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## FUND FOR NATIONAL AND REGIONAL ROADS OF THE REPUBLIC OF MACEDONIA


**Final Construction of Corridor X, Highway E – 75, Section Demir Kapija – Smokvica**

# ENVIRONMENTAL IMPACT ASSESSMENT STUDY - Revised

**Skopje, March 2008**

## Foreword to the revised study (March, 2008)

The original EIA study of the section Demir Kapija - Smokvica of the highway E-75 (Corridor X) was prepared in April 2007. It was based upon comparison of two alternatives, named Alternative A and Alternative B. The final recommendation of that EIA study was inconclusive since both alternatives had very negative impacts on the natural environment (in the case of Alternative B) or human environment and higher construction costs (Alternative A).

As a result of the process of revision of the EIA study a new proposal was elaborated for Alternative B in order to overcome the most negative impacts of this alternative. The original route of Alternative B was passing through the right side of Demir Kapija canyon and over the Bela Voda cave. The new proposal contains solution that avoids the right side of the narrowest part of the Demir Kapija canyon and completely avoids Bela Voda cave. The new design of Alternative B overlaps with Alternative A from the beginning point and all the way to the exit of the tunnel in the left side of Demir Kapija canyon. After this point, routs of Alternative A and Alternative B split. The route of new Alternative B crosses Vardar river (newly proposed bridge) and joints the old route of Alternative B at point 2 km +100,

The analysis of impacts of Alternative B in this revised study is based only on the new alignment of Alternative B and already analyzed Alternative A. Hence, the term Alternative B in this study refers to the **new** alignment of Alternative B. Analysis of old Alternative B can be found in the EIA study prepared in April 2007.

Consequently, there are changes in the

- length of Alternative B (new one is 32.3 km and theold one was 27.7 km);
- number and length of tunnels, bridges and different crossing types (rivers, streams, existing roads) for Alternative B;
- corridor area of Alternative B and combined corridor area of both alternatives;
- surfaces of land use types in the case of Alternative B and combined for both alternatives;
- sensitivity estimation for natural environment for Alternative B;
- sensitivity estimation for settlements (Demir Kapija town) and archaeological sites for Alternative B;
- estimation of impacts on natural environment (Bela Voda cave, Greek Juniper community) and human environment.

Besides these changes, the text was improved and some of the old charts were corrected and replaced (land use, sensitivity etc.).

A new Habitat map (Appendix I.4.) was produced which represents slight modification of the habitat map produced in the study of April 2007. The same is true for the Sensitivity map (Appendix I.5.).

*DATA ON THE PROPONENT*

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|---|---|
| *Proponent:* | *FUND FOR NATIONAL AND REGIONAL ROADS* |
| *Register number:* | *4089600* |
| *Location:* | *Ul. "Dame Gruev" Br. 14 Skopje* |
| *Statutory representative for the Proponent:* | ***Natasha Valkanovska, Director*** |
| *Tel., E-mail* | *02 3118 044 e-mail dinevski@roads.org.mk* |

**EXPERT TEAM (REVISED STUDY, March 2008)**

**Team leader:**
Dr. Ljupcho Melovski

**Participants:**
Dr. Slavcho Hristovski
Metodija Velevski
Vasko Avukatov

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**ENVIRONMENTAL IMPACT ASSESSMENT STUDY**
**Project: FINALISATION OF CORRIDOR 10, HIGHWAY E-75**
**Section: DEMIR KAPIJA - SMOKVICA (32.8/27.3 km)**

## *Project intention*

The project intention is to construct a modern highway with four lanes (two in each direction + additional lane for stopping) with predicted traffic frequency of 12000 vehicles per day as an annual average. It includes two proposals for the alignment:

- First variant/alternative (hereafter referred as Alternative A) represents upgrade of the existing motor road from Demir Kapija to Smokvica, which runs along the river Vardar valley on its left side and mostly close to the river; for this alternative there is a final design already 10 years old.
- Second variant/alternative (hereafter referred as Alternative B) is upgrade of the beginning section of the existing motor road from Demir Kapija to the end of the existing tunnel, after which the alignment turns on the right side of the river Vardar and construction of a completely new highway on a predominately hilly and mostly natural area on the right side of the valley, far from the river; for this alternative the design is in a very early stage (preliminary design/feasibility study).

The **proponent** (Investor) of the project for construction of the Highway Demir Kapija-Smokvica is the "FUND FOR NATIONAL AND REGIONAL ROADS". The Highway Demir Kapija-Smokvica is part of E75 road (ETC 10) which runs through Macedonia in North-South direction along the river Vardar valley and connects the Republic of Serbia and the Republic of Greece.

For the purpose of the EIA Study two corridors of one kilometre width were set up along the two proposed alternative alignments (500 meters from both sides of the alignment axis). Both corridors are passing through the central-southern part of the country, along the valley of the river Vardar. First corridor follows the alignment along the river Vardar that overlaps with the existing motorway (32.7 km) and the other one is stretching on the hills that make the right side of Demir Kapija gorge (27.3 km).

The major reason for implementation of the project under review is discontinued highway connection of the city of Skopje (capital of the Republic of Macedonia) with the town of Gevgelija at the southernmost part of the country, and Greece. The decision to complete this highway was derived from several key factors:

- Necessity for good connection with Greece as a country of EU
- Improvement of traffic to Thessaloniki - sea connection to Macedonia
- Faster and safer transportation
- Enhancement of the national and local economy
- To take advantage of available funds - grants.

The Investor provided the information concerning the raw materials, energy consumption, waste production and other basic data concerning the construction and

operation phase of the highway Demir Kapija - Smokvica. However, during the elaboration of the study, several inadequacies in knowledge and/or uncertainties were identified: elaboration of the highway design for the Alternative B was in the phase of preliminary design study, while final road design did not exist; detailed information about road construction was not yet available and present status of environmental parameters (air and climate, water and to a certain degree biodiversity) in the area under assessment was not known in details as there are no monitoring stations located there.

### *Applied methodology*

The elaboration of the presented Environmental Impact Assessment Study was performed according to the requirements of the current national legislation and EU Directives as well as the obligations emerging from international conventions to which Macedonia is party. The respective procedure is presented in Chapter III.

During elaboration of the Study, the following methodology was applied:

- In order to assess the impacts of the project/intention on the environment, two detailed descriptions were elaborated and presented:
  - The scope of intention (size, activities, economic parameters etc.) is presented in Chapter II.
  - The detailed description of natural and anthropogenic environment (Chapters V and VI).
- Sensitivity of ecosystems, habitats, sites and localities was assessed (Chapter VII).
- Impacts arising from the construction and operation were identified and analysed (Chapter VIII).
- All negative impacts were reviewed and adequate mitigation or compensation measures were proposed in order to diminish or eliminate negative impacts (Chapter IX).
- Analysis of alternatives was done and recommendation for the best option/solution is presented.

### *Administrative procedure*

Environmental Impact Assessment (EIA) is legal procedure stipulated by the Law on Environment by which a proponent is granted consent for the realization of the project by the Ministry of Environment and Physical Planning (MoEPP). According to the Law on Environment the EIA procedure consists of several steps:

*Notification on the intention for project implementation* (responsibility of Investor)

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*Screening* (responsibility of MoEPP)

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*Scoping* (responsibility of MoEPP)

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*Preparation of the EIA Study* (expert team)

↓

*Review of the EIA Study* (responsibility of MoEPP)

↓

*Granting consent*

(*or rejection of the application*) (responsibility of MoEPP)

One of the most important parts prescribed by the legislation on EIA is **public participation** in different phases of the EIA procedure. In the first phases, the Investor can involve public in the form of direct discussion after the presentation of the key objectives of the project. Ministry of Environment and Physical Planning shall present the most important documents during the EIA procedure in daily newspapers, local TV and radio stations as well as on the web page of the Ministry.

### *Spatial plan*

The whole area of the highway corridor is foreseen in the Spatial Plan as "Transit Corridor". Additionally, a dam on river Vardar is planned.

There are two protected areas in the highway corridor:

1. Demir Kapija which is protected as Monument of Nature.
2. Iberliska Reka as "Special Plant and Animal Species outside the Protected Areas".

Other six localities are designated for protection according to the Spatial Plan projections.

### *Natural characteristics of the area of interest*

The current status of the basic environmental features of the project area, including the surrounding regions, that may be affected by the project construction and operation is presented in the respective chapter.

The area of interest of this study is well-defined geographical unit that is encircled by mountains from west and east and opened on the north and south by the river Vardar valley and it has specific climatic characteristics. The region is one of the warmest regions in the Republic of Macedonia with characteristic Mediterranean climate.

From the geotectonic point of view, the investigated area (Demir Kapija–Gevgelija) belongs to the very unstable geotectonic unit in the Republic of Macedonia known as Vardar Zone of folding which is forming a composite valley i.e. it flows through many plain parts and gorges.

The area (projected high-way corridor) can be divided into two well-defined morpho-logical units such as:

- Demir Kapija gorge including the River Vardar valley to village Udovo;
- Valandovo valley, hilly area between Valandovo valley and Gevgelija valley.

Geological composition is characterized by the presence of cliffs and Jurassic carbonate complex in the beginning part of the corridors. Ten caves in the carbonate complex on both sides of River Vardar can be found. Fluvio-denudation relief is prevailing from both sides of the river-valley (Demir Kapija–Udovo).

The main geologic compounds for the region are diabases (green or grey-green coloured and homogenous, massive textured rocks).

The area is characterized by rich hydrographical network represented by the flow of river Vardar and it's tributaries as well as the thermo-mineral and mineral springs, wells, etc.

Typical soils are cinnamon soils in the hilly area and modified soil types in the plain area.

Climate in the region of interest is modified sub-Mediterranean characterised by hot and dry summer and moderately cold and wet winter.

Very important characteristic of the intention of constructing the highway from Demir Kapija to Miravci is that (especially in case of Alternative B) it will occupy almost entirely natural or semi-natural territories. The part from Miravci to Smokvica has more anthropogenic features - rural areas and more or less degraded habitats.

### *Ecosystems and habitats*

Very thorough fieldwork along the existing and projected highway line from Demir Kapija to Smokvica resulted in establishing a long list of habitats, which were systematised in six main groups according to the type and density of the vegetation cover, type and relief characteristics of the site, natural/anthropogenic origin of the vegetation, presence or absence of human settlements or objects and water areas. According to these criteria the following habitats were identified (see also Habitat map in the appendix):

- forests and shrublands (both natural and anthropogenic);
- open terrain: grasslands, shrubby grasslands, meadows etc. (both natural and anthropogenic);
- rocky areas (including caves);
- water biotopes;
- agricultural land: orchards, fields, gardens, vineyards and cattle breeding areas;
- urban or urbanised and industrial areas;

The dominant forests in the project area are xerophytic Kermes oak forest (pseudomaquis) and thermophyllous deciduous oak forests. Pseudomaquis, as a vegetation type is represented by the Kermes oak community, an evergreen shrub-like oak. Very important pseudomaquis type is the Greek Juniper shrubland on rocky sites, especially in Demir Kapija canyon. Oak forests (forests of Pubescent oak and Oriental hornbeam) develop on higher altitudes (above 300 m).

Riparian forests and shrublands develop along the riverbanks and streams everywhere in the area under consideration. The most important habitat types are the Oriental plane woodlands and belts along the rivers, dales and ravines. Willow stands and belts usually occupy the banks along river Vardar in the lower parts of the valley. Tamaris shrublands and sands are important habitats for the diversity of bird species.

Dry grasslands in the area cover small surfaces but their importance comes from the dominance of annual plant species and very rich fauna (European priority habitat type).

Rocky areas are occupied by some chasmophytic (rock-dwelling) plant communities, which are very rare, and some of them are unique for Demir Kapija canyon.

There are about 10 caves in the limestone complex of Demir Kapija and Chelevechka Reka gorge. Most of them are very short caves used by many bat species as shelter. Out of these caves, Bela Voda (955 m) is the longest and the most important. There are several cave-dwelling species that are restricted only to the underground habitat of Bela Voda (cave cricket, cave beetles etc.).

River Vardar has the dominant drainage area in Macedonia (20535 $km^2$) and in the area of the road corridor has about 45 km length. Boshava is the largest tributary of Vardar in the highway corridor. Chelevechka Reka and Petrushka Reka have unique geomorphologic values while Mala and Golema Javorica watersheds represent refugial regions with remains of plant assemblages from distant geologic periods.

Broadleaf and coniferous plantations in the highway corridor cover very small surfaces. Out of the anthropogenic habitats, abandoned fields and meadows differ by their greater biodiversity values. Agricultural land (fields and acres, orchards, vineyards, gardens) have smaller importance as habitats for important plant and animal species. Some of the villages in the area still hold values as habitats for several endangered bird species.

During the analysis performed on the basis of National Biodiversity Strategy and relevant international conventions, several habitats and number of species were identified as important. According to EC Habitat Directive there are several important habitats like Greek juniper community, Plane woodlands and belts, Willow woodlands and belts, dry grasslands, caves, chasmophytic vegetation of cliffs and rocks etc. About 40 plants, 30 fungi, 10 insects, 10 amphibians, 20 reptiles, 60 birds and 35 mammals are protected by several international conventions and documents (IUCN, Bern Convention, Emerald Network Species).

### *Anthropogenic environment*

**Occupation**: Agriculture is the most important economic activity in the region of interest. The intensive farming (vegetables), crop growing and production of industrial cultures as well as vineyards are characteristic ones.

The agriculture is the basic economic activity for the population of the rural settlements in the highway corridor. According the land-property 90% of the land belongs to the public sector and only 10% are private property.

The most important are fields and acres, vineyards and gardens while the orchards are represented by insignificant surfaces. The most frequent acre cultures are corn, especially the maize and wheat.

Livestock breeding is an important economic activity in the region. The goats and sheep are dominating by their importance followed by cattle. Goats are especially well adapted for foraging on shrubby species of the pseudomaquis.

**Settlements**: Several populated places are found along the highway corridors: Demir Kapija town and villages Klisura, Davidovo, Miravci, Miletkovo, Smokvica, Udovo, Josifovo and Marvinci. Demir Kapija is the largest populated place along the corridor, with main occupation of the population in agriculture (see also map in the appendix).

In the frame of Gevgelija–Valandovo valley as a natural opening to the south, i.e. to Thessalonica, there is a developed line infrastructure represented by roads, railways, irrigation systems etc.

**Quality of environmental spheres**: Air, water and soil were considered as unpolluted (in natural areas) or moderately polluted (in settlements and agricultural land). Only river Vardar has poor water quality. Also Boshava and Anska Reka show signs of pollution impact from the agriculture.

**Archaeological sites:** The area south of Demir Kapija is extremely rich in cultural, historical and archaeological sites. More than 20 archaeological sites were identified in the corridor area (see also map in the Appendix).

**Land use**: The main land use types in the highway corridor area are forest and shrublands, agricultural areas and urban/rural areas. Agricultural land occupies significant surface in the lower parts of the highway corridor: along river Vardar and in the Valandovo-Gevgelija valley. Most of the agricultural land is represented by fields and acres (see also map in the Appendix).

The highway corridor area overlaps with the territory of two forestry districts "Demir Kapija" and "Kozhuf" from Gevgelija. Forests in the corridor have low biomass and production. Pubescent oak provides most of the timber in the corridor area.

**Tourism**: Tourism is not well developed branch in the area of the highway corridors although there are potentials to develop this type of activity. The best known tourist places are the Demir Kapija canyon and Bela Voda cave.

### *Sensitive ecosystems, habitats and other sites*

The most sensitive sites were pointed out, identified on the basis of 15 criteria. Separation of these key or high valuable ecosystems, habitats or sites is necessary in order to assess the possible impacts of highway construction and operation more thoroughly and to propose effective measures for their protection or future management.

Oriental plane woodlands and belts, caves and rocks and cliffs were assessed as *very high sensitive*. Pseudomaquis, willow woodlands and belts, Tamaris shrublands, dry grasslands, streams and some other habitats were assessed as *high sensitive*. The rest of the habitats were grouped into *medium sensitive* (degraded pseudomaquis, agricultural land, reed beds) or *low sensitive* (urban settlements, ravines and gullies).

Similar methodology was applied for the sites of human importance. Some of the archaeological sites that lie close to the alignment were assessed as *very high sensitive*. Some villages that will be affected the most were identified as *high sensitive* (Udovo, Miravci and Miletkovo).

### *Assessment of the impacts*

#### *Impacts of the road construction*

**Forests**: The most affected forest ecosystems will be Kermes oak shrublands and Oak forests at number of localities by direct destruction and fragmentation effect.

The destruction of some Plane trees is recognized as the most possible impact during the road construction in the areas of streams, dales, ravines and gullies.

**Water habitats**: Impact on water ecosystems as a result of pollution and filling with construction material including stones, concrete waste, wood, steel, packaging plastics in the streams was assessed as significant.

**Species**: The construction of the highway will cause direct interruptions in the breeding cycle (clutch loss) and decrease in the breeding success of the birds breeding along the highway corridor. Bird community of the pseudomaquis, which holds significant number of species with unfavorable conservation status, will be the most affected. This is also true for the arable fields and oak forests. The passerine species (Shrikes, Thrushes, Warblers, Tits, Finches and other families) will be the most affected by fragmentation and direct habitat lost (both for breeding and foraging), but depending on the locality, highway constriction will also strongly influence the breeding behavior of some raptors. The most sensitive areas in this direction are the cliffs of Demir Kapija and their surroundings, especially in case of Alternative B. The entry point of the tunnel on the route at the right bank of the river Vardar will be in close proximity to the nest of the Egyptian Vulture, species threatened at European level and expecting uplisting to Globally Threatened Species under IUCN criteria. On the same location there is a nest of long-legged Buzzard, another threatened species in Europe. Both species have small populations in Macedonia, first one with strong declining trend and in need of special conservation measures. On the other hand, very close to the exit point of the tunnel a pair of Booted Eagle breeds, another rare species in Europe with Macedonian population less than 15 breeding pairs. This species is highly sensitive to fragmentation and disturbance. Another rare species breeding in this section is the Black Kite. Furthermore, close to the exit point is the locality Dolni Krastavec, where Griffon Vultures used to breed in the recent past and currently only a pair of Egyptian Vulture breeds.

**Caves**: The cave Bela Voda is sensitive habitat because of its stable conditions and specific fauna. Changes of the water regime and other disturbances can have severe impact on all animal species in the cave. Bats and other temporary cave inhabitants are susceptible to any type of disturbance and there is a danger that they will abandon the cave habitat. Similar consequences can be expected for the facultative cave inhabitant species. However, the real cave inhabitant species, which are adapted for this particular habitat, can be considered as the most threatened group. The destruction or severe disturbances of the cave system can lead to their extinction. At the present moment, the complete list of the cave species of Bela Voda cave is not known. It means that the disturbance of the cave will have impact on species that are not yet discovered or registered.

**Impact of mining activities** in the area of Demir Kapija limestone canyon. The conflict arises from very high sensitivity of this complex locality. The complexity is a result of presence of different habitats settled by rare and endangered species, especially bird species. The risk for these species arises from the construction work. The mining is unavoidable since the tunnel has to be staved through Jurassic limestone rocks. Although the area of the canyon was assessed as very high sensitive (Chapter X), the highway line must pass through the canyon since there is no other solution (the canyon is extremely narrow and both sides of the river are valuable). The conflict becomes the most expressed during the breeding period of vultures (laying eggs, incubation period and fledging, from March to July).

Other conflict connected to this area that may arise from constriction work is damaging or destroying the protected area Chelevechka Reka. For this particular part, the conflict is not just during the construction period but also during the highway operation (due to the pollution of the stream). In this case, as it was the case with previous, the

recommendation for sellecting the Alternative B is not possible (at the other side of the river Vardar, the Bela Voda cave is situated next to the river which may produce another conflict).

**Agriculture**: The most important impact on agriculture during highway construction is destruction of agricultural land. The surface of agricultural land that will be destroyed if Alternative A is accepted equals 56.6 ha. In the case of Alternative B, significantly smaller agricultural land will be destroyed (approximately 13 ha). Fragmentation of agricultural land is also significant impact.

**Archaeological sites**: As presented in the baseline situation, the area is rich in cultural heritage. Monuments under special protection regime are close to construction undertaking. Unknown archaeological sites might be found during the construction of the highway. Therefore it is suggested to pay special attention to this potential impact particularly because destruction of archaeological sites or their parts is irreversible process.

**Pollution**: The level of emissions and duration of the construction period will not exceed the carrying capacity of the natural ecosystems. A certain increase of air pollution in the broader area of interest will certainly occur due to the increased traffic frequency. However, these emission levels will be insignificant for human health.

Waste related to construction of the highway section Demir Kapija - Smokvica will be diverse and produced in large quantities. Most of the waste will be inert waste, but also large quantities of hazardous and toxic waste are expected to be produced. One can predict sufficiently accurate that the level of impact would not be significant due to the reasonably short duration of the construction activities.

**Risk assessment (oil leakage, fire, hazardous substances, personal risks etc.)** was performed in order to propose adequate mitigation measures. In the course of road construction and respective infrastructure only individual risk of work injury, leak of fuel or oil from trucks or construction machines and/or risk of fire is considered.

### *Impacts of the road operation*

The fragmentation of the **forest ecosystems and pastures** will actually be a result of the road operation. In case of Alternative B, fragmentation of forest and shrubland habitats is particularly important, due to the cut of regular biological movement routes of large animals from Kozhuf Mt. to river Vardar (for drinking water and feeding). Many animal species depend on these migration routs, including species of European conservation concern, such are row dear, wolf, otter and wild cat. Even Brown bear was registered in this area several times (last time in March 2007). For more details see Impact on species.

**Rivers and streams**. The pollution of water ecosystems is caused by discharging of residues from fuel combustion (lead and hydrocarbons), lubricants and tyre parts. All of these contaminants will enter the rivers with wet deposition that washes out the surface of the road.

Usage of defrosting agents (salts and sand) will increase conductivity of river and streams' water, and sand will increase turbidity. In both cases, water quality will decrease with great impact on aquatic life. This kind of pollution is typical for strong winters with very low temperatures.

**Species**: In general, the impacts on the species can be divided into fragmentation effects, increased collection or hunting/poaching, changes in the reproduction and road kills (important for amphibians, reptiles, mammals).

**Agriculture**. Impacts on agriculture are presented by the effects of air, soil and water pollution by the increased traffic on the highway. One of the specific impacts will be fragmentation of agricultural land caused by intersection of the "agricultural" roads and new highway.

**Settlements**. The operation of the highway Demir Kapija - Smokvica will have both positive and negative impacts on the settlements in the area of intention. However, negative impact will be much more severe than positive ones (positive impact concerns socio-economic aspects).

**Noise**: The noise generated by vehicle traffic on the highway will affect the settlements located alongside the planned highway. For evaluation of noise impact and determination of suitable noise abatement measures, calculations of noise levels were carried out. The predicted noise levels were evaluated with respect to noise standard regulations of Macedonia, WHO and EC regulations. The applied noise standards for existing residential areas were 60 dB(A) at daytime and 50 dB(A) at night time. However, 55 dB(A) at daytime and 45 dB(A) at night time are recommended for the residential areas.

**Soil pollution**. It is well documented that the most significant pollution from gaseous substances and aerosols (emitted from exhaust pipes of vehicles) occurs in 10 meters distance due to the fast sedimentation of substances heavier than the air. The sedimentation depends on the geomorphology of the terrain, wind speed, vegetation cover etc.

**Air quality**. The fuel consumption on the new alignment has to be compared with the amount being emitted currently along the existing road to Gevgelija. For both situations, the number of vehicles will be the same. The speed is high with no stop-and-go characteristics.

**Waste**: Waste materials that will be generated during the road operation are not numerous and variable as in the case of the road construction.

**Socio-economic impact**: Increased traffic will improve employment possibilities to a certain extent and enlarge incomes of the local population.

**Impact on human health** can be considered only for the residents of the settlements close to the alignment (Demir Kapija, Udovo, Miravci and Miletkovo). Such impact can result from air pollution emission and to a limited extent to the noise generation.

**Risks**: in the case of traffic accidents, uncontrolled spilling of oil, oil derivates, chemical and other toxic substances might occur. Fires are also possible as a result of traffic accidents. Of the outmost importance are the risks that may occur during transport of transformer oil (PCB). The danger of possible traffic accidents is very important impact.

