

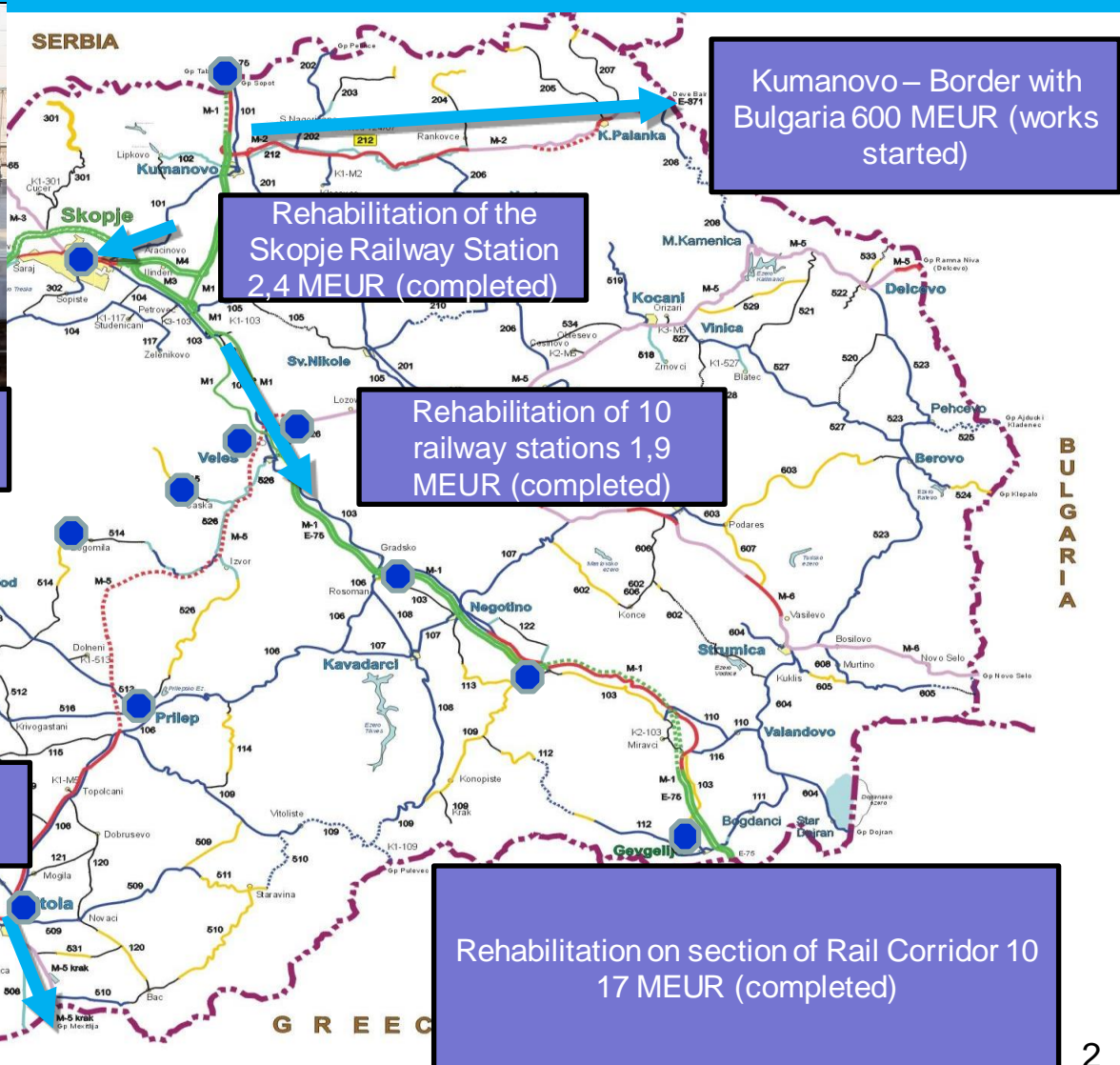
How to develop resilient infrastructure (Global SDG9)

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***Development of resilient rail infrastructure,
practices in the Republic of Macedonia***

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Investments on indicative extension of the TEN – Comprehensive Rail Network 2010 – 2025, 650 Million of EURO



Corridor X from Skopje to Thessaloniki, built in 1873 by the Ottoman Empire

(transport of goods)



Rehabilitation of Railway station Skopje (completed in November 2015)



Rehabilitation of 10 Railway stations (Completed November 2016)



Bitola – Kremenica 25% completed



Focus in the forthcoming period on investments on Rail Corridor VIII

Railway connection between Bulgaria, Macedonia and Albania – Corridor VIII



Corridor VIII, rail link between Sofia and Skopje

Divided in three parts:

