 metres along the Vere River and a further 16 along its tributaries;

- Total estimated approximate volume of each = 10,000 m^3.

In order to approximately quantify the number of check dams to be built along the Vere River's course, the following qualitative statement may be assumed:

- The check dams will, tentatively speaking, be built along the last 3 or 4 kilometres of the Vere River;
- Actual average river bed gradient: 2.4%;
- Envisaged spacing between check dams: 300m;
- Check dam height not to exceed 4m;
- Theoretical final river bed gradient approximately ≥ 1%;
- Environmental assessment needed.

The proposed works will preserve the original geometry of the river course and reduce flow velocities.

Considering the dominant role that floating and surface transported materials and debris played in blocking the downstream tunnels in June 2015, it will be necessary to design at least 7 of the planned check dams as selective weirs that will block wood materials (see Annex E, photographs 20, 21, 26, 27 and 28).

The general indications for the inclusion of check dams are the following:

- The check dams should be simple in design;
- The type of structure chosen should be easily reproducible and easy to build in a variety of locations, including those difficult to access (in some locations it may be necessary to use specialist equipment, e.g. spider excavators;
- Site selection will be based upon the best geological and morphological conditions, including:
    - shoulders on solid rock;
    - sections with suitable widths;
    - in a straight section of the stream;
    - far from side ravines; and
    - far from the foot of landslides.

3. Medium to long term (> 36 Months)

k. Implementation of a drainage basin management plan

The "Basin Plan" should be a tool for sustainable development and an instrument of technical regulation that directs policy planning. It should be aimed at all public entities such as regional local authorities, etc., as well as at the private entities such as businesses, entrepreneurs and citizens.

It is suggested that international experience of relevant legislation which has already been adopted in areas with similar problems be used as an example.

l. Reforestation

- The reforestation of terraces along the main course of the Vere River could decrease debris load during floods.
- The reforestation of neighbouring and unstable slopes could lower peak rates of flooding in the medium to long term.

Table 16. COST ESTIMATE of mitigation studies and associated construction of work

Table 16: Estimated cost of mitigation studies and of the construction of required structures[13]	
Items	**USD**
Lidar DEM (1m resolution over 180 km^2)	180,000
Thematic maps	30,000
Mathematical hydraulic model of the Vere River (5 km)	70,000
Check dams design (preliminary study + final design + geotechnical investigations)	180,000
TOTAL	**460,000**

Table 17: Estimated cost of check dams[14]			
Items	**Volume (m^3)**	**USD/m^3**	**USD**
Check dams (gabion weirs)	10,000	80	800,000
Contingency (10%)			80,000
TOTAL			**880,000**

Table 18: Timeline for studies and data collection[15]	
Items	**Time (months)**
Lidar DEM 1m resolution (180 km^2)	2
Thematic maps + mathematical hydraulic model of the Vere River (5 km)	3
Check dams design (geotechnical analyses + preliminary study + final design)	5
TOTAL	**10**

Table 19: Timeline for the construction of check dams[16]	
Type of work	**Time (days)**
Site preparation, cleaning, foundation and shoulders excavation	12
Gabion cages erection (300 m^3 per site)	36
Final completion	12
TOTAL	**60**

Table 20: Cost of other river related items (in USD)			
No.	**Description**	**Cost**	**Remarks**
1	Hydraulic computer modelling of Vere River drainage basin and river including the tunnel and culvert system within the city boundaries	120,000	
2	Construction of new, modern and suitably equipped gauging station (automatic rainfall and stage recorders linked to NEA office by telemetry) close to the site of the earlier Tbilisi-Vere station that was destroyed in the June 13 floods	35,000	Assumed to be run and supported by NEA in Tbilisi
3	Construction of 3 additional new, modern and suitably equipped gauging stations (automatic rainfall and stage recorders linked to NEA office by telemetry) to supplement replaced Tbilisi Vere station	100,000	Assumed to be run and supported by NEA in Tbilisi
4	Inspection and repair of damage to all tunnels and culverts conveying the Vere River within Tbilisi city boundaries, including the 1958 tunnel to the confluence with the Mtkvari (Kura) River	120,000	It has been assumed that these costs have been taken into consideration when the damage to infrastructure was assessed. This additional cost has been added as a contingency in case all aspects are not included.
5	Maintenance of tunnel and culvert systems	10,000	Routine annual maintenance of tunnels (2%)
6	Construction of metal posts at the entrance to 1958 tunnel to restrict the entry of very large washed material, such as vehicles and large trees, that have not been blocked by the debris collection mechanism in the river channel in the Didgori area.	15,000	
7	Introduction of updated building and construction regulations for Georgia	25,000	
8	Provision of radar prediction software for real-time information as part of the early warning system (common in many European countries)	10,000	
9	A. Drainage basin studies.		Given in Table 4
10	B. River bank stability study and investigations		Given in Table 4
11	Introduce or improve land usage norms and relevant criteria	30,000	Training, guidance and technical support to assist implementation
Contingency (10%)		51,500	
TOTAL		**511,500**	

Tbilisi Zoo

With around 500,000 visitors a year (over 10% of the entire country's population), Tbilisi Zoo is an object of national pride in Georgia. By providing ex-situ conservation and educational opportunities, the Zoo has led conservation efforts which highlight the importance of preserving Georgia's wildlife. Its proposed expansion and relocation will undoubtedly further enhance visitor experience, thus contributing to the Zoo's ultimate mission.

For the moment, the Zoo must manage the urgent needs of many of the surviving animals, especially as winter is approaching, and several priority actions must be taken immediately. In the short, medium and longer terms, however, discussions which have already begun over a master plan for the Zoo's relocation need to continue in order to find sustainable solutions for the recovery of the Zoo and its animals. Furthermore, the complexity of the consequences of this disaster demonstrates the need for collaboration between all engaged stakeholders.

Table 21: Zoo needs (in millions)

Recommendations	Needs (GEL)	Needs (USD)
Immediate needs for buildings and enclosures[17]	1.5	0.7
Replacement of animals[18]	0.5	0.2
Roads and utilities (sewage, water, gas, electricity)	0.7	0.3
Other (equipment, attractions, etc)	0.4	0.2
Cost of clearing mud and debris	0.5	0.2
Relocation of Zoo[19]	134	60
TOTAL	**137.6**	**61.6**

1. Immediate measures

Immediate needs for buildings and enclosures—GEL 1.5 million

- Construct temporary winter holding shelters in order to maintain the welfare of animals such as the penguins, particularly those endemic to warmer climates—hippopotamus, white rhino and crocodiles.
- Replace the Zoo's perimeter fencing, which was removed when debris was cleared.

Roads and utilities—GEL 700,000

- Repair the roads and utilities (water, gas, sewage, electricity) infrastructure. (Sewage and water systems are currently being repaired.)

Other—Part of GEL 400,000 budget

- Supply administration staff, particularly accountants, with computers and other office equipment to enable them to share financial documents with the municipality and process tenders with other organizations or zoos for the procurement of materials for general zoo maintenance and daily upkeep (food, transport vehicles for animals, cleaning products, etc.).

Cost of clearing mud and debris—GEL 500,000

- Finish clearing remaining mud and debris from the Zoo's premises.

Relocation of the Zoo—Part of GEL 134 million budget

- Elaborate a master plan for the Zoo's relocation, including: working out a timeline, financing, appropriate engineering and infrastructure work, drafting an action plan, communicating with stakeholders, staff capacity building, environmental factors, etc.

Figure 16. Damaged Animal Enclosures

2. Short-term measures

Relocation of the Zoo—Part of GEL 134 million budget

- Turn a master plan into a concrete action plan.

- Build housing for hippopotamus, wolf, brown bear and crocodile in a new location by November 2016.

Before the floods occurred in June, discussions had already taken place over the possibility of relocating the Zoo, and land for its new location had already been allocated close to the Tbilisi Sea.

3. Medium and long-term measures

Relocation of the Zoo—Part of GEL 134 million budget

- Relocate the Zoo with infrastructure that is risk-informed and resilient to natural disasters.

- Introduce capacity building opportunities for staff, focusing upon all aspects of animal management including but not limited to emergency response practices and protocols.

- Liaise with transport providers to facilitate travel to the Zoo's new location.

- Continue working as a candidate member to meet the requirements of the European Association of Zoos and Aquaria (EAZA) with the goal of becoming an accredited member. Benefits of such accreditation would include becoming a member of a large network of European zoos and zoological facilities whose Association helps with education and promoting conservation, as well as enriching the entertainment, tourism, and culture sectors of the Georgian government.

SECTION IV: RECOMMENDATIONS FOR IMPROVING DISASTER RISK MANAGEMENT

Description of institutional mechanisms and capacities for disaster risk reduction (DRR)

Georgia's disaster risk management system is governed by the Civil Safety Law (2014), which defines the following emergency response levels:

- National level (when facing a country-wide crisis);
- Autonomous level (within the boundaries of an autonomous republic);
- Regional level (within the boundaries of a region);
- Local level (within the boundaries of a municipality); and
- Unit level (within the boundaries of a local administrative unit).

Georgia's Civil Safety Law regulates the roles and responsibilities of various state entities, at each level, in terms of preparedness, response, prevention and early recovery. In addition, the law names the *Emergency Management Agency* (EMA) as the agency responsible for emergency prevention, preparedness, response and early recovery and reconstruction; and the *State Security and Crisis Management Council* (SSCMC), under the Prime Minister, as responsible for co-ordination during a national crisis.

A National Plan for Civil Safety is currently being drafted. According to the Civil Safety Law, it must be drafted and adopted before the 31st of December 2015[22].

Different agencies are responsible for different types of hazards: the *National Environmental Agency* (NEA) is responsible for hydro-meteorological and geological hazards (except earthquakes); Ilia State University's *Seismic Monitoring Centre* and *Institute of Geophysics* for earthquakes and secondary hazards caused by earthquakes (informal mandate); the *National Forestry Agency* for forest fires; etc. The EMA is also responsible for carrying out the National Plan for Civil Safety.

More specifically, Tbilisi's EMA Emergency Management Unit is responsible for:[23]

- Contributing to emergency management activities in Tbilisi;
- Disaster preparedness, prevention and mitigation, and early recovery;
- Developing disaster risk management plans for Tbilisi;
- Co-ordinating civil safety activities within Tbilisi's city boundaries;
- Public awareness and trainings as well as alerting the population in case of emergency; and
- Co-ordinating fire-fighters and rescue services, including during training exercises.

The Civil Safety Law also states that local governments, including Tbilisi municipality, are responsible for[24]:

- Designing and implementing disaster prevention measures;
- Developing and approving disaster risk management plans together with the EMA;
- Evacuating and sheltering people during an emergency;
- Distributing humanitarian aid;
- Emergency response and recovery activities; and
- Awareness raising and training.

22 Article 56 of Civil Safety Law No. 2,467.

23 Paragraphs 1 & 2 of Article 15 of Civil Safety Law No. 2,467.

24 Article 23 of Civil Safety Law No. 2,467.

Even though Tbilisi municipality currently does not have a dedicated DRR department, various DRR-related functions fall under the responsibility of different agencies, e.g.:

- **Tbilisi's Architecture Service** is responsible for land usage planning as well as reviewing, approving and issuing construction permits for Tbilisi. The city's current (2009) land usage master plan is not risk informed, but its revision is ongoing. In addition, construction permits are granted solely based upon architectural design, with no consideration given to additional key aspects such as structural design, geotechnical studies, etc.

- **A supervision service** is responsible for enforcing building codes and construction laws as well as identifying violations. Building codes are currently not based upon a multi-hazard risk assessment.

- **An improvement service** is responsible for the structural assessment of buildings and infrastructure in case of disaster as well as their repair and retrofitting.

- **A property management agency** is responsible for maintaining records of real estate across the city. This agency was involved in the damage assessment of real estate (buildings and land plots) following the floods of 13 June.

- **The ten district administrations** of Tbilisi's administrative units are responsible for infrastructural, environmental, social and economic development projects.

Tbilisi's hazard, risk and vulnerability profiles

Tbilisi is prone to earthquakes, floods, mudslides, debris flows and landslides, all of which have has a significant impact over the years (see Annex 2). The frequency of landslides peaked following the 2002 earthquake which struck Tbilisi (NEA, 2015). The most active landslide zones, all located in surrounding areas of Tbilisi, include: the northern slope of Mtatsminda Hill; the Nutsubidze Plateau; the slopes of Mukhatgverdi Hill; a large area across the right bank of the Vere River, stretching from Tamarashvili Street to Varaziskhevi (the so-called Vake Landslide); the Khevdzmari Ravine near the village of Gldani, etc. (UNEP et al., 2011).

With a population of 1,118,035 people (Geostat, 2015), Tbilisi has seen a rapid rate of urbanization in an area which is prone to natural hazards. This has contributed to the current level of risk. In 2015, the city extends over an area of 490 square kilometres and its population density stands at about 2,400 people per square kilometre (Colliers International, 2014). Tbilisi has expanded rapidly over the years, and the formerly rural areas of Mtskheta and Gardabani municipalities are now part of the city (see Figure 17). This expansion has been at the expense of forests and other areas of vegetation (UNEP et al., 2011).

Vulnerability assessments have been performed at local and national levels as part of various projects (Varazanashvili, 2012; Van Westen, 2012; Oxfam, 2011). Given the lack of a standardized methodology, however, results cannot be compared, integrated or used for risk assessments at local levels. Georgia's National Statistics Office[25] provides information on demography, levels of education, health conditions, levels of employment, environmental factors and cultural aspects, but this data is only available for the country as a whole.

To date, a local level multi-hazard risk assessment has not been conducted. A seismic hazard map of Tbilisi[26] (see Figure 18) was developed in 2012[27] by the Idea Design Group in co-operation with Georgia's Institute of Geophysics, the Zavriev Institute of Structural Mechanics and Earthquake Engineering (ISMEE), the Georgian National Committee for DRR and Environmentally Sustainable Development (GNCDRR). This assessment was, however, not widely disseminated or used for decision-making at local levels.

25 See http://www.geostat.ge/?action=page&p_id=11&lang=eng

26 See http://www.ideadesigngroup.ge/eng/projects?info_id=82

27 With the financial support of UNDP and of the Swiss Agency for Development and Co-operation (SDC).

A seismic hazard map for Tbilisi is also available from the Institute of Earth Sciences. In the aftermath of the 13 June floods, a preliminary slope stability hazard map was created by a team of U.S. Department of Agriculture (USDA) Forest Service staff working together with Georgia's National Environmental Agency. This map indicates that 8% and 11 % of the entire Vere River drainage basin is characterized by either potentially high or moderate slope stability hazards (Bennett et al., 2015).

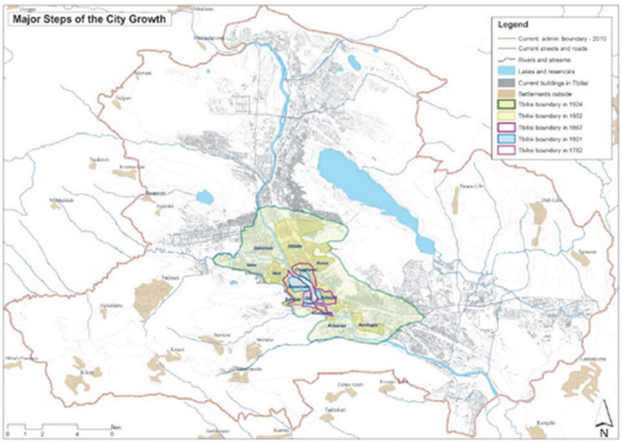

Figure 17: Tbilisi urban extension (1782-2010) (UNEP et al. 2011).

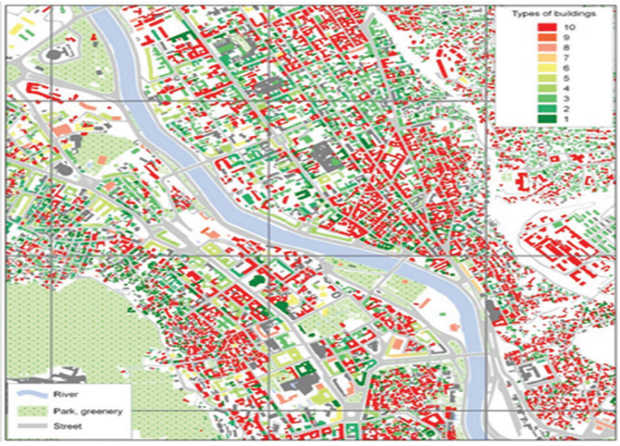

Figure 18: Seismic hazard map for Tbilisi.

Historical disaster-related data is scattered across different agencies, newspapers and media archives. Similarly, Tbilisi municipality does not maintain a centralized database to record historical disasters and their impacts.

The first attempt to establish a national disaster database[28] was made as part of the "Institutional building for natural disaster risk reduction in Georgia" project, which was implemented by the University of Twente's Faculty of Geo-Information Science and Earth Observation (ITC) in the Netherlands, the Caucasus Environmental NGO Network (CENN), Georgia's National Environmental Agency and Emergency Management Agency and Ilia State University. This database has not, however, been maintained since its creation in 2012, and is now out of date.

Weather monitoring and forecasting systems

Currently, Tbilisi does not have an operational multi-hazard early warning system to mitigate losses from potential disasters. If there had been warnings, roads could have been closed, traffic could have been diverted, and the impact of the disaster could have been minimized, potentially saving lives.

The main agency responsible for monitoring hydro-meteorological and geological hazards (except earthquakes) is Georgia's National Environmental Agency (NEA), which operates under the Ministry of Environment and Natural Resources Protection through its Hydro-meteorological and Geological Departments. The main functions of the NEA are observation, analysis and forecasting and the dissemination of predictions and warnings.

Hydro-meteorological measurements for Georgia date back to the establishment of its first meteorological observatory in 1844. The country's monitoring network has, however, been allowed to degrade over the years (see Figure 19); the forecasting capacity of the Hydro-meteorological Department has obviously also suffered due to the lack of data and staff. Until the 1990s, the Department operated standard and specialized observations, but some of those observations were stopped over the years (e.g. upper air,

28 See http://drm.cenn.org/index.php/en/disaster-database/historical-disaster-information

radar, ozone, water-balance, glaciological observations, etc.)[29]. There are currently only 2 meteorological stations and 1 hydro-meteorological post in Tbilisi, and there is no regular monitoring of Georgia's gorges and small rivers.

In the aftermath of the 13 June floods, two automatic meteorological stations were installed within the Vere River drainage basin. The NEA has also benefited from support for capacity building and the improvement of its monitoring network over the years from the World Meteorological Organization, the World Bank, USAID, Canada, Finland, the UNDP and the Global Adaptation Fund. Its monitoring network has not, however, been fully upgraded, and more importantly does not cover the entire country or cities.

According to the Civil Safety Law, which is the reference regulatory framework for disaster response, the Emergency Management Agency (EMA) under Georgia's Ministry of Internal Affairs is responsible for disseminating warnings in case of disaster. The EMA receives information from the NEA and the Seismic Monitoring Centre[30] and distributes it to heads of regional emergency management units and teams via SMS. In addition, governors, mayors and the emergency services of potentially at-risk areas are also informed so that they may begin to mobilize all relevant units and teams. The timeliness and accuracy of the information it received from the NEA and the Seismic Monitoring Centre is key for the EMA to begin operations.

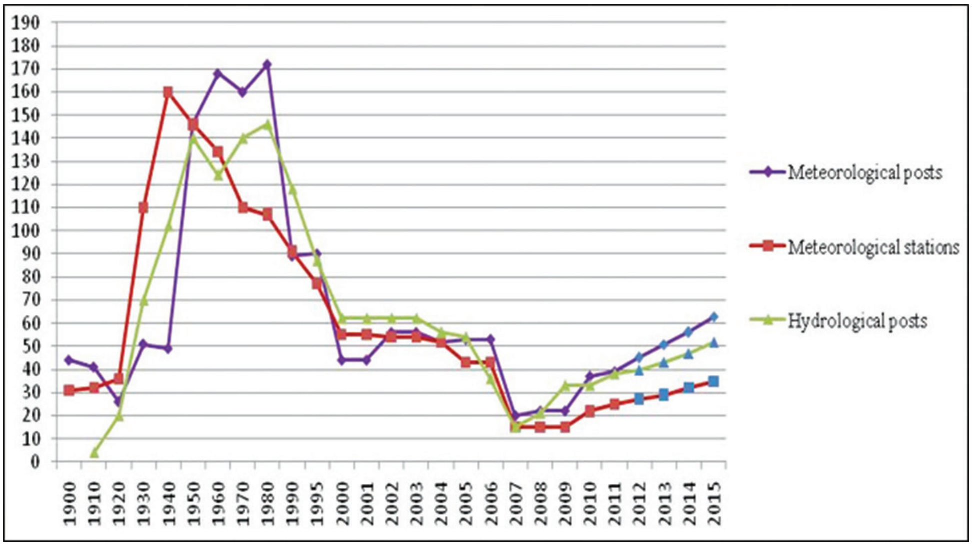

Figure 19: Georgia's hydro-meteorological monitoring network (1900-2015) (source: NEA)

29 See https://www.wmo.int/pages/prog/amp/pwsp/SEB_Seminar_2015_RAVI.htm

30 Based upon data collected from river gauges, the NEA publishes a daily bulletin to provide flash flood alerts with information on observed water levels and a two-day forecast (NEA et al., 2010). This bulletin is sent in hard and soft copies to the government, to the SSCMC as the most senior authority operating under the Prime Minister's office, to operators of hydropower plants and to other users upon request. In case of estimated potential risk, the information is also shared with potentially affected municipalities. Flood forecasting associated with snow melt is based upon field surveys done twice a year in February and March. In addition, the NEA provides short and medium-term weather forecasts on a daily basis using the high-resolution model of the *Deutscher Wetterdienst* (DWD; Germany's meteorological service) and the US Weather Forecast Model (WRF-EMS). The NEA's Geology Department also provides an annual geo-hazards bulletin which is sent to municipalities, the EMA, Georgia's Ministry of Regional Development and Infrastructure and other interested parties, along with an outlook for the year to come. Due to a substantial reduction in the Department's staff and equipment, however, the geological monitoring of Tbilisi was stopped in 2000. Ilia State University's Institute of Earth Sciences and Seismic Monitoring Centre are responsible for seismic data collection and processing. The Centre maintains a seismic monitoring network composed of 25 stations, and, if an earthquake strikes Georgia, provides information on the location of the epicentre and magnitude by SMS as well as on its website.