### *Mitigation measures*

#### *Mitigation measures for road construction phase*

Mitigation measures concern three phases of the realization of the project: preparatory phase, construction and operation of the highway.

Extensive mitigation measures were proposed for the **preparatory phase**.

Standard **general measures** for the construction phase were identified on the basis of the best international practice and recommendations of international institutions (e.g. World Bank). Some of the proposed measures concern specific habitats, localities and sites aiming to avoid construction of access roads and setting up work camps in sensitive habitats. Measures directed toward improvement of supervision of the construction work were proposed. The construction in the area of caves and archaeological sites is prohibited.

**Special measures** were proposed concerning tunnel construction at Demir Kapija canyon (construction works should not be undertaken during the breeding season of vultures and other birds of prey).

Constructions of culverts for amphibians, reptiles and mammals: in the regions without natural passes and without underpasses, tunnels or bridges will be constructed.

The most adequate compensation measure in order to mitigate the impact on the forest is to fund aforestation activities in the frames of the affected forestry districts. Aforestation should be performed with native (autochthonous) tree species as stated in the Law on Nature Protection.

It is necessary to design and construct appropriate objects along highway route in order to maintain the existing local roads and important forest paths. By implementing this measure, the fragmentation of agricultural land shall be avoided as well as access to various parts/localities in the hilly region for grazing. Enabling good connection between forest lands on both sides of the highway is essential for accessibility and interventions in case of forest fires.

Extensive mitigation measures were proposed to avoid the adverse impacts on waters (storage of liquid agents, set-up of the work camps, preservation of vegetation, erosion prevention measures etc.).

It is well established practice that investor and proponent compensate the damage to the environment by setting a scheme for enhancement and improvement of environment in adjacent regions, especially in biodiversity conservation field. This is an integral part of environmental assessment process according to World Bank rules. Extensive damage to the natural and seminatural habitats (irrespective to which alternative) should be compensated by providing conditions for elaboration of management plan for Demir Kapija protected area (Monument of Nature, including Chelevechka Reka water gap) and action plan for conservation of vulture colony in the gorge. Creation of information center for Demir Kapija canyon will be expression of good will and will have positive socio-economic effect on the local population. The investment will be in the range of tens of thousands of Euros.

As a general mitigation requirement for noise reduction during the construction phase contractors will be required to use modern noise silenced equipment and to keep to usual daytime work hours (exceptions may apply for certain structures). Preferably, equipment that meets the requirements of the European Directive EC/2000/14 on noise emission by equipment for outdoor use should be used.

Borrow pits: In order to exclude the exploitation of the existing limestone mine at the entrance of the Demir Kapija Gorge and limestone marbleized masses on the section Josifovo–Valandovo–Dojran necessary quantities of carbonate material (limestone, marble) shall be provided from the reserves of the open quarry between the villages Kosturino and Memesli; the gravels and the sands from the alluvial stratum should be exploited from the existing localities at Przdevo and Gevgelija. It is necessary to prepare separate Environmental Impact Assessment for borrow pits after the design is avalialbel. Appropriate re-cultivation measures of all fields of structural stone, gravel and sand etc. should be proposed.

### *Mitigation measures from road operation*

**General measures** include elaboration of emergency plans, recommendations for storage of hazardous substances, decrease dustiness (cleaning of roads etc.) and elaboration of plan for action in emergency situations.

**Specific measures** include:

- Landscaping and forestation of bare land in the surrounding.
- Construction of protective panels along the highway, establishment of monitoring system for bird casualties and movements of amphibians, reptiles and mammals in order to construct direction barriers towards the culverts.
- Ground waters: construction of collecting ditches and sealing of surfaces by the road to reduce the area through which surface water can infiltrate into the ground (re-vegetation of the embankments).
- Surface waters: construct road channels and side ditches; outfalls must be equipped with oil separators to prevent environmental damages to the existing ground and surface water regimes. Considering potential surface water pollution, herbicides should not be used on the road shoulders or embankments for maintenance. Mowing of the verge is highly recommended as well as to leave green cut on site (it should not be used as animal fodder, could be polluted). It will be necessary for the local highway authorities responsible for maintaining the new infrastructure, to be equipped and well trained to service the oil separators and treatment facilities in addition to other normal road maintenance requirements. Emergency plan for threats from water pollution has to be prepared. Compensation measures such as improvement and strengthening of the habitat function of the rivers and riparian vegetation should be undertaken.
- Air pollution: vegetation as a buffer along the alignment has to be planted and monitoring of the air pollution has to be established.
- Noise: *reduction of noise emissions* (reduction of the vehicle speed, construction of special noise reducing road surface which is efficient for speeds over 60 km/h and avoidance of additional noise sources of constructive origin and damages of the road surface); *Reduction of sound transmission* **(**construction of noise abatement barriers like walls or embankments and construction of tunnels, housing-in-tunnels, or noise abating buildings at the road border) and *Reduction of noise impact at the impact area* **(**respecting a setback-/ noise buffer for new developments and installation of noise reducing windows in affected houses).

### *Analysis of the alternatives*

As already mentioned, the two basic options were considered for comparison of alternatives within this Study:

- Alternative A (Upgrading of existing motorway from the left side of the river Vardar)
- Alternative B (Partly upgrading and mostly construction of a new section from the right side of the river Vardar but higher up in the hills)

In case of Alternative A - construction works will comprise widening of exiting road for its use as two lane road in one direction and construction of another two lanes in opposite direction next to the existing road, or close to it.

In case of Alternative B construction works will comprise construction of a completely new highway on the most of the length.

Advantages and disadvantages of each alternative were analysed through comparison of the participation of sensitive or low sensitive habitats and ecosystems, sites, localities, infrastructure and socio-economic activities along both alternative alignments. It was not possible to perform Full Cost/Benefit analysis due to the lack of data, especially in sense of economic parameters.

**Sensitivity of natural habitats:** Analysis of participation of sensitive habitats in each alternative highway corridors showed that "very high sensitive" and "sensitive" habitats participate with larger percent in Alternative B (51.6% in Alternative A and 80.0% in Alternative B).

**Sensitivity of sites of human interest:** For both alternatives, the number of objects (settlements/ archeological sites/ agricultural land) with "low sensitivity" is equal. "Medium sensitivity" objects are mostly presented in corridor of alternative A (in ratio 8:3 to alternative B). Alternative B is critical concerning "high sensitive" objects due to their closeness to the highway. **Alternative A has no “very high sensitive" objects while in case of alternative B there are three archaeological localities marked as "very high sensitive". In this case (if Alternative B is choose), a realignment of the future road must be considered**.

If the Alternative A is accepted, the following situation will occur in the area around the alignment from Demir Kapija to village Smokvica (nature concerns):

- There will be no significant increment in terms of traffic and emission of pollutants produced by the traffic and other facilities along the whole length of the Alternative A route; on the contrary, much of current unfavourable conditions will be improved.
- The destruction of natural habitats will be less significant compared to the case of Alternative B scenario, especially in case of high sensitive habitats; high rate of disturbances to threatened species will be restricted to the region of Demir Kapija canyon.
- There will be no destruction of very high and high sensitive habitats and sites, particularly the valuable Oriental plane woodlands and belts, pristine streams, oak forests and pastures (destructions of oak forests and pastures were assessed as comparatively small and compensation is possible - see Chapter IX.2.3.3.).

- There will be no disturbance to the living organisms in all ecosystems (particularly threatened species) and there will be no fragmentation of important biocorridors.
- Very high sensitive archaeological sites as non-recoverable objects of human history will be less threatened.

If the Alternative B is accepted, the following situation will occur in the area around the highway from Demir Kapija to village Smokvica.

- Most of the situations described above will be opposite.
- There will be a significant change in landscape characteristics (structural and functional) in the broader area of interest by introducing completely new line object of a large scale.

Although there are not enough data in the current stage of design for economic evaluation, several socio-economic considerations can be stated.

- No matter which of the alternatives will be accepted, none of the local communities will be favoured or neglected since the difference (distance between) of the alternatives is the greatest at unpopulated area.
- After implementation of proposed mitigation measures, no significant impact on land fragmentation and land accessibility is expected on both alternatives.
- Irrespective to the chosen alternative, there will be positive effect of highway construction and operation on job creation and opportunities.
- There will be large scale benefit on national scale due to the improvement of the traffic in north-south direction and accessibility of Thessalonica harbour.
- Alternative B solution is 5 km shorter and much cheaper variant compared to Alternative A.

Construction of Alternative B highway will require higher expenses for mitigation measures.

It is not possible to make final decision in this study which alternative will be the most appropriate due to the lack of necessary information for Alternative B. Much of the conducted analyses suggest that Alternative A is environmentally more suitable especially form biodiversity point of view. During the following process of finalization of the design, analysis of different stakeholders' interests has to be done, economic parameters have to be evaluated and measured against the environmental concerns described in this study. In any case, full implementation of mitigation measures is necessary.

### *Remarks and recommendations*

Construction and operation of highways causes significant adverse impact on the natural areas and human environment. Beside implementation of the mitigation measures which intends to avoid significant negative impacts, some recommendations for conservation and promotion of the environment should be taken into account during the construction work and operational phase of the highway.

The destruction of the forested areas, grasslands, agricultural land can not be avoided during the construction although several mitigation measures were proposed in order to minimize this impact. About 165 ha (Alternative A) and 140 ha (Alternative B) of natural and agricultural land will be destroyed during the construction. In order to

compensate this impact, reforestation measures along the highway are strongly recommended. This will contribute towards the erosion-prevention which improves the maintenance of the highway during its operation. According to the provisions of the Law on Nature Protection, autochthonous plant species should be used during the aforestation in natural areas. The best places for reforestation are highly degraded pseudomaquis habitats on steep slopes along the highway: in the vicinity of village Udovo (in case of Alternative A) and surrounding of the village of Miletkovo (in the case of Alternative B).

After the completion of the construction works, agricultural roads should be repaired and adopted for their use by local population. After the completion of the construction works in forested areas, unnecessary access roads should be re-vegetated and closed for operation. This measure will prevent illegal woodcutters and poachers from reaching undisturbed natural areas.

Since there are a lot of uncertainties and unforeseeable situations, recommendations for elaboration of additional assessments (in case of access roads, borrow pits etc.) after producing a final design for the preferred alternative have to be elaborated and respected.

Promotion of environmental quality in the region of Demir Kapija gorge could be done by compensating the damage to some sites by conservation of other part(s), namely Demir Kapija canyon. Special study has to be elaborated in order to get knowledge about the financial and administrative needs for this measure.

# I. INTRODUCTION

This Environmental Impact Assessment Study aims to assess the impacts from construction and operation of the Highway Demir Kapija-Smokvica along with all associated interventions and to find out if this intention is environmentally feasible.

The project under review has been assessed pursuant to point **7c - *Construction of a new road of four or more lanes, or realignment and/or widening of an existing road of two lanes or less so as to provide four or more lanes, where such new road, or realigned and/or widened section of road would be 10 km or more in a continuous length*** in Annex I of the Decree determining the projects for which an environmental impact assessment shall be carried out (referred to Article 7 of the Law on Environment).

The submitted EIA Study was elaborated in compliance with Law on Environment and its Annex 3 - Ordinance regulating the procedure for carrying out the environmental impact assessment. On the other hand, Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, amended by Council Directive 97/11/EC - EIA Directive was also taken into consideration (see Chapter IV).

Additionally, the study shall serve to screen the situation concerning necessity for elaboration of additional individual EIA studies for certain constructions (investments) in the scope of the highway construction (access roads, borrow pits, landfills).

The project intents to construct a modern highway with six lanes (three in each direction) with predicted traffic frequency of about 11.000 AADT (Annual Average Daily Traffic) vehicles for 2020 (high scenario). This is the last section of the European Transport Corridor 10 (ETC 10) in the Republic of Macedonia that is not upgraded. E75 road (ETC 10) runs through Macedonia in North-South direction along the river Vardar valley and connects the Republic of Serbia and the Republic of Greece. There are two proposals for the alignment:

- First variant/alternative (hereafter referred as Alternative A) represents upgrade of the existing motor road from Demir Kapija to Smokvica which runs along the river Vardar valley on its left side and mostly close to the river; for this alternative there is a final design
- Second variant/alternative (hereafter referred as Alternative B) is upgrade of the beginning section of the existing motor road from Demir Kapija to the end of the existing tunnel, after which the alignment turns on the right side of the river Vardar and construction of a completely new highway on a predominately hilly and mostly natural area on the right side of the valley, far from the river; for this alternative the design is in a very early stage (preliminary design/feasibility study).

# I. 1. THE SCOPE OF THE STUDY

The following EIA Report presents the summarised results of habitat types mapping, field observations and literature data on flora, fauna and fungia composition of the corridors along the existing and planed E-75 road (highway) alignment (ETC 10), starting from the town Demir Kapija down to the village Smokvica. It contains the habitat description, distribution and importance on the local and regional scale and recommendations for their preservation and protection during construction of the road. It also contains description of rare species and their status (distributional and legal), delineation of sensitive habitats, forecasting of possible conflicts during construction works and operation of the highway, socio-geographic aspects, archaeological sites, cumulative effects in relation to the development future of the whole area, water resources and water ecosystems–their quality and biological value. The aim of habitat mapping and flora, fauna and fungia composition investigation was to recognise and make the inventory of the existing habitats and to present them on the map with the scale 1:25000.

On the basis of habitat recognition and description, to evaluate the biodiversity of existing ecosystems and different sites and localities, (in the following text - habitats) along the road alignment, to recognise the sites of special importance concerning the biodiversity and natural, historical and ethnological heritage - all this in order to prevent ecosystems and species populations, as well as archaeological sites, infrastructural objects and other important locations and phenomena from disturbance, damaging or destroying during the construction works. Special attention was paid to rocky sites at Demir Kapija canyon, the forest biotopes in the rest of the Demir Kapija gorge, both on a hill slopes and along the river, and agricultural land in the valley.

The Study also presents the anthropogenic environment and environmental spheres (air, soil pollution and water quality). In this context, description of human settlements, main economic activities (especially agriculture) and infrastructural objects was presented. Conflicts (as well as positive impacts) arising from the road construction and operation were assessed and discussed. Special attention was paid on air pollution, noise and vibration impacts of the highway construction and operation on settlements and human health. Negative effects of fragmentation of agricultural land on working activities were treated as well.

Due to the large distance between the two proposed alignments along the most of their length, the study encompasses two examined corridors that overlaps only at the starting part of about 2 km. **Each road corridor is one kilometre wide (500 meters from both sides if the alignment axis)**.

Both corridors are passing through the central-southern part of the country, along the valley of the river Vardar. The first corridor that is following the alignment along the river Vardar is with total length of 33+800 km and the other one stretches on the hills that make the right side of Demir Kapija gorge with total length of 28+300 km. Each corridor is one kilometre wide (500 meters on both sides from the axes of the proposed alignment. The corridors partly overlap in considerable length: town Demir Kapija - km 0+000 to km 4+500 and km 25+800 to 28+100 (Smokvica).

The whole section of a newly proposed alignment can be divided on three distinctive parts (units):

- Town Demir Kapija - village Klisura region (km 0+000 - km 5+700, it stretches along the Vardar valley or is passing through a tunnel)
- Village Klisura region - village Miravci (km 5+700 - km 21+100, hilly, unpopulated area in the case of alternative B, or in case of alternative A there is only one village - Udovo)
- Village Miravci - village Smokvica (km 21+100 - km 27+200, more or less lowland area, populated and with a lot of human activities.

The old design alignment runs exclusively along the river Vardar valley (See Map in Appendix I.1.).

The most important difficulty during the habitat study along the road corridor was the inappropriate period of the year. This is more important if one take into consideration the stage of investigation of the proposed corridor, which is very poor concerning all aspects of biodiversity.

## I. 2. METHODOLOGY APPLIED WITH SHORT DESCRIPTION OF THE CONTENT OF THE STUDY

The elaboration of the presented Environmental Impact Assessment Study was performed according to the requirements of the current national legislation and obligations emerging from international conventions to which Macedonia is party. The respective procedure is presented in Chapter III.

During elaboration of the Study, the following methodology was applied:

1. In order to assess the impacts of the project/intention on environment, two detailed descriptions were elaborated and presented:
    a. The scope of intention (size, activities, economic parameters etc.) was presented in Chapter II.
    b. The detailed description of natural and anthropogenic environment (environmental spheres - air, waters, soils; biodiversity - species, habitats, ecosystems etc.) was done using all existing literature data (Chapter XIII.), personal experience of the contributors to the study and targeted fieldwork; the results are presented in Chapter V and VI; detailed information used for elaboration of Chapter V. is given in appendices.
2. Based on the information from Chapter V and VI and using matrix methodology with application of various criteria, the sensitivity of the ecosystems, habitats, sites and localities was assessed; the results are presented in Chapter VII.
10. Based on the sensitivity character of different sites and localities in the range of the area affected by the intention and information from Chapter VII., the main conflicts arising from construction and operation of the intention were pointed out and analysed in Chapter VIII.
11. Data from Chapter VII have served to define all possible impacts on natural environment, human health and anthropogenic objects and sites, which are presented in Chapter VIII as impacts during highway construction and operation

12. All negative impacts were reviewed and adequate mitigation or compensation measures were proposed in order to diminish or eliminate negative impacts in Chapter IX.
13. Based on all afore mentioned concerns, the final discussion for implementation of proposed project/intention was carried out in Chapter X along with analysis of two main alternatives and proposal for preferred alternative. After that the final conclusion was brought out.
14. At the end, the recommendations for future sustainable development of the region were elaborated in Chapter XI.

# II. BASIC DATA

The data presented in this chapter are related to the scope of the project, the main reasons for its development, technical and technological characteristics, materials to be used, products/outputs as well as plans for future development. All the information supplied by the Investor/Proponent is included here. However, there were several constraints due to the lack of data posed to the team, such as: not having definite design of the Alternative B, only approximate figures on resources (drinking water, fuel) to be used during the construction and operation period of the highway, not well defined facilities and technologies for water treatment etc.

## II. 1. DATA ON THE PROJECT/INTENTION

### II.1.1. PROJECT SCOPE

The **proponent** of the project for construction of Demir Kapija-Smokvica is national (public) institution Fund for National and Regional Roads. The predicted traffic frequency is 11.000 AADT.

| | |
|---|---|
| ***Name:*** | *E75 (ETC 10) Highway - Section Demir Kapija-Smokvica* |
| ***Size (traffic frequency) of the intention:*** | Annual Average Daily Traffic AADT of 11.000 vehicles 2020 (high scenario) |
| ***Investor:*** | *Fund for National and Regional Roads of the Republic of Macedonia* |

***Location:*** Central-south part of the Republic of Macedonia: region of Demir Kapija gorge - Miravci (Valandovo valley) - Smokvica (Gevgelija valley). Location of the area of interest can be seen from the map in Appendix I.2. This area belongs to the municipalities Demir Kapija, Valandovo and Gevgelija.

| | |
|---|---|
| ***Municipality:*** | Demir Kapija, KO<br>Valandovo, KO<br>Gevgelija, KO |
| ***Cadastral units:*** | KO Chelevec<br>KO Koreshnica<br>KO Kosharka<br>KO Klisura<br>KO Davidovo<br>KO Smokvica<br>KO Miravci |

**Character of the intention and possible cumulative impacts with other intentions**

The subject of the intention (project) is to build new highway from the town Demir Kapija down to the village Smokvica. That is the last un-upgraded section of the existing motor road/highway E-75, that runs through the Republic of Macedonia and connects Republic of Serbia and the Republic of Greece. Construction of the remaining section of this highway is a joint Macedonian-Greek venture (with the assistance of EU IPA funds) that will enable faster and more safe transportation of people and goods from Central Europe to Greece, or to Turkey and Near East since it will be connected to "Via Ignatia" (West-East) highway in Greece. The investment is predicted to reach about 100 million EUR: 60 million EUR - Greek investment and 30 million EUR EU-IPA funds grant (unofficial data).

The highway section is passing through the Demir Kapija canyon and the remaining gorge and through the more or less flat area from the village Miravci to the village Smokvica. The total length of the alternative A is 32.8 km and the total length of the alternative B is 27.3 km. The whole alignment is situated at low elevation (60 m a.s.l. to 500 m a.s.l.) with altitudinal difference of about 400 meters. The project anticipates construction of a number of bridges, tunnels, culverts, underpasses etc. (Tab. 1).

Tab. 1. *Overview of the planned object to be built along the alignment of both alternatives.*

| | **Alternative A** | **Alternative B** |
|---|---|---|
| **Bridges** | 12 (Ltot=2010m) | 6 (Ltot = 1650m) |
| **Tunnels** | 7 (Ltot=2855m) | 2 (Ltot = 1830m) |
| **Culverts** | No data available | No data available |
| **Underpasses** | 2 (Ltot=18m) | 0 |
| **Overpasses** | 4 (Ltot=146m) | 14 (Ltot-296m) |
| **Electric power supplies** | No data available | No data available |
| **Petrol station(s)** | No data available | No data available |
| **Other objects (restaurants, etc.)** | No data available | No data available |
| **Landfills** | No data available | No data available |
| **Construction of access roads** | No data available | No data available |
| **Construction of parking places** | No data available | No data available |
| **Borrow pits** | Borrow pits will be necessary in the section Udovo-Smokvica for the material of sub-layers, base layers and road layers. The position of the future borrow pits are not known at present, but they will be probably on the alluvial deposits of Vardar River, except if existing borrow pits can be used, with sufficient potential of materials for the project. The investigations of potential borrow pits will use shovel pits, drilling and core boring, or auger drill. | |

This intention in character is a project that will represent either highly significant environmental impact or significant impact on human health during its operation. Its operation will represent certain degradation of and threat to biodiversity and will contribute to current (negligible) air pollution and noise levels in the area especially of

the Alternative B. These contributions are evaluated in the respective chapters of this Study.
With respect to the character of the project, cumulative impacts of air emission and noise from transport related to the highway operation, as well as surface and underground water pollution created by the highway operation are expected. Apart from this, significant land and biodiversity deterioration will be unavoidable.
However, this project will have positive effect on the whole region in sense of enabling faster and safer transportation and connection of municipality Miravci and Valandovo to the main transportation route. It will stop migration of the rural population in the region (which is not high in this part of Macedonia anyway), construction of the local communal infrastructure etc.

**Reasons for implementation of the intention and its location, including view of considered alternatives and main grounds for their selection or rejection**

The major reason for implementation of the project under review is discontinued highway connection of the city of Skopje (capital of the Republic of Macedonia) with the town of Gevgelija at the southernmost part of the country and Greece (see Appendix I.1.). The decision to complete this highway was derived from several key factors:

- Necessity for good connection with Greece as a country of EU
- Improvement of traffic to Thessalonica - sea connection to Macedonia
- Faster and safer transportation
- Enhancement of the national and local economy
- To take advantage of available funds - grants.

There is no zero option (non construction) alternative solution for the proposed project. The only alternatives consider only different alignments, described above.

**Concise description of technical and technology features of the project/intention**

The technical design of the highway is based on the following details:

| | **Alternative A** | **Alternative B** |
|---|---|---|
| Assumed vehicle speed (flat terrain) | 100 km/h | 120 km/h |
| Assumed vehicle speed (hilly terrain) | 80 km/h | 120 km/h |
| Maximum longitudinal inclination | -2.185 ÷ 1.342% | -4 ÷ 3.300% |
| Number of traffic lanes//width | = 2x3.75m = 7.50 | |
| Stopping lanes | = 2.50m | |
| Edge lanes | = 0.5m | |
| Verge | = 1m | |
| Planum | = 25.0m | |
| Rigoli (drainage channel) + | = 0.75÷1.0 m | |
| Berme | = 0.5m | |
| | | |
| **On bridge** | | |

| | |
|---|---|
| Traffic lanes | = 3.75m |
| Stopping lanes | = 1.0m (only for L≥ 50m) |
| Edge lane | = 0.5m |
| Verge | = 0.45m (only for L≤ 50m) |
| | |
| **Tunnels** | |
| Traffic lanes | = 2x3.50m =7m |
| Edge lanes | = 2x0.30m = 0.60m |
| Verges | = 2x0.50m = 1m |

**Expected commencement date and completion date:**

The expected starting date of Demir Kapija-Smokvica highway construction is 2008. Assumed date of completion is 2012. Start of the operation is supposed 2013.