1. First section (Kumanovo-Beljakovce) is under construction (45 MEUR)
2. Second section (Beljakovce-Kriva Palanka) is in procurement phase (estimation 140 MEUR)
3. Third section (Kriva Palanka-Border with R. Bulgaria) is in phase of preparation of the detailed design (estimation 350 MEUR)

Measures concerning the resilience on rail Corridor VIII (in the design phase)

The measures concerning the resilience of the infrastructure are mainly done during the designing phase in order for the infrastructure to be:

- Resilient to water (existing and sudden flows)
- Resilient to earthquakes

WATERSHEDS DETERMINATION

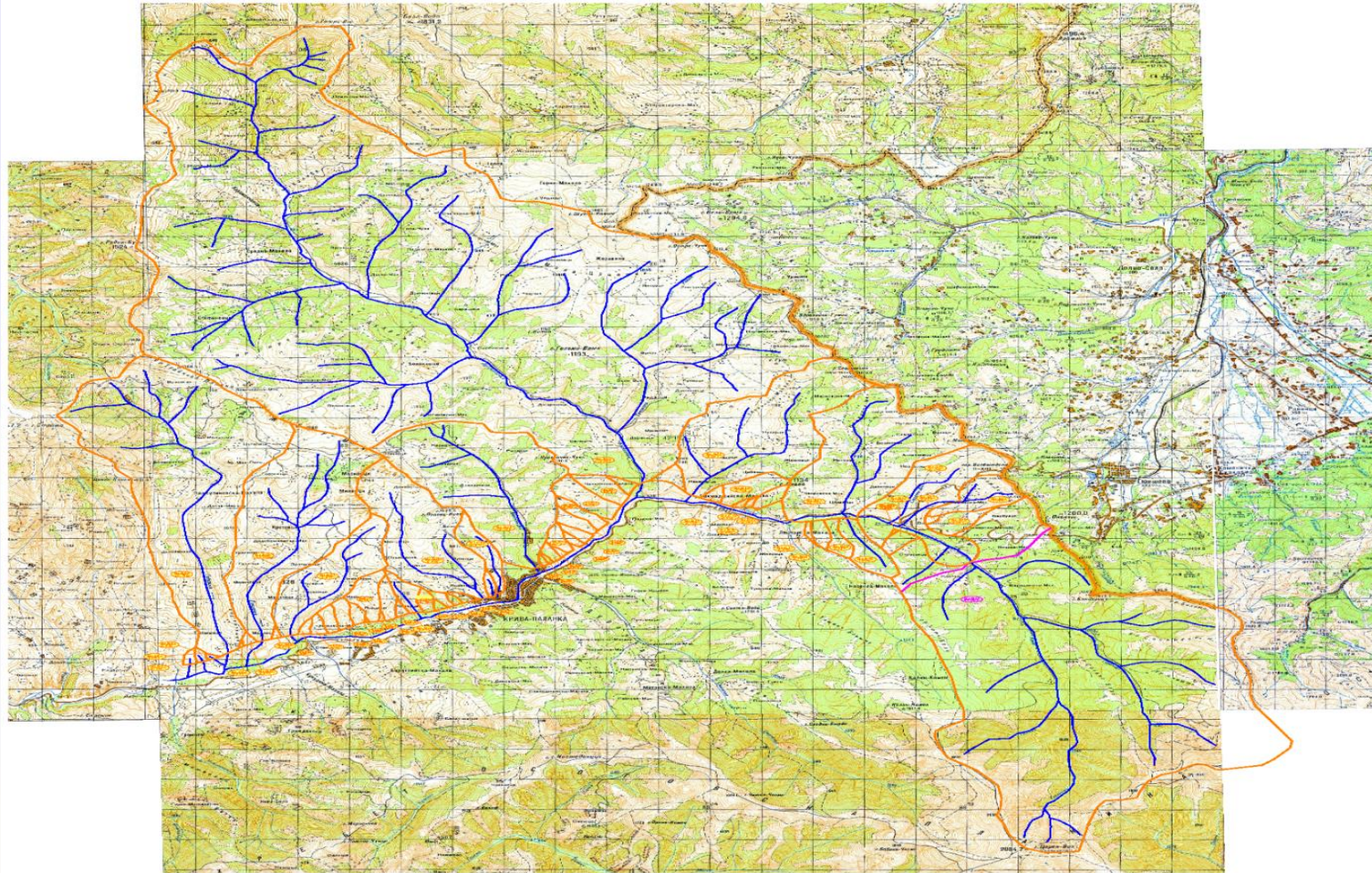


FIGURE 1-1 : RIVER CATCHMENTS (ORANGE COLOUR) AND RIVER NETWORK (BLUE COLOUR) ALONG THE RAILWAY BACK-GROUND, GENERAL LAYOUTS SCALED 1:25.000

WATERSHEDS DETERMINATION

- The catchment areas along the railway line Kriva Palanka- Bulgarian Border are of very small size and only the main tributaries of Kriva River have greater catchment areas. All catchment areas are of smaller stream tributaries to Kriva River.