The environmental impact of the 13 June floods

Because governments choose to focus upon sectors with more immediate needs, e.g. housing or health, the environmental impact of disasters can often be overlooked. This impact can, however, have negative consequences for tourism, livelihoods and community social capital, as well as for the affected area's biodiversity.

The 13 June floods impacted the environment in many ways (see Table 22 for an overview of the environmental impacts as of July 2015, based upon information available at the time of writing). In order to arrive at a conclusive statement on the environmental impact of this disaster, an environmental impact assessment that accounts for the dynamic nature of the impact over a period of time should be considered.

Table 22: Environmental impacts of the 13—14 June, 2015 floods

Impact	Description
Landslides and mud flow into river waterways	A large landslide of about 1 million cubic metres near the village of Akhaldaba (Tskhneti area) collapsed material and accumulated more debris from several smaller landslides in the drainage basin area, transforming it into a massive mud and debris flow which ran into the Vere River (see above). The risk of future landslides still exists (Bennett et al., 2015) and a detailed assessment needs to be carried out (as part of a multi-hazard risk assessment, see above).
Damage to vegetation	The landslide swept away all the vegetation (up to 4,000m^2 of forest) between the village of Akhaldaba and Tskhneti according to the NEA's Geology Department.
Drainage and sewage released into waterways	Old sewage lines were severely damaged by the floods. As a consequence, the sewage is routed directly into tributary streams that run into the Vere River or falls at outfalls from the broken pipes high above the river channel with a considerable health risk for the community (Bennett et al., 2015). In addition, tens of manholes were flooded and covered with silt (see above). Pipes were damaged and were reported to be leaking wastewater directly into the Vere River (see recommendations for the water sector).
Contamination of landscape with hazardous materials	The tunnels divided the flooded disaster zone into two separate sections—one from Heroes' Square up to the Vake-Saburtalo road, and the second from the Vake-Saburtalo road to the end of Svanidze Street (CENN, 2015). While most of the debris was removed, the long-term effect of any pollutant release needs to be studied as current information is insufficient for this risk to be assessed.

Assessing the performance of the DRR system at the municipal level

The Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) is a 15-year, voluntary, non-binding agreement which recognizes that governments play a primary role in reducing disaster risk, but that responsibility should be shared with other stakeholders—including local government, the private sector and others.

Its four priorities for action are:

- **Priority 1: Understanding disaster risk**
- **Priority 2: Strengthening disaster risk governance to manage disaster risk**
- **Priority 3: Investing in disaster risk reduction for resilience**
- **Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction**

Over the past few years, the Georgian government has taken steps to make disaster prevention and preparedness a national priority (UN, 2014). The current revision of the building code as well as Tbilisi's land usage master plan demonstrate the government's continued commitment to move towards a more resilient society. The performance of the DRR system during the 13 June floods highlighted some positive aspects, e.g. the rapid mobilization of rescue teams and volunteers and special equipment, but also revealed some deficiencies. This analysis is based upon a desk review as well as upon consultations with government representatives, NGOs, academics and other national and local stakeholders (see Annex 1).

The results of the analysis are presented here and are organized according to the four priorities of the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015), which is the main reference document for DRR:

1. Understanding disaster risk

Disaster Risk: "The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period".

Hazard: "A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage".

Exposure: "People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses".

Vulnerability: "The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard".

(UNISDR, 2009)

The 13 June floods shed light on the significant levels of risk Tbilisi is exposed to. The analysis found that the understanding of disaster risk is insufficient at the local level due to the **lack of a local multi-hazard risk assessment**, which would be necessary for informing policies, plans and practices for disaster risk management. The city's seismic hazard maps are outdated and assessments covering hydro-meteorological hazards are not available. A preliminary slope stability hazard map was produced for the city in the aftermath of the flood but needs further analysis (Bennett et al., 2015). The analysis also noted the **absence of a centralized database to record historical disasters** and their impacts; such a database would provide a solid basis for informing policy decisions seeking to reduce disaster risks and increase resilience in Tbilisi.

The analysis also found that **early warning capacity is limited** due to several factors (see above). In addition, while technical expertise exists in various sectors and for specific technical areas, the analysis found that **low risk awareness and knowledge** complicated evacuation after the flood. Preparedness programmes and emergency drills, which are essential for communities to be prepared and ready to react to warnings, were also found to be insufficient.

2. Disaster risk governance to manage disaster risk

Tbilisi has seen fast but poorly regulated rates of urban development; this has contributed to the creation of risk, and requires efforts to improve disaster risk governance for prevention, mitigation, preparedness, response, recovery and rehabilitation.

The analysis found that the city's current land usage master plan is not risk informed, and that building codes are not based upon a multi-hazard risk assessment. Nevertheless, the ongoing revision of both provides a huge opportunity for change to "build back better" and to prevent the creation of new risk. A bid for the revision of the city's land usage master plan has been issued by Tbilisi's Architecture Service. The plan will be the main reference document to guide Tbilisi's development. It will regulate development in key sectors such as housing, transport, infrastructure, environmental protection, cultural heritage, industry, etc. At the same time, prevention, preparedness, response and early recovery plans will be developed for Tbilisi in the immediate future, as required by the Civil Safety Law (2014). According to the new building code which is being drafted, a certification system will be put in place for architects, engineers, structural designers, etc.; this will improve the quality of construction as Tbilisi City Hall will only accept projects which have been prepared by certified professionals.

Building permits are currently granted based solely upon architectural design, and changes to land usage can be granted on demand. Moreover, many illegal buildings in at-risk areas have been legalized over the years, leaving both buildings and residents exposed to a significant level of risk—a level which is even unknown due to a lack of local multi-hazard risk assessments. Efforts to prevent the creation of new risk should be accompanied by actions to reduce previously accumulated risk due to earlier developments and investments. In addition, the analysis found that risk transfer practices (disaster risk financing and insurance schemes) were also missing in addition to the corrective risk management strategies mentioned earlier.

The analysis also found **unclear mandates for local risk assessment** as well as the need for clear standard operating procedures (SOPs), roles and responsibilities within and across sec3

3. Investing in disaster risk reduction for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures is essential as part of efforts to improve the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. Such measures are cost-effective and can save lives, prevent and reduce losses and ensure effective recovery and rehabilitation.

However, the assessment revealed that local and national authorities have made no investment for the inclusion of disaster risk assessment, mapping and management in urban development.

Georgia currently ranks 9th out of 185 countries in the World Bank's Ease of Doing Business rankings—ahead of all but 3 members of the G20 (Botting, 2013). This is a remarkable achievement, but on the other hand granting building permits in a day does not allow enough time for a thorough analysis of the land or construction design and potentially contributes to the creation of new risks.

Furthermore, no geological risk assessment and monitoring has been carried out in Tbilisi since the city was removed from the NEA's mandate in 2007; this is mainly because City Hall has not set up a specialized unit for doing so.

In addition, Tbilisi's low levels of risk awareness has led to a concentration of donor funding in other parts of the country, neglecting the fact that Tbilisi is also at high risk. This might be the consequence of a limited level of investment in the hazard and risk assessments needed to guide policies, prioritize investments and inform urban planning.

4. Disaster preparedness for effective response and for "Build Back Better" during recovery, rehabilitation and reconstruction

The aftermath of the 13 June floods saw **effective response operations** with full mobilization of rescuers, teams and special equipment for immediate clearing and repair. Roads that required specialized clearing and rescue operations were reopened in only 36 hours. Moreover, the event triggered a very **significant movement of civilian volunteers** for clearing-up operations.

Nevertheless, **appropriate policies and plans were not in place** to support the response phase; this was mostly due to the fact that the national response plan dates back to 2008, and for the 13 June floods—the most disastrous ever experienced in Tbilisi—response operations were merely based upon general guidance provided by the national plan.

The city did not have any *a priori* recovery plans at municipal or local levels even though smaller-scale floods had already occurred in the same area. The availability of such plans would have significantly expedited the recovery process and would have ensured that risk will not be reintroduced through poor reconstruction practices. The analysis found that **emergency drills for public buildings** (e.g. schools, kindergartens, hospitals, etc.) are ad hoc and are not regularly and systematically carried out. However, on a positive note and as required by the Civil Safety Law, **city preparedness and response plans will be developed** by Tbilisi municipality with technical support from EMA in the near future**.**

Another important component of the response system is the 112 emergency telephone number service, whose centre is based in Tbilisi but covers the entire country (including the Autonomous Republic of Adjara). This service unites the operations of the ambulance, police and fire-fighting services. The analysis noted that having only one centre does not provide the 112 service with back-up for data and does not ensure a continuity of operations.

SECTION V: RECOMMENDATIONS FOR STRENGTHENING TBILISI'S DISASTER RISK REDUCTION SYSTEM TOWARDS A RISK-INFORMEDDEVELOPMENT

Based upon the findings of the analysis, recommendations for improving Tbilisi's DRR system are presented here for the short, medium and long terms. It should, however, be recognized that the interventions identified may extend between periods. The division of interventions into different periods is useful for planning work during the initial stages of the recovery process, but must be reviewed regularly.

Short-term recommendations:

The UNDP's commitment to risk-informed development involves building the capacity of national and sub-national actors to reduce and manage their disaster and climate risks through a series of five interrelated components, which all contribute to risk-informed development:

- **risk assessment and communication;**
- **early warning and preparedness;**
- **inclusive risk governance;**
- **resilient recovery; and**
- **urban and local level risk management.**

1. Implement a multi-hazard early warning system (MHEWS) for Tbilisi (short to long term), as also indicated in the sectoral recommendations. It is recommended that the 4 components be developed, namely: risk knowledge, a monitoring and warning service, dissemination, and response capability (UNISDR, 2006). The MHEWS should be designed based upon the risk information available for Tbilisi (i.e. once a multi-hazard risk assessment is available, the MHEWS should be reviewed accordingly). Monitoring and predicting is only one part of the early warning process, and should be associated with communication systems and response plans (UNEP, 2012). The MHEWS should be based upon a **sound monitoring network**. Firstly, existing non-reporting stations should be rehabilitated. Early alert precipitation gauges (rain gauges) should be installed throughout the drainage basin. Water levels should be monitored through automatic stream-flow stage measurements that would warn of stream-flow rise. In addition, for areas where landslide stability risk has been identified, a warning should be based upon the duration and intensity of rainfall (Bennett et al., 2015). In at-risk communities, level sensors could be installed to track landslide movements. The installation of a radar should be considered. The risk of secondary hazards associated with earthquakes (e.g. landslides) should be estimated based upon data recorded by seismic stations. In addition, the need for additional seismic stations should be studied. A satellite system would be needed for transmitting data; the latter should be interpreted by professionals qualified to know when to send out an alert in case of potential risk (e.g. flood, landslide, earthquake, etc.). Data and products should be fed into an operational crisis management centre. In case of emergency, qualified experts should be called to duty in a situation room in order to assess any given situation and provide expert advice. It is recommended that possible scenarios and standard operating practices be defined beforehand, as time is limited during disasters. To enhance forecasting capabilities, training and twinning arrangements with other institutions should be considered as options. Finally, local awareness-raising campaigns should be organized along with regular community preparedness trainings and emergency drills. It is strongly recommended to harness international and regional expertise—e.g. the Flash Flood Guidance System (FFGS)[31] developed by the World Meteorological Organization, whose Black Sea—Middle East region Georgia belongs to[32]. The FFGS provides products to support efforts to increase levels of warning for flash floods from rainfall

31 See http://www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php

32 See .../ffgs/documents/BSMEFFG_UserGuide-opt.pdf

through the use of remotely sensed data and hydrological models[33]. The FFGS also provides information on the risk of landslides due to heavy rainfall. To harness Georgia's currently available resources, e.g. access to the FFGS, supplementary training for duty-forecasters is suggested, as well as the improvement of models in order to transition towards a combined model for the entire drainage basin that could be used for the operational prediction of both flash floods and large river floods. Finally, the FFGS includes an extensive training programme that can benefit FFGS countries such as Georgia.

2. Avoid re-creating risk in affected sectors by ensuring that disaster risk reduction concepts are embedded in reconstruction efforts. (DRR recommendations were included in the sectoral recommendations in the first part of this report.)

Medium-term recommendations:

3. Undertake a multi-hazard risk assessment[34] for Tbilisi that would consider both geological and hydro-meteorological hazards and their interaction, as well as different return periods depending on the level of infrastructure damage, as also indicated in the sectoral recommendations. In order to achieve this task, there is a need to review mandates within Tbilisi municipality so as to ensure that there is a department dedicated to regularly carrying out and updating local risk assessments. For a sound assessment, it would be important to **strengthen links between decision-making and science** in order to harness and build upon the existing technical expertise available within the country and region. As such, there is a need to initially develop qualitative risk assessments which prioritize risks in various sectors, livelihoods and the city at large. Once this is achieved and successfully linked to the decision-making process, a dedicated municipal body will be tasked with refining the risk assessment results and carrying out quantitative risk assessments.

4. The ongoing revision of Tbilisi's land usage master plan and building codes offer a key opportunity to prevent the creation of new risks. One should therefore ensure that **the new land usage master plan and building codes are risk informed**. The city's land usage master plan should consider: the restoration of the Vere River as it passes through Tbilisi (immediate to long-term, as also indicated in the sectoral recommendations), regulating development along the river's banks, and reforestation along the riverbanks and in unstable areas (e.g. by protecting them from grazing) (Bennett et al., 2015).

5. A high-quality centralized and standardized **historical disaster database[35]** should be developed at the city level. Data collected should be gender-disaggregated and contain information for hazard characterization, including geographic area affected, as well as damage and loss accounting (both human and economic) in key economic sectors. Environmental impacts of disaster should also be included. Over time, the accumulated data would provide information on cumulative loss and damage, its geographic distribution, the main hazards, the types of loss and damage that occur, and temporal trends.

6. Develop prevention, preparedness, response and early recovery plans for Tbilisi. The Civil Safety Law requires that such plans be drafted. It is recommended that these be risk informed based upon a thorough multi-hazard risk assessment. In particular, there is a paramount need to ensure that the risk management strategy portfolio contains prospective, corrective and compensatory components, and that

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33 See .../hwrp/documents/FFI/Flash_Flood_Guidance_Systems_Background_Information.pdf

34 See http://www.ecapra.org/sites/default/files/documents/Book%20Multi%20Hazard%20Risk%20Assessment_0.pdf

35 UNDP (2013) provides a key reference for developing such databases. Moreover, the European Commission (2014) provides recommendations for European Union member states that would help increase the quality of (shared) loss data within the current policy framework, and in particular for the targets and indicators of the post-2015 framework for disaster risk reduction.

it is not limited to preparedness and response activities. In addition, critical infrastructure[36] should be identified, including all the infrastructure that is necessary for the social, economic, health, cultural, political and environmental welfare of the city and its inhabitants.

7. Regularly update and test response and contingency plans for critical infrastructure and sectors as part of a much broader critical infrastructure resilience programme. Again, there is a need to ensure that response and contingency plans for critical infrastructure sectors form part of the effort to build resilience, and that prospective and corrective strategies for building resilience are also adopted.

8. Increase the co-ordination of civilian volunteers as part of a city-wide response framework that allocates roles and responsibilities to all stakeholders with a role to play in response operations.

Long-term recommendations:

9. Strengthening the institutional set-up for DRR. The analysis showed a need to allocate clear roles and responsibilities at all different levels of administration to relevant entities that are responsible for different aspects of DRR within and across sectors (including risk assessment and early warning). Mandates and legislation should be reviewed to harmonize the legal and institutional frameworks. Training and capacity-building regarding the use of data and information for DRR and development should be performed at multiple levels. There is a need to ensure that all development actors take part in the drawing of hazard and risk maps in order to ensure that the information provided meets all the needs they have identified. Only in this manner can links between science and policy be improved and strengthened.

10. Reduce existing risk (based upon a multi-hazard risk assessment). The results of the risk assessment referred to above should inform the development of long-term sectoral risk reduction programmes designed to reduce existing sectoral risks while preventing new risk from accumulating in the future (e.g. school safety programmes). The multi-hazard risk assessment will identify high-risk areas that require action. Top priority should be given to critical infrastructure. Measures that can be taken include: relocating schools and hospitals to safer areas; renovating and rehabilitating existing buildings and infrastructure situated in high-risk areas; switching the land usage classification of high-risk areas from "residential" to "recreational"; limiting population density in at-risk areas; etc.

11. Ensure the enforcement of building codes and regulations by developing mechanisms for the review of designs and construction without significantly delaying the awarding of building permits. In order to successfully achieve this, there is a need to build the capacity of municipal staff tasked with reviewing adherence to codes and/or liaising with verification bureaus.

12. Ensure sustainable funding for DRR. To this end, various financing mechanisms for reducing risks should be examined as part of risk retention and reduction and risk transfer strategies. The role of the insurance sector should be carefully examined and elaborated in this regard. The threshold between risk retention and reduction on the one hand and risk transfer to insurance markets on the other should be determined based upon a consultative participatory approach with all relevant stakeholders.

13. Increase the "112" emergency call centre's ability to ensure that it has back-up capacity for data and operations.

A detailed recovery plan for DRR will be provided separately by the UNDP—working in a recovery framework in close co-operation with relevant governmental stakeholders—as a stand-alone document separate from this Tbilisi Disaster Needs Assessment.

36 'The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.' (UNISDR, 2009)

ANNEXES

ANNEX 6: List of institutions interviewed for assessment of DRR Sector

The Tbilisi Zoo

Emergency Management Agency, Ministry of Internal Affairs

Vake district authority

Ministry of Regional Development and Infrastructure, Roads Department

National Environment Agency, Ministry of Environment and Natural Resources Protection

Ministry of Environment and Natural Resources Protection, DRR Unit

Georgian Red Cross Society

GIS and Remote Sensing Consulting Center "Geographic"

State Security and Crisis Management Council, PM's Office

Tbilisi Municipality Services (Architect, Property Management)

Seismic Monitoring Center, Institute of Earth Sciences, Ilia State University

Ministry of Health and Social Affairs

112 Call Centre

Ministry of Economy and Sustainable Development/Department of urban and spatial planning

ANNEX 7: Tbilisi Disaster Profile

Tbilisi, the capital city of Georgia, lies in the center of eastern Georgia, in the foothills of the Trialeti mountain range. The city is prone to both geological and hydro-meteorological hazards (Table 18). Several active faults surround Tbilisi, with historical records dating back to the 13th century (Varazashvili et al., 2008). However, the first seismological station was installed in the city only much later, in 1899 (Figure20). On April 25, 2002 the strongest earthquake ever recorded (since 1900) occurred in Tbilisi, with its epicenter within the city borders. The 4.5 magnitude earthquake was characterized by an intensity of 6-7 in MSK[37] scale. The earthquake accounted for 5 deaths and nearly 160 million USD in economic losses (Javakhishvili et al., 2004).

37 Medvedev-Sponheuer-Karnik

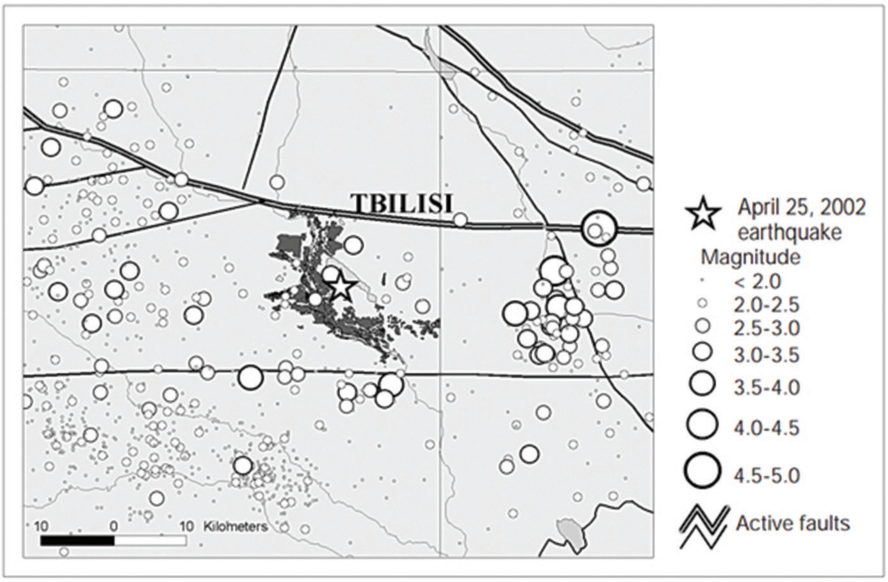

Figure20. Recorded earthquake epicenters from 1955-2002 in the area of Tbilisi (Javakhishvili et al., 2004).

Table 23. A record of historical hydro-meteorological events and associated impacts recorded in Tbilisi (NEA, 2015; Tsanava, 2004).

Date of the event	Description of impacts
12 June, 1924	After 1 hour of extended heavy rains, a mudflow in Vere gorge carried away peasants with their bulls and carriages and threw them into the river Mtkvari.
10 May, 1940	109 mm of rain fell in 24 hours causing mudflows and flashfloods in all rivers and gorges of Tbilisi and in particularly the Vere River. The water level of Vere River increased by 2 metres. The zoo was badly damaged.
4 July, 1960	Water discharge was 259m³/s. It swept away land and buildings located in the river bank between Vake-Saburtalo road and the zoo. The zoo was considerably damaged.
1961	Flashflood in Vere gorge damaged zoo infrastructure, the animals were killed.
Summer, 1972	Water discharge was 153 m³/s. Several streets were washed away.
13 May, 1980	As a result of heavy rains, the barrage of the artificial reservoir in Tskhneti broke through, resulting in 8 deaths, destroyed houses, loss of a large amount of cattle and significant damage to the infrastructure of the zoo.
28 August, 1999	As a result of heavy rains, mudflows originated in the dry ravines surrounding the city. The basements of various houses were flooded. The major part of the road at Varaziskhevi was damaged.
15 October, 2002	As a result of heavy rains, the districts of Mtatsminda, Sololaki, Chughureti, Nadzaladevi and Sololaki slopes were washed away by mudflows. Several houses were flooded on Ketevan Tsamebuli street. A landslide affected the Nadzaladevi district and Dadiani street. Varaziskhevi and Chanturia streets were severely damaged as well as about 40 streets in Chughureti district. In addition, 200 houses were damaged and the city accounted nearly 200 million GEL in economic losses.
4 June, 2015	Water discharge was 155,3 m³/s. "Elizbarashvili dog shelter" located on Svanidze street was flooded, dogs were killed.