**List of affected territorial self-governing units**

| | |
|---|---|
| *Region:* | *Central-South Macedonia* |
| *Municipality:* | *Demir Kapija, Valandovo, Gevgelija* |
| *Town/city:* | *Demir Kapija* |

**Enlistment of the intention into the respective category and paragraph according to the Law on Environment**

The intention (project) is ranked according to Ordinance determining the projects for which an environmental impact assessment shall be carried out (Annex 1 of the Law on Environment).
During the preparation of this Study, existing national legislation in the Republic of Macedonia and International Conventions ratified by the Republic of Macedonia were used as a legal basis and analyzed. On the other hand, Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, amended by Council Directive 97/11/EC - EIA Directive was taken into consideration (see Chapter III).

## II.1.2. PROJECT INPUTS AND OUTPUTS

### II.1.2.1. Data on inputs

#### II.1.2.1.1. Raw materials and energy resources during construction:

Tab. 2 gives details for the quantities of earthworks, sub-grade and pavement to be used for the works for alternative A. These quantities are detailed for a staged construction of the upgrading.

Tab. 2. *Quantities of earthworks, sub-grade and pavement to be used for the works for alternative A**

| Section | Upgrading of existing road | | | | | New carriageway | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Earthworks | | Subgrade | Pavement | | Earthworks | | Subgrade | Pavement | |
| | | | | Base Course | Wearing Course | | | | Base Course | Wearing Course |
| | CUT | FILL | Width | Width | Width | CUT | FILL | Width | Width | Width |
| | m³ | m³ | m | m | m | m³ | m³ | m | m | m |
| Demir Kapija-Udovo | 0 | 7000 | 3.00 | 5.00 | 10.00 | 0 | 28000 | 13.00 | 10.00 | 10.00 |
| | 5600 | 0 | 3.00 | 5.00 | 10.00 | 28000 | 0 | 13.00 | 10.00 | 10.00 |
| | 3000 | 3000 | 3.00 | 5.00 | 10.00 | 13800 | 12500 | 13.00 | 10.00 | 10.00 |
| | 9700 | 2000 | 3.00 | 5.00 | 10.00 | 48500 | 8000 | 13.00 | 10.00 | 10.00 |
| | 90600 | 4000 | 3.00 | 5.00 | 10.00 | 453000 | 16000 | 13.00 | 10.00 | 10.00 |
| | 90400 | 1900 | 3.00 | 5.00 | 10.00 | 452000 | 7600 | 13.00 | 10.00 | 10.00 |
| | 18600 | 1400 | 3.00 | 5.00 | 10.00 | 93000 | 5500 | 13.00 | 10.00 | 10.00 |
| | 5200 | 0 | 3.00 | 5.00 | 10.00 | 261000 | 0 | 13.00 | 10.00 | 10.00 |
| Udovo- Smokvica | 46400 | 0 | 3.00 | 5.00 | 10.00 | 232000 | 0 | 13.00 | 10.00 | 10.00 |
| | 76800 | 13900 | 3.00 | 5.00 | 10.00 | 384000 | 55600 | 13.00 | 10.00 | 10.00 |
| | 24800 | 2400 | 3.00 | 5.00 | 10.00 | 124000 | 9600 | 13.00 | 10.00 | 10.00 |
| | 1500 | 8500 | 3.00 | 5.00 | 10.00 | 7600 | 33000 | 13.00 | 10.00 | 10.00 |
| | 13000 | 10500 | 3.00 | 5.00 | 10.00 | 64700 | 42000 | 13.00 | 10.00 | 10.00 |
| | 43200 | 33500 | 3.00 | 5.00 | 10.00 | 216000 | 134000 | 13.00 | 10.00 | 10.00 |
| | 20000 | 1500 | 3.00 | 5.00 | 10.00 | 100000 | 6000 | 13.00 | 10.00 | 10.00 |
| | 5600 | 43500 | 3.00 | 5.00 | 11.00 | 28000 | 174000 | 14.00 | 11.00 | 11.00 |
| | 21000 | 23000 | 3.00 | 5.00 | 11.00 | 105000 | 577000 | 14.00 | 11.00 | 11.00 |
| | 17000 | 33500 | 3.00 | 5.00 | 11.00 | 85000 | 134000 | 14.00 | 11.00 | 11.00 |
| **TOTAL** | **492400** | **189600** | | | | **2695600** | **1242800** | | | |

* Quantitative data of earthworks, sub-grade and pavement to be used for the works for alternative B were not available since that solution is at early stage of design.

*a) Land/Soil (occupation of land)*

**Occupation of land during highway construction, including infrastructure:** The road will be aligned in cadastral area(s) in the municipalities of Demir Kapija, Valandovo and Gevgelija and cadastral units in KO Chelevec, KO Koreshnica, KO Kosharka, KO Klisura, KO Davidovo, KO Smokvica and KO Miravci. The total area occupied will be about 149.8 ha in case of Alternative A and 128.4 ha in case of alternative B (road planum, cuts and embankments). According to the field observations, soils in the area are of various qualities: I-II bonity class in Valandovo plain and on alluvial deposits along the river Vardar or V-VI category (class) on hilly region. Soils along the Alternative A alignment is of higher quality compared to soils along Alternative B alignment.

There are no protective zones in the area of intention.

Pieces of land affected by construction of the Demir Kapija-Smokvica highway and related objects and constructions and their size according to the dominating land use type are presented in Chapter VI.8.

*b) Water*

There are no data concerning the quantity or sources of technical water (road construction). During the construction phase this water will be used for cleaning of machinery, as a raw material, for the road sealing etc.

There are no predictions concerning the quantity of fire fighting water although the exact amount of fire fighting water can not be predicted.

*c) Raw materials*

In the current phase of design of the highway it is possible to determine exact quantities only for the alternative A (see. Tab. 1) and it is not possible to determine sources of construction materials or their exact quantities for alternative B. Construction materials will be supplied by commercial suppliers. However, even in case of Alternative A available data are not sufficient for precise assessment of impacts (generation of waste, soil and pollution).

Supply of material is expected in order of tens of thousands tons. Largest volume will constitute mineral sealing, concrete, soil into embankments. It is expected that for mineral sealing and construction of banks autochthonous material will be used. Excavated and used earth is not well balanced in case of Alternative A. Other materials used for construction will be steel structures, aggregates, asphalt and concrete panels for construction and surface adjustment of communications.

*d) Energy resources*

**Diesel fuel:** During the construction period the diesel fuel will be used for construction machinery and heavy trucks. Refuelling of trucks will be carried out at public petrol stations outside of the construction site. Refuelling of construction machinery will be done in necessary extent on the construction site.

The fuel will be stored on the site in the barrels or tanks located in the safety retention pit provided with the oil-resistant coating. The volume of retention pit will always exceed the capacity of the largest barrel/tank located in a retention pit by at least 10 % to be able to keep all fuel in case of leakage. Barrels can also be stored in retention tubs. Only diesel fuel for the machinery operated on the construction site (bulldozers, excavators, etc.) could be stored at the construction site.

**Natural gas:** No natural gas will be used during the construction period.

**Electric power:** During the construction period the electricity will be used especially for power supply of the construction site (for example lighting of the construction site, power supply of electric equipment, welding etc.).

For the road construction, contracted company will supply energy for construction with diesel fuel generators.

There are no exact data for predicted use of gasoline for the construction of the highway or about the number of machinery and vehicles engaged.

### II.1.2.1.2. Raw materials and energy resources for operation

*a) Energy resources*

**Electric power:** Electric power will be provided from external public distribution network. The supplies of electric energy shall be connected to the distribution network of the power supply company “Elektrostopanstvo na Makedonija”. The final design and

the point of the connection of the highway facilities to public will be defined in next stage of the design
There are no data about the total installed capacity of the highway electrical equipment

**Natural gas:** It is not foreseen to use natural gas for energy during highway operation. However, natural gas will be used in individual vehicles (personal cars mainly) as a fuel. The amount of this fuel can not be calculated at the moment. Since this fuel is used in towns and cities normally, it is not expected that it will cause any environmental deterioration ("clean" fuel) or unexpected hazards. There is no legal constrains either.

**Diesel fuel:** Predicted operation frequency can serve as a basis for calculation of diesel fuel consumption.

*b) Raw material and auxiliary materials*
Within the operation and maintenance of the Demir Kapija-Smokvica highway (including all related activities) raw and auxiliary materials will be consumed (send, oils, cleaning agents, defrosting agents). The amount of these materials were not specifies by the Investor.
Liquid materials shall be transported in bottles, cans (10 or 20 litres) and barrels with the capacity of 50 or 200 litres. Loose chemicals shall be supplied in transportation packs (barrels and bags) on palettes.
All the auxiliary materials will be stored safely in the storage area according their properties. Substances hazardous to the environment (oils, lubricants, etc.) will be stored only in amounts as necessary to ensure a continuous maintenance of the highway.
There are no detailed data about the management of future highway.

#### II.1.2.1.3. Demands on auxiliary structures (access roads, borrow pits etc.)

Some basic data concerning auxiliary structures are presented in Chapter II.1.1. However, these data are not sufficient for precise and correct assessment of impacts even in case of Alternative A. There are no such data for Alternative B alignment except for the number and length of objects (tunnels, bridges, overpasses and underpasses). Borrow pits and landfills are not defined yet.

### II.1.2.2. Data on outputs

Data on outputs comprise data about produced degradation and produced pollutants during construction and operation of the intention/project. All these outputs were analyzed and discussed in the scope of the impacts' assessments and are presented in the respective chapters.

## II. 2. SPECIFICATION OF MISSING INFORMATION AND UNCERTAINTIES, WHICH APPEARED DURING ELABORATION OF THE STUDY

The following inadequacies in knowledge and/or uncertainties had to be accepted during elaboration of this study:

- Elaboration of the highway design for the Alternative B was in the phase of feasibility study, while the road design did not exist. That is why certain detailed information about road construction was not yet available.
- Present status of environment parameters (air and climate, water and to a certain degree biodiversity) in the area under assessment is not known in details as there are no monitoring stations located there.
- Missing information concerning some parameters (geomorphology, climate, biodiversity) was collected for the purpose of this study directly on field but not throughout the whole year (or the whole vegetational season). Thus, many data could be missing.

This implies that "precautionary principle" has to be applied when necessary (when no reliable information exists, and when presence of certain negative impact is expected, than no action is recommended).

However, regarding extent and type of the activity under assessment (construction and operation of the Demir Kapija-Smokvica section of the highway) it can be stated, that any principle inadequacies in knowledge and/or uncertainties, that could negatively influence the extent and content of the assessment carried out within this study, did not occur. In individual cases when available information is not sufficient, elaboration of separate environmental impact assessment study(s) will be recommended.

In general, one can conclude, that available information and background materials concerning construction and future operation of the highway were sufficient for elaboration of this EIA Study.

# III. PROCEDURE FOR ELABORATION OF THE STUDY

## III. 1. LEGAL ASPECTS

Environmental Impact Assessment (EIA) is legal procedure prescribed by the Law on Environment[1] by which a proponent is granted consent for the realization of the project by the Ministry of Environment and Physical Planning (in the Law: organ of the state government responsible for the issues if the protection of the environment).
During the preparation of this EIA Study for the construction and operation of the proposed ski-centre, national legislation and international documents and conventions ratified by Macedonia were taken into account

### III.1.1. SHORT DESCRIPTION OF THE EIA PROCEDURE

The Law on Environment describes the EIA procedure in details. It is consisted of Screening and Scoping as well as description, evaluation and assessment of the direct and indirect impacts on the environment resulting from realization or non-realization of the project (Article 79).

#### III.1.1.1. Notification on the intention for project implementation

Legal entities and natural persons intending to implement a project that require EIA shall send a notification on their intention to implement the project, together with an opinion of the need of environmental impact assessment to the Ministry of Environment and Physical Planning (Article 80). The content of the Notification is described by the *Regulation for defining the procedure for EIA* (Regulation on Procedure). The Article 4 of the Regulation on Procedure states that the Notification should be published in some local newspaper in the municipality where the realization of the project shall take place. Ministry of Environment and Physical Planning shall inform the investor within 10 days from the date of the receipt of the notification on the need for supplementing the notification.

#### III.1.1.2. Screening

After the Notification, the Minister of Environment and Physical Planning should evaluate the need for EIA.
The proposed project for construction of the highway Demir Kapija-Smokvica is included in the projects that require procedure of Environmental Impact Assessment according to point **7c - *Construction of a new road of four or more lanes, or***

[1] Law on Environment, Official Gazette of the Republic of Macedonia /05

***realignment and/or widening of an existing road of two lanes or less so as to provide four or more lanes, where such new road, or realigned and/or widened section of road would be 10 km or more in a continuous length*** in Annex I of the Decree determining the projects for which an environmental impact assessment shall be carried out (referred to Article 7 of the Law on Environment). The screening procedure should not be longer than 30 days (Article 81).

#### III.1.1.3. Scoping

The scope and the content of the EIA Study shall be defined by the Ministry of Environment and Physical Planning on the basis of Article 82 of the Law on Environment and Article 9 of the Regulation on Procedure. However, no time frame is envisaged by the Law on Environment. The EIA Study should at least contain the following information:

1. Description of the Project with the information on location, character and size of the project as well as land surface needed for the realization of the project;
2. Description of the environment and its components on the proposed location;
3. Description of the historical and cultural heritage and the landscape;
4. Description of the type and quantities of expected emissions and waste, especially the atmospheric emissions, solid communal waste and waste waters as well as other information needed for assessment of the significant impacts on the environment;
5. Description of the measures for prevention, reduction or elimination of the impacts on the environment as well as alternative measures in the case of environmental and landscape changes;
6. Description of the effects of the project having in mind the present knowledge and accepted methods for assessment;
7. Description of the characteristics of the technology to be used;
8. Description of alternatives for realization of the project proposed by the investor and main reasons for selecting the proposed location;
9. Short description of the EIA study without technical details
10. Assessment of the obstacles (technical defects or lack of knowledge) that the investor faced during the preparation of the study
11. Recommendations for the scope and characteristics of the changes in the project that will require amendments of the EIA study.

The presented Study elaborates all of the points presented above.

#### III.1.1.4. Public participation

One of the most important parts prescribed by the legislation on EIA is public participation in different phases of the EIA procedure. In the first phases, the Investor can involve public in the form of direct discussion after the presentation of the key objectives of the project (Regulation on Procedure: Article 9). The method for public participation (access to information, presenting opinions, comments on the EIA study, organization of public hearing) should be defined by the Ministry of Environment and Physical Planning on the basis of Articles 11 and 12 of the regulation on Procedure. Ministry of Environment and Physical Planning shall present the most important documents during the EIA procedure in daily newspapers, local TV and radio stations

as well as on the web page of the Ministry (Law on Environment: Article 90). The Ministry of Environment and Physical Planning information shall:

1. Publish the Notification in at least one daily newspaper available throughout the territory of the Republic of Macedonia and on the website of the Ministry of Environment and Physical Planning;
2. Publish the decision for the need of EIA in at least one daily newspaper available throughout the territory of the Republic of Macedonia, on the web site as well as on the notice board of Ministry of Environment and Physical Planning;
3. Announce that the study on the project for environmental impact assessment has been prepared and is available to the public in at least one daily newspaper available throughout the territory of the Republic of Macedonia, local radio/TV station, while non technical report of the study shall be published on the Website of the Ministry of Environment and Physical Planning;
4. Publish the report on the adequacy of the study on the project environmental impact assessment in at least one daily newspaper available throughout the territory of the Republic of Macedonia and on the Website of the Ministry of Environment and Physical Planning;
5. Publish the decision for granting consent to or rejecting the application for the project implementation in at least one daily newspaper available throughout the territory of the Republic of Macedonia, on the web site as well as on the notice board of the Ministry of Environment and Physical Planning;
6. Announce the time and the place of the public hearing in at least one daily newspaper available throughout the territory of the Republic of Macedonia and local radio and TV station.

The public i.e. the interested persons can have access to information concerning the environmental issues in the scope of project (Law on Environment and Aarhus Convention[2]).

#### III.1.1.5. Review of the EIA Study

Ministry of Environment and Physical Planning is responsible for the preparation of the Report of the adequacy of the EIA Study (Law on Environment, Article 86). The term for preparation of the adequacy report should not be longer than 60 days from the date of the submission of the study. According to Article 91 of the Law on Environment, the Ministry of Environment and Physical Planning should organize public hearing regarding the EIA study. The public hearing should be organized within the 60 days for the preparation of the Report of adequacy.

#### III.1.1.6. Granting consent

Based on the EIA Study, the Report on adequacy, public hearing and received opinions, the Ministry of Environment and Physical Planning
The Ministry of Environment and Physical Planning shall, on the basis of the EIA study, Report on adequacy, the public debate and the opinions obtained, issue a decision on whether to grant consent to or reject the application for the project implementation

within 40 days from the date of submission of the Report on adequacy (Law on Environment, Article 87).

### III.1.2. TRANSBOUNDARY IMPACTS

Macedonia has ratified the ESPOO Convention i.e. the Convention on Environmental Impact Assessment in Transboundary Context (Official Gazette 44/99). The main goals of the Convention are incorporated in the Law on Environment (Articles 93 and 94). According to these provisions, the Ministry of Environment and Physical Planning shall notify the neighbouring country for the proposed project that might cause serious impacts on the territory of the neighbouring country and provide for the competent authority of the foreign country equal treatment in the participation in the procedure as for the domestic public.

The highway corridor area is about 20 km from the national border with Greece. Having in mind the potential impacts of the highway construction and operation as well as the distance of the border zone it is not expected that the project will have impacts on the environment of Greece as a neighbouring country. The operation of the highway will have only insignificant indirect impacts on the socio-economic conditions. Thus, the ESPOO Convention is not applicable in the case of the highway Demir Kapija-Smokvica.

### III.1.3. OTHER LAWS AND DOCUMENTS

The presented Study was prepared with account on other national laws and legal documents than the Law on Environment:

- *Spatial Plan of the Republic of Macedonia*;
- *Law on Spatial and Urban Planning* (Official Gazette of RM 4/96; 28/97; 18/99 and 53/01);
- *Law on Nature Protection* (Official Gazette of RM 67/04);
- *Law on Waters* (Official Gazette of RM 4/98 and 19/00);
- *Law on Air* (Official Gazette of RM 20/74 );
- *Law on Mineral Resources* (Official Gazette of RM 18/99; 48/99 and 29/02);
- *Law on Energetic* (Official Gazette of RM 7/97; 40/99 and 98/00);
- *Law on Urban Land* (Official Gazette of RM 53/01 and 97/01)
- Decision for declaration of the species *Ilex aquifoloium* for monument of nature. Official Gazette of Gevgelija No.1, pp.2, 4.02.1997.
- Fungal species proposed for protection according to the Preliminary Red List of fungi of the Republic of Macedonia (Karadelev 2000)

### III.1.4. RATIFIED CONVENTIONS

The following international conventions, ratifies by the Republic of Macedonia were taken into account during the elaboration of the Study:

- Convention on Environmental Impact Assessment in Transboundary Context -Espoo Convention (Official Gazette of RM 44/99);

- Convention on access to information, public participation in decision-making and access to justice in environmental matters - Aarhus Convention (Official Gazette of RM 40/99);
- Convention on Biological Diversity (Official Gazette of RM 54/97)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979) (Official Gazette of RM 38/99)
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1972) (Official Gazette of RM 49/97)
- CORINE - Coordination of Information on the Environment
- Fungal species protected to the European Red List of Fungi (Ing 1978)
- Fungal species proposed for protection by the European Council for Conservation of Fungi (33 fungal species according to Bern Convention).

### III.1.5. WORLD BANK REGULATIONS ON EIA

According to the Screening procedure prescribed by the World Bank and IBRD, proposed project "Construction of section Demir Kapija-Smokvica of E-75 highway" falls into category A: "Development activities likely to induce significant impacts upon environment and biodiversity".
Among other activities that can significantly impact biodiversity *Transportation projects involving construction of highways, bridges, rural roads, railways. airports, or canals that penetrate natural habitats and ecosystems and open them to colonization and immigration: also, canalization of rivers for navigation and dredging and coastal land reclamation for ports* are noted.
Besides national legislation some other EIA procedures were taken into consideration. In order to improve the efficiency of subsequent data collection and management, proponent and EIA team agreed on significant impacts for assessment (scoping). Three basic methods for determining impacts were: checklists, matrices and overlay mapping/GIS according to the prescriptions by the World Bank.

## III. 2. SPATIAL PLAN

The Spatial Plan of the Republic of Macedonia is valid for the period up to 2020. It projects several activities concerning the development of tourism and expanding the network of protected areas in the region of Demir Kapija.

### III.2.1. TOURISM DEVELOPMENT

There are only two foreseen activities for the development of the tourism in the region. The whole area of the highway corridor is foreseen in the Spatial Plan as "Transite Corridor". The area around town of Demir Kapija is noted as "Mountain Spa" (Fig. 1).


*Fig. 1. Extract from the Spatial Plan of the Republic of Macedonia - tourist regions and localities*

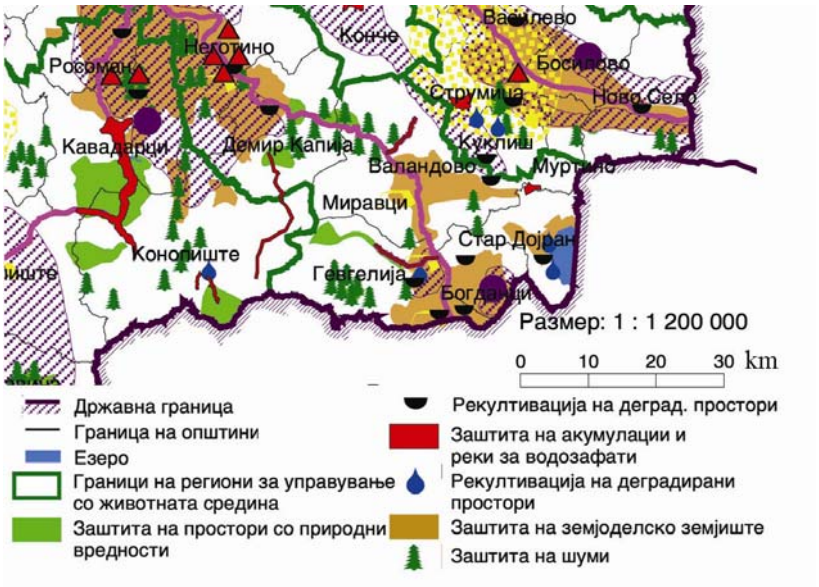



*Fig. 2. Extract from the Spatial Plan of the Republic of Macedonia - protected areas*

## III.2.2. PROTECTED AREAS

From the aspect of the protected areas network in Macedonia, there are several activities that are noted in the Spatial Plan as well as several areas that are designated for

protection. The activities refer to protection of agricultural land in the vicinity of Valandovo and reforestation of the area between Demir Kapija and Valandovo.
In the highway corridor area there are two protected areas. Other six localities are designated for protection according to the Spatial Plan projections. The categorization of the designated areas is not in concordance with the provisions of the Law on Nature Protection. For the time being, there are not elaborated analyses for the exact position, borders, surface and other features of the designated areas.
However, in the case of the Bela Voda cave it is clear that the designation refers to the whole system of the cave.

Tab. 3. *Overview of the protected areas/species and areas denoted for protection in the broader area of interest (extract from the Spatial Plan of the Republic of Macedonia)*

| **locality/species** | **category** | **status** |
|---|---|---|
| **Iberliska Reka** | IPASON | **protected** |
| Klisurska Reka | SINR | proposed |
| Studena Glava-Rid Trnika | SINR | proposed |
| **Demir Kapija** | **MN** | **protected** |
| Krastovec | MN | proposed |
| Bela Voda cave | MN | proposed |
| Crni Orevi | MN | proposed |
| Shtuder | MN | protected |

IPASON - Individual Plant and Animal Species Outside of Natural Reserves; SINR - Nature Reserve for Scientific Research; MN - Monument of Nature (this classifications thus not correspond to the provisions of the Law on Nature)

#### III.2.2.1. Chelevechka (Iberliska) Reka

Iberliska Reka (syn. Chelevechka Reka) was proclaimed as a plane (*Platanus orientalis* L.) reserve. It is located along the river Iberliska Reka flow, between the villages Iberlija and Chelevec (Demir Kapija region). It represents a water gap cut into Demir Kapija Jurassic limestone. The reserve occupies 25 ha area. The forest is of a native origin and it is well preserved. It is distributed as a more or less narrow belt along the stream.