Especially:

- 59 catchments intersected by the railway route have been determined
- The area of these catchments ranges from 0.009 to 110.904km².

HYDROLOGICAL DATA

Intensity - Duration - Frequency (IDF) Curves

In the area of the Design there is a hydro meteorological station for measuring the rainfall, which provides rainfall data for the period of time from 1956 till 1988.

The data from the above mentioned hydro meteorological station were provided instead (Kriva Palanka), by the Hydro meteorological Service of Republic of Macedonia. IDF curve was produced from the data provided by the station of Kriva Palanka, for the return periods of $T=10$ and $T=100$ years

KRIVA PALANKA: I-D-F curves

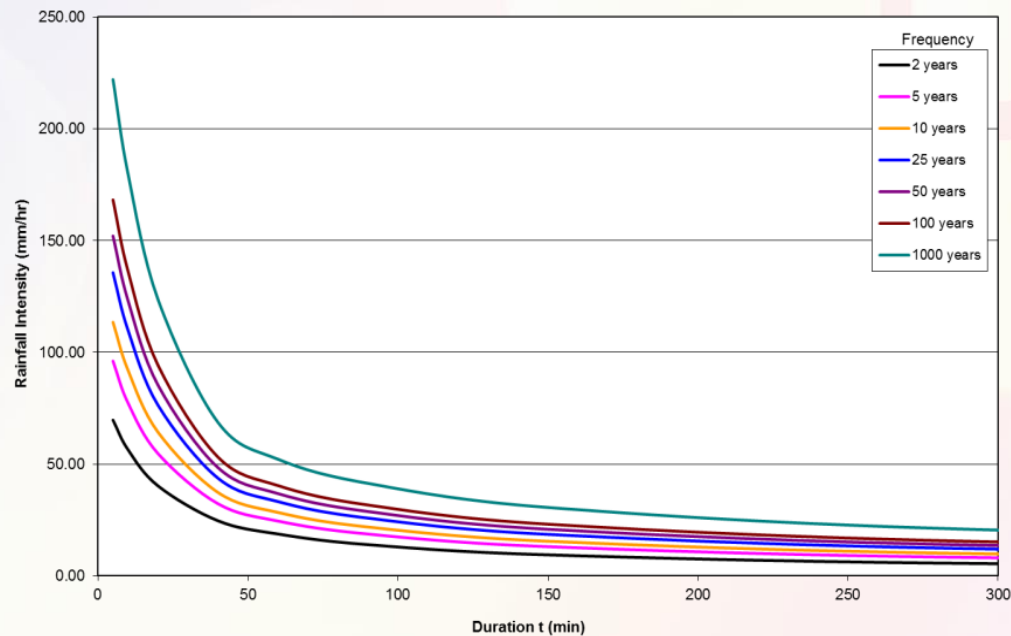


FIGURE 2-1 : IDF CURVES (STATION KRIVA PALANKA)

HYDROLOGICAL DATA

Return Period – T

The Return Period (T) was taken as follows:

- For the design of railway culverts equal to 100 years
- For the design of 51 bridges and important stream deviations equal to 100 years
- For the design of external ditches in cut equal to 100 years
- For the longitudinal structures (sewer pipes, shallow side ditches etc.) equal to 10 years