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
CAD	Computer Aided Drafting
CENN	Environmental NGO Network
DRR	Disaster Risk Reduction
EAZA	European Association of Zoos and Aquaria
EBRD	European Bank for Reconstruction and Development
EMA	Emergency Management Agency
EU	European Union
FFGS	Flash Flood Guidance System
GEL	Georgian Lari
GWP	Georgian Water and Power, LTD
MENRP	Ministry of Environment and Natural Resources Protection
MHWES	Multi-hazard Early Warning System
MRA	Ministry of Internally Displaced Persons from the Occupied Territories, Accommodation and Refugees of Georgia
NEA	National Environmental Agency
SIDA	Swedish International Development Co-operation Agency
SSCMC	State Security and Crisis Management Council
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
USD	United States Dollar
USDA	United States Department of Agriculture
VOC	Vehicle Operating Costs
WB	World Bank

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(Footnotes)

1 Total value of damage to housing pending: this figure only considers the value of completely destroyed houses and household goods. At the time of writing, figures for partial damage were not available, so the total value of damage to the housing sector may therefore be higher when the assessment is complete.

2 Total value of damage to housing pending: this figure only considers the value of completely destroyed houses and household goods. At the time of writing, figures for partial damage were not available, so the total value of damage to the housing sector may therefore be higher when the assessment is complete.

3 This figure only includes destroyed houses from Svanidze Street, the Tskhneti ravine and Chikovani Street. Only one house was destroyed in Akhaldaba and none in Upper Tskhneti.

4 This figure is based upon the total value of goods and the cost of temporary shelter.

5 Final figures for housing sector pending.

6 Includes multi-hazard risk assessment, structural assessment, planning development, land usage planning etc.

7 This number is based off the sum of Temporary Shelter costs and Goods

8 Includes houses that are not damaged but need replacement because they are in high risk zones

9 This number is based off the sum Temporary Shelter costs

10 This number does not include amount of legal acquisition of land

11 Including "Build Back Better" (BBB) provisions.

12 Includes hydrological computer modelling, repairing damage, building new infrastructure, maintenance, etc.

13 Some items may overlap or be combined with recommendations from housing sector recommendations

14 These costs include site preparation and the construction of the entire structure. Because of the uncertainty relating to site accessibility, a contingency sum has been included.

15 The check/selective dam (gabion weirs) should be 25 to 30 in number with the following estimated construction times.

16 The estimated time for the construction of each structure is approximately 60 working days, giving a total construction time of 1,680 days for 28 structures. It is recommended that construction be assigned to 4 different contractors, each organizing 2 teams to work on 2 sites simultaneously. With such an arrangement it would be possible to complete the work in about 210 days. Once the difficulties arising from operating in a river together with the risk of adverse weather conditions and delays in obtaining materials and/or equipment from abroad have been taken into account, a more conservative estimate would be that construction activities could be completed in about 250-300 days. If more teams are used, construction time would be further reduced.

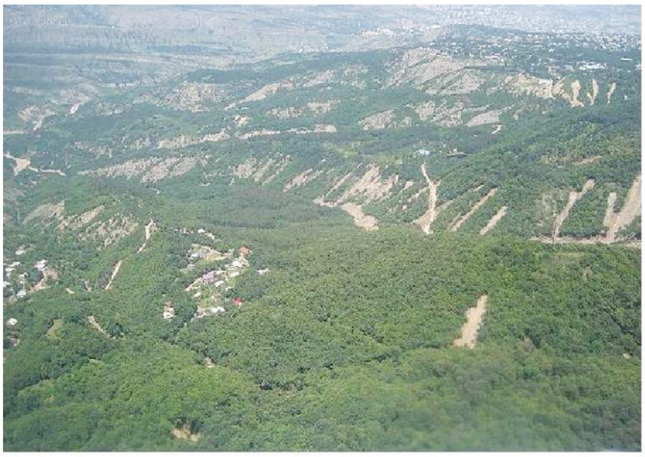
17 Includes estimated costs of perimeter fence removed when debris was cleared.

18 Includes cost of animal transportation in most cases.

19 Includes cost of completely moving the Zoo, building new infrastructure with BBB, replacing animals, technical assistance, etc.

ANNEX I

GEORGIA/TBILISI FLOOD ASSESSMENT MISSION



TECHNICAL ASSESSMENT REPORT OF EVENTS

WORLD BANK

20 JULY 2015

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EXECUTIVE SUMMARY

The rainfall and associated landslide events that caused the damaging floods of 13th/14th June 2015 were extreme and an unfortunate combination of unusual circumstances. However, it is important to learn from these experiences and to put in place, those measures that will both minimise the impact of any future rare natural events and give confidence and reassurance back to those people living in and working around the capital Tbilisi.

There has been much supposition as to the causes and whether they could have been about avoided, but when the sequence of events are analysed more carefully, it can be seen that there was a combination of extreme natural events, the coincidence of which could not have been predicted and that there were a number of contributing factors that added to the extent of the subsequent damage. The exceptional circumstances that caused the second-largest flood on record (155 m^3/sec) to occur just 10 days prior to the 14 June flood aggravated the impact of that flood (estimated by NEA at 468 m^3/sec) and needs to be considered alongside the previous largest flood that occurred over 50 years ago in 1960 (259 m^3/s) and caused substantial damage at that time, including the flooding of the Tbilisi zoo, but when the city was much smaller.

High intensity and the long duration of rain appear to be the major cause of the flood as they determined the:

- High flood water level, characterized by discharge values in excess of design values;
- Triggering of several shallow landslides (soil slip) that developed into debris/mud flow;
- High flow velocity in the river course that consequently enabled the tractive force of the flow to move the landslide materials into the Vere river valley as floating, suspended and, partially, heavy loads.

Much has been made of the impact of restricting the Vere River in tunnels as it passes through its final reaches within the city of Tbilisi. However, examination of the buildup to the floods and the capacity of this sequence of tunnels/culverts has indicated that although this is not ideal, it is most likely that had the large lorry not have been washed into the river by the first flood peak and blocked Tunnel #6, the first and oldest tunnel, by the time the second wave of the flood arrived, it would still have passed through the tunnel system comparatively freely. There would have been some attenuation of water at the intake to Tunnel #6, but any debris that collected there, even as a result of a landslide, would not have created such a dam and head of water to initiate the sudden explosive clearance that resulted from excessive hydraulic pressure and the subsequent knock-on effects down the tunnel system to the Kura River that impacted on all those living and working near to the Vere River.

The contractors who approached the construction highway work including the culverts did so in a professional manner and engaged the expertise of international companies to examine the hydraulic carrying capacity of the tunnels. These indicated that the closed conduit system of tunnels/culverts was capable of carrying flood flows in excess of free flow conditions (i.e. unsubmerged conditions) but maybe not the unpredictable severe conditions that were caused by the combination of an exceptional very intense rainfall and subsequent floods and the near simultaneous occurrence of a large landslide in a comparatively small and compact catchment.

In a period where climate change is obviously being experienced throughout the world, extremes in the hydraulic events are to be expected. Our duty therefore, is to take advance measures that may not be able to predict exactly what is going to happen but puts in place physical interventions and warning systems to inform both officials and residents at the earliest possible moment and reduce the impacts.

There is no doubt that if the large lorry not been washed into the tunnel, providing the basis for the blockage, most of flow and transported material would have passed through the tunnel with much less upstream increase in water level and such severe consequences downstream. What is also clear is that a lack of effective physical planning and land use policies within the catchment and inadequate enforcement of those that existed was a significant contributing factor to the severity of the flood event.

Any very costly proposals to re-green the former floodplain of the Vere river in Tbilisi must be seriously evaluated as they will be extremely difficult to implement and will probably not be justified if suitable and much-needed flood control and preventative measures are introduced into the immediate and further away catchment. This is a relatively unstable area (geologically) and has been designated officially as such. The use of any financial resources to respond to a rare collection of extreme events may be better utilised in addressing the natural occurring mechanisms that are present in the catchment and that are being accelerated by human intervention whether it be housing developments, road construction or to a lesser extent, deforestation and farming.

In spite of earlier indications of the instability of some of the catchment near to Tbilisi, no practical and effective early warning system had been put in place to guide the population in case of extreme events. There was technical advice and knowledge within the city that could have and should have been consulted when the unusual precipitation persisted, but this was not done and thus many who are in charge were slow to appreciate the gravity of the events. However, the response to the catastrophe was quick and effective which is encouraging for the future. What is important now is that much is learnt from these events, including the need for better coordination and cooperation with technical departments and the establishment of effective, practical early warning system. There are many other associated areas where much greater efforts and regulation are required and these are described in the next sections of the report.

In the final sections of this report (sections 5 & 6), suggested measures and associated costs have been presented to provide an effective early warning system, to monitor rainfall and streamflow to indicate when severe conditions are occurring and to begin to stabilise the small Vere River catchment that is clearly vulnerable to large soil movements and hence potential landslides. Complementing this is the immediate need to improve planning and building regulations, not only in this catchment but in the country generally to ensure that people fully appreciate the implications of taking shortcuts. It is only when events like this occur, that these are highlighted and these contributory effects must not be washed under the carpet but dealt with in a coherent and robust manner. Different timescales have been indicated, but what is imperative is that basic data collection and preparations must begin immediately. Rare events have a habit of recurring more frequently than the probabilities assigned to them and therefore the earlier that these measures are put in place, the less likely that such a combination of extreme events will produce such a catastrophic result.

A. Immediate actions (0 to 12 months): (a) Ministerial Responsibilities, (b) Physical planning and building control along and adjacent to the course of the Vere River, (c) Hydraulic Modelling, (d) Rainfall and Stream flow recording, (e) Early Warning Systems, (f) Studies and Data Collection, (g) Repairs to the Flood Damaged Tunnels/Culverts.

B. Short to Medium-term actions (12 to 36 Months) (a) Achievement of Appropriate Norms On Land Use, (b) River Training Works, (c) Flood Mitigation Structures.

C. Medium to Long-Term (> 36 Months): (a) Implementation of Catchment Management Plan, (b) Recreation Autochthonous forests

1. INTRODUCTION

The objective of this report has been to present the findings of a small technical team[38] fielded by the World Bank to identify the causes of the flood event on the 13th/14 June 2015. This killed around 25 people and displaced over a hundred families. The report proposes measures essential to ensure, as far as possible, that the impact of subsequent similar events is less catastrophic and damaging. Most importantly, measures have been proposed to not only safeguard the population of the city and those living in and around it, but also to provide them with sufficient early warning to enable them to take personal security measures in the case of impending extreme events. Issues that are covered include (i) why did it happen - probable sequence of events, (ii) could the consequences have been prevented - contributing factors and main conclusions (iii) what needs to do to be done to reduce the impact of such events in the immediate, medium and longer term as well as preventing the reoccurrence of similar catastrophic events in the future (iv) interventions that are needed to complement the investments already identified to bring services and infrastructure back to relatively normal and already described in the earlier submitted World Bank report[39], (v) the costs of the proposed flood protection and impact mitigations measures, and (vi) complimentary essential measures to be introduced relating to early warning, building control, designation of flood control area, enforcement of actions taken and an estimated time scale for implementation.

The report has been prepared in a relatively short time and although may not have gone into some of the technical details as much as the team would have liked, it is felt that had more time and data been available, the conclusions would not have changed. What the report has set out are those measures and data that need to be collected in the immediate future to enable short, medium and longer term plans to be prepared and implemented. As the Vere river is not classified as one of the most important rivers in Georgia, hydrological data collected in the past have not been extensive. Similarly, although parts of the catchment had been identified as geologically at risk, associated mapping has not been prepared in sufficient detail to enable essential risk maps for the catchment to be compiled and for flood protection zones to be delineated.

38 The mission consisted of David Meerbach, Sr. Water Resources Specialist and team leader, Luciano Minetti, Senior Eng. Geologist, Consultant and Ian McAllister Anderson, Civil engineer/Water Resources Consultant, who conducted the hydrological and geotechnical assessments. The mission visited Georgia from 29 June to 3 July 2015, during which time they consulted in detail with technical professionals in the country and experienced in hydrology and geology/geomorphology.

39 A separate World Bank team was fielded to prepare a detailed assessment of the damages that were incurred and together with government, compiled details of investments and measures necessary to rectify these damages and where possible, bring normality back to those living and working in and around Tbilisi.

2. BACKGROUND

Georgia has emerged as one of the new Democratic countries in the Caucasus. It is located to the east of the Black sea in the South Caucasus. It shares borders with Russia in the north and Turkey, Armenia, Azerbaijan in the south (Figure 1.). It has a population of about 5 million of which 20% lives in the capital Tbilisi. Although the economy started from a relatively low base at the time of its independence in 1991, it is gradually improving and although it may not have the oil based wealth of its neighbour Azerbaijan, the economy is slowly developing utilising its considerable hydropower potential as well as its natural beauty and historic buildings to bolster its international tourism. Foreign investment and economic reform have driven growth. Agriculture, including wine-making, is a key economic sector.

Figure 1. Location Map of Georgia

2.1. Water Resources

The rivers of Georgia comprise those that drain into the Black Sea basin (12 main rivers) and those that drain into the Caspian Sea basin (9). The Vere River falls into the second category being located close to the capital Tbilisi in eastern Georgia and east of the Trialeti Range and near Mount Digori. It is a right bank tributary of the Kura (Mtkvari) River, the longest in Georgia (length 1,364 km), that flows eastwards into Azerbaijan and the Caspian Sea. The Vere River has a relatively small catchment (area 194 km^2; length of 45 km) that is located immediately upstream and south west of Tbilisi. The river flow in the Vere River is fed by rain, snow melt and underground water flow and it has been characterized by flash floods but none of the scale that was experienced on 14 June 2015. The Vere gorge upstream from Tbilisi is known for its beauty and in former times was a popular location for dachas (seasonal or year-round second homes) occupied and rented by the inhabitants of the capital. In more recent years, these have developed into quite substantial Villas.

The geography of the Vere catchment is characterized by its location in the tectonic area with shales, slates and sandstone predominating. There is much evidence of historical and more recent geological and soil movements in this area and in particular in the area immediately north and south of the capital. The recent geodynamics of the Caucasus and adjacent territories is determined by its position between the still converging Eurasian and Africa-Arabian plates.

2.1.1. Climate.

The location of Georgia on the border between the moderate humid Mediterranean and the dry continental Aral Caspian areas is responsible for the climate of the country. A humid subtropical climate dominates in western Georgia, while eastern Georgia features a transition from subtropical to moderate. The climatic zones range from humid subtropical to the eternal snow and glaciers. The greater Caucasus range moderates local climate by serving as a barrier against cold air from the north.

The mean January temperature varies from -2 degree (Kolkheti) to 3 degrees; in August it ranges from 23 to 26 degrees. The mean annual precipitation varies from 1000 to 2800 mm and from 300 to 600 mm in eastern Georgia. Along the Black sea coast, from Abkhazia to the Turkish border, and in the region known as the Kolkhida lowlands inland from the coast, the dominant subtropical climate features high humidity and heavy precipitation. For the Vere catchment, daily rainfall measurements have been kept for about 50 years at the Vashlijvari hydrometeorlogical station close to Tbilisi in the vicinity of the conference of the Vere and Kura Rivers (Lat: 41°45'; Lon: 44°46'; Altitude 427 m amsl) – Figure 2 & 3.

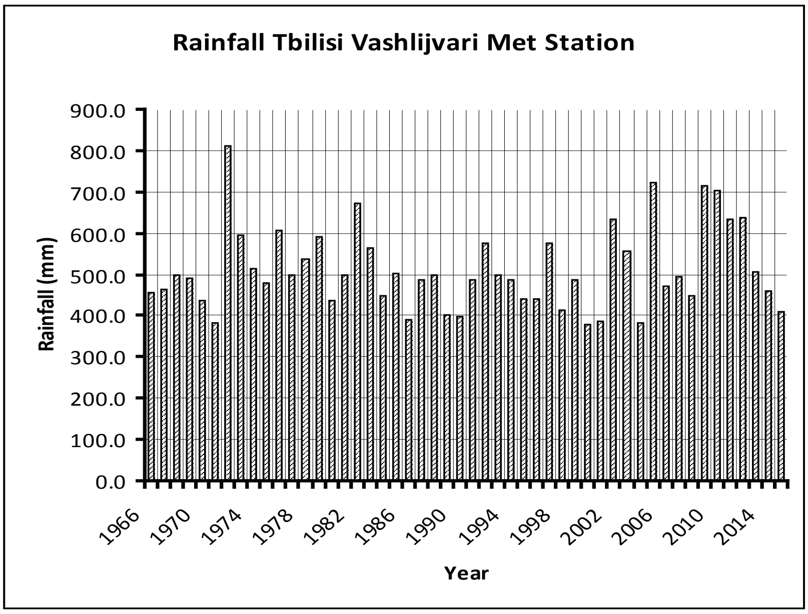

Figure 2. Precipitation measurements at Vashlijvari Met Station, Tbilisi.

The annual average rainfall data for the Vere catchment is about 514 mm and varies from 813 mm (1972) to 379 mm (2000). Unfortunately, as the Vere River is not listed as one of the most important rivers in the country, detailed rainfall records have not been kept in locations further upstream in the catchment.

The plains of eastern Georgia are shielded from the influence of the Black sea by the Likhi Mountains that provide a more continental climate. Average temperature in summer here is 20-24c, in winter 2-4c. Humidity is lower. Alpine and highland regions in the east and west, as well as semi-arid region on the Lori plateau to the southeast have distinct microclimates. Alpine conditions start at 2,100 metres and above 3,600 metres year-round snow and ice are present.

Table 1. Rainfall Return Periods for Vashlijvari Met Station, Tbilisi

Return Period	mm
5-yr	66.9
10-yr	85.3
20-yr	103.6
50-yr	127.9
100-yr	146.3

Source: NEA, Hydrometeorlogical Department

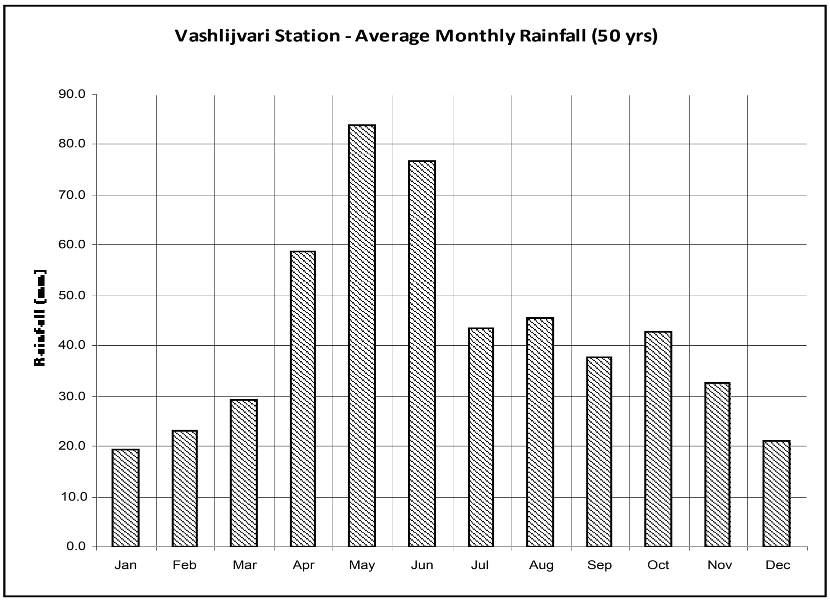

Figure 3 Average Monthly Rainfall for Vere River

2.1.2. Hydrology

Streamflow records have been recorded for the Vere River since April 1941. The gauging station (Tbilisi, Vere, Lat: 41°42' 55.22"; Lon: 44°44' 35.84"; elevation 452.13m amsl) was located just upstream of the first tunnel, built in 1958, where the river now enters the city of Tbilisi. Unfortunately, although surviving an earlier flood in June 2015, it was completely destroyed by the flood of 13th/14th June 2015[40]. This was the only stream gauging station for the Vere River. The mean annual discharge of the river is 1.0 m^3/s. The maximum flood flows occurring in late spring/ early summer with the 1 in 100 year flood estimated by the National Environmental Agency (NEA) at 240 m^3/s. None of the previously recorded flood flows were of the magnitude experienced on 14 June 2015 (Table 2).

Table 2. Maximum Recorded Flood Flows for Vere River at Tbilisi

Year	m^3/s	Date
2015	468	14-Jun
2015	155	04-Jun
2012	153	12-May
2009	133	17-Jun
2002	67	30-Jun
1992	117	21-Jun
1960	259	04-Jul
1963	140	03-Aug

40 Although data should be available for the period right up to the start of the second storm on the 13th/14th of June 2015, much of these were stored in the office at the Tbilisi zoo compound and it is not certain yet whether all these data have been lost.

3. ANALYSIS OF THE EVENT

3.1. The Build Up to the Event

The Vere River upstream from Tbilisi city is confined by quite steep gorges and rock outcrops that permit some meandering but which are controlled by the outcrops (Figure 4).

Figure 4. Vere River Upstream from Tbilisi - Possible locations for some River Training.

As it enters the city boundaries, the river starts to become constrained by the considerable urban buildings, road infrastructure and other developments. Some of these encroach directly onto the river course and flood plain and present significant constraints on the passage of peak and regular flood flows. Once it enters the city, the river course is in part canalized into a series of tunnels and Armtec corrugated steel culverts of varying length separated by reaches of open channel that convey the river water through the city into the larger Kura River (Figure 5). The most upstream and oldest tunnel, 230 m in length, was built by the Russians in 1958 and lengthened as part of more recent infrastructure related developments[41].