It was protected since 1963 as a category Individual Plant and Animal Species Outside of Natural Reserves.

#### III.2.2.2. Demir Kapija

Demir Kapija canyon is protected area (since 1960) in the category–Monument of Nature (III category according to IUCN). It has extraordinary importance from the biodiversity point of view (for its location, see Habitat map-Appendix I.4.).

Demir Kapija (in broad sense) is the longest gorge of the river Vardar (19 km). It is passing through limestone and eruptive rocks, which are dividing Tikvesh valley on the north-west and Gevgelija-Valandovo valley on the south-east. The entrance in the gorge is especially impressive canyon, 0,9 km in length, with different carstic shapes on its slopes–caves (9): the longest is Bela Voda cave (955 m), crevices, cuttings with steep cliffs etc.

The Demir Kapija canyon (Photo 1) is among the richest ornithological reserves in Europe considering the rare birds of pray: *Gyps fulvus*, *Neophron percnopterus*, *Aquila chrysaëtos*, *Circaëtus gallicus*, *Buteo rufinus*, different falcons–*Falco peregrinus*, *Falco naumanni* and other rare and scientifically important bird species. In the Demir Kapija gorge important mammal, reptiles and insects species are presented as well. Also, rare and endemic plant species are presented there (*Lilium heldreichii*, *Lilium martagon*, *Kitaibelia vitifolia* etc.).

In 2003 there was an initiative of the Ministry of Environment and Physical Planning to re-categorize the Demir Kapija Monument of Nature as "strictly protected reserve". An Elaborate was prepared for this purpose but the proposal was not accepted. According to the proposal from 2003, the strictly protected reserve "Demir Kapija" should cover area of 4250 ha.

*Photo 1. Demir Kapija is protected as Monument of Nature because of its ornithological and geomorphologic values. However, a number of infrastructural objects are passing through Demir Kapija canyon.*

# IV. CHARACTERISTICS OF THE AREA OF INTEREST

This chapter describes the current status of the basic environmental features of the project area, including the surrounding regions that could be affected by the project construction and/or operation. Both natural and anthropogenic environment are considered.

The projected highway is going to pass along the river Vardar valley. The river Vardar is flowing through the central part of the Republic of Macedonia, from north-Northwest to south-Southeast, thus dividing the country into two parts: western and eastern part. The lower part of the valley, where the investigated highway corridor is passing, is spread from Demir Kapija to Gevgelija (village Smokvica is situated about 10 km on the north of Gevgelija).

Foothills of Marjanska Planina (the lowest and easternmost part of Kozhuf Mt. mountains surround the valley from the right side and hilly, small mountains, from the left side: Konechka Planina, Gradeshka Planina, Plaush and many smaller hills at the southernmost part (Appendix I.2.).

Beside the main water flow (river Vardar) the valley is characterised by several rivers (Boshava from the right side and Anska Reka from the left) and small rivers and streams, among which Chelevechka Reka from the left side and Javorica and Petrushka Reka from the right side, are more important, since they have permanent water flow. Some of the streams are with temporal flow in the lower part due to the use of their water for irrigation of the fields in the valley.

Presently, the area is hardly urbanised (one urban systems is touching the project area corridor - town Demir Kapija). Several villages are distributed along the road corridor under project impact: Udovo, Josifovo, Miravci, Miletkovo, Davidovo, Marvinci and Smokvica at the end of the project area. Villages Gradec and Klisura are abandoned.

From this point forward, the terms like "project area", "the area of intention", "affected area", "affected region", "the area under project impact" or similar, shall mean the area as described in previous paragraphs.

## IV. 1. CLIMATIC CHARACTERISTICS

The area between Gevgelija, Valandovo and Demir Kapija is well defined geographical unit that is encircled by mountains from west and east, and opened on the north and south by the river Vardar valley has specific climatic characteristics. It is one of the warmest regions in the Republic of Macedonia. Gevgelija-Valandovo valley is about 60 km away from the Thessalonica gulf.

The characteristics of climate for the section of highway corridor area are presented on the bases of three meteorological stations: Demir Kapija, Valandovo and Gevgelija. The meteorological stations in Gevgelija and Valandovo are outside of the highway corridor

area. However, the data of these two stations can be used to reflect the climatic conditions of the southern-most parts of the highway corridor (Miravci- Smokvica). The meteorological station in Demir Kapija represents the climatic conditions of the north part of the highway corridor as well as the gorgy and hilly parts. The measurements of the meteorological station in Valandovo present the climate in the area of Village Miravci. The climate of the area of village Smokvica is more similar to the climatic characteristics described by the data of the meteorological station in Gevgelija.

Mediterranean climate from the Thessalonica gulf penetrates into the Gevgelija-Valandovo valley and spreads along Vardar River to the north of Demir Kapija. The Mediterranean influence determines the basic characteristics of the climate of the area in whole and some climatic elements separately. Mediterranean influence in Tikvesh valley (northern of Demir Kapija) is less manifested than in Gevgelija-Valandovo valley. The Demir Kapija gorge represents natural frontier for the Mediterranean influence along the river Vardar. Because of the Mediterranean influence, the climate is characterized is modified Mediterranean climate. However, the climate of Demir Kapija shows transition to the continental climate with strong sub-Mediterranean influence.

In general, the climate is semiarid with the exception of semiarid period (July-September). The precipitation is higher during the autumn than the spring period (Fig. 3). The humid period lasts from November to March.

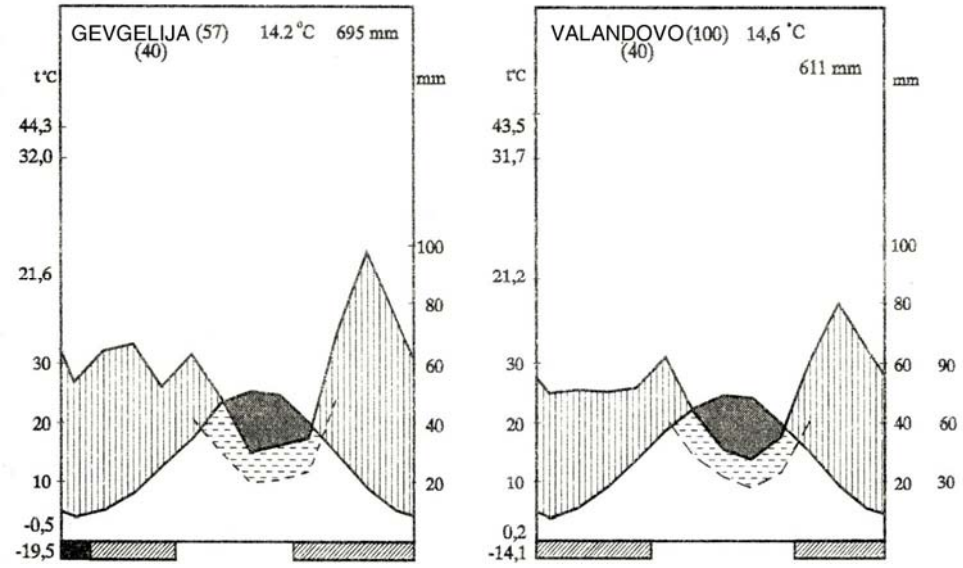



*Fig. 3. Walter's climate diagrams of Gevgelija and Valandovo (from: Filipovski et al. 1996).*

## IV.1.1. AIR TEMPERATURE

The characteristics of temperature regime are presented in Tab. 4-8. Gevgelija-Valandovo valley has highest annual average air-temperature in the Republic of Macedonia of about 14.4°C (Gevgelija) to 14.8°C (Valandovo). Compared to the neighbouring valleys, the Gevgelija-Valandovo valley has 1.4°C higher temperature than Strumica valley and 1.3°C than the Tikvesh valley. Gevgelija-Valandovo valley

has about 1.3$^0$C higher temperature than the north-most valley along the river Vardar– the Polog valley (Tetovo).

The average annual temperature in Demir Kapija is 13.5 $^o$C. It is lower than the temperature of the southern parts of the corridor area which are represented by the Gevgelija and Valandovo stations.

However, Gevgelija and its vicinity compared to Valandovo have lower temperatures because of the winds blowing in this part, although it is situated on south. Valandovo and its vicinity have higher air-temperatures because of the mountains that are surrounding the valley and protect the valley from the cold winds that are blowing from north. Average temperature in January is relatively high: 3.2$^0$C (Gevgelija) and 3.6$^0$C (Valandovo). Relatively high temperature is registered in the remaining winter months (December and February).

Tab. 4. *Average monthly and annual air temperatures [$^o$C]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | 1,6 | 4,6 | 8,5 | 13,5 | 18,3 | 22,2 | 24,4 | 23,9 | 20,2 | 14,0 | 8,2 | 3,3 | 13,5 |
| Valandovo | 3,6 | 5,5 | 8,8 | 13,5 | 18,3 | 22,3 | 24,8 | 24,3 | 20,4 | 14,7 | 9,3 | 5,2 | 14,2 |
| Gevgelija | 3,5 | 5,4 | 8,6 | 13,3 | 18,4 | 22,8 | 25,1 | 24,5 | 20,3 | 14,2 | 9,2 | 5,1 | 14,2 |

Tab. 5. *Average maximum monthly and annual air temperatures [$^o$C]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | 5,3 | 9,1 | 13,6 | 19,3 | 24,5 | 28,7 | 31,3 | 31,2 | 27,1 | 20,2 | 12,6 | 19,1 | 20,1 |
| Valandovo | 7,6 | 10,2 | 13,8 | 19,3 | 24,3 | 29,0 | 31,7 | 31,7 | 27,3 | 23,9 | 15,0 | 9,7 | 20,3 |
| Gevgelija | 8,0 | 10,4 | 14,0 | 19,6 | 24,9 | 28,6 | 32,0 | 31,7 | 27,7 | 21,1 | 14,4 | 9,8 | 20,2 |

Tab. 6. *Average minimum monthly and annual air temperatures [$^o$C]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | -1,9 | 0,2 | 3,6 | 7,2 | 11,6 | 15,3 | 17,3 | 16,5 | 13,4 | 8,5 | 4,5 | 1,0 | 8,2 |
| Valandovo | 0,2 | 1,5 | 3,5 | 7,5 | 11,2 | 15,2 | 17,3 | 18,9 | 13,7 | 9,4 | 5,4 | 1,6 | 8,7 |
| Gevgelija | -0,5 | 0,8 | 3,4 | 7,0 | 11,5 | 15,3 | 17,3 | 16,7 | 13,3 | 8,3 | 4,6 | 0,9 | 8,2 |

Tab. 7. *Absolute maximum monthly and annual air temperatures [$^o$C]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | 19,3 | 22,7 | 28,7 | 35,3 | 36,1 | 39,5 | 43,6 | 41,4 | 36,7 | 32,2 | 25,6 | 20,8 | 43,6 |
| Valandovo | 19,0 | 23,5 | 27,8 | 31,5 | 34,4 | 39,5 | 43,5 | 40,4 | 37,2 | 32,6 | 25,6 | 20,0 | 43,5 |
| Gevgelija | 19,5 | 23,0 | 30,0 | 31,0 | 37,0 | 40,0 | 44,3 | 42,5 | 38,6 | 33,6 | 27,0 | 21,6 | 44,3 |

Tab. 8. *Absolute minimal monthly and annual air temperatures [$^o$C]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | -18,5 | -18,6 | -11,0 | -2,5 | 1,4 | 5,7 | 7,8 | 6,1 | 1,1 | -5,7 | -8,4 | -15,4 | -18,5 |
| Valandovo | -12,5 | -14,1 | -9,5 | -0,7 | 1,9 | 7,5 | 10,5 | 8,8 | 3,2 | -3,5 | -10,5 | -12,5 | -14,1 |
| Gevgelija | -19,5 | -15,0 | -10,7 | -3,0 | 0,5 | 5,1 | 8,4 | 6,8 | 0,0 | -5,7 | -9,5 | -10,1 | -19,5 |

The average monthly temperatures during winter period in the highway corridor area are constantly above 0 $^o$C (Tab. 4). Gevgelija-Valandovo valley and Demir Kapija have highest average January air-temperature in the Republic of Macedonia. Only during January in Demir Kapija and Gevgelija, the average minimum temperatures are lower

than 0 $^{o}$C (Tab. 6). The absolute minimum temperatures (Tab. 8) show that the temperatures can drop almost to -20 $^{o}$C. Temperatures below freezing point were measured at all three meteorological stations during the period from October to April.

The average maximum annual temperatures are above 20 $^{o}$C (Tab. 5). The absolute maximum temperatures are very high (Tab. 7). These values are highest for the Republic of Macedonia. The maximum temperature measured in Gevgelija is 44.3 $^{o}$C. Demir Kapija and Valandovo have somewhat lower maximum temperatures of 43.6 and 43.5 $^{o}$C.

The differences of the temperature values between warmest and coldest month in the year are varying from 22.3 $^{o}$C (Valandovo) to 22.5 $^{o}$C (Gevgelija). Absolute variance of the temperature has similar characteristics. The difference between absolute maximal and minimal temperature is varying between 23.0$^{0}$C (Gevgelija) and 28.1$^{0}$C (Valandovo). It is much bigger than the differences between absolute maximal and minimal temperatures in other valleys in Macedonia (Polog valley - 10.5 $^{o}$C, Strumica valley - 16.5 $^{o}$C, Tikvesh valley - 24.0 $^{o}$C) etc. The varying of the temperature indicates that the temperature regime of the valley is determined by the Mediterranean influence as well as by the local orographic characteristics and sporadic penetrations of cold winds from north in the winter period. This is the reason for the disturbance of the temperature stratification that should exist according to the geographic position of the valley. The dynamics of average seasonal temperature is another important parameter for the characterisation of temperature in the area.

### IV.1.2. PRECIPITATION

The characteristics of precipitation regime for highway corridor area are presented on the bases of the three meteorological stations–Demir Kapija, Valandovo and Gevgelija. The average values of precipitation parameters are presented in Tab. 9 and Tab. 10.

The Gevgelija-Valandovo valley belongs to the Mediterranean pluviometric regime according to the rainfall distribution. The annual quantity of precipitation varies between 561.0 mm in the northern part (Demir Kapija) and 694.6 mm in the southern part of the valley (Gevgelija). The average annual quantity of precipitation in Gevgelija and Valandovo valley is bigger than one in the adjacent regions as well as in the other micro-regions with Mediterranean climatic modifications such as Demir Kapija area. This phenomenon is determined by the movement of the warm air that finds the high mountain frame as an obstacle in the way of its moving from north and west. The consequence of this process is cooling of the air mass and condensation of the vapour followed by the rainfalls in the valley.

Maximal precipitation is registered in November. The minimal precipitation is registered in the summer period: in July: Demir Kapija – 32.5 mm, Valandovo – 31.9 mm and Gevgelija – 32.2 mm; in August: Demir Kapija – 21.0 mm, Valandovo – 27.8 mm and Gevgelija – 32.2 mm. It is the period of highest air-temperatures. Such distribution of precipitation (monthly and seasonal) causes appearance of dry periods that are characteristic for the summer. Dry periods have tendentious to redistribute in the first months of autumn. Dry periods in the Gevgelija-Valandovo valley do not last that long as ones in the central regions of the Republic of Macedonia (northern of Demir Kapija). The precipitation in the Gevgelija-Valandovo valley consists mainly of

the rainfalls. It is snowing very rare and the snow cover lasts for a short period of time. There are six days with snow cover in average in the Gevgelija plain. Number of days with snow cover is varying between 0 and 24 days in the year. The average date for the snow appearance for the first time in the year in Valandovo plain is December 22nd and on February 24th for the last time in the year. Average duration of snow cover in Demir Kapija region is 22 days per year. Maximal registered height of the snow cover is 100 cm in January 1962 and 62 cm in January 1969.

Tab. 9. *Average monthly and annual precipitation [mm]*

| meteorological station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Demir Kapija | 48,0 | 46,8 | 49,0 | 44,7 | 58,1 | 41,1 | 32,5 | 21,0 | 31,0 | 50,8 | 63,9 | 71,5 | 561,0 |
| Valandovo | 48,7 | 51,3 | 50,8 | 51,7 | 62,3 | 42,9 | 31,9 | 27,8 | 35,5 | 60,0 | 83,8 | 64,0 | 610,8 |
| Gevgelija | 53,6 | 65,3 | 67,4 | 53,9 | 62,7 | 47,5 | 30,7 | 32,2 | 35,0 | 71,5 | 99,0 | 75,8 | 694,6 |

Tab. 10. *Temperature (A) and precipitation (B) by seasons*

| | Winter | | Spring | | Summer | | Autumn | |
|---|---|---|---|---|---|---|---|---|
| meteorological station | A | B | A | B | A | B | A | B |
| Demir Kapija | 3,1 | 166,3 | 13,4 | 151,8 | 23,5 | 94,6 | 14,1 | 145,8 |
| Gevgelija | 4,4 | 128,2 | 13,4 | 184,0 | 23,8 | 109,8 | 14,6 | 190,0 |

### IV.1.3. WINDS

Winds are important climatic factor. They are one of the most characteristic features of the area between Demir Kapija and Gevgelija. Their direction of blowing is determined by the morphoplastics of the region. Most frequent are south and north winds. South winds bring warmth in the winter period because they carry warm sea air mass. The north winds are cold and they bring continental cold air.

Winds from north-west (Vardarec) and from south-east (Jug) are prevailing in the Demir Kapija region. Vardarec is most frequent in summer (July, 237 ‰) although it blows in the whole period of the year with high frequency. Vardarec blows with much smaller speed in the Demir Kapija region. Its average month speed is 1.9 $m \cdot s^{-1}$ in October to 2.8 $m \cdot s^{-1}$ in February and March, while its maximum speed is 15.5 $m \cdot s^{-1}$. The wind called Jug is second by the frequency in the Demir Kapija region after the Vardarec. It blows along the River Vardar and it is characterised as warm wind. It blows very frequently in the whole period of the year especially in April, March and November. Average wind speed in September of Jug is pretty constant and varies from 4.5 $m \cdot s^{-1}$ to 7.1 $m \cdot s^{-1}$ in December. Winds with different directions in Demir Kapija region are not so well expressed with exception of the eastern wind (it is on the third place according its frequency). Its average monthly speed varies from 4.5 $m \cdot s^{-1}$in July to 7.0 $m \cdot s^{-1}$in January.

In the Gevgelija-Valandovo valley most expressed winds are Vardarec (blows from the north) and Jug (blows from south-east). Vardarec blows in the whole period of the year and most frequently in January (327‰), February (278 ‰) and December (275 ‰). It is no so frequent in the spring and autumn. Vardarec appears with high frequency in the summer particularly in July (238‰) and August (220‰). The duration of the period when this wind blows is 1-2 days in average, but in some years it blows continually for a whole week. Vardarec has characteristics of a gust wind: in some moments it blows

with big intensity and speed. Along the River Vardar valley it blows with moderate speed and reaches the greatest speed in the Gevgelija and Valandovo valleys (23 $m \cdot s^{-1}$). Great speed of Vardarec is characteristic for winter months. Average month speed in January is 7.2 $m \cdot s^{-1}$, in February - 7.0 $m \cdot s^{-1}$ and in December - 6.2 $m \cdot s^{-1}$. Average speed of the Vardarec in summer is 6.2 $m \cdot s^{-1}$, while it is speed in autumn is very constant. Vardarec wind decreases the air temperature during the year. It is very cold wind in the winter. The wind Jug is frequent in Gevgelija-Valandovo valley. Its frequency is high in spring and autumn with maximum of 150‰ (May - 133‰ and October 122‰). Wind speed of Jug is much smaller than the Vardarec one. The average monthly speed is not bigger than 2.1 $m \cdot s^{-1}$. Jug is warm wind, particularly in the winter.

The Gevgelija-Valandovo valley is very spacious and framed with high mountains from west-north-west. This provides conditions for the appearance of local winds i.e. daily change of winds is expressed as a result of the different warming of the air in the bottom of the valley and in the mountain part. The local winds are most frequent in the warmest part of the year. Vardarec and Jug are result of atmospheric processes of bigger proportion. More important local wind are wind from north-west direction blowing from Kozhuf Mt .to the Gevgelija valley and eastern wind that blows mostly in June and July and very rare in winter. Besides these local permanent winds, there are some local whirl winds appearing as a result of the instability of the air mass with thunderstorm connective clouds. These winds are most frequent in spring and summer. Sometimes blow with great intensity and can damage the vegetation cover and crops.

## IV. 2. GEOMORPHOLOGIC CHARACTERISTICS

In the geotectonic point of view, the investigated area (Demir Kapija –Gevgelija) belongs to the very unstable geotectonic unit in the Republic of Macedonia known as Vardar zone of folding. River Vardar that is flowing in this geotectonic unit formed a composite valley i.e. it flows through many plain parts and gorges. After the Tikvesh basin, River Vardar cuts through the blocks composed of Jurassic limestone and have created the Demir Kapija gorge –one of the most spectacular along its river basin. After the Demir Kapija gorge, River Vardar flows through the plain part of the Valandovo valley and cuts the hilly area between v. Marvinci and v. Smokvica (Smokvica pass) and runs into the Gevgelija valley.

### IV.2.1. RELIEF

Considering geological aspect, the explored area of Demir Kapija-Smokvica belongs to a very instable geotectonic unit in the Republic of Macedonia known as Vardar zone. The region through which the corridor of the designed motorway passes is mostly mountainous area where fluvial-erosive type of relief prevails. The major characteristics of the relief were formed by the tectonic processes. The terrain has been characterized by existing of peaks with an elevation of 150-700 m whose slopes in the East steeply plunge down towards the Vardar River or towards its tributaries. After the Tikvesh basin, the Vardar River cuts the massive Jurassic limestone, builds the Demir Kapija ravine and continues to flow through flatten parts of the Valandovo valley where fluvial type of relief is dominant.

## IV.2.2. IMPORTANT GEOMORPHOLOGIC STRUCTURES

### IV.2.2.1. Aboveground geomorphologic structures

The Demir Kapija ravine, with a length of about 20 km presents a dominant geomorphologic structure of the explored terrain. It starts eastern from Demir Kapija, about 500m after the empty of the Boshava River into the Vardar River. By out flowing of the middle Vardar Lake, towards the end of the Pliocene, the Vardar River starts building this ravine penetrating gradually across the compact Jurassic limestone. In its beginning part, the Demir Kapija ravine has a character of a canyon because the sides of the ravine are almost vertical and they fall at an angle of 70-90˚. The length of the canyon part of the ravine is 900 m. The bottom of the canyon is at an elevation of 103 m while the highest peaks reach 355 m at the left side and 230 m at the right side. In the middle part of the Jurassic carbonate complex, at the left side, the spring of the Chelevechka River has been cut which also forms a canyon with a length of 750 m.