Rail Corridor VIII-Section Kumanovo - Beljakovce



Culvert CU74 km 30+821

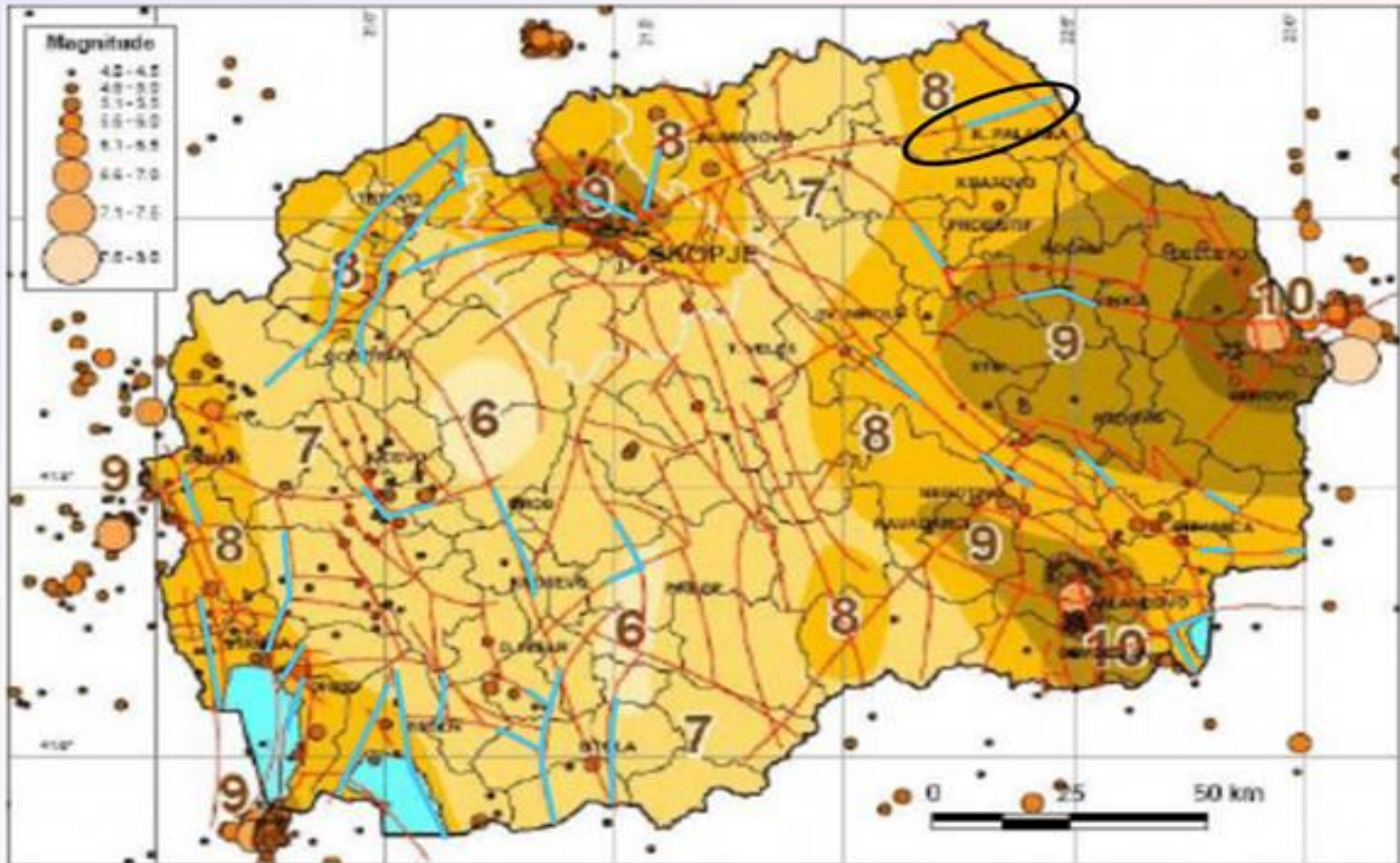
Discharge Estimation

For the estimation of the design discharge for all the structures two methods were used.

Rational method and unit hydrograph method.

- Rational method is used for catchments with area up to 100 ha.
- For larger catchments the unit hydrograph method is used. HEC-HMS (Hydrologic Engineering Center - Hydrologic Modelling System) software has been developed by the U.S. Army Corps of Engineers to simulate the precipitation-runoff processes of dendritic watershed systems.

Seismicity



Seismotectonic and maximum observed seismic intensity map of Macedonia. Regional faults in red line; Faults with evidence of recent activity in blue line; the study area is indicated by black ellipse (tectonical data from Dumurdzanov et al, 2005).

Seismicity

- The main fault in the wider area of the alignment is the Kriva River, running with NE-SW direction, which is the only fault considered active.
- According to the existing seismic map of Republic of Macedonia, for recurrence interval of 500 years, recommended EUROCODE 8 for seismic analyses is used during the designing process.
- According to the existing criteria, for this kind of expected earthquake intensity, it is recommended to adopt a seismic acceleration coefficient $a=0.25g$ and this is confirmed by the reviser of the detailed design
- The design is also reviewed and must have positive opinion by the Institute for seismic engineering of Republic of Macedonia

During construction

- The Engineer (supervisor) monitors if the works are executed according to the technical specifications and the design
- For the structures (bridges and tunnels) the Institute for seismic engineering also tests the structures and their stability (regulated with the national law for construction)

Connectivity Reform Measures Management Plan

- Transport Facilitation Working Group-
TFWG within SEETO dealing with
Connectivity Reform Measures-CRM
- Measure: Improving Transport Network
Resilience in the Western Balkan to
climate change
- Sub-action: Building resilience of the
Core/Comprehensive Network
- Start: beginning of the next year

The background features a light blue and yellow gradient. On the left, there are several white five-pointed stars of varying sizes. On the right, there is a large, stylized graphic of a ribbon or bow, rendered in shades of red and yellow, with a central white circle. The overall aesthetic is clean and celebratory.

Thank you for your attention