Figure 5. Course of Vere River in Tbilisi City

Most of the spring rainfall in the Vere Catchment occurs in April, May, and June (Figure 3). The precipitation that occurred in the first 6 months of 2015 was quite exceptional and amounted to 80% of the long term annual average (514 mm). Compounded with this, a severe storm occurred on 3/4 June (over 50 mm in 3 to 4 hours) added to the already saturated catchment cover materials. From the evening of 13 June through 14 June, further more intense rainfall was experienced over the south eastern part of the Vere River catchment (about 100 mm in 2-3 hrs). This added to the continuous and heavy rain that fell over all of the catchment during the previous 10 days and resulted in a flash flood flow that was the highest on record (Table 2).

41 The numbering is defined by the designer/ contractor responsible for the construction of the subsequent tunnels/large culverts – numbering upstream from the confluence with the Kura River.

3.2. How it Happened

As the flash flood was passing down the Vere River system, a large landslide[42] was triggered on the steep right bank slopes as a result of the intense storm falling on an already saturated catchment. This occurred near to Akhaldaba village (about 20 km from Tbilisi). In addition to destroying part of the Akhaldaba to Tbilisi road, it created a surge of "mudflow" that entered the already swollen Vere River and exacerbated the extreme hydrological events adding considerable amounts of mudflow, timber, trees and other debris and created a second peak to the unusually high flood flows.

As the first flood peak passed down the River, the severity of the flood flow volume was increased by the narrowing of the river course 225 m upstream from the tunnel inlet due to incursion into the river course by the unapproved extension of buildings (Dog Home; Sausage Factory; low bridges) – Figure 6 and Photos 3.1 & 3.2. Not only did this restrict the carrying capacity of the river, more importantly it caused it to adopt a new course over the left bank thereby transporting a parked lorry into the mouth of the first tunnel (now designated Tunnel 6 + extension). This blocked the tunnel entrance and facilitated the build up of trees and other debris that together completely dammed the tunnel entrance.

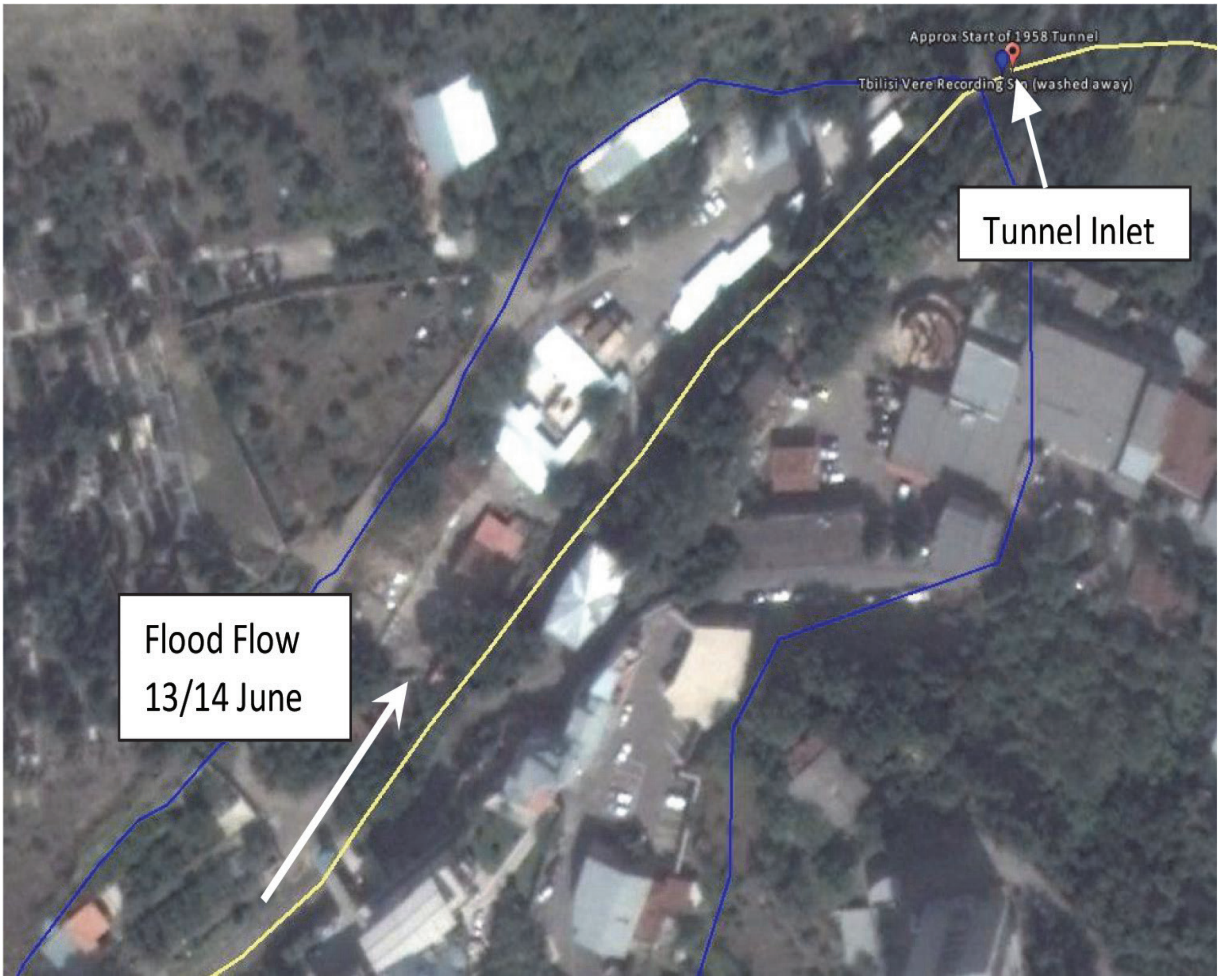

Figure 6. Development Restricting the Vere River course Upstream from the 1958 Tunnel.

42 Estimated at One million cubic metres of soil, rocks and trees.

Photo 3.1 Unapproved Bridges Upstream from the 1958 Tunnel

Photo 3.2 River Encroachment u/s from 1958 Tunnel

It was then impossible for debris laden flood waters to pass unhindered through the tunnel and this caused the water level upstream from the tunnel to rise between 5 and 10 metres (Photos 3.3 & 3.4) and caused flooding of Svanidze Street and neighbouring buildings.

Photo 3.3 Inlet to 1958 Tunnel Cleared After Flood

Photo 3.4 Inlet to 1958 Tunnel after Flood

Eventually, the high head of water (10m = 1 atmosphere) was sufficient to create an hydraulic explosion that cleared the blockage. Unfortunately this created a surge flow down the entire tunnel system that had such a high velocity (>5m/sec.) that not only brought much of the deposited sediment back into suspension, but also caused considerable damage to other tunnels, downstream river banks undermining buildings and anything in the flood flow path.

Photo 3.5 Outlet from Tunnel 6 showing extent of Scouring of Bed

Photo 3.6 Exposed Pile caps & piles at Outlet from Tunnel 6

Photo 3.7 Flood Scoured RB of Vere River d/s from Tunnel 6 showing undermining of Buildings

Additional debris and material (wooden houses; retaining walls; etc) were washed down the river together with newly eroded river bank material. This initially blocked the entrance to Tunnel 5, and caused the water head over the inlet of the Tunnel to increase encouraging a repeat of the process that affected tunnel 6 and caused overland flow until the hydraulic pressure again removed the blockage "explosively". This sudden release created more hydraulic surges, shock waves and high velocities of flow as the flood discharge passed further downstream. With the series of tunnels/culverts separated by open channel sections, the elevated velocities created in the confined tunnel sections decreased once the flow reached the open flow sections and this in turn resulted in greater water depths and deposition of suspended sediment.

Photo 3.8 Flood Damaged Entrance to Tunnel 5

Photo 3.9 Flood Damage to 2nd Part of Tunnel 5

Photo 3.10 Flood Damaged Exit to Tunnel 4

The whole process was repeated down the tunnel system. This is evidenced by the considerable material distortion at the entrance and outlets of subsequent tunnels and downstream damage (Photos 3.5 to 3.13). At the exit to Tunnel 2, the excessive velocities washed away the last 10 to 15 metres of the culvert, undermined the two carriageway highway that crossed over it and caused deep flooding and sedimentation in the Mziuri Park on the right bank.

Photo 3.11 Open Vere River Channel Section after Tunnel 4

Photo 3.12 Flood Damaged Exit to Tunnel 2

Photo 3.13 Flood Damaged Entrance to Tunnel 1

Once again, as the deep and fast flood proceeded downstream, it again crossed over the two carriageway highway as by then too much water had accumulated to pass easily through the next entrance to the final Tunnel 1. Unfortunately the Tbilisi Zoo was located on the other side of this highway (Photo 3-15) and at a lower elevation from which the only exit was the small underground pedestrian walkways (Photo 3-14) and the lower road sections of the roundabout at Heroes Square[43].

Photo: 3-14 looking downstream towards Heroes' square

Photo: 3-15 looking upstream at same location as Photo 3-14 from the Tbilisi Zoo

Flooding occurred upstream of each tunnel/culvert section and occurred due to the rapid approach velocity caused by the sudden release of water by the rapid hydraulic removal. The severe flooding that resulted affected the Vake-Saburtalo district in Tbilisi, the right bank of the Mtkvari (Kura) River, and the surrounding areas of Lisi, Tsodoreti, Napetvrebi, Bevreti, Tskaldidi and Betania-Tskneti. A total of 25 people lost their lives and over 108 families were displaced. In addition, around 40 roads, urban infrastructure and communication systems were badly damaged and the Tbilisi zoo was completely destroyed. The disruption that was caused had severe repercussions on activities and traffic flows within the city and created much congestion that still continues.

43 This is not the first time that Tbilisi zoo has been flooded as the 1960 flood in the Vere River had the same result.

3.3. Analysis of the extreme floods of 13/14 July 2015

Both the storm and the intense rainfall that occurred on 13 June were unusual (Table 2) and the peak flood flows of both 4 June (recorded @ 155.3 m^3 /s) and 14 June (estimated @ about 468 m^3 /sec.[44]) were the highest consecutive floods ever recorded in the Vere Catchment and nearly twice the last devastating flood of 1960 (Table 1). Although the 14 June flood far exceeded the 1/100 year design flood, it was also probably above the estimated design capacity of 300 m^3/sec of the tunnel system[45] for that would have occurred but only a relatively short duration, had the damming not occurred. [The NEA 2015 report[46] notes that the 1/100 year flood would be about 240 m^3/sec.].

The National Environment Agency (NEA) has computed the maximum discharge of the Vere River for 14 June 2015 to be 468 m^3/sec using slope-area methods. Unfortunately, the supporting calculations have not been seen and nor has the exact location for this calculation. This method can over estimate the flood peak, which depends upon the assumed roughness and the adopted long slope. Another factor that will influence the result is whether the sudden landslip created a hydraulic wave in the river. This would give higher indicators of apparent maximum flood level. The estimated peak value must therefore only be considered as indicative in the absence of more detailed data. However, it is clear that whatever the actual value of the computed peak flood, it was nearly twice as large as the previous highest recorded flood of 259 m^3/sec in 1960 (Table 1).

Estimates of its design flow of the tunnel system vary from 126 m^3/s (under free flow conditions) to a design flow of 260 m^3/s, considering a 1 in 100 year return period and submerged flow at the inlet. If excessive velocity occurs within the tunnel sections where the height is constrained, once the open sections are reached and the pressure released, velocity of flow will decrease and depth of flow will increase accordingly. This is what happened with the extreme flow conditions that developed at the entrance to the first tunnel and that were repeated down the river length to the confluence with the Kura River. By the time the floodwater reached the exit at the Kura River (Figure 7), most of the excessive energy had been dissipated and what remained was lost, together with any other sediment load, into the Kura River flow.

Although the river is conveyed through a series of tunnels or culverts (starting with the 1958 tunnel constructed under the former Soviet Union), there is sufficient capacity to pass the flood flow provided that blockages such as occurred on the 13/14 June 2015 are not allowed to recur. Under very high flood flows, the approaching flow may submerge the Tunnel Inlet(s), but if not hindered by debris, this will only be for a relatively short period. Although it is important to size the tunnels and corrugated steel culverts to pass water containing suspended sediment and debris, the flood flow that occurred on the 13/14 June, before the landslide in the catchment, would have probably passed through the culverts without major problems other than some inlet submergence. As has been suggested in the NEA report[47], without the mud flow event, including the washing into the river of sections of woodland from the landslide, together with its timing near to the beginning of the peak flood runoff from the catchment and the blocking of the tunnel by a wrecked lorry, all of which are considered rare events, it is likely that the drainage tunnels/culverts would not have been blocked and the tragedy that engulfed the city would have been avoided.

Although there are opinions to the contrary, there is evidence that the hydraulic characteristics of the tunnel and covered sections of the Vere River from the 1958 Russian built tunnel (#6) down to the conference with the Kura River (#1) were tested under free flow (unsubmerged) and submerged flow conditions prior to the extension of the culvert system using Armco type culverts. This included sediment laden run-off, which will have "supercharged" the flow and increased the in channel velocity. Although

44 Hydrological Post-Disaster Study of the Vere River, NEA June 2015. This flood was estimated after the event on 18 June using slope area methods for the river section in the Didgori district upstream from Tbilisi and at the junction of the Vere and Jokhoniskhevi Rivers and was considered to have a return period of 1/300 yrs.

45 Unsubmerged = 165 m^3/sec; submerged with 6 m head = 300m^3/sec.

46 Hydrological report of Vere River, Report on Natural Disasters Occurred in Vere River Gorge on 13-14th of June, 2015, National Environmental Agency (NEA).

47 ibid

flow conditions would not be ideal, the normal amount of debris associated with such flood flow would have been able to pass freely through these culverts had their passage not been hindered by the large vehicle that not only impaired flow through the tunnel, but also provided an anchor to which the larger transported trees and other such debris could collect and form a dam comprising the large amount of transported settlement occurring in the river as a result of the landslide.

Although it has been reported that as-built drawings for the tunnel/culvert system do not exist, the contractor who was responsible for the works is in the possession of good quality CAD drawings, giving plans and sections of completed works. In spite of the apparent difference in the dimensions of the tunnels/ culverts, especially when compared with the 1958 tunnel #6 (A~=60 m2), when the tunnel shape and depth from invert to soffit is considered, as well as the longitudinal slope, the carrying capacity can be similar. The contractors that implemented the relatively recent extension of Tunnel #6 and the construction of the new tunnels/ culverts from pre-fabricated steel corrugated pipe, reported that the capacity throughout the system was checked not only by the suppliers of the steel corrugated pipe, Armtec Canadian manufacturer[48]) but also by a specialist international consultant working with one of their associates. This included advice on the sizing and carrying capacity of the tunnels/culverts but also on the compatibility of the system and the carrying capacity of the closed sections for both free flow and submerged flow conditions.

It has been reported that they were satisfied that flows that entered the first tunnel would be passed through the system to the confluence with the Kura river. These suppliers use recognised empirical formulae for estimating floods in ungauged river culverts[49] and no doubt have comparable computer software for estimating pipe sizes and carrying capacity. An important factor in this case is that it is normal to design the culvert/tunnel for unsubmerged conditions (in this case this will give a discharge of about 165 m^3/sec) but also to check for submerged conditions that would allow the passage of more extreme floods (in this case would increase the capacity to about 272 m^3/sec) under the submerged conditions reported at the inlet to the tunnel[50]. Although the calculations that were carried out at that time are not yet available, examination of the sites combined with discussions with hydraulic experts in Georgia[51], would indicate that flows that were entering the first tunnel during normal flood conditions would be able to continue through the whole covered network. Most certainly, they would at least pass the storm with the design return period of 1 in 100 years, if not much more infrequent flood flows such as the peak flood of 259 m^3/sec recorded in 1960 at the Tbilisi-Vere gauging station.

3.4. Upstream event - Geology and soil slippage

Such high return period of rain events described above, when recurring and persisting for 10 days, determines extraordinary cumulated values that represent unpredictable extreme hydrologic and hydro-geologic conditions. The superficial local instability of slopes in the Vere valley and its tributaries caused the collapse of several shallow landslides (soil slip and debris/mud flows) and the combination and overlap of these factors, together with the high urban pressure in the lower reaches of the Vere river valley have generated and magnified the event's devastating results. The complexity of the overlap of these factors makes the event hard to predict and to mitigate the consequent effects.

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48 www.armtec.com

49 It should be noted that the Handbook of Steel Drainage and Highway Construction Products (CSPI) used in Canada states that the criteria for balanced design includes:

- the culvert shall be designed to discharge
  - a ten-year flood without static head at the entrance
  - 100 year flood utilising the available head at the entrance

50 ibid

51 Annex A

3.4.1. Landslides and their consequences on the overflow

The above-mentioned hydrological conditions caused and had a high impact on soil/material conditions and made soil masses flow almost as fluid. As they reached the saturation threshold, the physical and geotechnical features worsened and the stability causing:

- Increase in weight;
- Soil/material softening, which causes:
  - Reduction in apparent cohesion due to dissolution of colloids;
  - Reaching of soil liquid threshold limit, in particular at the rock mass contact, caused by high pore-fluid pressure;

The new state of the soil masses, combined with the magnifying effect of the steep slopes, caused instability and the sudden and widespread high-energy gravitational collapse in form of shallow landslides (soil slip) that evolved in debris and mud flows (See Annex E - photos from 8, 9, 10). This high energy movement induces, sometimes, the dragging of the underlying rock mass with rock fall generation. There are many published research papers that discuss the threshold limit for rainfall levels capable of triggering superficial landslide considering the geographic context, climatic conditions, geomorphologic features and the geotechnical properties of terrains.

The triggering limits of rainfall intensity are:

- Rain intensity higher than 50 mm/hr for at least 1-2 hours;
- Rain intensity higher than 70 mm/hr for less than 1 hour;

The findings converge to indicate that the rainfall amounts that occurred on 13 June 2015 as potentially responsible for the critical conditions for primary shallow landslide (first generation soil slip, evolving in mud flow and debris flow). In addition, the mostly liquefied flow body contains a higher percentage of sand, silt and clay and these fine sediments help to retain high pore-fluid pressures that enhance debris/mud flow mobility. The collapsed material includes vegetal cover (floating load) that generated aggradations in the watercourse.

At the same time, the Vere River and its tributaries reached high energy of flow, transporting landslide materials, particularly the finest, with the selection determined by the tractive force of the water current inducing:

- the deposition the coarser materials, gravel and boulders (heavy bed load) along the river course;
- the transport of fine, sand, silt and clay (suspended load) and the woody debris (floating load) up to the downstream end of the valley;

This transported material collected on the trapped wreckage of the lorry in tunnel #6 and contributed to the obstruction of tunnels and blockage of flood flow all of which was then deposited in the downstream urban areas after it was "explosively" cleared.

High intensity and the long duration of rain appear to be the major cause of the flood as they determined the:

- High flood water level, characterized by discharge values in excess of design values;
- Triggering of several shallow landslides (soil slip) that developed into debris/mud flow;
- High flow velocity in the river course that consequently enabled the tractive force of the flow to move the landslide materials into the Vere river valley as floating, suspended and, partially, heavy loads.

3.4.2. Contribution of Secondary Valley and Tributary of the Vere River

At a first analysis, it seems that the major contribution, in terms of flooding and solid transport, has been from to the right bank tributary valleys upstream from Tbilisi and particularly those closest to the city (Figure 5). In addition, this part of the Vere valley appears to be more prone to slope instability because of geologic, geomorphologic and tectogenic factors. This is confirmed by the NEA post-flood measurements[52] that indicated that the estimated contribution of the Jokhoniskhevi tributary to the maximum flood discharge was in excess of 100 m^3/s. Indeed, when a valley of only 9.5 km^2 (5% of the size of the Vere River watershed) contributes about one third of the total flow immediately downstream, this indicates the importance of the contribution of the tributaries, especially closer to the urban area, in terms of discharge and, consequently, solid transportation and indicates areas where immediate attention/action are needed.

General instability with soil slips and debris/mud flow phenomena has been developing for some time at the slope of Trialeti range, surrounding the catchment area of Vere River. In this context, and as described above, the contribution of the secondary valleys and tributaries on the right bank of the Vere River close to Tbilisi is very relevant. The largest landslide settled towards the Akhaldaba village (Annex E Figure E.1 and photos 3, 4, 5 and) and was approximately 32 hectares in size, and moved 1.3 km to the Vere River course. A significant part of the estimated one million cubic metres of soil, rocks and trees were washed into the Vere River as well as contributions from the Zakro Jokhona, Kaitsdo, Dampalo, and Sakdrisi canyons, and the Ukankhevi River Watershed, which is about 2 km upstream from Tbilisi. These impact significantly on the overall discharge and solid loads transportation.

52 ibid

4. CONCLUSIONS

The preceding examination of the events leading up to the catastrophic floods that were experienced on 14 June 2015 have indicated that firstly, there was a combination of extreme natural events, the coincidence of which could not have been predicted in advance, and that there were a number of contributing factors that added to the extent of the subsequent damage.

There have been a number of assumptions relating to the construction of tunnels and large culverts in which the Vere River flows before it joins the Kura River in the centre of Tbilisi. What is clear from this examination is that the designers and constructors took all reasonable design considerations into account and could not have anticipated firstly, that a large lorry would be washed into the river course blocking the first tunnel and secondly that the severe rainfall events in the preceding days of June 2015 would saturate the catchment sufficiently that another rare event storm occurring in an unusual part of the catchment would trigger a large landslide and create a large mudflow and hydraulic surge that contributed to the already large flood that was passing down the Vere river. Such combinations of unusual natural events are beyond reasonable design prediction.

The additional exceptional circumstances were that 10 days prior to the 14 June flood, the second-largest flood on record occurred in the catchment (155 m^3/sec). The previous largest flood occurred in 1960 (259 m^3/s) and caused substantial damage at that time, including the flooding of the Tbilisi zoo, but this was at a time when the city of Tbilisi was quite small and developments in and along the Vere River were at a much more modest scale than is currently the case.