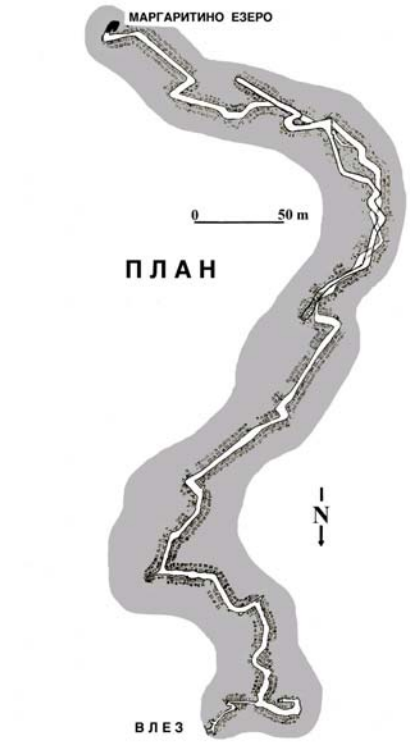
In the remaining part, the Demir Kapija ravine has a typical ravine character which was conditioned by the change of the geological composition as to the end, at the Udovo village, the terrain has been built of spilite and diabase. The fluvial-erosive relief is dominant at both sides of the river valley (Demir Kapija-Udovo) so that the inclination at the surface of the terrain formed at the right and the left side of the valley varies between 20-50˚. The average width of the bottom of the river valley in this part is 300 m to a maximal width of 600 m on some places. The widened parts of the ravine have been filled with alluvial deposits, being to 20m thick, represented at both sides of the river flow. The river valley of the Vardar River, at the right side has been cut by tributaries that have a ravine character of valleys which have formed alluvial-proluvial fans in the lower parts. Because of the low degree of weathering of the diabase, there are no typical erosive forms such as ravines and rills in the Demir Kapija ravine. At the right side of the Vardar River, significant tributaries are the following: The stream Stara Reka, the Strkovski Dol, Golema and Mala Javorica. The alignment of the designed motorway cuts the Stara Reka stream, in the middle part at a height of about 300 m, it cuts the tributaries Mala and Golema Javorica in their spring parts and it goes on along the Kratica River flow, which is a left tributary of the Petrushka River.

The wavy hilly area which stretches from the exit of the Demir Kapija ravine, at the Udovo village, continues at the right side of the Valandovo valley and ends above the Smokvica village, can be distinguished as the second geomorphologic unit. This area has been characterized with low peaks, with a gradient of the slopes of 20-30˚ which plunge down with a less gradient towards the valley of the Petrushka River or towards the Valandovo valley and river flows that have calm character. As regards the geological structure of this part of the terrain, the spillite which is rather degraded at the surface and weathered to a depth of 2-3 m as well as liable to flushing and line erosion, are dominant. The influence of the tributaries at right side of the Vardar River along with their intensive erosive activity can be clearly noticed within the peripheral parts from the western part of the Valandovo valley, expressed through numerous and

swallow ravines and rills above the following villages : Davidovo, Miravci, Miletkovo and Smokvica as well as along the Kratica Reka flow. Beneath the Miravci village, the terrain is mildly inclined in the East towards the Valandovo valley.

The third distinguished geomorphologic unit is the Valandovo Valley which stretches in the East of the Davidovo and Miravci villages. There is striking towards East-West, in the East, it is confined by southern-eastern slopes of the Belasica Mountain, in the West, by the Plaushka Mountain, and in the South, it is connected with the Gevgelija valley. The fluvial relief is characteristic for the Valandovo valley presented by alluvial fans and river valleys of large and small waterfowls. The greatest number of the alluvial fans is located at the western peripheral parts of the valleys to the following streams: Sermeninska, Kovanska, Zuica and Stara Reka, which are characteristic for the tributaries of the right side of the river Vadar. At both sides of the Vardar River, within the lower parts of the valley, there is a great area covered with terrace material.

### IV.2.2.2. Belowground geomorphologic structures (caves)




Apart from the insignificant occurrence of some karst forms at the surface of the terrain within the Demir Kapija gorge, in other words, within the carbonate complex both sides of the Vardar River, about ten (10) caves were registered as very important karst forms. The dimensions of the caves are inconsiderable with exception of the Bela Voda cave. The entrance of the cave (Photo 2) is located at the right side of the Vardar River (very near the railway station) and according to its dimensions it is one of the biggest caves in the Republic of Macedonia. It consists of two channels (a higher and a lower one), with different length (Photo 3). The length of the lower channel is 722 m, and to the higher one is 233 m, or 955 m total. At the end of the lower channel, there is an underground lake-sag pipe full of water (Fig.4).

*Fig. 4. Longitudinal and vertical profile of Bela Voda cave*

*Photo 2. Entrance of Bela Voda cave*

The cave ornaments (Photo 4), stalactite and stalagmite are very unusual while it was determined that there is modern fauna in the cave. In designing the corridor of the future motorway, the cave, being a significant geomorphologic form, should be preserved as a natural phenomenon.

*Photo 3. The main canal of Bela Voda cave*

*Photo 4. Ornaments in Bela Voda cave*

# IV. 3. GEOLOGIC AND TECTONIC CHARACTERISTICS

## IV.3.1. GEOLOGIC STRUCTURE

In the initial part of the designed alignment of the motorway, Eocene flysch sediments were ascertained at the left side of the Vardar River. The flysch sediments have been mostly presented by fine to medium grained sandstone and thin interbeds of claystone and marl which often interchange rhythmically. The horizontal, and unusually the inclined, bedding is characteristic with a thickness of the layers of 20-200 cm.

At both sides of the Vardar River, after the emptying of the Boshava River, in other words, from 1.8 to 3 km along the designed corridor of the motorway, the Upper Jurassic limestone was developed. The limestone, in the lower parts, is marly, platy to thick-bedded and it gradually interchanges into massive one. The colour of the limestone is white, grey-white to grey. Several fractures can be noticed in it, somewhere rather wide, filled with crushed limestone material. At some places, the limestone is karstificated, so that small and great caves are noticed. Basal conglomerate occurs below the limestone, which transgressively lie above the rocks of the gabbro-diabase massif. It has a green colour and it has been built of gabbro-diabase pebble, spilite etc. with a size of 5-30 cm.

Most part of the terrain has been composed of rocks of the gabbro-diabase complex which occupy a great expanse, which occur from 3-22 km along the alignment of the designed corridor, presented by spilite and diabase. They also occur at the end of the alignment from 26-28 km where they are presented by spilite and smaller masses of quartz keratiphyre. Towards West, the diabase gradually changes into gabbroid rocks, through gabbro diabase into gabbro.

Within the gabbro diabase complex, the diabase which occurs from 3-6 and 9-19 km along the corridor are dominant. It is distinguished with green or grey-green colour, suphobite structure, homogeneous and massive texture. It is fine grained and the size of the grains doesn't exceed 1mm. It is rather hard and tenacious rock, and it is often cut by veins of calcite and epidote. The major compounds are: the basic plagioclase, augite and not often amphibole. The limonite and the magnetite are accessory minerals. $SiO_2$ with 56.02 %, $Al_2O_3$ with 14.55 % and FeO with 5.80 dominate in their chemical composition. Within these minerals, here and there, parallelepiped jointing can be noticed as well as spherical one, bit not often, and fractures with different orientation, especially along the valley of the Vardar River. The diabase represented along the Kratica river have been fairly degraded at the surface, weathered and more liable to flushing and holing (cutting) in relation to the diabase represented along the valley of the Vardar River. At the same time, ravines and drills start forming with a length to 300 m and depth of 2-3 m. The diabase is mostly fractured and altered at the surface as it has undergone a process of various transformations: uralitization, sericitization, kaolinization and mechanical deformation. These fractures are filled with weathered material and calcite veins.

Within the gabbro-diabase complex, the spillite along the alignment of the designed motorway has occurred after the Jurassic limestone in the beginning part from 6-9 km, at the end of the alignment from 19-22 and 26-28 km. The spillite has been developed along the Vardar River and in the surrounding of the Klisura village where it occurs as a great mass, but at other places as well in the diabase mass, where they occupy small areas. The spilite is submarine flows, it occurs as a type of pillow lava and has dark green colour, dark purple and pure black colour. It is characterised with a vuggy reticulate structure with numerous small and large vugs with a size from 3-8 mm, filled with secondary minerals: calcite, chlorite, epidote etc. At the surface, these minerals are often flushed, so that the rocks in these cases have porous texture. The structure of the

spilite is vuggy, while the basic mass is sub ophitic. For the spilite, spherical jointing is characteristic especially expressed along the left side of the Vardar River near the tunnel at Demir Kapija, in the vicinity of villages Davidovo, Klisura etc. The size of the balls is not equal and it varies from 0.2-1 m. Considering the composition of the spilite, fine grained acicular plagioclase (albite) dominates and small quantities of pyroxene, which is mostly altered or totally destroyed. The chemical composition of the spilite is : $SiO_2$-51.80%; $Al_2O_3$-13.22%; $Fe_2O_3$-6.73%; CaO-6.35% ; FeO-6.0% ; MgO-4.17% etc. The spillite that has been represented above the villages Davidovo, Miravci, Miletkovo and Smokvica is rather degraded at the surface, weathered and more liable to flushing and holling in relation to the spilite represented along the valley of the Vardar River. At the same time, ravines and drills have been formed with a length to 200 m and a depth of 2-3 m.

Small masses of quartz- keratophyre occur towards the end part of the alignment within the spilite from 26-28 km. These masses have been represented in a form of a dike and veins. The veins have different length which varies from 10-350 m and a thickness from 1-3 m, rarely to 5 m. The contact with the spilite is sharp and clearly visible. Its colour is light green, pink and yellowish. It is fine grained, has porphyry structure and massive texture. It usually occurs along with the keratophyre from which it differs in the greater content of quartz. As regards its composition, the plagioclase is dominant and it is represented within the basic mass and as phenocryst and small quantities of quartz and rarely feldspar.

At several places in the area of the villages Davidovo, Miravci and Miletkovo, within the spilite, there are small and great masses of bedding sandstone and claystone in a form of narrow zones. Regarding the close relation with the spilite, which they interchange with, their age was determined to be Jurassic one.

The alluvial sediments have been represented in the beginning part of the designed motorway, at Demir Kapija, at the empty of the Boshava river into the Vardar River and along the flow of the Petrushka river, composed mostly of grave land sand, primarily of the gabbro-diabase composition, with a thickness of about 10 m.

The terrace sediments have been largely developed in the valley of the Vardar River, in the South of the Davidovo village and in the East of the villages Miravci and Miletkovo where they occupy a large territory. They are presented by clayey material mixed with grave land sand in the upper parts and pebbles and blocks with gravel piled without order in the deeper parts of these sediments whose thickness is about 30 m.

The diluvial deposits occur in the passing zones of the mountainous slopes towards the valley part of the Valandovo valley, in other words, at the villages Davidovo, Miravci, Miletkovo, and Smokvica and above the alluvial sediments at both sides of the Vardar River at Demir Kapija. They have been composed of slope debris mixed with sandy clay, not classified and poorly processed material.

For more information on distribution of geologic masses refer to Geologic map-Appendix I.3.

### IV.3.1.1. Engineering geological characteristics of the rock masses

The alluvial sediments and the terrace deposits have been mainly composed of coarse clastic sand and gravel, with heterogeneous granulometric and petrographic composition. They are distinguished by a good processing, low constraining, with no classification and medium to good compactness. The conditions for constructing in them are favourable, especially above the aquifers level. The conditions for working within the ground water zone have been complicated because of the constant ground water flowing up.

The diluvial deposits, composed of clayey sandy debris, have been distinguished by heterogeneous granulometric composition, poorly to medium compacted, not classified and poorly processed material. They are a favourable medium and stratum for constructing any kind of structures.

Because of the specific lithological composition and the great mechanical damage, the flysch sediments are liable to intensive surface weathering. In the surface parts, because of the weathering of its lithological members, thick deposits of diluvial detritus often occur, composed of sandy-clayey composition, with pieces of conglomerate, sandstone and claystone liable to sliding which is a characteristic of the flysch complexes. The conditions for constructing within the flysch sediments are not equalized in dependence of the local composition of the flysch, the degree of mechanical damage and bedding. On these terrains, the conditions for working do not refer to the difficult excavation, cutting, very much, but to the instability of their slopes.

The limestone occurring at the Demir Kapija gorge is massive but much fractured, with fractures that have different orientation and length to 50 m. The fractures are mostly open and filled with clayey debris. At certain places, it is karstificated, here and there, great caverns and caves occur. It is a good stratum and medium for building, but its advantage decreases with the increase of its fracturation, cavernosity and karstification. The stability of the slopes within the cuts, to the walls in the tunnels and other underground structures is great and is conditioned of the degree of fracturation of the limestone. The conditions for constructing civil engineering structures in the limestone are most usually suitable. Lining of the underground rooms is often unnecessary, except for the hydrotechnical tunnels, where it is most often obligatory and necessary.

The rocks of the gabbro-diabase complex (diabase and spilite) which dominate on the terrain are hard and tenacious, but at the surface they are weathered and covered with piled and not classified soil debris, with a thickness to 5m, more expressed in the second part of the alignment of the designed motorway. The terrains composed of these rocks are characterized by good bearing capacity and stable slopes. The conditions for working within these rocks are rather favourable, with an exception of the parts that ate tectonically more damaged and mylonitized Lining is necessary in the shaly and tectonically damaged zones. They are seismically most resistant rock masses, they are characterized by most favourable elastic properties and with equal reactions to seismic shocks. Earthquakes in these rocks can cause only local rock falling and crumbling under conditions of intensive fracturation and at inclinations of the slopes of 40-60˚. When the intensity of the earthquake is greater than 7 degrees, it may initiate everlasting damages to the structures with rare permanent deformations.

## IV.3.2. MINERAL RESOURCES

In the region where the future motorway is going to pass, actually, within the gabbro-diabase complex at both sides of the Vardar River, occurrences of copper were registered and they have been connected to the Mesozoic magmatism. The copper occurrences were ascertained in the vicinity of the Gradec village, at the left and the right side of the Vardar River valley, in the South of the Davidovo village and in the surrounding of the Negorci village. These copper occurrences are of a vein type and are related to the dislocations in the massif. Quartz veins occur with a little length and thickness, mineralized with chalcopyrite. These occurrences, because of the little reserves do not have any great economic significance.

In the immediate vicinity of the corridor to the designed motorway, there are several quarries of building stone which may be used as a material in constructing the motorway and the greatest part is located in the vicinity of Demir Kapija.

In the close surrounding of the Demir Kapija settlement, at the left side of the Vardar River, the diabase deposit is situated from where the material is used as aggregate for concrete. Very near to it, the locality Koreshnicka Krasta is found from where, kajanite-basalt was exploited, but because of the bad quality of the remaining reserves, the deposit has been abandoned.

At the left side of the entry to the Demir Kapija gorge, there is an open pit mine being under exploitation. It is a part of the big limestone massif of Upper Jurassic age with a strike North-South. It has been active for more than ten years, used by the Stock Holding Company « Granit « . Continual blasting in the quarry leads to disturbing of the general stability of the terrain within the zone of the influence of the detonations and to the geotechnical state of the rock masses in the zone of constant and future tunnel constructions through the gorge. Working in this quarry has a negative influence upon the environment; it leads to degrading and destroying certain geomorphologic phenomena, geological-paleontological localities, special landscape characteristics etc. Downstream of the gorge, at the right bank of the Vardar River, an exploitation of diabase is being performed by the same company, in the area of Javorica (Photo 5). Because of its good physical-mechanic characteristics, the material of this quarry is used as aggregate for asphalt and concrete. The concession area of the company-user is 2.5 $km^2$.

The borrow pits of sand and gravel along the Vardar valley and the marble borrow pit located at the Kosturino village -Strumica are potential locations of building stone which may be used in constructing the future motorway.

Along the valley of the Vardar River, in a wide area, there are two localities where alluvial detritus is being exploited and separated. The first is located 10 km upstream of Demir Kapija, in the East of the Przhdevo village, with an installed capacity of separation of 30 $m^3$ per hour and it is used by the company Civil Engineering Enterprise « Granit » . The second locality is found in the alluvium around the empty of the Konjska Reka into the Vardar River, 0.5 km downstream of Gevgelija. It is used by the same company and has similar capacity of separation. (Not in the area of the project interest.)

*Photo 5. Quarry of the Holding Company « Granit « in the area of Golema Javorica stream*

The marble quarry, located 2-3 km in the South of the Kosturino village, in other words 4-5 km in the East of Valandovo, in the vicinity of the regional road Valandovo-Strumica may be used as potential deposit of building stone in constructing the motorway. This quarry is used by the company »Ograzhden » from Strumica and the production capacity from all fractions is about 50 tons per hour. According to the analyses that were made, the material from this quarry can be used for all purposes in civil engineering.

In the designed corridor of the motorway, the Demir Kapija gabbro-diabase block and the Valandovo extended valley present a dominant structural form.

The Demir Kapija gabbro-diabase block, in other words, the complexes of gabbro-diabase rocks, and partially sediments of the Jurassic age, have been developed at both sides of the Vardar River. In the internal structure of the gabbro-diabase block, fractures were ascertained, somewhere filled with weathered material or with hard and tenacious rocks (quartz porphyry). The greatest length of the fractures is 350m. On the whole, two joint sets are noticed with a direction of striking NW-SE and SW-NE. In the northern part, above these rocks, a block of Jurassic limestone lies with monoclinal dip towards NW and a simple structure. The numerous registered fractures in this block have a different orientation and a length to 50m.

Towards the East from the Demir Kapija gabbro-diabase block, in other words, in the South of the Udovo village, the Serta Gradeshka anticline was developed whose orientation is towards NS-SE. In the North of the gabbro-diabase block, the Tikvesh ridge is stretches, located at both sides of the Vardar River. It is filled with Paleogene,

Neogene and Quaternary sediments and vulcanite. In the East of the villages Miravci and Miletkovo, the Valandovo valley is located. It is filled with Quaternary sediments with E-W strike. This valley was formed between the Paleogene and the Neogene.

*Photo 6. Pillow lava along the existing motor road (photo taken near village Udovo)*

### IV.3.2.1. Field of structural materials – actual conditions

Considering the necessary quantities of structural stone for construction of the highway, besides the existing quarries we shall present potential localities for exploitation. There are existing resources of structural stone directly to the settlement Demir Kapija on the left side of Vardar River. It is the field of diabase wherefrom the material is using mainly as aggregate for asphalt. Close to the same field, there is the locality Koreshnichka Krasta where from before certain time kajanite-basalt, but because of the poor quality, the rest of the reserves are unusable for this purpose and the field is leaved.

On the left side of the Demir Kapija Valley there is open pit mine in exploitation that presents part of the large limestone massive of Early Juristic Age, which comprehends surface of approximately 12km$^2$ with general spreading north – south. Opening of this quarry before more than 10 years ago caused serious reactions of the institutions for environmental protection because of eventual exploitation impacts to the natural valuable resources of the region. Namely, large part of the area (200ha) of karst region has been proclaimed for natural monument under the name of Demir Kapija Gorge yet in 1960 because of the birds of prey, habitats and flora, and also presence of different geomorphologic phenomena, geological – palaeontology significant localities,

particular landscape characteristics and similar. These values of the region were not respected by the authorities of that time and the same permitted exploitation of this quarry. Thereby, inherently were degraded primary ambient characteristics of the terrain, and because of the often blasting during mining, many animal species, predatory birds above all disappeared from their habitats forever. Otherwise, the question rises for the impact on the mining at this locality over the geo-technical condition of the rock masses within the zone of the existing and future tunnel structures through the gorge and over the general terrain stability in the zone of the detonations impact.

Close to the Regional Road Valandovo – Strumica on approximately 4 to 5 km east of Valandovo, i.e. 2 to 3 km south of the village Kosturino, several years ago, a quarry has been opened within the distal zone of a Palaeozoic marble mass spreading NWSE. The same uses the Mine Ograzhden from Strumica, and according to the installed Crushing Plants the production capacity is 50t/hour. According to the executed quality analysis of this rocky region has very good characteristics and it can have wider usage in the civil engineering.

Along the Vardar River Valley, at this region there are two active localities wherefrom alluvial sediment is exploiting and separating. One of these localities is situated east close to the village Przhdevo on approximately 10km upstream of Demir Kapija and the installed separation capacity is 30$m^3$/hour.

The other field of gravel and sand is situated in the alluvial around the confluence of Konjska Reka in Vardar River on 0,5km downstream of Gevglija and it is with similar capacity with the previous separation.

## IV.3.3. TECTONICS AND SEISMIC CHARACTERISTICS

The region where the designed motorway will pass belongs to the Vardar zone, which, according to the structural characteristics, is the most unsteady tectonic unit in the Republic of Macedonia. As regards the composition, separate types of metamorphites in this area have the same characteristics as those in the Serbo-Macedonian massif, which points to the fact that these areas in the course of the Precambrian and Palaeozoic were the only ones and they presented a unit. In the geological development of the region, 4 basic phases may be distinguished: Precambrian, Paleozoic, Early Alpine and Late Alpine stadium. The gneiss as the oldest rocks in this area was formed in the course of oldest phase, when they were compressive sediments of the great geosyncline area that was clutched between the Pelagonian massif and the Serbo-Macedonian zone. But, during the Early Palaeozoic, in the beginning of the Caledonian orogeny, the Vardar zone was distinguished from the neighbouring positive structures and was formed as a special unit with a tendency of deeper rifting and deposition of the Early Paleozoic sediments. Its major plan was made most probably during the Hercynian orogeny by intensive tectonic processes, followed by intrusions of ultrabasic and basic igneous rocks, and by the Alpine orogeny, it has been processed to that level which clearly differs from the neighbouring positive structures. The intensive tectonic processes in the course of the Alpine orogeny conditioned uprising and rifting of separate parts of the Vardar zone, in other words, formation of blocks folded in linearly expanded folds with an occurrence of breaking off**,** imbrication and overthrust accompanied by intrusion

and effusion of granite and gabbro-diabase rocks along the deep seated faults. Contrary to this, the concave parts (grabens) were established, for example: The Tikvesh, Valandovo and Gevgelija valleys.

As a geotectonic unit, the Vardar zone is a tectonic lineament of a great size, which in the South-South East sinks into the Aegean sea. In the valley of the Vardar River, it has a classical development, and in the North- North West sinks below the Neogene-Quaternary sediments of the Panonian basin. Within the explored part of the Vardar lineament, it is presented by a zone of deep faults which mutually differ in genesis, age, level of activity and expressiveness in relief with a direction of striking NW-SE. Along its whole length, the East-Northeast boundary fault, in the course of the Neogene, presented a tectonically unstable zone along which the volcanic activity was taking place, while in contemporary conditions, the activity is manifested through many post-volcanic occurrences and thermal springs. The West-Southwest contour fault has been followed by diapir intrusions of serpentinites, whose contacts with the surrounding rocks are contrastly, expressed, and a great number of them are active even today.

In relation to the seismicity, the region where the designed motorway is supposed to pass as a part of the Vardar zone is an area with high seismic risk, with an occurrence of earthquakes with maximal intensity of X degrees and a magnitude of 7 Richter degrees. The greatest part of the registered earthquakes are connected to the Valandovo seismogeneous focus which is one of the most active seismogeneous sources in the Republic of Macedonia. The high seismic activity of this area is a result of the tectonic movements where the radial movements related to the deep faults have had a dominant role. The seismic activity in the Valandovo valley is connected to the deep faults with a direction NW-SE and the fault Miletkovo-Valandovo with a meridial direction. The activism of the above mentioned faults is due to the pressures of the south part of the Serbo-Macerdonian mass to the gabbro-diabase massif which have been lasting with a changeable intensity from the Jurassic period until today. The high degree of tectonic crushing of the basic intrusive rocks in that part of the Vardar zone is related to them. The highest values of the expected magnitudes of earthquakes for the Valandovo area in the future are 6.5-7 while for the Gevgelija area they are to maximal 6 Richter degrees.

## IV. 4. HYDROLOGIC AND HYDROGEOLOGIC CHARACTERISTICS

Water of the Gevgelija –Valandovo valley is represented as underground water, springs and superficial water flows, depending on the geological composition, relief structure and climatic characteristics.

### IV.4.1. GROUND WATERS

Underground water lie on waterproof base and under permeable layers consisted of coarse sand and gravel. The common underground waters, freatic (well) waters, and the presence of artesian waters were registered as well. The most plentiful terrains with

underground waters with 10 $l \cdot s^{-1}$ situated close by river Vardar. These underground waters are connected to the water level of the river Vardar. Starting from Udovo toward the south, the area with underground waters gradually starts to expand and riches the highest proportions in the area between Gevgelija, village Gjavato and Bogdanci.

The Gevgelija-Valandovo Valley has three structure stages: Precambrian, Hercynian and Alpine stages. The rocks of the Precambrian structural stage represent compressive forms. In the Vardar zone, Bogdanci anticline and the Belasica anticay are distinguished within the Serb - Macedonian massif. The rocks of the Hercynian structural stage form the east wing of the Belasica anticline.