There is no doubt that if the large lorry not been washed into the tunnel, providing the basis for the blockage, most of flow and transported material would have passed through the tunnel with much less upstream increase in water level and such severe consequences downstream. What is also clear is that a lack of effective physical planning and land use policies within the catchment and inadequate enforcement of those that existed was a significant contributing factor to the severity of the flood event.

Any proposals to re-green the former floodplain of the Vere river in Tbilisi must be seriously evaluated as they will be extremely difficult to implement and will probably not be justified if suitable and much-needed flood control and preventative measures are introduced into the immediate and further away catchment. This is a relatively unstable area (geologically) and has been designated officially as such. The use of such financial resources to respond to a rare collection of extreme events may be better utilised in addressing the natural occurring mechanisms that are present in the catchment and that are being accelerated by human intervention whether it be housing developments, road construction or to a lesser extent, deforestation and farming.

In spite of earlier indications of the instability of some of the catchment near to Tbilisi, no practical and effective early warning system had been put in place to guide the population in case of extreme events. There was technical advice and knowledge within the city that could have and should have been consulted when the unusual precipitation persisted, but this was not done and thus many who are in charge were slow to appreciate the gravity of the events. However, the response to the catastrophe was quick and effective which is encouraging for the future. What is important now is that much is learnt from these events, including the need for better coordination and cooperation with technical departments and the establishment of effective, practical early warning system. There are many other associated areas where much greater efforts and regulation are required and these are described in the next sections of the report.

5. FLOOD PREVENTION AND MITIGATION

Measures are needed to reduce the impact of any similar extreme events that may occur in the future close to and impacting upon the city of Tbilisi, its surrounding areas and those who live and work in this area. The separate WB report[53] deals with the damages that occurred and investments needed to rectify the losses incurred and to remove the considerable constraints on everyday life in Tbilisi. A certain level of fear still exists in the capital that such an event might recur. In this respect, this report has identified mitigation measures needed to both reduce the impact of similar extreme natural events and thereby restore confidence among the citizens living and working in or close to the capital. These include (i) improvements that the government needs to introduce to improve the safety of people living in Tbilisi and the surrounding areas, such as early warning systems related to real-time weather monitoring, (ii) control measures, such as planning and building control and standards that need to be effected to ensure that people cannot build wherever they like, especially in or near designated flood areas, nor carry out certain activities within the same areas, including parking of vehicles, camping, dumping materials, (iii) measures to reduce the occurrence of landslides in an area that has already relatively unstable (iv) general catchment interventions to reduce the impact of large floods and associated mudflows, especially in tributaries adjacent to the capital and finally (v) studies and longer term planning to quantify the levels of risk and causes and put in place and maintain measures and interventions essential to not only reduce and mitigate flood flows in the catchment in the medium to long term but also reduce the probability of similar catastrophic events occurring in the future.

5.1. Flood Mitigation

It is essential to remember that there are no quick fixes available to mitigate the risk of flooding. As the discussions in Section 3 have shown, if no action is taken to prevent and slowdown the arrival of suspended and transported materials from reaching the last sector of Vere river (where it enters the city boundaries) blockage of first and subsequent tunnels and culverts is a real possibility. Initial measures to be instigated in the short-term must therefore address this in professional and sustainable manner. In addition to including appropriate studies followed by implementation of proposed works in as short a time scale as is possible, this goal will not be achieved. A number of actions and considerations are important in this context:

- Until such measures have been determined in detail and implemented, Tbilisi can still be considered to be vulnerable to extreme events such as those that occurred on the 13/14 June 2015 within the Vere catchment.
- In addition to physical interventions, actions that must be immediately implemented for risk mitigation include the adoption of appropriate and proven methods for providing Early Warning to those living and working in and around the city and Vere catchment coupled with appropriate training associated with civil protection suitable to prevent, especially, the loss of lives.

5.2. Flood Risk Zones

Sufficient attention has not been paid to the relationship between physical planning, land use and flood risk zones. If people do not adhere to the mandatory guidelines and they are not adequately enforced, the incidents that occurred on 14 June will be repeated. Examination of the Google Earth images before the flood indicated that there were significant urban developments (housing; factories; businesses) within the Vere River floodplain and in the 300 m upstream of the 1958 built tunnel (Figure 6). This should never have been allowed to happen particularly considering the narrowing of the river course and the construction of two bridges that could not pass even the comparatively small floods that can occur.

53 Tbilisi Flash Floods Needs Assessment 2015, World Bank, July 2015.

Physical planning and building control within the city has not been adequate with the result that the conditions have been suitable for extensive damage should an extreme event occur. It is essential, therefore, that this situation is immediately changed and measures put in place to cover all aspects mentioned above. The lack of enforcement of basic planning laws is evidenced on the left bank of the Vere River upstream from the University where city rubbish, building debris and old machinery are dumped willy-nilly (Annex D – Photos D.5 to D.8).

Under the proposed hydrological studies (Annex B), delineation of the flood prone areas will be one of the products and is considered of immediate priority. Serious thought will need to be given to the implementation of the findings of this study as some buildings already lie within and interfere with the important Vere flood plain area upstream of tunnel #6. In order not to exacerbate the situation, it is essential that damaged or destroyed buildings located within potential flood risk zones are not rebuilt or repaired and that alternatives for those affected are adopted in the immediate and short terms, if not in the longer term.

5.3. Structural Interventions

The upper/medium sections of the Vere River are characterized by meandering that is controlled by the site geology. The sinuosity and the long Thalweg path of the river, in respect to the valley length, acts as an important reducer of the flows' energy during floods and consequently decreases the peak flows of the floods (Figure 4, Annex G - photos 1 & 2). In the last 3 km of the river, just upstream from the urban area, the river loses these characteristics resulting in:

- shorter river length;
- increases of river gradient;
- acceleration of flood flows;
- higher peak flood flows;

Structural intervention is needed in the immediate catchment close to Tbilisi. This will derive from the proposed hydraulic modelling of the river proposed in the immediate future (Section 5.5.1 below) which will provide data for the selection of the type of mitigation works, their spacing and dimensioning. An important aspect of the structural interventions is to reduce the amount of sediment and transported material reaching the main river course (Annex E – Photos E.17 to E.28), to slow down the movement of material already in the river course, to endeavour to reduce the longitudinal river gradient to slow down the progress of the flood peak as well as the *time of concentration* of flows for the Vere River. This will reduce the peak of the flood hydrograph, as well as ensuring that the contributions to this peak from the important tributaries of the Vere River do not coincide with the maximum flows.

In addition, it has been observed that discharge and solid transportation from the first right bank valleys upstream of Tbilisi (Photo D.4 & D.6) are significant contributors to the recent and disastrous event. It is for this reason that it is proposed that a preliminary study, followed by a final design regarding mitigation works, includes the last 10 km of the Vere River valley including associated secondary valleys on the right bank (Annex E - Figure 1).

As mentioned in section 5.1 above, with such a volatile and potentially unstable catchment, it is important to trap as much floating and transported debris further up the catchment, so that it has reduced opportunities of reaching the city limits. This goal can be achieved by building transverse structures (cross-checks; gabion weirs; etc) in order:

- Decrease the riverbed gradient with consequent reductions in velocity, energy and peak flood flow;
- Confining and fixing the transported deposits of erosion;

- Trapping the large part of the transported load, particularly the floating woody debris;

The selection of the transverse works, their spacing and dimensions, will be determined by several parameters:

- proper geological, geomorphologic and geotechnical conditions, pointing out particularly the eventual presence of potential soil slip in the reservoir area, which could be soaked and then destabilised during high flow periods;
- expected transport energy;
- reduction of the riverbed gradient due to the sustainable diminution of the flow peak;
- design discharge at the selected river sections;
- availability in the riverbed of deposits suitable for works construction;
- accessibility to the selected sections;

Cleaning and Maintenance. An essential part of the above use of transverse works is to carry out and ensure that there is regular maintenance and removal of collecting material. This also requires both the allocation of suitable cleaning machinery at times of peak flood and high river stage and also pre-arranged access to the sites, both a prerequisite for effectiveness.

Discussions with those involved with the tunnels and culverts through which the Vere River passes have indicated that cleaning and maintenance has not been regularly carried out, if at all, and that this has been the case for the older upstream tunnel (Tunnel #6 – 1958 part) as well as the longer Tunnel #1 close to the Kura River. Adequate annual financial provisions must be made for this to ensure that there is no buildup of material or debris within the tunnels/culverts, and that uniform longitudinal gradients that encourage subcritical flow are maintained. This could easily be accommodated under the current agreements by the city for employing maintenance contractors.

Tunnel Protection. Although the measures proposed above should be adequate, it is recommended that additional steel piles are located in the Vere River course immediately upstream of tunnel #6 to prevent any large objects such as vehicles from being washed into and blocking the tunnel system. This would be regarded as a backup measure should the others proposed be ineffectively maintained or damaged or broken or not be implemented in time should another severe flood occurred.

5.4. Catchment Management

This appears to have been an oversight as there is no single organization responsible for monitoring and controlling activities within the watershed[54]. Such management is essential to ensure that:

- No modifications are made that would either obstruct the river course or alter the floodplain and that the cross-sectional area of the river flow is maintained.
- No changes are permitted or made that will alter the longitudinal slope of the river or its tributaries except for the construction of control weirs to be implemented as part of the short and longer term programmes.
- Maintenance and enforcement of delineated flood risk and hence exclusions zones to ensure that no rebuilding or new building construction is permitted or takes place and that vehicles are only parked in designating locations away from the flood risk zones.

54 The EU Water Framework Directive - integrated river basin management for Europe including Waternote 12 : A Common Task - Public Participation in River Basin Management Planning (http://ec.europa.eu/environment/water/participation/notes_en.htm) & (http://ec.europa.eu/environment/water/water-framework/index_en.html)

- Ensure that runoff from roads and villages/towns in the catchment are better controlled, and conform to newly established norms and design criteria. This will not only minimize erosion, but also reduce the flow of water towards potential landslip areas and slow down the passage of run-off water is through the catchment.
- Continual improvement and review of slope control measures, both within the catchment as well as along the river and its tributaries, to ensure that the longitudinal slope of the river is reduced in general and in particular at certain critical locations. This will not only slow down the peak flood flows and the contribution from the side valleys, but also encourage the deposition of transported sediment in certain sections of the river rather then creating head-cutting and subsequent surges of sediment flow.

5.5. Recommendations

The recommendations that derive from the above have been considered in three time phases (1) the immediate short-term – the next 3 to 12 months, (2) the medium-term – the next 12 to 36 months, and the longer term – greater than 36 months.

5.5.1. Immediate actions (0 to 12 months)

(a) Ministerial Responsibilities

Management of water resources in Georgia is not carried out by one single organization. The management mandates are shared among several agencies, including central government and local authorities. This must be addressed to include not only environmental protection and water management, but also to ensure that aspects such as developments in or close to rivers is adequately controlled and that enforcement does not fall between two or more organisations.

Although hydrological monitoring is carried out by the National Environmental Agency, they must be given more financial support to enable them to collect data more regularly and more widely. In addition to this, direct links between various institutions involved with water and risk management must be established and improved to the extent that such data can be available and utilised as part of the early warning strategy.

(b) Physical planning and building control along and adjacent to the course of the Vere River

The existing regulations relating to this need to be reviewed and where required, reinforced to ensure that they can be enforced and non-approved developments immediately stopped and the River course reinstated. Environmental Impact Assessments (EIA) should be mandatory and not "selective and only implemented for projects financed by international institutions" as has been reported[55]. An in-depth environmental policy is needed to ensure that the current gap between the national and municipal authorities is overcome and that appropriate policies are included in all relevant documents for planning and building control.

Construction (new buildings; renovation or rebuilding of old ones; infrastructure development ;) has been one of the most rapidly growing economic sectors of Tbilisi in the last 15 years. A variety of Codes, Practices, Standards and Specifications have been used during this period and this has effectively reduced quality control as many involved do not understand the details and requirements of each and others take advantage of this knowledge gap.

Urban and periurban drainage and runoff must be covered in such documents with establishment of improved road designs within urban and rural areas to take account of runoff design and storage

55 GEO-Cities Tbilisi. : An integrated environmental assessment of state and trends for Georgia's capital city, United Nations Environment Programme (UNEP) December 2011.

to reduce flood peaks, the safe disposal of storm runoff both within the city and from highways to and within rural areas. This runoff exacerbates large river floods by creating unnecessary peaks to the flood hydrograph and also concentrates flow in the ravines encouraging erosion and subsequent landslides. Also, the improvements must include better requirements for road construction to ensure adequate attention to disposal of excavated material and the control of runoff emanating from the roads to reduce the probability of downslope scour and initiation of landslides.

(c) Hydraulic Modelling.

To ensure that the sequence of events that occurred on the 13/14 June are not repeated, some immediate activities/measures need to be carried out to determine the capacity of the river system as-built (both open and closed) to convey flood flows to the Kura river and to identify any hydraulic constraints. The proposed computer modelling of the river system will also determine the flood flows for different return periods and the capacity of the river system as built to carry these floods. The results will be used inter alia to delineate the flood prone zones, not only by flood water height, but also by probability of occurrence. These results would also be essential inputs into the designing of the type and height of riverbank protection, elevation of road infrastructure and similarly associated reconstruction works.

Hydraulic modelling of the river proposed in the immediate future will determine not only flood flows through the tunnel system, but also flood passage information[56] (flood elevations; flood return periods; flood risk zones; flood prone area delineation) as well as establishing criteria for the design and selection of check dams and debris collectors within the Vere catchment covering not only the mainstream, but also the tributaries. It will also provide an assessment of sediment transport for at least the last 15 km of Vere River as it approaches the Tbilisi city boundary. An outline of the requirements for this Hydraulic Modelling exercise is presented in Annex B.

(d) Rainfall and Stream flow recording.

With the destruction of the Tbilisi-Vere automatic recording station, the only such station within the catchment has gone. It is not only imperative that this is replaced without delay, but it should be equipped with up-to-date automatic rainfall, stream flow and sediment monitoring and recording equipment that is linked by Telemetry to the appropriate office in Tbilisi. In addition, further similar automatic total recording stations fitted with data loggers should be provided in key areas of the catchment, especially near where much of the peak flood and suspended material were thought to have originated. The data collected will be accessed directly as part of the proposed early warning system.

(e) Early Warning Systems.

Until such time that proposed interventions become effective, Tbilisi can still be considered to be vulnerable to extreme events such as those that occurred on the 13/14 June 2015 within the Vere catchment. It is therefore mandatory to introduce immediately mechanisms for risk mitigation, implementing Early Warning Systems and civil protection suitable to prevent, especially, the loss of lives.

In general, the early warning system should be supported by guidance to be followed in the case of the warning of an imminent flash flood. This level of warning can be defined from an estimate of how much rainfall over a specified time in a small basin is needed to initiate flooding on small rivers, usually having a catchment area of less than 200 km^2, as is the case of the Vere Watershed. Once developed, this could form part of a system of:

- Modelling the flood threat (in particular flash flood) over the basin utilising:
  - Streamflow data;
  - Rainfall measured by rain gauges (real time), radar, satellite, etc.; and/or,
  - Rainfall forecasts;

56 This is a high priority need considering not only other mitigation proposals but also as damage repair and rebuilding has already been started and is on-going without adequate realistic hydraulic data.

Initially the Early Warning can be based on a simple operational framework and in the short term it can be improved through monitoring using proven and more sophisticated means. Precursors to events should be monitored on a continuous basis with the data analyzed to generate a forecast. In the framework of Early Warning, the emergency committees will initiate actions as proposed in the emergency plans using real time information available from automatic strategically placed measuring equipment in a linked telemetry network together with simple rain-gauges and river level gauges.

The Ministry of Environment, through the National Environmental Agency, has started work on the installation of automatic rainfall measuring equipment and hydrological stations in Vere Valley (apparently the precipitation-measuring are already being installed). The Early Warning System will be supported mainly through the preparation of maps identifying the sectors of flooding in urban areas, linked to the significant return periods. Utilising these maps, an assessment will be carried out of the vulnerability of all structures and infrastructure, and above all, of the population likely to be affected by the event. This knowledge will allow the creation of a safety and action plan, of course linked initially to the weather alert mechanism. This would be used to activate evacuation, in a relatively rapid and reliable manner, of all predetermined affected people giving priority to the most vulnerable persons and structures (children; old and sick people; schools; hospitals; main roads; etc.). As part of the safety and action plan, assembly areas outside the flood risks zones would be identified together with the number, types and location of appropriate evacuation transport to implement the plans.

As a first stage in the alert process, one of the priority actions must be the removal of all vehicles from within the areas subject to flooding to safe parking areas outside the at risk zones. Such a safety and intervention plan, should consider establishing a dedicated and efficient system of civil protection involving structured entities, such as army, local police, community leaders etc., but also including those living in at risk areas by assigning tasks and intervention procedures to them.

Above all, it is essential that the concept and perception of the dangers caused by flooding need to introduced and instilled among those people potentially subject to the event and this will be complimented with the behaviour to be followed during the event with a focus on mechanisms of evacuation. This will be possible through training and awareness at the neighborhood level and especially in schools at all levels. These courses must be conducted using simple manuals that are easy to understand and read and such courses should be consolidated with annual (or more frequent) repetitions, with appropriate, practical tests of the evacuation carried out where considered necessary. The awareness should consider not only aspects related to the event, but be also extended to include the concept of respect and annual maintenance of the structures established.

(f) Studies and Data Collection

There are no solutions to mitigate the risk of flooding if measures are not taken to prevent the arrival of transported and large amounts of suspended material in the last lower downstream sections of the Vere River before it enters Tbilisi city boundary and the area that could result in blockage of tunnels. It is therefore important to provide for studies and works to achieve this goal.

It is essential to augment the present state of knowledge of the event and of the catchment to be able to accurately plan and implement suitable measures to mitigate future risks of flooding. This will be achieved through river training and river bank protection interventions for the Vere River and its major contributing tributaries. It is there important to activate in the short term the following group of studies:

A. Catchment Studies. These will be focused on obtaining a better understanding of the Vere watershed. These studies will select and design the interventions to mitigate the risk of events such as those that occurred in June 2015. The design works will be based on the results of these studies and will lead directly onto the construction of the mitigation works.

The feasibility study and preliminary design should be made for the last 10 km along the main water course and for the same extension in the tributary valleys on the right river bank. It is anticipated that the final design will follow directly on from the completed studies to ensure the early implementation of construction of the selected structures for the training of the last 3-4 km of Vere River upstream from the urban areas, similarly in some of the closer tributaries on the right bank (See Annex D). This approach and methodology will be considered as a Pilot project with the results used to implement similar interventions in other similarly threatened valleys.

The studies and design may include:

- Lidar DEM* at 1 m resolution and elaboration of the following thematic maps :
    - contour lines (spacing 1 m);
    - geomorphologic map – 1:5000 (Aerial imagery interpretation)
    - slope map – 1:5000
    - aspect map – 1:5000
    - hydrographical network map with watershed basins
    - geological map – 1:5000
    - Landslide vulnerability map, possibly indicating type of movement and hazard level.

*Lidar DEM will be extended to all the Vere Watershed (apparently a Lidar has been recently developed by a donor; we do not know the details of this study)

The combination of geomorphological map, survey data (landslides) and DEM derived geomorphic indexes (plan and profile curvature, convergence index, topographic wetness index, stream energy index) will allow to obtain a susceptibility map that subdivide the territory in hazard levels. Lidar will be performed in the whole Vere watershed (about 180 km^2).

B. River Bank Stability. Some of the open river sections between the existing tunnels and culverts in Tbilisi City were badly damaged during the floods and especially those at the upper end of the system near the outlet from Tunnel 6 and the inlet to Tunnel 5 as described in Section 3.3.1. (See Annex E - photos 6 & 7). Although some works are on-going in this area, the right river bank is very unstable due to the number and size of the upslope buildings (see Annex E - photos 13 & 14). It is therefore imperative that without delay, the following studies and investigations are initiated:

(i) Geotechnical investigation[57] to characterize the site lithology in order to realize geologic/ geotechnical cross sections of the riverbank. Investigations should extend to the works foundations and construction material for each selected site, including:

- detailed geologic survey, comprising geomechanical survey of all the possible outcrops;
- geological survey of the footprint of the work, properly extended, particular attention should be spent in recognise the outcrops of firm rock in riverbed, that are acting as hydraulic permanent threshold;
- geomechanical survey of the shoulders that will host the work;
- at least 8 vertical boreholes with continuous coring, tests in hole and sampling to suitable depths
- trial pits in the central axis, extended upstream to investigate the presence of materials suitable for construction, with stratigraphy, samples collection and in situ tests;

57 Details of geotechnical investigation and laboratory tests are reported in Annex C.

- laboratory tests will be carried out on soil and rock samples taken during the boreholes and Test Pits implementation and consist of classification tests, mechanical tests etc. (The details of geotechnical investigation and laboratory tests are reported in Annex C);

(ii) Detailed topographic survey to precisely describe the actual status; the survey must be extended to the whole right riverbank between Tunnel 6 and the inlet to Tunnel 5;

(iii) Design studies that will include the design of recommended works and this would then be followed immediately by the construction of the same:

- Design of the slopes stabilization, performed considering the geological and geotechnical parameters as derived from the investigation and the topography; a stability analysis under various conditions.
- Selection the sustainable engineering solution for the entire stabilization of the slopes, the analysis will take in account the seismic condition. The more sustainable design solutions would probably involve a slope reshaping with the consequent loss of areas that actually include houses.
- Works for the restoration of safety.

(g) Repairs to the Flood Damaged Tunnels/Culverts

All of the river tunnels and culverts within the Tbilisi municipality will need to be cleaned, structurally examined in detail and repaired. It has been assumed that these aspects and associated costs have been taken into consideration when the damage assessments had been made for the road infrastructure as almost all are directly related to the reinstatement of good transport communications within the city.

5.5.2. Short to Medium-term actions (12 to 36 Months)

(a) Achievement of Appropriate Norms On Land Use

A significant lack of general land use management was observed and in such relatively unstable areas is one of the main contributory causes of its fragility. It is therefore essential to introduce / improve land use norms and criteria that will be part of a future “Basin Plan” (long term) and in line with the Water Framework Directive.

(b) River Training Works

The feasibility study and preliminary design should be made for the last 10 km along the main water course and for the same extension in the tributary valleys on the right river bank. This stage will be shortly followed by the final design for the training of the last in the last 3-4 km of Vere River before the urban area, and for some of the closer tributaries on the right bank. (See Annex E – Figure 1).

(c) Flood Mitigation Structures

At present, only preliminary indications of interventions are included. Once the above planned studies have been completed, it will be possible to give exhaustive answers. Preliminary interventions envisaged include the construction of low transverse works such as check dams, (gabion weir structures) and debris flow barriers in order to:

- Decrease the riverbed gradient with consequent reductions in velocity, energy and peak flood flow;
- Confining the transported deposit erosion;
- Trapping the large part of the transported load including the floating woody debris;

In the first analysis, a typology of structure corresponding to gabion weir (check dam) - see typical configurations in similar contexts, (see Annex E, photos from 17 to 28) is proposed as the most appropriate intervention particularly considering the experience gained in Georgia and the number and size of the works envisaged are:

- 10 - 14 check dams (gabion weirs) with a max height of 3-4m of the Vere River and 16 in the secondary tributaries;
- Total estimated approximate volume of each = 10,000 m^3

In order to approximately quantify the number of check dams to be settled along the Vere watercourse, the following qualitative statement may be assumed:

- Considering to build, tentatively, the check dams (gabions) in the last 3-4 km of Vere River;
- Actual average river bed gradient = 2.4%;
- Check dam Foreseen spacing: 300 m;
- Check dam height not exceeding 4m;
- Theoretical final river bed gradient approximately ≥ 1%.
- Environmental assessment.

The proposed works will preserve the original geometry of the river course reducing the flow velocity.

Considering the dominant role that floating and surface transported material/debris had in blocking the downstream tunnels, it will be necessary to design at least 7 (See Annex E – photos 20, 21, 26, 27, 28) of the planned control works as selective weirs that will stop the woody material.

The general indications for the inclusion of check dams are the following:

- The check dams should be simple;
- The type of structure should be repeatable and easy to implement in locations of difficult access and sites, in some situation should be necessary to utilise special equipment as spider excavator (see Annex - photos 20, 30 31);
- The site selection will be based on the best geological and morphological conditions including:
    - shoulders on firm rock;
    - section with suitable widths;
    - in a straight sector of the stream;
    - far from side ravines;
    - far from the foot of landslides.

5.5.3. Medium to Long-Term (>36 Months)

(a) Implementation of Catchment Management Plan

The "Basin Plan" should be a tool for sustainable development, and an instrument of technical regulations that directs policy planning. It is aimed at all public entities such as regional local authorities etc. and private entities as traders, entrepreneurs and citizens.

With its norm it allows to:

- address choices for planning and operating following strategies aimed at a global politics of land management;

- defines strategies intervention territory, for accommodation organic whole river basin;

Harmonizes topics related to anthropic impacts and to natural phenomena exceeding the limits and logic of develops.

It is suggested to utilise as an example, international experience for this type of legislation already adopted in areas with similar problems.

(b) Recreation Autochthonous forests

- The reforestation of river terraces along the main stream of the Vere River could decrease debris load during flood flow events.
- The reforestation of the neighbouring and unstable slopes could produce in medium/long term lowering of flood peak.
    - o Designation of flood prone/flood risk areas inside which strict rules to need to be adhered including restrictions on parking of all vehicles, no building development, including the expansion of existing buildings and the construction of new buildings or the rebuilding of damaged or destroyed buildings.
    - o Implementation of strict codes of practice conforming to recognized international standards (FIDIC etc).

6. OUTLINE OF FLOOD PREVENTION AND IMPACT MITIGATION PROJECT

Treating the identifying causes in a holistic manner is the only approach that can be effective. There are no shortcuts and some of the measures necessary will not be popular with certain sections of the community living in these less controlled areas. However, certain restrictions area essential for the well-being of the urban and rural population.

The current after-event condition of Vere River and tributaries and hazards, in case of other similar events, are as follows:

- High sedimentation (See .in Annex c, photos 4, 6,7) in the riverbed : due to the heavy load deposits (sandy, silty clayey, gravel and boulders), in the sections closer to Tbilisi, in case of events characterised by high discharge, deposits can be again transported downwards, with danger of tunnels obstruction.
- Apparently the high riverbed gradient has been maintained: as in the recent event this condition will cause high discharge level and flow velocity with the consequent high tractive force that will cause erosion in the riverbed and transportation of deposits downwards with the consequent danger of tunnels obstruction.
- The numerous unloaded shallow landslides (soil slip), prone to collapse could induce debris/mud flows and even produce the damming of the river course See .in Annex c, photos 11, 12).

All these conditions would result in a catastrophic flood similar to the experienced on 13/14 June 2015. The key aspects of the event caused by the exceptional and the related possibility of mitigation are summarised in the following table:

Table 3. Extreme Events and Possibility of Mitigation

Extraordinary peak flow.	Likely to mitigate
Extraordinary activation of several shallow landslides (soil slip) evolving in debris/mud flow.	Hardly/not to mitigate
Exceptional floating, suspended and heavy load transportation	Likely to mitigate

6.1.COST ESTIMATES

Regular work carried out for the municipality is executed by a variety of contractors working on agreed unit rates. As this usually involves machinery and equipment, the rates are based on hours and, depending on the work are included, with or without fuel. This process should work well for the routine annual maintenance that is needed, as well as the additional works suggested in this report. The capital works are required for the mitigation works will require the preparation of detail bills of quantities on which contractor shall be invited to tender. It would be advisable therefore, for the government of Georgia to invite consultants, both national and international, to assist them in this process. This will speed up the delivery of the works and also ensure that they are complete, appropriate and that management, operation and maintenance (MOM) is also covered together with the associated costs. This is something that is lacking in some contracts at the moment but included in others.

Table 4. Estimated Costs of Mitigation Studies and Associated Construction of Works

ITEMS	USD
Lidar DEM. 1 m resolution (180 km^2)	180,000
Thematic maps	30,000
Mathematical Hydraulic model of the Vere Stream (5 km)	70,000
Check dams Design (preliminary study + final design +Geotechnical Investigations	180,000
TOTAL	**460,000**

Table 5. Cost Estimate for Transverse Structures

ITEMS	Volume m^3	USD/m^3 Cost in place	USD
Check dams of Gabion Weirs	10,000	80	800,000
Contingency @ 10%			80,000
TOTAL			**880,000**

Note:

(i) The cost includes site preparation and construction of the complete structure.

(ii) Because of the uncertainty relating to site accessibility, a contingency sum has been included.

Table 6. Timeline for Studies and Data Collection

ITEMS	Times in months
Lidar DEM 1 m resolution (180 km^2)	2
Thematic maps + Mathematical Hydraulic model of the Vere River (5 km)	3
Check dams Design (Geotechnical Investigations + preliminary study + final design	5
Total	**10**

The check/selective dam (gabion weirs) should be 25 to 30 in number with the following estimated construction times.

Table 7. Timeline for Construction of Each Transverse Structure (Check Dam /Gabion Weir)

Type of work	Times in days*
Site preparation, cleaning, foundation and shoulders excavation	12
Gabion cages erection (large ext. =300 m^3 per site)	36
Finale completion	12
Total	**60**

*Considering 5 work days per week

Note: (i) The estimated time for construction of each structure is approximately 60 working days giving a total construction time for 28 structures of approximately 1680 days.

(ii) It is recommended that the work should be assigned to 4 different contractors, each organizing 2 teams to work on 2 sites simultaneously and with this arrangement, it will be possible to complete the works in about 210 days.

(iii) Once the difficulties arising from operating in a river together with the risk of adverse weather conditions and delays in obtaining materials and/or equipment from abroad have been taken into account, a more conservative estimate would be that construction activities could be completed in about 250-300 days. If more teams are used, construction time would be further reduced.

Table 8. Costs of Other River related Items

No	Description	Unit	Cost (US$)	Remarks
1	Hydraulic Computer Modelling of Vere River Catchment and river including the tunnel and culvert system within the city boundaries.	Sum	120,000	
2	Construction of new modern suitably equipped gauging station (automatic rainfall and stage recorders linked to NEA office by telemetry) close to the site of the earlier Tbilisi-Vere station that was destroyed in the June 13/14 floods	Sum	35,000	Assumed to be run and supported by NEA in Tbilisi
3	Construction of 3 additional new modern suitably equipped gauging station (automatic rainfall and stage recorders linked to NEA office by telemetry) to supplement replaced Tbilisi Vere station.	Sum	100,000	Assumed to be run and supported by NEA in Tbilisi
4	Inspection and repair/reinstatement of damage done to all tunnels and culverts conveying the Vere River within the Tbilisi municipality and including the 1958 tunnel to the confluence with the Kura River	Sum	120,000	It has been assumed that these costs have been taken into consideration when the damage assessments had been made for the infrastructure. This additional cost has been added as a contingency in case all aspects are not included.
5	Maintenance of Tunnel and Culvert Systems	Sum	10,000	Routine annual maintenance of tunnels @ 2%
6	Construction of metal posts at the entrance to 1958 tunnel to restrict the entry of very large washed material, such as vehicles and large trees, there have not been blocked by the debris collection mechanism in the river channel in Didgori district.	Sum	15,000	
7	Establishment of updated building and construction regulations for Georgia	Sum	25,000	
8	Provision of radar prediction software for real-time information as part of the early warning system and common in many European countries	Sum	10,000	
9	Early Warning Systems	Sum	50,000	Training, guidance and technical support to assist implementation
10	A. Catchment Studies.	Sum		Given in Table 4
11	B. River Bank Stability Study and Investigations	Sum		Given in Table 4
12	Introduce / improve land use norms and criteria	Sum	30,000	Training, guidance and technical support to assist implementation
	Contingency @ 10%		51,500	
	TOTAL		**566,500**	

ANNEXES:

A. LIST OF PEOPLE MET AND DATA RECEIVED

B. OUTLINE TOR FOR COMPUTER MODELING

C. OUTLINE TOR FOR FEASIBILITY STUDIES

D. PHOTOS ILLUSTRATING TECHNICAL ASSESSMENT OF THE FLOODS

E. GEOMORPHOLOGIC PHOTOS TO ILLUSTRATE PROPOSED ACTIONS.

A. LIST OF PEOPLE MET AND DATA RECEIVED.

Name	Profession	Contact Details	Organisation	Brief Summary of Reasons for Meeting
Karen Bennett	Regional Program Manager, Soil & Watershed Resources	kabennett@fs.fed.us	USDA Forest Service	Part of USAID team and coordinating with World Bank
Liz Schnackenberg	Hydrologist	lschnackenberg@fs.fed.us	USDA Forest Service	Part of USAID team and coordinating with World Bank
Badur Ukleba	Senior Hydrologist	995-599-704028	Consultant	Discussion relating to hydrological events and availability of data
Dimitrio Talinashvili	Civil Engineer	995-599-021909	Tbilisi Municipality	General and detailed discussion relating to the sequence of events, the river system within Tbilisi, contractors costs, municipality means of implementing and maintaining works, etc
George Gotsiridze	Director/ Geologist	995 32 382542	Geographic, Georgia	Discussion relating to the geology of the Vere catchment, sequence of events and data availability
Tariel Beridze	Deputy Head, Hydrometeorological Department	995-32-2439504	National Environmental Agency (NEA)	Availability and details of rainfall and streamflow data, their analysis of the floods and the build-up to the 13/14 June events, previous floods etc. [River Flow data received by email]
Ramaz Chitanava	Head, Hydrometeorological Department		National Environmental Agency (NEA)	Availability and details of rainfall and streamflow data, their analysis of the floods and the build-up to the 13/14 June events, previous floods etc.
Lika Megrelidze	Head of Meteorology and Climate Division	+995 32 24339528	National Environmental Agency (NEA)	Availability and details of rainfall and streamflow data, their analysis of the floods and the build-up to the 13/14 June events, previous floods etc. [Rainfall Data received by email}
Vakhtang Geladze	Head of Hydrology		National Environmental Agency (NEA)	Availability and details of rainfall and streamflow data, their analysis of the floods and the build-up to the 13/14 June events, previous floods etc.
Vazha Trapaidze	Associate Professor	995-32-2290812	Ivane Javakhishvili Tbilisi, State University, Chair of Hydrology and Meteorology	Data from the Tbilisi-Vere recording station and the build-up to the events of the 13/14 June. [River Flow data received by email]
Merab Alaverdashvili	Director of Educational Hydrometeorological Laboratory	995-32-2227958	Ivane Javakhishvili Tbilisi, State University, Department of Geography	In charge of the Tabilisi- Vere Gauging Station. Data from the Tbilisi-Vere recording station and the build-up to the events of the 13/14 June.
Paata Trapaidze	Owner & CEO	995 32 2439096	Caucasus Road Project Ltd.	Details of the tunnelling system for the Vere River in Tbilisi, tests and hydrological studies and relating issues. [CAD Data on Tunnels received].
Ken Walsh	Civil Engineer/ Dean	995 32 2290820	San Diego Spate University, Georgia	Met during donor meeting at World Bank. He was part of the resource persons for the NEA assessment. Discussion relating to hydrological records and the flood events.
Fadi Hamdan	Managing Director	fhamdan@drmcentre.com	Disaster Risk Management Centre, Lebanon	Met during donor meeting at World Bank. He was part of the resource persons for the UNDP assessment.

B. TOR OUTLINES FOR HYDROLOGICAL STUDIES

To facilitate the initiation of the immediate hydraulic modelling of the Vere River and associated studies in the catchment, suggestions for aspects to be included in the terms of reference have been provided below. These are aimed to provide the basis for the studies but the details will need to be worked out and discussed with prospective organisations capable of implementing them and carrying them out in a relatively short timescale. They should not be considered as definitive but to prompt discussion to bring them to prompt fruition.

Hydraulic Computer Modelling

- Determine the capacity of the river system as-built (both open and closed) to convey flood flows to the Kura River and to identify any hydraulic constraints.
- Determine the flood flows for different return periods and the capacity of the river system as built to carry these floods.
- Utilising the results, delineate the flood prone zones, not only by height, but also by probability of occurrence.
- Prepare guidelines for designing of the type and height of riverbank protection, elevation of road infrastructure and similarly associated reconstruction works.
- Determine flood passage information[58] (flood elevations; flood return periods; flood risk zones; flood prone area delineation)
- Establish criteria for the design and selection of check dams and debris collectors within the Vere catchment covering not only the mainstream, but also the tributaries.
- Estimate rainfall intensity, duration curves for the Vere River upstream from Tbilisi
- Identify flood protection and bank protection works needed.

Solid transport assessment

- sediment sampling and laboratory test (grain size analysis); extended to boulder by mass grain size; sampling frequency: 1 sample per 500 m along the Vere and its tributaries on the right river bank ;
- computation of flow velocity and related tractive force at the most relevant sections of the main watercourse for different return period (100, 200, 400 and 1000 years);
- Solid load modelling in different conditions and at the most relevant sections. This model will be part of the complete mathematical model for fluvial dynamics that will be prepared for at least the terminal 10 km of Vere River.

58 This is a high priority need considering not only other mitigation proposals but also as damage repair and rebuilding has already been started and is on-going without adequate realistic hydraulic data.

ANNEX C. TOR OUTLINE FOR GEOTECHNICAL FEASIBILITY STUDIES

To facilitate the initiation of the studies (feasibility studies and follow-up detailed design work) related to the control works recommended for the Vere catchment, an outline table of contents has been set out below. These should be regarded as a minimum. They are expected to determine the location(s) and precise details of the check dams, as well as a number required. Most of this content will be common to almost all the works planned as the structures proposed are neither complicated nor large.

The check dams should be simple, but the goal is to have works that can be easily replicated either in the same catchment or in other areas that are similarly threatened. Access to these sites for which arose and construction machinery will often be a constraint and this needs to be taken into consideration in the studies to be carried out.

Site selection will be determined from a number of factors, but importantly, they must be based on the best geological and morphological conditions. It is most important that the shoulders/abutments of the structures are located on firm rock and in the sections that present morphologies of suitable widths and as straight reaches as possible that are away from the influence of side ravines and gulleys.

In order to guide the work, two tables have been included detailing how the costs have been built up and the works that are envisaged for geotechnical investigation for studies and designs of Check Dams (gabion weirs) (Table C.1) and the Stabilization of the Vere right bank between the 1° and 2° tunnel (Table C.2)

Table C.1 Geotechnical Investigations for Check Dams (Gabion Weirs) for Vere River and Two Tributaries

Check dams in Vere River and 2 Triburaries					
GEOTECHNICAL INVESTIGATION					
Sr.	Description	Unit	Quantity	Rate USD	Amount USD
3	TEST PITS				
3,1	Establishment at location of test pit	No.	30	250,00	7.500,00
3,2	Depth not exceeding 3.5 m (approx. Test Pits N°= 150)	No.	150	60,00	9.000,00
4	SAMPLING + In Situ Tests				
4,1	Bulk disturbed sample from Tests Pits	No.	200	3,00	600,00
4,2	Permeability test in situ "double Rings" (ASTM D 3385-03) or similar	No.	20	50,00	1.000,00
4,3	In Situ Density test (sand cone or similar) ASTM D1556 / D1556M	No.	30	50,00	1.500,00
4,4	Point Load Strength Method for determination Point load index ASTM D 5731*	No.	100	5,00	500,00
5	LABORATORY TESTING				
5,1	Determination of particle size distribution by wet sieve analysis on bulk disturbed samples from test pits	No.	200	50,00	10.000,00
5,2	Permeabilty reconstructed samples	No.	20	40,00	800,00
5,3	Atterberg limits BS 1377:Part 2 or ASTM D 4318	No.	30	40,00	1.200,00
5,4	Specific gravity BS 1377:Part 2 or ASTM D 854	No.	10	20,00	200,00
5,7	Compaction (proctor) (BS 13286)	No.	0	12,00	0,00
5,8	Consolidation Oedometer test BS 1377:Part5 or ASTM D 2435	No.	10	320,00	3.200,00
5,9	Unconfined compression strength (1377)	No.	15	20,00	300,00
6,2	Determination of soil shear strength(shear box of 30x30 cm) (BS 1377) - 3 stages each sample	No.	20	300,00	6.000,00
	TOTAL				**41.800,00**

Table C.2 Geotechnical Investigation for Stabilization of Right Bank of Vere River between Tunnels 6 & 5.

Stabilization of Vere River right bank between Tunnels 6 and 5					
GEOTECHNICAL INVESTIGATION					
Sr.	Description	Unit	Quantity	Rate USD	Amount USD
1	BOREHOLES				
1,1	Prepeare site, mobilise, set up rig, demobilise reinstate site	No.	8	325,00	2.600,00
1,2	Vertical Boring with continous coring including all temporary	m	300	65,00	19.500,00
1,3	installation of PVC standpipe piezometer (prov. quantity)	m	200	15,00	3.000,00
1,4	Records of ground water table (one pair month and after rain fall)	No.	5	100,00	500,00
2	INSITU TESTS IN BOREHOLES				
2,2	Standard Penetration Test (SPT)	No.	100	30,00	3.000,00
3	TEST PITS				
3,1	Establishment at location of test pit	No.	10	25,00	250,00
3,2	Depth not exceeding 3.5 m	m	322	10,00	3.220,00
4	SAMPLING				
4,1	Bulk disturbed sample from borehole	No.	80	1,00	80,00
4,2	Undisturbed sample from borehole(minimum dia. 100 mm)	No.	20	50,00	1.000,00
4,3	Condition rock samples taken in core box	No.	20	10,00	200,00
4,4	Bulk disturbed sample from test pits	No.	20	2,00	40,00
5	LABORATORY TESTING				
5,1	Determination of particle size distribution by wet sieve analysis	No.	20	50,00	1.000,00
5,2	Determination of particle size distribution by wet sieve analysis	No.	80	40,00	3.200,00
5,3	Atterberg limits BS 1377:Part 2 or ASTM D 4318	No.	20	4,00	80,00
5,4	Specific gravity BS 1377:Part 2 or ASTM D 854	No.	19	3,00	57,00
5,7	Compaction (proctor) (BS 13286)	No.	0	12,00	0,00
5,8	Consolidation Oedometer test BS 1377:Part5 or ASTM D 2435	No.	10	320,00	3.200,00
5,9	Unconfined compression strength (1377)	No.	15	20,00	300,00
6,2	Determination of soil shear strength(shear box of 30x30 cm) (BS	No.	12	300,00	3.600,00
	TOTAL				**44.827,00**

D. ADDITIONAL PHOTOS ILLUSTRATING TECHNICAL ASSESSMENT OF THE FLOODS

Photo D.1 River Encroachment

Photo D.2 Exit from Tunnel 1 at Kura River

Photo D.3 Confluence of Vere and Kura Rivers

Photo D.4 Proximity of Tskneti to Scoured Area and associated landslips

Photo D.5 Proximity of Rubbish Tips to Vere River close to City

Photo D.6 Proximity of Road to Tskneti to Steep Slopes Close to Vere River

Photo D.7 Proximity of Rubbish Tips to Tbilisi and Vere River as it Approaches the City