Within this basin, the following types of aquifers are represented: inter-granular and unconsolidated aquifer, fissured aquifer and karst aquifers. The aquifers are developed in the rocks with inter-granular porosity, i.e. the alluvial sediments, diluvial and proluvial deposits as well as the terrace, lacustrine and mud sediments. The alluvial sediments at the section of the designed alignment of the motorway are represented at Demir Kapija, at the mouth of the Boshava river into the Vardar River and long the flow of the Petrushka river, composed mainly of gravel and sand, primarily of gabbro-diabase composition with a thickness of about 10 m. Considering hydrogeological aspect, these sediments are characterized by intergranular porosity, they are water permeable and water bearing and function as a hydrogeological collector in which a confined type of aquifer was formed. The ground water level in these sediments is shallow below the surface of the terrain and it is in a hydraulic relation with the water level in the river. These sediments are composed of a mixture of sandy clay materials as well as sandy gravel debris with a total thickness of 30 m and present significant groundwater aquifers. The levels of this aquifer are various, depending on the infiltration degree and the surface water level.

The Terrace deposits at the section of the designed alignment of the motorway have been developed a lot in the valley of the Vardar River, in the South of the Davidovo village and in the East of the villages Miravci and Miletkovo where they occupy a great expanse. They have been mostly presented by grave land sand and in the upper parts by pebbles and blocks with gravel piled up without any order within the deeper parts of these sediments whose thickness is about 30 m. In the surface parts, these deposits have been covered by silty clay with fine grained composition. Considering hydrogeological aspect, these sediments are characterized by intergranular porosity, they are water permeable and water bearing as well and function as a hydrogeological collector in which a confined type of aquifer was formed. The ground water level in these sediments is shallow below the surface of the terrain.

The soil debris, at the section of the designed alignment of the motorway has been represented within the transition zones from the mountainous slopes towards the continental part and they mix with the alluvial sediments of both sides of the Vardar River at Demir Kapija. It has been composed of slope debris mixed with sandy-clay not classified and poorly processed material. As regards hydrogeological aspect, these rocks are characterized by intergranular porosity, they are water permeable and locally water bearing. They mostly function as hydrogeological conductor of ground water which gravitates towards lower elevations, while, at certain localities, they function as a hydrogeological collector depending on their composition and position.

The karst aquifer is represented in the marble and the carbonate schist, which are distributed in the Kozhuf Mountains from Vladaja, Deribash to the Belasica massif. The carbonate rocks of the Jurassic complex (limestone) have been represented in the initial part of the designed alignment of the motorway, from 1.8-3.0 km. At the surface, at several places, fractures and fissures can be noticed, and at certain places they have been affected by considerable karstification, here and there with an occurrence of greater caverns and caves. Regarding hydrogeological aspect, these rocks, at some places having been affected by karstification are characterized by karst-fracture porosity, they are water permeable and function as a hydrogeological collector in which, a karst-fracture type of aquifer was formed and a ground water level mainly at an elevation of the Vardar River. According to the type of karstification, they belong to the group of medium karstification with a density of karst occurrences to 10 per 1 $km^2$The circulation and the accumulating of groundwater are being done through systems of fractures and caverns, mutually well connected and 100 m in depth. The aquifer is recharged by precipitation and the drainage by many springs with a yield of over 1 1/s.

The Eocene flysch sediments were ascertained in the initial part of the designed alignment of motorway, at the left side of the Vardar River. Concerning hydrogeological aspect, these sediments are poorly water permeable to water impermeable, with slightly expressed fracture porosity shallow below the surface of the terrain. They are in practice a water impermeable medium and the terrains that were formed by these sediments are waterless. The most part of the precipitation run down at the surface, a very little part in the underground, and at the same time taking away the surface weathered material which is deposited within the lower parts of the terrain.

The rocks of the gabbro-diabase complex are dominant along the alignment of the designed motorway. Regarding hydrogeological aspect, these rocks are, here and there, characterized by fracture porosity with very poor water permeability to practical water impermeability, but in places, because of the great number of fissures and fractures, they could be poor collectors. Aquifers of ground water have been formed in the shallow parts below the surface, poor with water and the numerous springs have a small discharge. The ground water level in these rocks is in the shallow parts below the surface of the terrain. Most part of the precipitation runs down at the surface, a very little part in the underground, at the same time taking away the thin detritus that is deposited in the lower parts of the terrain.

In the Gevgelija-Valandovo valley, the average thickness and the surface area of the Quaternary sediments are estimated to be 15 m and 114 $km^2$. The static amount of groundwater resources in the Quaternary sediments of the Gevgelija-Valandovo valley is calculated to be 342 million $m^3$. The dynamic amount of groundwater resources in the Quaternary sediments of the Gevgelija-Valandovo valley is calculated to be 0.3 $m^3$/sec. Regarding determination of the amount of karst groundwater resources in the Lukar aquifer of the Kozhuf Mountain, the infiltration area is estimated to be 20 $km^2$ The amount of karst groundwater resources in the Lukar aquifer is calculated to be 0.55 $m^3$/s. In the case of karst groundwater resources in the Huma aquifer of the Kozhuf Mountain, the infiltration area is estimated to be 200 $km^2$ and the amount of karst groundwater resources in the Huma aquifer is calculated to be 0.18 $m^3$/s.

## IV.4.2. SURFACE WATERS

The hydrographic network of the terrain along the designed motorway has been well developed. There are many rivers and streams, which belong to the catchment areas of the rivers Petrushka and Vardar.

The major water artery of the terrain is the river Vardar towards which the tributaries Starata Reka, Strkovski Dol, Golema and Mala Javorica, Simenska river, the Petrushka river flow as well as other smaller watercourses located mainly at the right side of the river, while at the left side, the greater tributaries of the Vardar River are the following: Chelevechka Reka, Stojkov Dol, Arazliska Reka, Mushtenica, Kosharechka Reka, Lutkovska Reka and the Anska Reka. The Petrushka Reka, being the greatest tributary of the Vardar River, at the right side was formed by its tributaries: the stream Kalica, the Starata Reka, the Gabrovska Reka and the stream Varnica. Most of the watercourses are constant but poor with water and only a small part of them are temporary. The greatest part of the registered springs are not captured, with a low discharge and they do not have a great significance.

The constructed dams, being important water economy structures, are located at the section Miravci-Miletkovo and we consider that they are out of the possible Alternative B for the alignment of the motorway. Considering the existing hydro-technical structures, an important one is the Kalica dam, built at the same called tributary of the Petrushka River, with an available volume of 640,000 $m^3$ with which about 150 ha are irrigated. The water economy base foresees a construction of five dams more, of which two are within the wider zone of planning the alignment of the motorway. It is the dam of the Petrushka river with an available volume of 4,000,000 $m^3$. It is supposed to irrigate about 100 ha, as well the dam of the Kovanska Reka with an available volume of 10,000,000 $m^3$.

The project for constructing the dam to the Vardar River, Gradec is a capital water economy and hydroenergetic potential, but the water of the future reservoir will not have an influence to the magistral communications, except to the railway, which in conditions of a construction will have to be dislocated above the maximal elevation of the reservoir.

The river system in Gevgelija - Valandovo valley is represented by river Vardar. River Vardar has a source on the south slopes on Shara Mt., near the village Vrutok (Gostivar) at 683m.a.s.l. The total length, till the Aegean estuary in Greece is 388 km with 301 km belonging to Macedonia. It has the dominant 20535 $km^2$ drainage area in Macedonia as well. The total inclination of the riverbed is 640 m, while the average relative one is 2.1%.

The river Vardar on the section from Udovo to Gevgelija, as opposite to its part in the area between Demir Kapija- Udovo (30 km in length) has all characteristics of typical lowland river (Photo 7 and 8). The average inclination of the riverbed in the Valandovo valley is 1.0 ‰, in Smokvica isthmus is 1.19 ‰ and in Gevgelija valley- 0.72 ‰. River rapids appear only in places where the river is influenced by torrent flooding that have deposited large amounts of coarse material. Bank erosion in Gevgelija - Valandovo valley is very intensive process. As a result of it the destruction of the river banks and

horizontal dislocation of Vardar Riverbed is quite often phenomenon. It is especially expressed near the railway station Miravci, where the right site bank is under strong influence of this process. The left side bank and the already existing motor road are threatened by this process in area of the village Josifovo. The destruction of the riverbanks, more intensive on the left side, continues downstream allowed to the Smokvica ishtmus. Accumulation of the sand and gravel is dominant process in these places. Also, it is stimulated by the water- flows after torrent rainfalls that inflow into river Vardar from both sides. Thus, the river flow is divided into many river arms and become wild and makes additional bends.


*Photo 7. General view of Vardar valley*

In the area of the road corridor for alternative 1, river Vardar has about 32 km length. It is characterised by faster flow in the upper part of the corridor (Demir Kapija– Smokvica), steep slopes rising on some places directly from the river banks, the river bank is mostly stony and gravely, and fast flow does not enable organic sediment formation. The water is characterised by high degree of turbidity almost throughout the whole year.

The water flow of river Vardar in Gevgelija-Valandovo valley during the whole year is varying. Average water current quality at the water- meter- station (Gevgelija) is 170m³/s, the maximum is 2400 m³/s and minimum is 14.4m³/s. In the same time, this water quantity is the biggest in Republic of Macedonia.
River Vardar has high water level during the spring period as a result of the snow melting and spring rains. High water level may appear during the autumn, due to the long lasting and intensive rainfalls. The low water level was registered (August) with tendency of changing in September due to the low rainfall quantity, intensive evaporation, water sinking into earth and the use of water for irrigation.

*Photo 8. River Vardar*

During the periods of high water level, river Vardar floods out of its riverbed. These flooding may be of catastrophic dimensions such are floods in 1838, 1895, 1900, 1907, 1916 and 1937. During these periods the water level reached over 7m at the bridge near Gevgelija. Recent floods, as in 1962 and 1979, were registered.

Many tributaries inflow into the river Vardar in the Gevgelija–Valandovo valley such are Anska Reka (Bojmica), Luda Mara (from the left side) and Stara Reka, Zuica, Kovanska Reka, Sermeninska Reka and Konjska Reka (from the right side).

Anska Reka is left tributary of river Vardar. The spring of Anska Reka is situated in the west foothill area of Belasica Mt. It flows in the south part of Valandovo valley. Its length is 22 km with drainage area of 168 km². The total inclination of the riverbed is 492m, while the average relative is 2.2%. The river Anska Reka has similar characteristics of water flow and riverbed as Vardar in that area. The water level is varying to a great degree as a consequence of its water use in irrigation purposes. There are period during the summer when there is almost no water in the riverbed. River is divided in well-developed network of irrigation channels. There are few tributaries in the upper part of Anska Reka (Prsten Tepe, Kodzha Dere and others). Till 1958 Anska Reka was flooding in the plains of Valandovo, Pirava and Marvinci and was causing big damages. The average water current quantity is 1.08m³/s.

River Boshava, According to its basic characteristics is completely different in respect to Vardar and Anska Reka. It has characteristics of a mountain river along the largest part of river flow, i.e. very fast flow, stony bed, and mostly clean water. At the lowest part, before its mouth of the river Vardar it becomes more similar to Vardar by all characteristics, due to the human influence from Demir Kapija town. Namely, the last 2 km of the river are passing through or next to the town.

The spring of Stara Reka stream is in the foothill area of Marjanska Mt. and all the way to Miletkovo flows in a hilly- mountainous area. In this part, Starata Reka has great number of tributaries such as: Klisura, Kriva Reka, Crnevska Reka etc. Starata Reka (Photo 9) flows in the Miletkovo Pole plain, after v. Miletkovo to mouth in the river Petrushka Reka (Photo 10). During the periods of high water level, it floods out its

riverbed and deposits large amounts of coarse material on fertile soil. The length of Stara Reka is 22.3 km and the surface of its drainage area is 84 km². Average annual water current quantity is 0.67 m³/s.

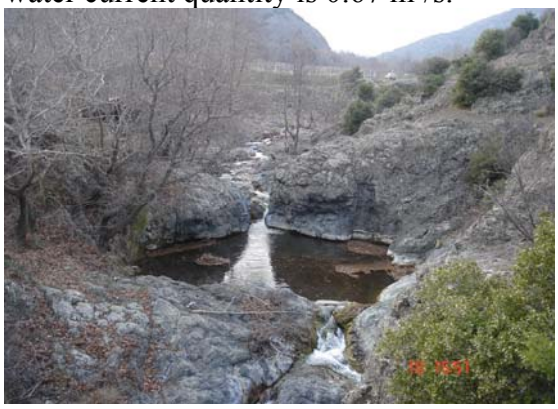


*Photo 9. Stara Reka stream*

*Photo 10. Petrushka Reka stream*

*Photo 11. Mala Javorica stream – lower flow*

*Photo 12. Mala Javorica stream – upper flow*

*Photo 13. Golema Javorica stream - middle flow*

*Photo 14. Golema Javorica stream - upper flow*

*Photo 15. Stara Reka river – lower flow*

*Photo 16. Stara Reka river – middle flow*

Tab. 11. *Overview of the main rivers and streams in the corridor area*

| **Right tributaries of Vardar River** | **Approximate point of crossing with highway Alternative B** | **Left tributaries of Vardar River** | **Approximate point of crossing with highway Alternative A** |
|---|---|---|---|
| River Boshava | Km 0+900 | Chelevecka Reka | Km 1+600 |
| Stara Reka (Photo 15 and 16) | Km 5+700 | Kosharachka Reka | Km 6+200 |
| Linski Dol | Km 9+100 | Lutkovska Reka | Km 8+700 |
| Golema Javorica (Photo 13 and 14) | Km 10+100 | Gradeshka Reka | Km 14+000 |
| Dragovski Dol | Km 11+800 | Stream Mushtanica | Km 15+100 |
| Mala Javorica (Photo 11 and 12) | Km 14+300 | Arazliska Reka | Km 17+500 |
| Simenska Reka | Not crossing | Anska Reka | Km 28+800 |
| Petrushka Reka (Photo 9 and 10) | Km 22+300 | - | - |
| Dukovec Dol | Km 25+700 | - | - |

In the area with the most plentiful terrains, the well water is obtained from depth of 6 to 20 m and in the lower parts nearby the river, from 1 to 2 m. In the spring, when the river Vardar has high water level, underground water is very close to the surface on some places. Such situation was noticed at the locality Gjolot and partly at the locality Dimchev Chair. In the areas poor with underground waters, it lies on the depth of about 20 m.

Water springs are characteristic and very important phenomena in the Gevgelija-Valandovo valley. Their appearance is not equal in the whole area, due to the differences in petrographic composition, elevation, climate and forestation of the terrain. The greatest number and the most plentiful springs is in the foothill area of mountain massifs, below the highest peaks, on the river terraces and on the valley slopes. The greatest number of springs was registered on the foothill area of Kozhuf Mountain and Plavush Mountain. Particularly great number of spring originates at the source area of Konjska Reka, carstic region around village Huma and in the region of Balija (on the north from Valandovo and village Pirava). The water springs in these regions are characterised by the water capacity of 4-10 $l \cdot s^{-1}$ and do not get dry during the whole year. Some of them, like "Izvorot" near Valandovo, "Fik" and "Shopot" near village Negorci, "Shupkar Cheshma" near village Huma have water capacity higher than 10 $l \cdot s^{-1}$.

Thermo-mineral and mineral springs that originate in many places connected to the fault lines are of a special importance for Gevgelija –Valandovo valley. The most famous are springs near village Negorci. Many springs are present there on a relatively small area. Such springs exist in the source area Konjska Reka, near village Konjsko and Gornichet. There is excavated well with thermal water near village Smokvica, close to the river Vardar. It is considered that an extremely rich area with thermal water is the area between villages Smokvica and Grchishte.

## IV. 5. PEDOLOGIC CHARACTERISTICS

Pedological characteristics will be presented by the description of the natural and modified soil types in the highway corridor area as well as the intensity of erosion that implies the quality of the soils.

### IV.5.1. SOIL TYPES IN THE ROAD CORRIDOR AREA

The presence and distribution of the soil types in the highway corridor area are given according to the monographs “Soils of the Republic of Macedonia” (Filipovski 1997-2004).

Pedological composition is diverse in the river Vardar valley (from Demir Kapija to village Smokvica). There are atypical (non-developed) soils and typical (developed) soils that were formed due to different influence of pedogenetic factors (bedrock, relief, climatic and hydrographic characteristics). Alluvial, delluvial, silicate syrozem and skeletal soils (lithosols) are the most abundant of the atypical soils. Typical soils are represented by cinnamon soils (Fig. 5: 15a+35) and very rare and insignificantly by vertisols. Cinnamon soils are the dominant soil type in the area, especially under natural vegetation.

**Cinnamon soils** are the climazonal soil type in the highway corridor area. They have richer clay horizon (B) that lies between horizon A and C. These soils appear on the localities where the influence of Mediterranean climate (climazonal soils) is well expressed. Cinnamon soils in the investigated area occur up to 500 m a.s.l. and mainly in the xerophilous and thermophilous oak vegetation (forest communities of *Quercus*

*coccifera* and communities of *Quercus pubescens* and *Carpinus orientalis*) as well as under pastures. Cinnamon soils in the agricultural land have changed characteristics due to the anthropogenic influence. Although the climatic-vegetational factors are dominant, some other ones (relief, parent material, time and human influence) have great importance for their genesis, evolution and features. They appear in the parts of with wavy-hilly (fluvio-denudation) relief and on the lake terraces. Cinnamon soils are formed on the different types of parent material. The bedrock determines their characteristics and their subtypes (e.g. in the foothill area of Kozhuf Mt. they are formed on the parent material; on the delluvial soils appear young, undeveloped cinnamon soils).

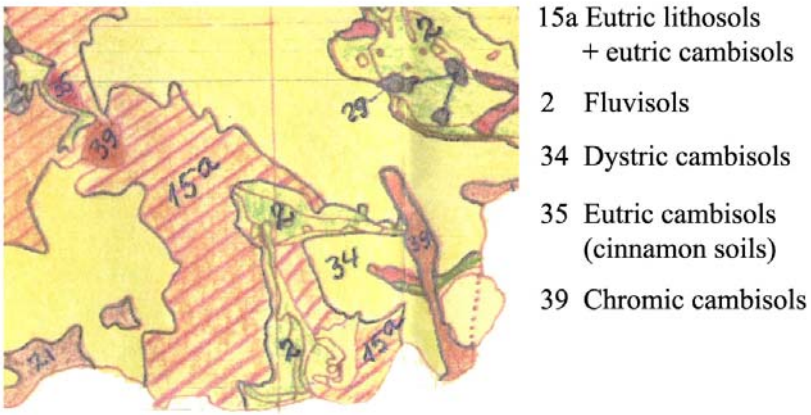



*Fig. 5. Distribution of the main soil types in the wider area of interest*

**Cambisols** (brown forest soils) in the highway corridor area are present in the well developed oak forests. These soils are the next stadium of development of the cinnamon soils. Cambisols in the highway corridor area are distributed in the area of Demir Kapija and probably in the upper parts of the highway corridor area – Kalica river valley (Fig 5).

**Alluvial soils** may be found in the middle part of the valley that extends up to 100 m a.s.l. They are widely distributed along the river Vardar. The layers of these soils are well sorted. They are water permeable i.e. have well expressed capillary ability for the water ascending. Alluvial soils are poor with humus (under 1 %). There are many varieties of alluvial soils in dependence of some specific features. Such varieties are alluvial fine sorted carbonates, alluvial shallow soils on gravel materials, alluvial covered soils etc. The most distributed is the alluvial fine-sorted soil.

The formation of **lithosols** depends on parent material and on the conditions of the locality (relief, climate, and vegetation). Lithosols in the investigated area are formed on different compact rocks. The most of the lithosols are formed of the bedrocks that produce stony (skeletal) detritus without grus and small particles. They appear only on higher parts of the mountain relief with steep inclinations (over $30^0$).

Lithosols are not used as agricultural land because these are shallow soils and they have unfavourable skeletal characteristics. Another reason is that they appear on very steep slopes. Some of them are covered by poor pastures, and another part is afforested (mostly with degraded forests).

**Syrozems (regosols)** represent undeveloped substrate and poorly developed soils. They appear after erosion of previously existing soils on the remained material. Lithosols are shallow (20 cm), they have lithic contact and they are formed above massive rocks. Regosols are deeper, they do not have lithic contact and they are formed over mealy substrate. Regosols are conquered quicker by the higher flora and so, the pedogenesis is more intensive. Regosols in the investigated area appear on wavy hilly terrain (up to 800 m a.s.l.) where the erosion is intensive as a result of the destruction of the Oak complex. The characteristics of regosols depend on the parent material in the greatest part. These are rocks that easily disintegrate into grus or minute detritus. The profile of regosols is morphologically weakly differentiated.

**Delluvial (coluvial) soils** are formed by the erosion and transportation of the parent material and soils and sedimentation of the material in the foothills of these parts. These processes are caused by the torrent water-streams from the higher mountain and hilly regions. Important factors of their pedogenesis are the climatic conditions (torrent rainfalls and aridity of the climate i.e. poor natural vegetation and hard revival of the destroyed vegetation. The conditions of their formation are changing through the time, from one place to another and consequently they are very heterogenic. Delluvial soils may turn into different soil as a result of the influence of shallow underground waters or by the influence of the pedogenesis' processes in a longer period of time. In the investigated area the delluvial soils, in the most part, develop into rendzinas and cinnamon forest soils with appearance of cinnamon–red-brown horizon (B) that is more compact, more rigid and more clayey than the rest horizons of the profile. Compared to the alluvial soils (that usually border with), the delluvial soils have less productive features i.e. they are less sorted and they appear on terrain that is not so flat (as in the case of alluvial soils). They are poorer with water i.e. the underground water in these soils are on bigger depth. These soils are not used as agricultural land and represent very poor pastures in the greatest number of cases.

**Anthropogenic soils** are distributed in the agricultural area of the highway corridor area since their genesis is connected exclusively with the anthropogenic activities. **Rigosols** are the soils that are formed by human intervention in the vineyards and orchards; **hortisols** can be found in the gardens which are fertilized for longer periods of times, probably in the vicinity of Demir Kapija, Miravci and Smokvica; **anthropogenized soils** can be found in the previously mentioned natural soil types which are modified by erosion stimulated by human activities.

### IV.5.2. SOIL EROSION (EGZOGEODINAMIC PROCESSES AND PHENOMENA)

The terrains along the alignment for highway are characterized with complex geology structure, matured relief and relatively low representation and extensive of contemporary egzodynamic processes and phenomenon. On the processes intensity and representation affect different factors: lithology structure, region position and appearance of lithology components, rocks resistances and physiognomy, degree of decay, hydrogeology and geology characteristics of rocks, morphological conditions and terrain surface conditions. On the research terrain are developed next recent engineer geology processes: washing processes and inline erosion, rocks boulder, alluvial fan, and karstifications. As results of these processes are formed gulch,

presence of different kind of karst forms, rocks slide and high sediments of alluvium and proluvial debris disposed in the periphery parts of the Vardar Valley.

The processes of surface washing and gulch forming are most significant in rock masses from gabbros diabase complex (spilites and diabases) in the riverflow of river Kalica and river Petrushka and also over the villages Davidovo, Miravci, Miletkovo, and Smokvica. The processes of surface washing are in direct connection with surface rocks destruction which rapidly influenced on relief forming. As result of the processes of line erosion were formed numerous water gullies and gulches statement on researched terrain. During construction of the highway it is necessary to take measures for effectively drainage and safety disposal of rainfalls, especially on the places with riverflows, dales, and streams, using different methods and construction of channels, gutters, manholes, to protect the road surface and the future highway construction.

The processes of landslide are poorly developed on the research terrain. The most frequent are terrains constructed from good rocks, on the aslope parts of the terrain (vertical and sub vertical) represented with mechanical separation, falling, and surface rock destruction under exogenic factors. The separated materials (different granulations and blocks) under gravitation fall and disposed in the base of the slope thereat making alluvial fans, rockfalls, which have to be taken into consideration during designing and highway construction.

Karstifications processes are developed on terrains composed from carbonate rock masses and have big influence in forming of the relief. The results of carstification processes, which mean chemical resolution of carbonate rock masses under influence of surface and underground water flows, form geomorphologic and speleological forms – caves.