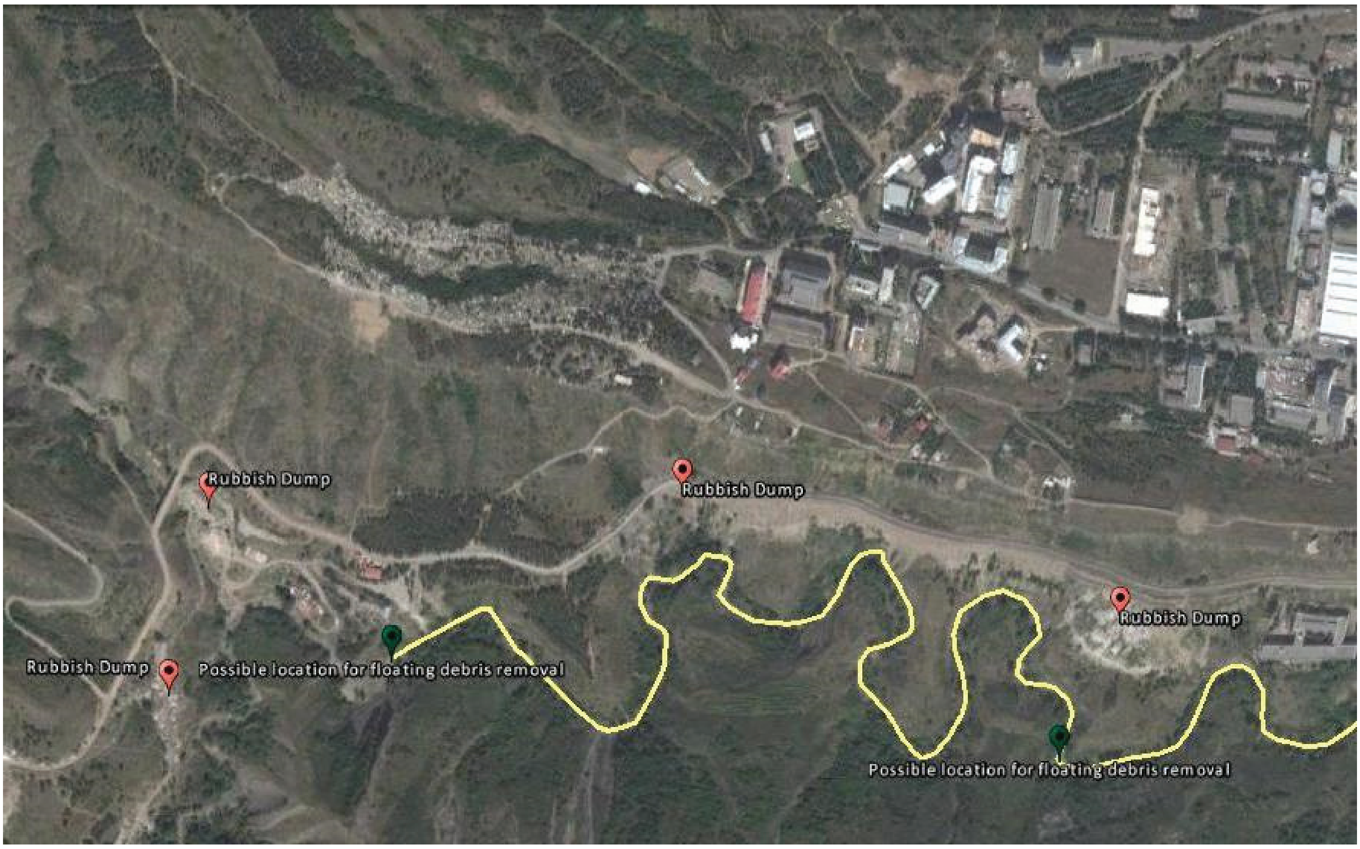

Photo D.8 Proximity of Rubbish & Construction Waste Tips to Vere River close to Tbilisi City

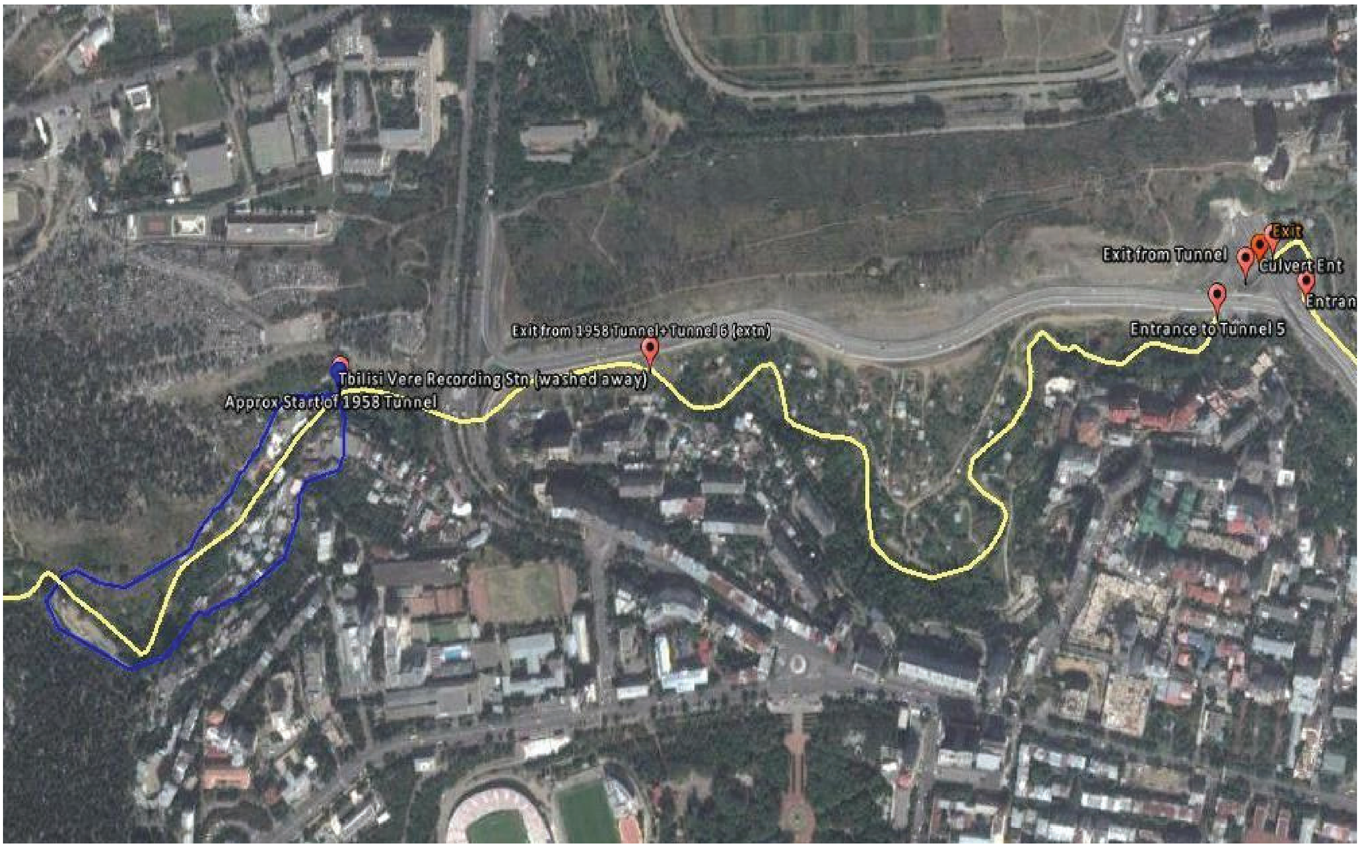

Figure D.1 Course of Vere River in Tbilisi City (from Tunnel 6 to 4)

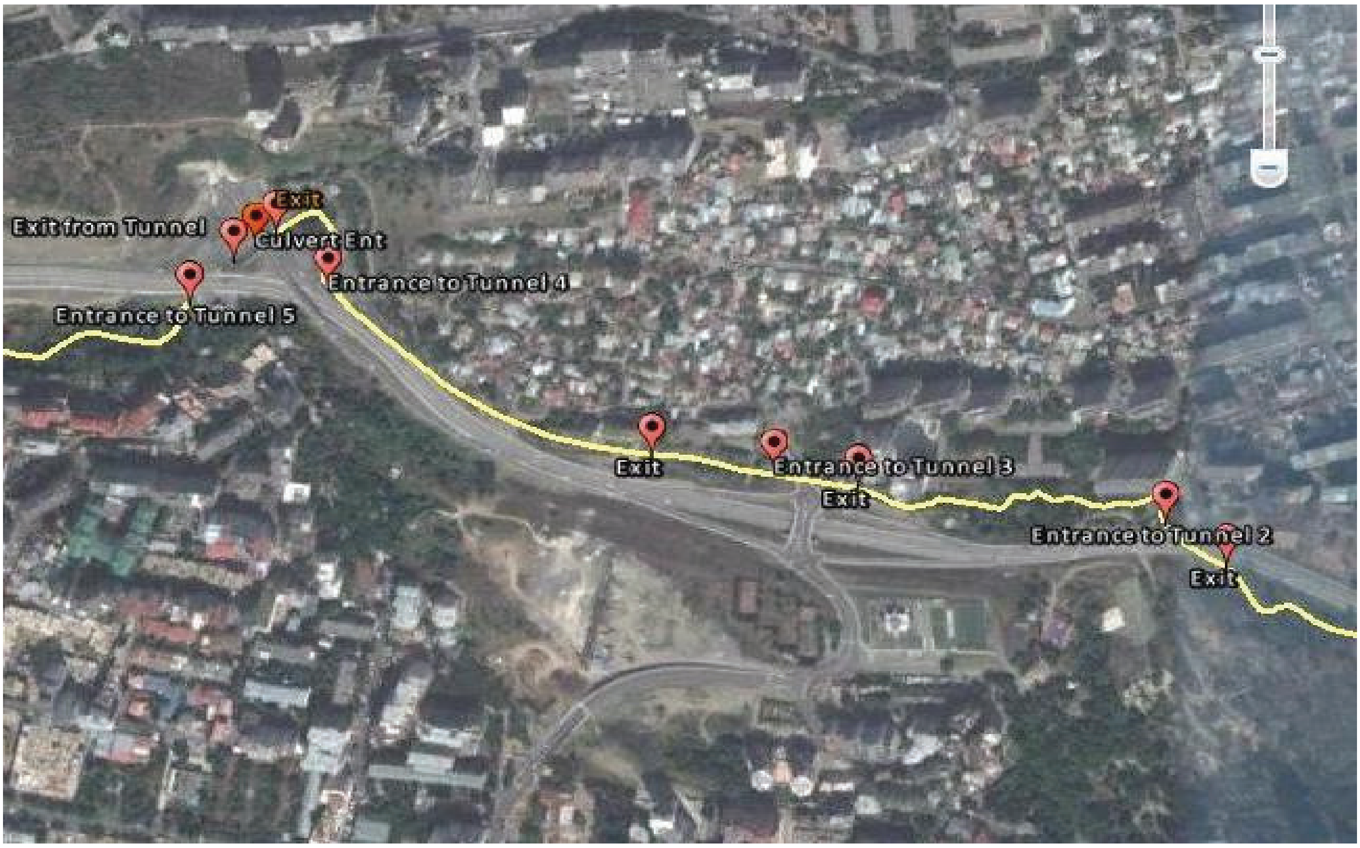

Figure D.2 Course of Vere River in Tbilisi City (from Tunnel 5 to 2)

Figure D.3 Course of Vere River in Tbilisi City (from Tunnel 2 to Exit at Kura River)

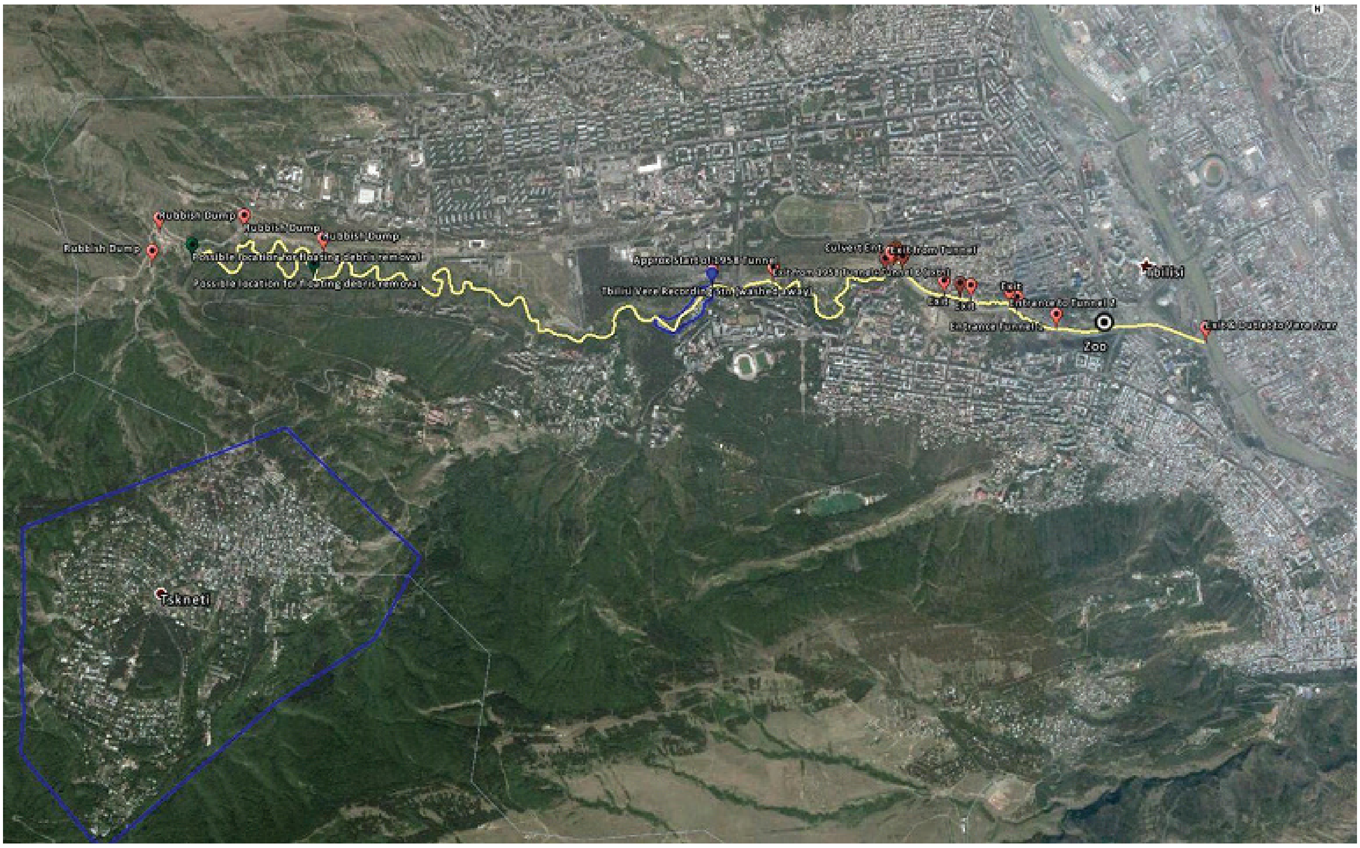

Figure D.4 Overview of Vere River in Proximity of Tbilisi City

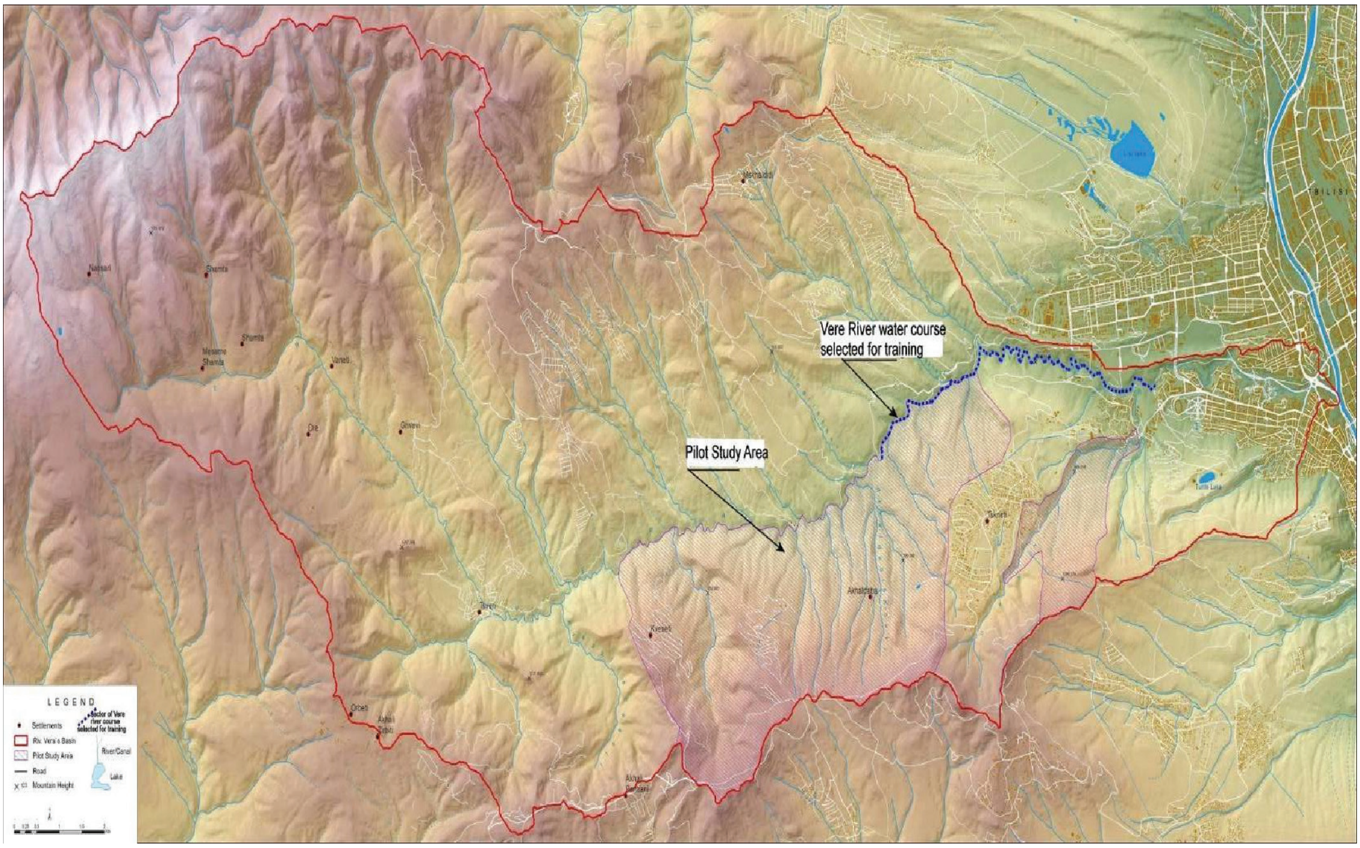

Figure D.4 Overview of Vere River in Proximity of Tbilisi City

Photo E. 1. Vere River

Photo E. 2. Vere River

Photo E. 3. Largest landslide settled towards Akhaldaba village.

Photo 4 E. View from downstream of landslide towards Akhaldaba village and related over silting for debris flow in Vere watercourse

Photo E. 5. Largest landslide settled towards Akhaldaba village. View from above towards Vere River

Photo E. 6. Sedimentation in Vere river

Photo E. 7. Sedimentation in Vere Catchment

Photo E. 8. Soil Slips

Photo E. 9. Soil Slips

Photo E. 10. Soil Slips

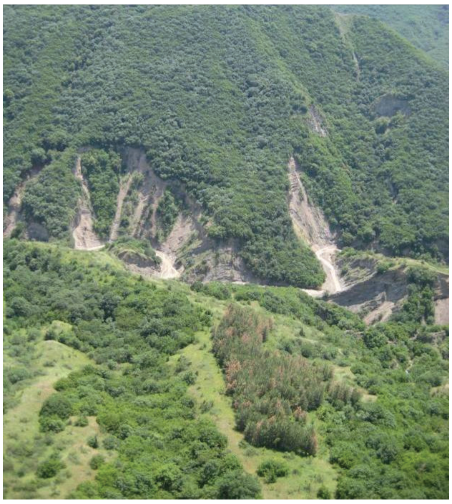

Photo E. 11. Partially Unloaded soil slip

Photo E. 12. Unloaded soil slips illustrating possibility of collapse and subsequent damming of the Vere River

Photo E. 13. Unstable right river bank in this section between Tunnel 6 and 5

Photo E. 14. Unstable right river bank in this section between Tunnel 6 and 5

Photo E. 15. Direct control of the water level flow

Photo E. 16. Automatic reading of the flow

Photo E. 17. Check dam, Gabion Weir

Photo E. 18. Check dam, Gabion Weir

Photo E. 19. Check/selective dam, Gabion Weir

Photo E. 20. Check/selective dam, Gabion Weir

Photo E. 21. Check/selective dam, Gabion Weir

Photo E. 22. Erdox Structure for secondary watercourses

Photo E. 23. Debris flow barrier for secondary watercourses

Photo E. 24. Debris flow barrier for secondary watercourses, with debris materials collected, it forms a natural weir

Photo E. 25. Debris flow barrier for secondary watercourses, with debris materials collected, it forms a natural weir

Photo E. 26. Floating Debris flow barrier for secondary watercourses,

Photo E. 27. Selective Barrier for floating load (debris timber)

Photo E. 28. Selective Barrier to capture the floating (debris timber) transportation (Utilized in Georgia)

Photo E. 29. Spider Excavator for difficult sites

Photo E. 30. Spider Excavator for difficult sites

Photo E. 31. Spider Excavator for difficult sites

ANNEX III

Tbilisi City Council
RESOLUTION 17-66
July 5, 2015, Tbilisi

On Approval of the Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality

In compliance with the organic law of Georgia "Local Self Government Code" [Article 61.2 and 68.1 (k)], the organic law of Georgia on the Rule of Cession of Property in case of Urgent Public Necessity and Decree N 18-57 of Tbilisi City Hall (dated December 19, 2014) on Approval of Tbilisi Municipal Budget 2015,

Tbilisi City Council RESOLVED:

Article 1

To approve:

a) "The Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality", in compliance with Annex N 1;

b) Template "Application on Purchase/Rehabilitation of Lost/Damaged Residence", in compliance with Annex N 2;

c) Template "Application on Cession of Lost/Damaged Residence, in compliance with Annex N 3;

d) Template Agreement on Provision of Monetary Compensation for Residence, in compliance with Annex N 4;

e) Template Agreement on Cession of Real Estate Property Rights, in compliance with Annex N 5.

Article 2

The Resolution shall come into force immediately upon its publication.

Chairman of Tbilisi City Hall

Giorgi Alibegashvili

ANNEX 1

The Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality

Article 1. General Provisions

1. These Rules define conditions for provision of residential area, cession of real estate property and provision of other types of monetary assistance to the disaster victims (persons and families) with the use of the funds of the relevant program provided for in Tbilisi municipal budget, as well as the rules for social and legal assessment and study of the damaged families and definition of the assistance criteria.

2. The goal of these Rules is to provide material assistance and residence to persons (families) who suffered from the natural disaster on June 13-14, on the territory of Tbilisi municipality.

3. The procedures related to provision of residence to the disaster victims (persons and families) with the use of the funds of the relevant program provided for in Tbilisi municipal budget and cession of their real estate property shall be implemented by the legal entity of public law Agency of Property Management (hereinafter – the Agency) subordinated to Tbilisi municipality; The procedures related to provision of other monetary assistance shall be implemented by Vake and Saburtalo District Governor's Offices (hereinafter "Gamgeoba") in compliance with the procedures provided for in the active legislation and these Rules.

Article 2. Definition of Terms

The terms and expressions used in these Rules shall have the following meanings:

a) The Commission – the governmental commission formed based on Decree N 274 issued by the Georgian Government on June 18, 2015, "On Forming a Government Commission and Approving its Charter in order to Liquidate the Consequences of the Natural Disaster that Took Place on June 13-14 in Tbilisi Municipality, Conduct Studies of the Vera River Valley and its Adjacent Territories and Organize Future Restoration Work";

b) Victim(s) (person(s)/family(s)) – owner(s) of the real estate properties located on the territory determined by the Commission and persons provided for in the Law of Georgia on Recognition of Land Ownership (Land Use) Rights of Individual Persons and Private Legal Entities, whose residential house/apartment was destroyed/damaged as a result of the natural disaster that took place in Tbilisi on June 13-14, 5015;

c) A Family – persons who permanently live in the same residence and jointly conduct household activities (a family may also consist of only one person);

d) Residence (residential area) – an apartment of one or more rooms equipped and used for permanent residence;

e) Cession of Real Estate Property – transfer of the real estate property legally owned (used) by a victim (person/family) into the ownership of Tbilisi Municipality in return for its market price;

f) Other monetary assistance – monetary assistance for purchase of household goods;

g) The Natural Disaster Zone - the territory determined by the Commission which is dangerous for life and health of its residents;

h) Rehabilitation – creation of safe living conditions in the buildings and structures;

i) Valuator – LEPL Levan Samkharauli National Forensic Bureau.

Article 3. Categories and Groups of Victims (persons/families)

1.Victims (persons/families) are divided into the following main categories:

a) The 1st Category - victim (person / family) whose residence was destroyed or damaged by the natural disaster and cannot be rehabilitated;

b) The 2nd Category - victim (person / family) whose residence was damaged by the natural disaster but can be rehabilitated.

2.Victims (persons/families) are divided into the following groups:

a) The 1st Group - owners;

b) The 2nd Group – legal owners of land lots under the Law of Georgia on Recognition of Land Ownership (Land Use) Rights of Individual Persons and Private Legal Entities (hereinafter – the Owner);

c) The 3rd Group - legal users of land lots under the Law of Georgia on Recognition of Land Ownership (Land Use) Rights of Individual Persons and Private Legal Entities (hereinafter – the User).

Article 4. The Rules for Provision of Residence

1. Residence shall be provided to the victims (persons/families) taking into account the categories and groups provided for in Article 3 of these Rules.

2. In order to provide victims with residence, the victims (persons/families) included into all groups of the 1st Category will receive cash for purchase of a residential house/apartment; the amount shall be calculated based on the number of the family members and the average market price estimated by the valuator for real estate property located on the territory defined by the Commission. The amount shall be calculated as follows:

   a) For 1-2 member families 45 m^2 price;

   b) For 3-4 member families - 65 m^2 price;

   c) For 5-6 member families - 90 m^2 price;

   d) For families of 7 and more members - 110 m^2 price.

3. In order to provide victims with residence, the victims (persons/families) included into the 2nd Category will receive cash for rehabilitation of their residential house/apartment and select the service pro-

vider for the implementation of rehabilitation in agreement with the Gamgeoba, conditional that the rehabilitation cost specified in the Valuator's Conclusion does not exceed 50% of the average market price of the house/apartment prior to the natural disaster.

4. In order to provide victims with residence, the victims (persons/ families) included into the 2nd Category will receive cash for purchase of a residential house/apartment in compliance with the rule provided for in Paragraph 2 of this Article, if the rehabilitation cost specified in the Valuator's Conclusion exceeds 50% of the average market price of the house/apartment prior to the natural disaster and/or if the house/apartment is located within the natural disaster zone.

5. By signing the agreement on payment of monetary assistance for purchase of a residence, Tbilisi Municipality shall undertake the obligation that after the definition of the natural disaster zone by the Commission, the pre-disaster price defined by the valuator for the real estate property (including land) located within this zone will be paid by Tbilisi Municipality to the owners of the residential houses/ apartments in return for cession of their property rights, while in case of possessors/users who have the right to claim recognition of the ownership – in return for cession of such rights. At the moment when such payment is made, the amount previously received by the victim (person / family) under Paragraph 2 of this Article shall be deducted from the payable amount, while if the amount exceeds the market price of the real estate property, the surplice amount will be left to the victim (person /family).

6. If the victim (person /family) refuses to accept the offer regarding provision of residence specified in Paragraphs 2 and 5 of this Article, the amount necessary for purchase of a residential house/apartment and calculated based on the pre-disaster price of the real estate property (including land) defined by the valuator, will be paid by Tbilisi Municipality to the owners of the destroyed/damaged residential houses/apartments in return for cession of their property rights, while in case of possessors/users who have the right to claim recognition of the ownership – in return for cession of such rights, with the exception of cases provided for in Paragraph 7.

7. In case if no more than 1/3 of the land owned/possessed/used by a victim (person / family) is located within the territory defined by the Commission or within the natural disaster zone, the victim (person /family) will receive compensation only for the area located within the territory defined by the Commission or within the natural disaster zone, while if the territory located outside the above zones is left without an access road, the municipality shall undertake the obligation to arrange the necessary access road.

Article 5. Rules for Payment of Other Monetary Assistance

The victims (persons/families) will receive one-time monetary assistance for purchase of household goods, namely:

a) For 1-2 member families – GEL 8 000 (eight thousand);

b) For 3-4 member families – GEL 8 700 (eight thousand seven hundred);

c) For 5-6 member families – GEL 9 400 (nine thousand four hundred);

d) For families of 7 and more members – GEL 10 500 (ten thousand five hundred).

Article 6. The Procedure for Payment of the Monetary Assistance for Provision of Residence and Other Monetary Assistance

1. The application submitted by the victim (person /family) to the Governor's Office (Gamgeoba) or the Agency for provision of residence, payment of the rehabilitation costs or cession real estate property rights shall have the following attachments:

   a) The ID documents of the victim (all family members);

   b) An abstract from the Public Register (if any);

   c) Documents proving the status provided for in Article 7 of these Rules;

   d) Bank account requisites.

2. While reviewing submitted applications, the Agency or the Governor's Office (Gamgeoba) will use the information and documents received as a result of the situation description (Inventory Report) provided by the Consultation Centre for Remote Sensing and Geographic Information GeoGraphic Ltd. and Tbilisi Municipal Laboratory, which includes:

   a) Photo materials;

   b) Assessment of damages received by the residential house;

   c) Information about the property rights;

   d) Information on existence of an alternative residence;

   e) Information on the number of the family members;

   f) Any other information necessary for the decision making.

3. If review of the documents specified in Paragraphs 1 and 2 of this Article prove existence of the preconditions for signing an agreement on payment of the amount provided for in Article 4 of these Rules, implementation of rehabilitation or cession of real estate property rights, corresponding District Governor's Office of Tbilisi Municipality or the Agency shall issue an individual administrative-legal act (hereinafter – the Act) on satisfying the Application.

4. After the Agency or the Governor's Office issue the Act provided for in Paragraph 3 of this Article, depending on the content of the Application:

   a) the Agency and the victim (person /family) will sign an Agreement on Payment of an Assistance Amount for Provision of Residence or an Agreement on Cession of Real Estate Property Rights, in compliance with Annex 4 and Annex 5 of this Resolution;

   b) the Governor's Office will give consent to the victim (person / family) to sign an agreement with a service provider chosen by the victim (person / family) for the implementation of rehabilitation;

   c) based on Form N 2 submitted by the service provider and attested by Tbilisi Municipal Laboratory, the Governor's Office will transfer to the service provider the amount due for the implemented work.

5. In order to provide a residential house for the victim (person /family), the Financial Department of Tbilisi Municipality, based on the letter received from the Agency, will transfer the amount provided for in Paragraph 2 of Article 4 to the escrow account specially opened for this purpose. The amount will be transferred to the seller's account based on the Property Purchase Agreement submitted to the bank. If the purchase price is lower than the above amount, the difference will be transferred to the bank account specified by the victim (person / family). In cases provided for in Paragraph 6 of Article 4, the Financial Department of Tbilisi Municipality, based on the letter received from the Agency, will transfer the amount to the bank account specified by the victim (person / family).

6. The families who suffered from the disaster and whose applications were satisfied will be given two months after signing the agreement for purchase of a residential house/apartment for the price within the amount provided for in Paragraph 2 of Article 4 of these Rules. During the period provided for in this Paragraph, the victim (person / family) who does not have another residential area will receive from Tbilisi Municipality's budget 2015 (in compliance with the set rule) an amount necessary for renting a residence, while if the victim (person /family) fails to purchase a residential house/apartment within the given period, the victim (person /family) will no longer receive any amount for renting a residence.

7. Neither the Agency, nor the Governor's Office will review applications of those victim families have already received from the state, donor organizations or any other physical persons or legal entities adequate residence or monetary assistance for purchase or rehabilitation of residence, due to the damages caused to them by a natural disaster.

Article 7. Definition of Priorities During the Implementation of the Procedures Pr5ovided for in these Rules

During the implementation of the procedures the priority will be given to the following groups:

a) Victim families in which none of the family members has any real estate property with safe living conditions;

b) Victim families who are registered in the data base of socially vulnerable population and have 100 000 or lower rating score;

c) Victim families with many children (three or more children younger than 18 years old);

d) Victim families in which one of the members is pregnant or breastfeeding;

e) Victim families in which one of the members has limited abilities;

f) Victim families in which one of the members is a war veteran.

Article 8. Making Amendments to the Rules

These Rules can be amended in compliance with the requirements of the Georgian legislation.

ANNEX 4

AGREEMENT
On Monetary Assistance for Provision of Residence
Tbilisi, 2015

1. The Agreement Parties

On the one hand Tbilisi Municipality (hereinafter referred to as the Municipality), represented by the Agency of Property Management, legal entity of public law, and on the other hand the victim (personal data) (hereinafter referred to as the owner /legal owner/ user), hereinafter jointly referred to as the Parties, make and enter this Agreement on the following:

2. Subject of the Agreement

Based on Resolution №17-66 of Tbilisi City Council ("Sakrebulo") issued on July 5, 2015 "On the Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality" and this Agreement and taking into account Valuator's Conclusion N ---, the Victim of the natural disaster is paid monetary assistance in the amount of GEL ---, for purchase of a residential apartment.

3. Rights and Obligations of the Parties

1. In order to provide the Owner /Legal Owner /User with residence the Municipality shall deposit the payable amount on the special escrow account, for the Owner /Legal Owner /User:

Name of the bank:

Account number:

Bank code:

1. The amount provided for in Article 1 shall be transferred to the seller's account upon submission of the Real Estate Sale and Purchase Agreement to the bank.
2. The Owner /Legal Owner /User is given two months to purchase a residential house/ apartment for the price which is within the amount specified in Article 1.
3. The Owner (Legal Owner /User) hereby agrees that within ---------- (period) after the definition of the natural disaster zone by the Commission, the Owner (Legal Owner /User) will make over to the Municipality the property right (concede the right to claim recognition of ownership) for the real estate property (address, total area, cadastre code, if any) in return for the amount paid by the Municipality based on the valuator's assessment and in compliance with Resolution №17-66 of Tbilisi City Council ("Sakrebulo") issued on July 5, 2015 "On the Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality".

4. Other Conditions

1. If any dispute arises out of or in connection with this Agreement, the Parties shall try to resolve it through mutual agreement. If the agreement cannot be achieved the dispute shall be reviewed by the Georgian court of the corresponding jurisdiction.

2. The Agreement is made in 5 (five) copies of equal legal value and shall become effective immediately after it is signed by the Parties.

The Head of the Agency of Property Management of Tbilisi Municipality

The Victim (name, surname)

ANNEX 5

AGREEMENT
On Cession of Real Estate Property Rights
Tbilisi, 2015

1. The Agreement Parties

On the one hand Tbilisi Municipality (hereinafter referred to as the Municipality), represented by the Agency of Property Management, legal entity of public law, and on the other hand the victim (personal data) (hereinafter referred to as the owner /legal owner/ user), hereinafter jointly referred to as the Parties, make and enter this Agreement on the following:

2. Subject of the Agreement

Based on Resolution №17-66 of Tbilisi City Council ("Sakrebulo") issued on July 5, 2015 "On the Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality" and this Agreement and taking into account Valuator's Conclusion N ---, the person /family who is a victim of the natural disaster is paid GEL ---- in return for cession of property rights for real estate (address, total area, cadastre code, if any).

3. Rights and Obligations of the Parties

1. In return for cession of real estate property rights by the Owner /Legal Owner /User the amount specified in Article 2 of this Agreement shall be deposited by the Municipality on the special escrow account for the Owner /Legal Owner /User:

   Name of the bank:

   Account number:

   Bank code:

2. The Owner (Legal Owner /User) hereby agrees to make over to the Municipality the property right (concede the right to claim recognition of ownership) for the real estate (address, total area, cadastre code, if any) in return for payment of the amount specified in Article 2 of this Agreement made by the Municipality in compliance with Resolution №17-66 of Tbilisi City Council ("Sakrebulo") issued on July 5, 2015 "On the Rules for Provision of Residence, Cession of Real Estate Property Rights and Provision of Other Monetary Assistance to the Persons (Families) who Suffered as a Result of the Natural Disaster on June 13-14 in Tbilisi Municipality".

4. Other Conditions

1. If any dispute arises out of or in connection with this Agreement, the Parties shall try to resolve it through mutual agreement. If the agreement cannot be achieved the dispute shall be reviewed by the Georgian court of the corresponding jurisdiction.

2. The Agreement is made in 5 (five) copies of equal legal value and shall become effective immediately after it is signed by the Parties.

The Head of the Agency of Property Management of Tbilisi Municipality

The Victim (name, surname)

ANNEX IV

Terms of Reference – Tbilisi flash floods needs assessment 2015

I. Disaster description

During the night of 13-14 June, heavy rains over the Vere river basin resulted in acute and destructive flash floods that affected the Vake-Saburtalo district, the right bank of river Mtkvari, Lisi, Tsodoreti, Napetvrebi, Bevreti, Tskaldidi, and Betania-Tskneti areas. The Government of Georgia officially deplored 19 people killed, 3 people missing, over 108 families displaced, up to 600 individuals affected, the majority of the zoo animals killed, a devastated zoo territory, up to 30 damaged roads, demolished infrastructure and communication systems, and a paralyzed city traffic. In addition, an important landslide occurred on the right slope of river Vere catchment area near the village of Akhaldaba (about 30km from capital Tbilisi), that may have played a role in the effect of the floods. The relationship between the landslide and the flash floods needs however to be thoroughly analyses.

II. Government and City Hall response and coordination

The Government rapidly mobilized relevant entities to engage in the immediate rescue and relief operation. The Government stated that at present there is no longer urgent need for immediate relief assistance. The Georgian Red Cross Society took the lead in organizing these efforts together with their pool of volunteers. In addition, groups of citizen and different NGO volunteers are mobilized and taking part in cleaning and relief operations.

The Government convened a first coordination/information meeting with the international community on 15 June where it highlighted several priorities that would require support from the donor community.

Treasury accounts were created with the Tbilisi Municipality for donation in GEL and with the Ministry of Finance for donation from abroad. Some donations were provided (e.g. close to USD 5 million by the Ministry of Finance, close to USD 500,000 by the Parliament of Georgia, and additional private donations). However, more financial support is needed.

Donors and international organizations, such as the EU, also mobilized substantial funding and human resources to support the Government in coping with the relief needs, and preparing the needs assessment as well as the recovery phase.

On June 19, the Government officially requested the support of UNDP and the World Bank in undertaking a needs assessment which will provide a basis for long term recovery and prevention.

III. Objectives and scope of the assessment

The objectives of the assessment are as follows:

- Assess the physical and human impacts and effects of the disaster on the transport (roads and vehicles), housing, water management, as well as cultural facilities sectors within the flooded districts and communities;
- Identify needs in all key sectors affected and establish their indicative costing, to provide the basis for a Recovery and Reconstruction Framework;
- Provide recommendations for Disaster Risk Management for the city and relevant national institutions.

While the scope of the assessment will focus on the most affected socio-economic sectors mentioned above, other sectors that suffered less damage may also be considered, including education facilities, energy and businesses, based on the preliminary assessments the relevant ministry or public authority may have conducted thereof.

IV. Schedule

Activity	Completion Date
Identify and mobilize sector teams	June 21-22
Data and preliminary assessments collection and field visits	June 23
Introduction to assessment method and templates	June 24
Data analysis, initial findings and draft sector reports submission	June 30
Needs assessment and prioritization	July 3
Finalization of the sector annexes and the full report	July 10
Presentation of full report to the National Government	July 15
Printing and dissemination of full report	By end of July

V. Assessment leadership and coordination

The assessment will be conducted under the leadership of the Georgian Ministry of Finance, and coordinated by the City Hall of Tbilisi. An assessment team composed of experts from Government and City Hall institutions, as well as international and local partners, will be set up. See team composition attached in Annex 1.

Annex I – Indicative Distribution of Sectors and list of focal points

<table>
<tr><th rowspan="2">Sector</th><th colspan="2">Lead Government Agency</th><th colspan="2">Co-Lead</th><th colspan="2">Donor Lead Partner</th></tr>
<tr><th>Agency</th><th>Individual</th><th>Agency</th><th>Individual</th><th>Agency</th><th>Individual</th></tr>
<tr><td colspan="7">Focus Sectors</td></tr>
<tr><td>Transport</td><td>City Hall
Transport dpt

Improvements dpt

Environment and Green spaces dpt

Zoo</td><td>Merab (koba) MamulaShvili
577 15 55 59
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Dimitri Tatinashvili
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Nato kirvalidze
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N.kirvalidze@tbilisi.gov.ge

Giorgi DarchiaShvili
599 41 36 81</td><td>Ministry of Economy and Sustainable Development

Ministry of Regional Development and Infrastructure</td><td>Team leader
Vasil Kapanadze
577 50 70 28
v.kapanadze@mrdi.gov.ge

Team member
Temur Kapanadze</td><td>World Bank</td><td>Mustapha Benmaamar
Ari Kolliokoski</td></tr>
<tr><td>Water Management</td><td>City Hall
Improvements dpt</td><td>Team member
Dito Tatinashvili
d.tatinashvili@tbilisi.gov.ge
599 02 19 09</td><td>Ministry of Regional Development and Infrastructure

GWP – privet company</td><td>Team leader
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Team member
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----------------</td><td>World Bank (lead)
USAID</td><td></td></tr>
<tr><td>Housing, Land and Settlement</td><td>City Hall

Architectural dpt

Property Management dpt</td><td>Team members
Oto nemsadze
599 90 66 87
o.nemsadze@tbilisi.gov.ge
-------------</td><td></td><td></td><td>World Bank
EU</td><td>Ahmed Eiweida</td></tr>
<tr><td>Culture and misc. (Church, Cemetery, Cultural assets, Zoo, recreational areas)</td><td>City Hall
Culture dpt

Ecology and Greenery dpt

Improvement dpt</td><td>Team member

Nato kirvalidze
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Dito tatinashvili
599 02 19 09
D.tatinashvili@tbilisi.gov.ge</td><td></td><td></td><td>World Bank</td><td>Ahmed Eiweida</td></tr>
</table>

Other sectors						
Environ-ment	City Hall Ecology and Greenery dpt	Focal point **Nato kirvalidze** 593792676 N.kirvalidze@tbilisi.gov.ge	Ministry of Environment and Natural Resources	Team leader Team member	UNDP	
Health	City Hall Social dpt	Focal point ---------------	Ministry of La-bour, Health and Social Affairs	Team leader **Valeri Kvaracxelia** (Deputy minister) 571977777 Team member -----------		
Education	City Hall Education, Sports and Youth Affairs dpt	Focal point **Salome Avaliani** 593 27 55 33	Ministry of Education and Sciences	Team Leader **Eka Kenchadze** 577121919 eka@mes.gov.ge Team Member **Grigol Gagoshidze** 577 054284 grigolgagoshidze@gmail.com		
Energy and Telecom-munication	City Hall Improvements dpt "City of lights"	Focal point **Dito tatinashvili** d.tatinashvili@tbilisi.gov.ge **599 02 19 09**	Ministry of Energy	Team leader **Davit Sharikadze** 577991944 d.sharikadze@energy.gov.ge Team member **Giorgi Shukakidze** 577 08 09 22 g.shukakidze@energy.gov.ge	World Bank	Joseph Meli-tauri
Trade and Industry	City Hall Economical affairs dpt	Focal point **Tamuna Frangishvili** 577158500 t.frangishvili@tbilisi.gov.ge	Ministry of Economy and Sustainable Development	**Qeti saluqvadze** 599 09 25 04		
Donor Communi-cation			Ministry of Finance of Georgia	Team Leader **Salome Chakvetadze** +995 595 90 00 07 s.chakvetadze@mof.ge Team Member **Maia Chaladze** +995 577 05 22 77 m.chaladze@mof.ge		
Liveli-hoods, em-ployment and Social Protection	City Hall Social dpt	Focal point ----------------	Ministry of La-bour, Health and Social Affairs	**Valeri Kvaracxelia** (Deputy minister) 571 97 77 77		