During detail design elaboration for highway the technical planner have to provide temporary and permanently safety disposal of soil and rock materials during highway construction. Thereat the soil landfill have to be designed with adequate safety slopes, surface protection from atmospheric influences, and drainage, all in accordance with positive actual standards and best engineering practices to mitigate negative environmental impact assessment.

# IV. 6. LANDSCAPE AND BIOGEOGRAPHIC CHARACTERISTICS

## IV.6.1. BIOGEOGRAPHY

The region of Demir Kapija is the warmest and almost the driest part of Macedonia. It is under the strongest Mediterranean influence, which is the main factor for its floristic, fungal and faunal composition.

The origin and the genesis of the biological diversity in the project area are closely related with the regional geological history, the climatic change in the past and the recent conditions. All these characteristics, accompanied with the migrations that had been presented during the Pleistocene glaciations, as well as in the postglacial period resulted in the recent composition of the local faunal and floral diversity. Consequently, the most striking features of the Demir Kapija gorge region biodiversity today are its richness and heterogeneity, especially Mediterranean faunal and floral elements.

### IV.6.1.1. Basic features of faunal biogeography

From zoo-geographical point of view, two main faunal complexes of Species - Eremial and Arboreal are present in the area of intention.

I. The Eremial complex of faunal elements includes species that originate from the Aral-Caspian Region adapted to survive in dry steppe-like and semi-desert conditions. In the project area these species are mostly present within the belt of *Sub-Mediterranean Region* (up to 600 m) in open habitats, mainly grasslands.

II. The Arboreal complex of faunal elements in the area of project interest is represented with its Mediterranean sub-complex. It encompasses species that are predominantly connected with broadleaved woodlands. It is further split on Holo-Mediterranean and Ponto-Mediterranean (East-Mediterranean) faunal elements. Within the Demir Kapija gorge and Miravci region the species that belongs to this sub-complex inhabit the belts of the *Sub-Mediterranean* (up to 600 m).

### IV.6.1.2. Basic features of floral biogeography

There is no common and widely accepted phytogeographical division of the territory of the Republic of Macedonia, although there are many attempts as a result of extensive botanical investigations in the region (there is no common biogeographical division either). The difficulties and different approach of different authors result from specific transitional position of Macedonia in Europe and Balkan Peninsula and from its specific geological history. The most important fact in this respect is lack of glaciations on the most of its territory (except for the highest mountains) which contributed for maintaining very rich biodiversity (floral and faunal). Lower Vardar valley was one of the most important refugial zones in Macedonia during Pleistocene glaciations.

For the purpose of this study, the most convenient division is the following (???):

Macedonian territory belongs to the Euro-Siberian sub-zone of the Holarctic floristic region. The following two floristic provinces are characteristic for the area of the highway corridor (compiled on the basis of different authors - Kostadinovski, not published):

1. Mediterranean biogeographical region, represented by its
    1.1. European-submediterranean sub-region, with its
        1.1.1. Macedonian-Thrace province

This is the area of Kermes oak (*Quercus coccifera*) shrublands, which occupies the lowest elevations of the slopes that create Demir Kapija gorge. It is much degraded on the left side of the river and more preserved (it has appearance of a real forest) on the right side of the river.

2. Middle-European biogeographical region, represented by its
    2.1. Sub-Middle-European-Balkan sub-region, with its
        2.1.1. Scardo-Pindic province

This is the area of Pubescent oak and Oriental hornbeam forests and woodlands. In the region of Demir Kapija gorge it grows above the previous vegetation type (biome) or on the northern faced slopes. In the region of interest (highway corridor as defined in Chapter II.1.) is distributed only on the slopes on the right side of the river Vardar.

The landscape division (section bellow) for the project area can be used as biogeographical division as well since the approach of Matvejev (biome division) and Filipovski at al. (vegetational-climate-soil division) is biogeographically based.

## IV.6.2. LANDSCAPES

Very important characteristic of the intention of constructing the highway from Demir Kapija to Miravci is that (especially in case of Alternative B) it will occupy almost entirely natural or seminatural territories. That is why the landscapes in the area of intention have natural appearance. The part from Miravci to Smokvica has more anthropogenic features - rural areas and more or less degraded habitats.

One principal landscape can be distinguished in the project area - **Sub-Mediterranean (hilly) forested landscape**. This principal landscape can be sub-divided into several functionally and spatially distinctive units. These are:

- limestone canyon part of Demir Kapija gorge
- Demir Kapija gorge from the canyon down to village Udovo
- hilly more or less natural area from village Klisura to village Udovo and
- broad valley from Udovo to Smokvica (Valandovo valley).

However, precise definition of landscape type(s) in the affected region is not possible due to the absence of landscape division of the country's territory (Republic of Macedonia) based on the contemporary perception of the landscape and its scientific concept.

To exceed this situation, one can use the existing biome (Matvejev 1995) or climate-vegetation-soil zones (Filipovski et al.) division. Especially biome division of Matvejev is appropriate since the author has landscape approach and formerly he used terms biome and landscape as synonyms.

According to Matvejev (1995) there are two types of forest biomes in the area of project interest: (a) Sub-Mediterranean-Balkan forests, and (b) Balkan-Middle European forests.

The second biome is not typical since the altitude in the whole project area is lower than typical altitudinal zone for this biome. There are only fragments of Balkan-Middle European forests on higher elevations of the project area (above 300 meters) only in deep valleys perpendicular to the main Vardar valley, from its right (western) side. Shady and moist conditions in these valleys have offered suitable sites for existence and survival of these atypical and azonal forest communities and have served as refugial sites for such mesophyllic forests. Actually, these forests are the most interesting and the most valuable biodiversity components in the area of intention. Due to the fragmentary character and small area that these communities cover, they are not prominent feature of the region as a whole. They are rather mixed and "lost" in the surrounding Sub-Mediterranean-Balkan forests and do not contribute for distinguishing separate landscape type. However, they give the landscape specific structural diversity.

Due to the above mentioned, only one landscape type in the area of the project interest can be distinguished - Sub-Mediterranean hilly forested landscape.

### IV.6.2.1. Sub-Mediterranean (hilly) forested landscape

Basic feature of this landscape is domination of dark Jurassic diabase bedrock mostly covered with shrubby vegetation of Kermes oak as characteristic species. Main geomorphologic feature is the long Vardar valley surrounded by small or high hills that are cut by deep dales or valleys perpendicular to the main valley direction. Dense, forest vegetation covers these dales mainly composed of Oriental plane community. Anthropogenic character of the landscape in the area of the project intention is not

expressed as in the Gevgelija region (on the south of the project area), but it is present all over the area. Main anthropogenic features are: line infrastructure (power lines, roads and railway), small fields and gardens along the valleys, individual houses in the valleys and few villages.

As mentioned before, four separate units of this landscape can be distinguished along the area of intention based on geological and geomorphologic features and degradation stage of the natural vegetation.

- limestone canyon part of Demir Kapija gorge
- Demir Kapija gorge from the canyon down to village Udovo (bottom of the valley)
- hilly more or less natural area from village Klisura to village Udovo and
- broad valley from Udovo to Smokvica (Valandovo valley).

### IV.6.2.1.1. Natural features of Sub-Mediterranean hilly forest landscape

The most striking features are the rich biodiversity of the landscape and particular geological features.

There are at least two very special biodiversity features that should be mentioned - domination of Kermes oak community (association Coccifero-Carpinetum orientalis) and frequent occurrence of Oriental plane communities (Juglando-Platanetum orientalis), shrublands and woodlands. For details see sub-chapters of V.1. This landscape (in accordance with Filipovski et all.) occupies the southernmost part of Macedonia with total participation of about 2% in country's territory. Since the road corridor is entirely in this territory, the destruction of the habitats in this landscape has significant impact on overall national biodiversity.

Due to Mediterranean character of the flora, fungia and fauna, this region is extremely rich in biodiversity (for details, see Appendix II). The level of biodiversity significance is pronounced with its refugial character, i.e. presence of many relict communities that give special aspect to the landscape - beech forest that grow on the lowest elevation in whole Macedonia (or probably the whole Balkan Peninsula), as well as rich Oriental plane community. Very important vegetation type for the landscape appearance is development of Greek juniper on many places as a tree stands of sporadic individuals everywhere.

Specific units of this landscape are described bellow.

1. Limestone canyon part of Demir Kapija gorge is the northernmost part of the project area and northernmost part of Kermes oak distribution. It is the narrowest part of the whole Vardar valley from the source to the mouth and it is about 1 km long. It distinguishes from the rest of the landscape because of the vertical cliffs, more than 200 m high, dominating white colour, and diverse plant communities (but all sub-Mediterranean with Kermes oak). Development of Phillyreo-Carpinetum orientalis, Pruno webbii-Juniperetum excelsae and Centaureo-Ramondietum nathaliae and other communities is the unique character for these cliffs. Vulture colony is the most striking feature of the canyon - large Griffons and Egyptian vultures are often flying above the rocks.
2. Demir Kapija gorge from the canyon down to village Udovo (bottom of the valley) is the dominant landscape unit along the alternative A. It is a continuation of the canyon. The valley is broadening and it has a feature of a gorge with different width along the valley. But, this is not the only difference to the previous landscape

unit. The main characteristic is the river Vardar flow with its narrow alluvial plain and dark bedrock with degraded Kermes oak shrublands on the slopes.

3. Hilly more or less natural area from village Klisura to village Udovo is the landscape unit with the most preserved natural characteristics in the whole landscape. Dense and more or less high shrubland and woodland stands are common in the area. Oriental plane stands along the dales are the most specific feature.
4. Broad valley from Udovo to Smokvica (Valandovo valley) differs from previous landscape units according to its geomorphology (it is more or less flat) and the most degraded natural Kermes oak vegetation. The most of it is actually the wide Vardar valley plain.

Geomorphologic and biodiversity characteristics of the region were described in more details in sub-chapters of Chapter IV.2.

#### IV.6.2.1.2. Anthropogenic features of Sub-Mediterranean hilly forest landscape

Human aspect of the whole landscape can be assessed as an important feature of the whole area. However, the natural features were low to moderately change throughout the rich history of the region (an important transport route since antiquity - Roman period). Archaeological sites are very abundant, especially in the wide valley plain from Udovo to Smokvica although they are not giving particular physiognomic appearance to the landscape. The reason for this low human intervention is inaccessible slopes of the gorge inadequate for agriculture and non-valuable timber produced in Kermes oak plant community. That is why the southern part of the project area in the wide Vardar valley was the most altered part of the landscape.

Different landscape units as defined above in the area of project interest are characterised by different degree of human interventions.

1. Limestone canyon part of Demir Kapija gorge is unsuitable for human use due to its steep slopes and sparse vegetation. However, the lowest parts of the canyon, next to the river, are heavily used since the available space for the main transport corridor (ETC 10) is only a few tenths of meters. Existing motor road E-75 is passing the canyon through a tunnel and it is not spoiling the landscape, but transmission lines and railway are giving the landscape human dimension.
2. Demir Kapija gorge from the canyon down to village Udovo (bottom of the valley) is a continuation of the canyon and continuation of the line infrastructural object - motor road from the left side of the river and railway from the right side. Very sparse individual houses (non-residential) can be seen from the right side. There are a lot of small fields and acres in alluvial plain along the river Vardar, especially on the sharp bends. The rest of the landscape is more or less natural, except for the ugly recent intervention - the quarry for diabase rocks from the right side of the river at km. 8+700
3. Hilly more or less natural area from village Klisura to village Udovo is the landscape unit characteristic for the large part of the area where alignment according to the alternative B is going to be constructed. There are almost no human interventions in this area.
4. Broad valley from Udovo to Smokvica (Valandovo valley) landscape unit is under the strongest anthropogenic influence. It is flat and fertile area where intensive agricultural activities are practiced (from the left side of Vardar (Udovo-Josifovo-

Marvinci) and area with gentle slopes with extensive agriculture practices (right side of the river - Davidovo-Miravci-Miletkovo-Smokvica. The most important feature of this landscape unit is presence of human settlements. All villages are active and dense populated. Main occupation of the population is agriculture. Line infrastructural objects are much more developed compared to the previous landscape units. (For details see Chapter VI.5.1.)

# V. DESCRIPTION OF ECOSYSTEMS AND HABITATS

During the field mapping and analysis of the aerial photographs of the area of highway corridors a high diversity of habitats was registered. This was expected concerning the diversity of geological substrates, relief, climate, hydrological characteristics, historical and cultural development of the area under consideration.

Historically, the investigated area was populated permanently for millennia. The strong and long lasting human impact on the environment, especially forests, resulted in different kinds of changes in the sense of degradation of natural ecosystems and producing new, managed ecosystems. The degradation of forests and shrublands led to appearance of hill pasture communities which are characterized by anthropogenic features. There are very diverse, mainly small fields and acres, vineyards, orchards, meadows and others. Most of them are managed using traditional practices and still hold a number of species of surrounding natural habitats.

The habitats in both highway corridors are divided in two main categories according to their origin: natural and anthropogenic habitats. Natural habitats include forests and shrublands, grasslands, rocky sites and water habitats. The division inside these categories followed criteria such as presence of different plant communities, distribution, degradation level and geomorphologic features, but the main criterion was the division proposed by Palaearctic Habitat Classification (European Commission, DG Environment).

Description of the habitats follows this pattern: description of the plant association, dominant and most common plant species and characteristic fungi species. Fauna of the habitats is presented by vertebrates (amphibians, reptiles, birds and mammals) and selected groups of invertebrates (dragonflies, ground beetles and daily butterflies). Fish species and some other groups of invertebrates (caddis flies, mayflies) are analysed in the description of wetlands. At the end of the description of habitats, their general distribution range and distribution in the highway corridor is presented.

The complete lists of species by habitats are presented in appendices: Appendix I.1. - plant species; Appendix II.2. – fungi; Appendix II.3 – fauna (Appendix II.3. – vertebrates (Appendix II.3.1 – amphibians; Appendix II.3.2. – reptiles; Appendix II.3.3. – birds; Appendix II.3.4. – mammals); Appendix II.4. – invertebrates (Appendix II.4.1. – dragonflies; Appendix II.4.2. – ground beetles; Appendix II.4.3. – daily butterflies)).

## V. 1. NATURAL FORESTS AND SHRUBLANDS

Forests and shrublands are divided into four habitat types: pseudomaquis, oak forests (forests of *Quercus pubescens* and *Carpinus orientalis*), refugial beech forests and riparian habitats.

Almost the whole area (from Demir Kapija to Smokvica) is situated in the belt of thermophyllous mixed evergreen and deciduous forests or shrublands belonging to the European-submediterranean sub-region – Macedonian-Thrace Province. It is dominant type of vegetation that determines the features of the Submediterranean hilly forested landscape.

The forests of *Quercus pubescens* and *Carpinus orientalis* represent the upper vegetation belt in the highway corridor area. They belong to the Sub-Middle-European-Balkan sub-region and its Scardo-Pindic province. In the frames of this zone, refugial beech forests can be found in the gorges of streams, penetrating outside of their main altitudinal zone (above 1000 m).

Plane woodlands and belts are developing in the gorges of streams as well as dales and ravines in the area of thermophyllous kermes oak shrubland. These habitats penetrate from the lowest parts of the highway corridor area up to 400-500 m a.s.l.

All of the four habitat types have been under strong anthropogenic pressure for many centuries. Almost all of them are in different stages of degradation. The degradation level was second criterion for division of forests and shrublands, especially the kermes oak shrubland (preserved, sparse and degraded).

### V.1.1. PSEUDOMAQUIS

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 32.71 Helleno-Balcanic pseudomaquis

The community of Kermes oak *Quercus coccifera* (Photo 17), an evergreen shrub-like oak (which is forming the typical plant association for this area - **Coccifero-Carpinetum orientalis** Oberd. 1948 emend. Ht. 1954) represents the habitat. This climazonal community in the Republic of Macedonia is spread up to Demir Kapija that is the north border of its areal. The community is occupying all steep and rocky terrains from the plain (57 m a.s.l.) up to around 400 m altitude.

There are other plant associations in the zone of the pseudomaquis. These associations are connected to different degradation stages or the development of the soil. Thus, association **Paliuretum submediterraneum (Riz., prov.)** is characteristic for highly degraded habitats, **Phillyreo-Carpinetum orientalis** develops on rocky sites etc. Rocky sites are very diverse according to the species composition and many other plant communities can be distinguished: Rhus coriaria shrubland (**Rhuetum coriariae** Toma{evi} 1959), Greek juniper shrubland (**Pruno webbii-Juniperetum excelsae** Em**)** and some other grass communities.

General qualitative composition of plant, fungal and animal species is very similar throughout the pseudomaquis. Thus, it is described in general context bellow. However, one should have in mind that the dominant species are different in the parts of the pseudomaquis which makes possible to distinguish two principal habitat types: kermes oak shrubland and shrubland on rocky sites. Specific properties for each habitat type are presented separately.

**Fungi**: The fungia of this biotope is characterised by thermophyllous, Mediterranean species. Lignicolous fungi are more characteristic since the dry climate is not

favourable for development of terricolous species. The most specific thermophyllous species for this habitat are *Peniophora meridionalis*, *Pulcheritium caeruleum*, *Meruliopsis hirtellus*, *and Vuilleminia megalospora*. The presence of thermophyllous trees and shrubs with limited distribution within the region, as a host to different substrate specific fungal species, caused presence of rare fungal species as well. Particularly for this biotope, 23 lignicolous species are noted for Kermes oak, 10 for *Phillyrea media*, 8 for *Juniperus oxycedrus* and 15 for Greek Juniper (evergreen trees and shrubs) and 43 fungal species on *Carpinus orientalis*, 23 on *Fraxinus ornus* etc. (deciduous trees). The most characteristic species for this habitat are *Peniophora quercina* and *Vuilleminia megalospora* (on *Quercus coccifera*), *Antrodia albida* (on *Phillyrea media*), *Peniophora jinipericola*, *Hyphodontia juniperi*, (on *Juniperus oxicedrus*), *Antrodia juniperina* and *Pyrofomes demidoffii* (on *Juniperus excelsa*) etc.

Among terricolous fungal species *Astraeus hygrometricus*, *Tulostoma brumale*, *Stropharia coronilla* are characteristic for this biotope. A comprehensive list of fungal species is presented in the Appendix II.2.

Since the fauna of the pseudomaquis is very similar in all of its types (well preserved, degraded etc.), the description of the common species is presented hereafter. The differences and specifics of the pseudomaquis types will be presented in respective sections.

*Photo 17. Kermes oak (Quercus coccifera)*

Most of the animal species living in the pseudomaquis are characteristic for dry and warm regions i.e. Mediterranean and mostly subterranean. Animals of the dense

evergreen oak shrublands prefer much more the open terrain in the community. For animal species compositions see Appendix II.3 and II.4.

**Vertebrates**

**Mammals** - characteristic and common species are Brown Hare (*Lepus europeus*), Red Fox (*Vulpes vulpes*), Wolf (*Canis lupus*), Golden Jackal (*Canis aureus*), Wild Boar (*Sus scrofa*) etc.

**Birds** - large number of species can be found here, owing to high number of breeding species (ca 50), but also large number of foraging species, especially birds of prey. Characteristic species for this habitat type are two Mediterranean passerine species, the rare Rufous Bushchat (*Cercotrichas galactotes*) and Sardinian Warbler (*Sylvia melanocephala*). One rare bird of prey is the Short-toed Eagle (*Circaetus gallicus*), with few pairs in the region of interest. Common species are Cirl Bunting (*Emberiza cirlus*), Sombre Tit (*Parus lugubris*), Blackbird (*Turdus merula*), Jay (*Garrulus glandarius*), Subalpine Warbler (*Sylvia cantillans*) etc.

**Reptiles** - characteristic and rare species are the Turkish Boa (*Eryx jaculus turcicus*) and European Legless Lizard (*Ophisaurus apodus*), while common species are Balkan Green Lizard (*Lacerta trilineata*), Greek Tortoise (*Testudo graeca*), Erhard's Wall Lizard (*Podarcis erhardii riveti*), Nose-horned Viper (*Vipera ammodytes*), Western Four-lined Snake (*Elaphe quatuorlineata*), Dahl's Whip Snake (*Coluber najadum*) etc.

**Amphibians** - due to generally dry conditions in the habitat, the overall number of amphibians is low, and there are no characteristic species. Commonly found species is the European Green Toad (*Bufo viridis*).

**Invertebrates**

Pseudomaquis is unique habitat type in Macedonia from the aspect of the composition of the invertebrate fauna. Many of the characteristic species of the area are spread in the southern parts of Macedonia, along Vardar River and its tributaries. The most common and characteristic species are centipedes *Scolopendra cingulata* and *Lithobius* spp., scorpion *Mesobuthus gibbosus*, spiders of the family Lycosidae (*Hogna radiata, Lycosa vultuosa*).

Regarding daily butterflies (Rhopalocera), the most characteristic species of this habitat are: *Iphiclides podalirius,* (Papilionidae), some satyrid species (*Hipparchia fagi, Maniola jurtina, Neohipparchia statilinus*) and pierid species (*Pontia edusa, Pieris mannii, Aporia crataeg, Euchloe ausonia*). *Colias crocea, Gonepteryx rhamni, Polyommatus icarus* and *Maniola jurtina* can be found in many different habitats including pseudomaquis.

Family Carabidae is represented by many thermophyllous species: *Zabrus brevicollis, Pachycarous atrocoerules, Carterus dama, Harpalus spp., Ophonus spp., Carabus graecus morio, Carabus preslii jonicus, Carabus coriaceus emgei*.

In the open places of the shrubby forests there are many orthopteroid species such as *Ancistrura nigrovittata, Poecilimon macedonicus, Saga natoliae, Acrida sp., Dociostaurus marrocanus*, *etc.*

### V.1.1.1. Kermes oak shrubland

The characteristic plant association is Coccifero-Carpinetum orientalis which implies the dominance of Oriental hornbeam (*Carpinus orientalis*). However, in the degraded stands the Kermes oak is dominant species and gives the appearance of the pseudomaquis. The dominance of kermes oak over the Oriental hornbeam in the present time is secondary feature produced through the anthropogenic influence in past periods. Humans exploited deciduous species (such as Oriental hornbeam, ash, white oak) and thus increased the abundance of evergreen species, especially the Kermes oak, juniper species and *Phillyrea media*.

Three separate types of the kermes oak shrubland were recognized on the basis of their degradation level.

*Photo 18. Well preserved pseudomaquis*

*Photo 19. Sparse pseudomaquis*

#### V.1.1.1.1. Well preserved kermes oak shrubland

*Carpinus orientalis* has edificatory role in the preserved sites, but *Quercus coccifera* and *Quercus pubescens* are also very abundant (Photo 18). Among evergreen species *Quercus coccifera* and *Phillyrea media* dominate, but also *Juniperus oxycedrus* and *Juniperus excelsa* are common. Other important tree species are *Fraxinus ornus* and *Pistacia terebinthus* and shrub species: *Colutea arborescens*, *Coronilla emeroides*, *Jasminum fruticans*, *Cistus incanus* etc., than liana species: *Ephedra campylopoda*, *Clematis flammula*, *Lonicera etrusca* and others. Characteristic species in herb layer are: *Anemone pavonina* var. *purpureoviolacea*, *Crocus chrysanthus*, *Romulea bulbocodium* and others. The extended list of plant species growing in this habitat type is given in the Appendix II.1.

**Distribution**: This biotope is distributed exclusively in the southernmost part of Macedonia up to 600 m a.s.l on south expositions. Its northernmost distribution is up to Demir Kapija, thus occupying the whole highway corridor as well as Gevgelija, Valandovo, Dojran and Strumica valleys.

**Distribution in the area of the road corridor**: the best areas representing this biotope are on the right side of the river Vardar, from Demir Kapija to village Davidovo. Only a small areas of the left side are covered by dense pseudomaquis community (see Habitat map-Appendix I.4.).

### V.1.1.1.2. Sparse kermes oak shrublands

The same plant community characterises this habitat as well. The difference results from the lower percentage of deciduous species (*Carpinus orientalis, Quercus pubescens, Fraxinus ornus, Pistacia terebinthus* and others) due to their overexploitation in the past, but also at present, so the physiognomy of the community has been changed (Photo 19). *Quercus coccifera* and other evergreen elements mark out the present appearance of the community such as *Phillyrea media*, *Juniperus oxycedrus* and *Juniperus excelsa*.

Other characteristics that separate this biotope from previous are: much better developed herb layer, due to the presence of open spots and clearings between the evergreen shrubs, than shallow, eroded soil, dense ravine system, smaller or bigger bare rocks etc. During the winter period green colour dominates as opposite to previous biotope, where brown colour with green spots is more characteristic.

The fungal composition is very similar to the previous biotope since it represents the same habitat and same host tree and shrub species. The difference is that here lignicolous macromycetes developing on evergreen tree species are predominating.

**Distribution**: The same remarks as for the previous biotope are true for this one too.

**Distribution in the area of the road corridor**: Almost all slopes from the left side of the Vardar valley, from Demir Kapija to Smokvica are occupied by this biotope. It is also presented sporadically on the small hills in the lower part of the road corridor (area of the village Smokvica). (see Habitat map-Appendix I.4.).

### V.1.1.1.3. Highly degraded kermes oak shrubland

This biotope type differs greatly from previous two, since both evergreen and deciduous tree and shrub species are very sparse (Photo 20). Degraded natural pseudomaquis stands representing this biotope are usually invaded by *Paliurus spina-christi*, *Pyrus amygdaliformis*, *Prunus spinosa*, *Juniperus oxycedrus* etc. (Photo 21) The plant association that represents this habitat is **Paliuretum submediterraneum Rizovski prov**. It differs from the other associations with domination of *Paliurus spina-christi* in different succession stages: in other areas it develops into Querco-Carpinetum orientalis, while in the area south of Demir Kapija it develops into Coccifero-Carpinetum orientalis.

The most important plant species in the tree layer of this association are *Paliurus spina-christi, Quercus coccifera, Phillyrea media, Juniperus oxycedrus, Juniperus excelsa, Pistacia terebinthus.* The herb layer is composed of *Minuartia glomerata, Euphorbia myrsinites, Ajuga laxmanii, Asphodeline lutea, Knautia orientalis, Tunica illyrica, Althea cannabina* etc.

Smaller or larger grassland areas discontinue the stands. Among other grass species, tall grasses like *Chrysopogon gryllus*, *Andropogon ischaemum* etc. are characteristic. This plant community is formed as a result of high anthropogenic pressure; thus characteristic elements of natural vegetation are rare and occasional. The natural vegetation has been cut in order to enlarge the agricultural areas or pastures. The typical biotope of highly degraded pseudomaquis has usually secondary origin, since the above mentioned elements invade abandoned fields and pastures afterwards. Consequently, this kind of biotope is usually distributed close to the settlements and next to the arable fields.

*Photo 20. Highly degraded Kermes oak shrubland on rocky sites (left side of Vardar valley)*

*Photo 21. Highly degraded pseudomaquis – Paliuretum submediterraneum*

The characteristic lignicolous fungal species for the biocoenosis defining this biotope more or less lack here, due to the absence of adequate hosts, but new tree species as *Paliurus spina-christi* with 9 lignicolous fungal species growing on it and *Pyrus amygdaliformis* with 15 species are enabling development of other fungal species such are *Peniophora incarnata* for *Paliurus spina-christi* and *Lopharia spadicea*, *Corticium polygonioides*, *Phlebia rufa* etc. for *Pyrus amygdaliformis*. Nevertheless, terricolous fungi have greater diversity in this biotope. Among others, *Pisolithus arrizus*, *Amanita vitadinii*, *Myriostoma coliforme* etc. are specific for this habitat.

Composition of the fauna is very similar to the overall fauna of pseudomaquis. A main specificity is that species of open terrains in the community are dominating over the species typical for well-preserved pseudomaquis. This especially refers to the invertebrate fauna such as daily butterflies *Hipparchia fagi, Neohipparchia statilinus*, *Pontia edusa, Artogeia mannii, Aporia crataegi* and ground beetles (*Harpalus dimidiatus, Harpalus rufipes, Ophonus azureus, Ophonus cribricollis, Cymindis coadunate, Amara aenea*). On the open places in the shrublands there are many orthopteroid species.

**Distribution**: This biotope is also connected to the pseudomaquis type, and so the remarks for general distribution are the same.

In the area of the road corridor it does not have regular distribution, but it is connected to the village surroundings, close to the agricultural land and usually close to the existing roads and railway (see Habitat map-Appendix I.4.).

### V.1.1.2. Shrubland on rocky sites

This habitat type is represented by two main communities: sparse *Phillyrea media* shrubland and Greek Junipers community accompanied by the *Rhus coriaria* shrublands (the latter is presented by association **Rhuetum coriariae** Toma{evi} 1959 characterised by domination of *Rhus coriaria*).

#### V.1.1.2.1. Sparse *Phillyrea media* shrubland on rocky sites

**Reference to Habitat Directive:** No specific reference

**Reference to Palaearctic Habitats:** No specific reference

Very sparse *Phillyrea media* shrubland occurs on rocky sites, but more often on the cliffs and bare rocks of the Demir Kapija canyon. Thus, it is described in Chapter V.3.1.1. Sparse *Phillyrea shrubland* on rocky sites is not presented separately on the Habitat Map (Appendix I.4.), but in the scope of *Phillyrea media* habitat on cliffs and rocks.

### V.1.1.2.2. Greek Juniper community

**Reference to Habitat Directive:** 9560 *Endemic forests with *Juniperus* spp.
**Reference to Palaearctic Habitats:** 42.A3 - Grecian juniper woods (*Juniperetum excelsae*) - forest formations dominated by *Juniperus excelsa*, of the *Ostryo-Carpinion* zone of the mountains of northern Greece (up to 900-1000m, around lake Prespa);

Plant associations **Pruno webbii-Juniperetum excelsae** occupies the rocky sites in the Demir Kapija gorge on both sides of the river Vardar (Photo 22). Dominant species is *Juniperus excelsa*. This species grows in the crevices of the limestone rocks, as well. Other important species of this community are *Prunus webbii, Phillyrea media, Prunus mahaleb, Pistacia terebinthus, Fraxinus ornus, Paliurus spina-christi, Ephedra campylopoda, Asyneuma limonifolium, Cerinthe retorta, Asphodeline lutea* etc.

The extended list of probable plant species growing in this biotope is given in the Appendix II.1. concerning the rocky area.

*Photo 22. Greek Juniper shrubland on rocky sites (Shtuder locality)*

The qualitative composition of fungi is very similar to that of biotopes 1.1.1. and 1.1.2., because of presence of the same dendroflora species.

Composition of the fauna is very similar to the previous habitats, but it is much poorer. The greatest deal of the species in the shrublands on bare rocks and rocky places are rare, even the species that are more frequent in the dense or sparse pseudomaquis forests.

Butterflies *Pyrgus sidae* and *Coenonympha pamphilus* are probably more frequent in this biotope than in other types of pseudomaquis. Characteristic butterflies for open rocky habitats with shrubs are: *Erynnis marloyi, Antocharis grunei, Carcharodus alceae, Lampides boeticus, Neohipparchia fatua, Polygonia egea, Leptidea duponcheli* and *Tarucus balkanicus.*

**Distribution:** This habitat is sporadically distributed on the slopes of Vardar valley and lower flows of its larger tributaries. It is strictly connected to the rocky and stony areas.

**Distribution in the area of the road corridor**: In the highway corridor this kind of biotope is distributed only on the rocks of Demir Kapija gorge covering relatively small area. The *Rhus coriaria* community is distributed as patches on the right side of the Demir Kapija gorge (not presented on Habitat map-Appendix I.4.).

## V.1.2. FORESTS OF PUBESCENT OAK AND ORIENTAL HORNBEAM (OAK FORESTS)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 41.82 Oriental hornbeam woods

It is characterised by the forest community **Querco-Carpinetum orientalis macedonicum** Rud. 39 apud Ht. 1946 (Photo 23). This thermophyllous and xerophyllous community is developing under regional climatic influence on the skeletal soils. The edifier species is Oriental hornbeam (*Carpinus orientalis*), and very abundant and frequent is Pubescent oak (*Quercus pubescens)* – Photo 24. Beside these tree species *Fraxinus ornus*, *Colutea arborescens*, *Coronilla emeroides*, *Acer monspessulanum*, *Rhamnus rhodopaea* are coming in the tree and shrub layers and *Cyclamen neapolitanum*, *Carex halleriana* are characteristic for the herb layer. The extended list of plant species growing in this biotope is given in the Appendix II.1.

The fungal characterisation of this biotope is presence of fungal species developing on deciduous trees such are *Radulomyces molaris*, *Vuilleminia comedens*, *Stereum hirsutum*, *Daedalea quercina*, *Dichomitus campestris*, *Hapalopilus rutilans* etc. (on *Quercus pubescens*) and *Hyphodontia crustosa*, *Steccherinum ochraceum*, *Phellinus punctatus* etc. (on *Carpinus orientalis*). The terricolous fungi are characterised by thermophyllous species like *Leccinum griseum*, *Amanita caesarea*, *Boletus fechtneri* etc. A comprehensive list of fungal species is presented in the Appendix II.2.

The characteristics of fauna representing this biotope are more or less the same as pseudomaquis type, at least in the area of the road corridor.

*Photo 23. Forest of Pubescent oak and Oriental hornbeam*

*Photo 24. Pubescent oak (without leaves) and Oriental hornbeam (foliated)*

**Vertebrates**

**Mammals -** Mammal fauna is similar with the one in Pseudomaquis. Nevertheless, some Rodent species (*Apodemus sylvaticus, Mus macedonicus, Dryomys nitedula*) can be found. Wild cat (*Felis silvestris*) is a typical forest species. Brown bear is common visitor in the area of this forests (frequently coming from Kozhuf-Nidze mountain range for feeding).

**Birds -** this is another habitat rich wit bird species (more than 60 species), two thirds of which are breeding. Common birds for the oak forests are Blackbird (*Turdus merula*), Jay (*Garrulus glandarius*), Chaffinch (*Fringilla coelebs*), Great Tit (*Parus major*), Robin (*Erithacus rubecula*) etc. There are two species with very small populations in Macedonia breeding in the oak forests around Demir Kapija, the Booted Eagle (*Hieraaetus pennatus*) and Black Kite (*Milvus migrans*).

**Reptiles -** Composition of reptiles is similar to that from the pseudomaquis. Erhard's wall lizard (*Lacerta erhardii riveti*), Green lizard (*Lacerta viridis*), Balkan green lizard (*Lacerta trilineata*), Aesculapian snake (*Elaphe longissima*), Dahl's Whip Snake (*Coluber najadum*) etc.

**Amphibians -** due to the more humid environmental conditions, more amphibian species are found here than in the pseudomaquis. The most characteristic species are Fire Salamander (*Salamandra salamandra*), Common Toad (*Bufo bufo*), Green Toad (*Bufo viridis*), European Tree Frog (*Hyla arborea*) etc.

**Invertebrates**

Ground beetle fauna is similar to the one of the pseudomaquis. Its composition is presented in Appendix II.4.2. The most interesting species are *Laemostenus cimmerius*, *Carabus coriaceus emgei* and *Carabus preslii jonicus*.

**Distribution**: This association is widespread in Adriatic and Aegean submediterranean region. In Vardar and its tributaries it is climazonally distributed up to about 600 m a.s.l. and on southern slopes it is climbing up to 1000 m altitude.

In the area of the road corridor this habitat is represented by small areas, only touching the corridor of Alternative B - on the right side of the river Vardar.

In some of the localities in the dales on the right side of Vardar valley, a special species complex with Box (*Buxus sempervirens*) is developing. Similar "habitat type" is mentioned under Habitat Directive as **5110 Stable xerothermophilous formations with *Buxus sempervirens* on rock slopes (*Berberidion* p.p.)** which corresponds to **31.82 Box thickets** of the Palaearctic classification. The stands are characterized usually by large boulders and deep soil. The tree layer in this habitat is consisted of tall tree species (*Quercus* spp., *Carpinus betulus, Fraxinus ornus*) but the most prominent feature is the evergreen shrub layer of Box. At some of the localities, Box can be found in the tree layer, as well. This unique species combination has the best stands at Golema Javorica gorge. Since the presence of Kermes oak is common in these stands, it is difficult to distinguish separate habitat out of dense pseudomaquis. That is the reason why this "habitat type" is not presented on the Habitat map, although the value of the site was stressed in many occasions.

In the upper parts of the Oak forest belt (Alternative B: Ushite, Stefan, Miravsko Ushche and Golata Chuka) there are stands of Italian oak (*Quercus frainetto*). This stands represent small patches of the forest belt **Quercetum frainetto-cerris macedonicum**, which is normaly above the lower Oriental hornbeam-Pubescent oak belt. In the area of project interest (Alternative B) it only touches the highway corridor and does not have particular significance for further analyses of impacts. Thus, it was not considered (and mapped) in details.

### V.1.3. BEECH FORESTS

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 41.17 Southern medio-European beech forests (41.175 Sub-Mediterranean calcicolous beech forests)

The beech forests that develop at lower altitudes belong to the piedmont beech belt. The beech forests in the area of Demir Kapija (Marjanska Planina Mt.) are peculiar having in mind the altitude they are developing on. These beech forests can be found in the sheltered localities of the gorges of streams and dales or ravines at altitudes of 500 m and lower. These types of beech forests are typical for the refugial regions.

The refugial beech forest on Marjanska Planina (Javorica region) is represented by the submediterranean beech community (ass. **Aristolochio-Fagetum** Em 1965 prov. = as. Fagetum submediterraneum). The dominant substrate is diabase. Only at the locality Linski Dol the substrate is consisted of basalt rocks. The soil is deep and fertile, and most probably cambisol.

The composition of the flora can not be presented in details due to the lack of data. It is characteristic that the species of oak forests prevail in this beech community. The following plant species were registered during field observations: *Quercus petraea, Carpinus betulus, Tilia tomentosa, Ostrya carpinifolia, Carpinus orientalis, Buxus sempervirens, Ilex aquifolium, Hedera helix, Corylus avellana, Aristolochia rotunda* etc.

There are probably some stands with Box (*Buxus sempervirens*) that gives distinctive features of the shrub layer. Such habitats may be included in habitat type 41.1751 Box beech forests of the Palaearctic Classification of habitats.

In the area of the highway corridor it is distributed in the catchment areas of streams Javorica and Klisurska Reka (Krastavec hill). The beech forest on Davidovski Rid in the catchment of stream Mala Javorica (locality Ushite) was destroyed in the period after World War II. Other stands in the area of interest are also heavily degraded and beech can only be found sporadically. Typical stands of this forest type are not present within the road corridor.

Refugial beech forests are distributed in several regions in Macedonia, especially western parts. The submediterranean beech community is recorded only for Marjanska Planina (area of Alternative B), Plavush Mt. and Serta Mt.

**Vertebrates**

**Mammals -** Mammal fauna is similar with the one in Pseudomaquis. Nevertheless, some Rodent species (*Apodemus sylvaticus, Mus macedonicus, Dryomys nitedula*) can be found. Wild at (*Felis silvestris*) and Brown Bear (*Ursus arctos*) are a typical forest species.

**Birds** - As the surface of this habitat is very small and on low altitude, there are no bird species that are typically found in the montane beech forests, but species moainly coming from the neighbouring habitats. Common are Robin (*Erithacus rubecula*), Blackbird (*Turdus merula*) and Chaffinch (*Fringilla coelebs*).

**Reptiles -** There is relatively small number of typical species, with Aesculapian Snace (*Elaphe longissima*) being most characteristic.

**Amphibians -** The composition of amphibians is very similar to that of the oak forests.

## V.1.4. RIPARIAN FORESTS, WOODLANDS AND SHRUBLANDS

These forests and shrublands are developing along the riverbanks and streams everywhere in the area under consideration (Photo 25). Well-preserved forests of this type are very rare presently. People were clearing these stands for providing fertile alluvial soil for agriculture. The advantage of Oriental plane wood biomass over oak's and hornbeam's was also important in this sense.

In this area, the forest communities belong to **Platanion orientalis** I. et V. Kárpáti 1961, **Salicion albae** Soó (30) 1940 alliance and shrublands to **Tamaricion parviflorae** I. et V. Kárpáti 1961 alliance.

### V.1.4.1. Well developed *Platanus orientalis* forests and woodlands

**Reference to Habitat Directive:** 92C0 *Platanus orientalis* and *Liquidambar orientalis* woods (*Plantanion orientalis*)

**Reference to Palaearctic Habitats:** 44.711 - Helleno-Balkanic riparian plane forests

This biotope is azonal distributed since the plant community that defines the biotope (**Ass. Juglando-Platanetum orientalis** Em et Dzhekov 1961) is developing along the rivers and streams up to 500 m a.s.l. on sandy, gravely or stony soils. The stands are usually temporarily flooded during the rainy period.

The forests of this type in the investigated road corridor are at different stages of degradation and typical mature communities are very rare.

The Oriental plane (*Platanus orientalis*) occupies the dominant position in the community and by its appearance and dimensions it determinates the physiognomy of the forest and thus the whole habitat. Beside Plane, *Juglans regia* has optimal growing conditions there. In some stands close to the river Vardar, *Salix alba*, *Populus alba*, *Populus nigra* and other hygrophilous tree species are present as well.

The special characteristic of this biotope is the presence of different liana species such are: *Hedera helix*, *Humulus lupulus*, *Periploca graeca*, *Vitis silvestris*, *Clematis vitalba*, and beneath them: *Solanum dulcamara*, *Clematis flammula*, *Marsdenia erecta*, *Rubus caesius* etc.

*Photo 25. Willow woodland and Plane belts along river Vardar*

In the herb layer *Ficaria grandiflora*, *Cynanchum acutum*, *Thalictrum angustifolium*, *Rumex tuberosus*, *Plumbago europaea*, *Dracunculus vulgaris* are common (Appendix II.1.).

*Platanus orientalis* in this particular habitat represent a host to 17 lignicolous fungal species among which *Panus tigrinus*, *Auricularia mesenterica*, *Stereum hirsutum*, *Laetiporus sulphureus*, *Schizopora paradoxa* are more important, and *Juglans regia* only to 6 (*Fomes fomentarius*, *Polyporus squamosus*, *Polyporus varius*, *Schizophyllum commune* etc.) Some of them, like *Fomes fomentarius* and *Ganoderma adspersum*, are dangerous parasites on old stems. The terricolous fungi are represented by species of *Russula*, *Agaricus* and *Lepiota* genera. (Appendix II.2.)

The fauna of the Plane community is very similar to the fauna of willow woodlands (V.1.4.1.) and shrublands of *Tamarix* and *Salix amplexicaulis* (V.1.4.5.) i.e. most of the animal species are common for these biotopes. Similarity is determined by the presence of the water ecosystems near these biotopes. Thus, the fauna of the biotope near river Vardar and its tributaries is very similar to the fauna of the biotopes near the ponds and channels filled with water. The main difference is the frequency of the species. Generally, animals in the Plane forests are less abundant than in the willow woodlands.

**Vertebrates**

**Mammals -** Vicinity to the rivers and broadleaved trees offer mammals' a good shelter, variety of food and water. Thus, the diversity of mammal species is bigger in this habitat. Most characteristic ones are: *Erinaceus concolor, Talpa europea, Lepus europeus, Canis aureus, Vulpes vulpes, Felis sylvestris*. Some bat species (*Pipisterllus pipistrellus, P. nathusii, Nyctalus noctula, Myotis mystacinus*) can be found in the hollow trees as well.

**Birds** - Bird composition of these narrow habitats depends on the bird assemblages in the neighbouring habitat. This habitat offers good conditions for foraging and breeding, and bird species are abundant. Characteristic species is the Levant Sparrowhawk (*Accipiter brevipes*) which rarely breeds on the larger plane trees. Common species are some finches (Goldfinch *Carduelis carduelis*, Greenfinch *Carduelis chloris*), Tits (Great Tit *Parus* major, Blue Tit *Parus caeruleus*), Blackbird (*Turdus merula*), Jay (*Garrulus glandarius*) etc.

**Reptiles** - similar to birds, reptiles usually find in the neighbouring habitats are found in this habitat as well. Some other whip-snakes (Aesculapian Snake *Elaphe longissima*, Leopard Snake *Elaphe situla*) are more common here than in the pseudomaquis.

**Amphibians** - due to more humid conditions in this habitat, amphibians are more numerous and diverse. Among the common species are Balkan Stream Frog (*Rana graeca*), European Tree Frog (*Hyla arborea*), Common Toad (*Bubo bufo*), Fire Salamander (*Salamandra salamandra*), etc.

**Invertebrates**

The Fresh-water Crab (*Potamon fluviatilis*) is very interesting inhabitant of the Plane community. It was registered near the Chelevechka Reka stream.

The group of Dragonflies (Odonata) is very diverse and represented by many species. The most common and distributed in the whole investigated area are *Orthetrum brunneum, Sympetrum sanguineum, Epallage fatime* and *Calopteryx splendens*.

Coleoptera is represented mainly by the ground beetles (Carabidae) such as *Chlaenius festivus, Tachyura diabrachys, Pterostichus nigrita, Bembidion* spp. as the most abundant species. Most common species of butterflies are *Limenitis reducta, Lasiommata maera, Thymelicus sylvestris, Polygonia c-album*, *Celastrina argiolus*, *Apatura ilia*, *Vanessa atalanta* etc.

In the projected road corridor the *Platanus orientalis* woodlands are more common than forests. They are spread throughout the whole corridor, along almost all streams and rivers. Well preserved forests are presented along Chelevechka Reka, the area along Petrushka Reka, Javorica river etc. (see Habitat map-Appendix I.4.).

The community that defines this biotope is distributed along the river Vardar valley up to river Pchinja inflow into Vardar on the north and in Strumica and Dojran region.

### V.1.4.2. Belts of *Platanus orientalis* along the rivers or in the dales and ravines

**Reference to Habitat Directive:** 92C0 *Platanus orientalis* and *Liquidambar orientalis* woods (*Plantanion orientalis*)
**Reference to Palaearctic Habitats:** 44.711 - Helleno-Balkanic riparian plane forests

Stands of the community that characterise the previous biotope are preserved as narrow belts along the streams and rivers, but also along the dales and ravines (Photo 26). These belts are more common than well-developed forests or woodlands. They are characterised by poorer floral composition and often lack of some characteristic elements.

These belts are regularly distributed along almost all ravines and dales in the investigated road corridor. The plane belts can be found along river Vardar and all of its tributaries from their inflow to the source areas in the highway corridor (see Habitat map-Appendix I.4.).

*Photo 26. Plane belt along Kalica stream*

### V.1.4.3. Well developed willow woodlands

**Reference to Habitat Directive:** *Salix alba* and *Populus alba* galleries
**Reference to Palaearctic Habitats:** 44.1412 Eu-Mediterranean white and crack willow galleries

The willow woodlands in the investigated area are developing on alluvial sandy soils on the river bank terraces. The ground is flooded regularly during the wet period. The biotope is characterised by permanent humidity, light structure and texture of the soil. On the wider areas along the rivers, often, open terrain and small meadows are present.

This woodland type belongs to the **Salicetum albae-fragilis Soó (1930, 1934) 1958** association. The most characteristic tree species are *Salix alba*, or mixed *Salix alba* and *Salix fragilis*. *Populus nigra*, *Salix triandra*, *Sambucus nigra*, *Viburnum opulus*, *Cornus sanguinea*, *Rhamnus frangula*, *Amorpha fruticosa* etc. are coming in small groups or individually. On some stands poplar trees (*Populus nigra*, *Populus tremula* and *Populus alba*) are dominating and the stand reminds the typical poplar community.

In the herb layer the most characteristic species are: *Poa trivialis*, *Poa palustris*, *Carex vulpina*, *Polygonum lapatifolium*, *Polygonum hidropiper*, *Rumex sanguineum*, *Veronica anagalis-aquatica*, *Scirpus lacustris* etc.

The willow woodland biotope is very rich with fungi, especially lignicolous, due to the high humidity and the diversity of host trees. Some species, like *Phellinus igniarius*, *Trametes gibbosa* and *Fomes fomentarius* are dangerous parazites on *Salix* spp. and *Populus nigra*. Some others, like *Perenniporia fraxinea*, *Funalia trogii*, *Ganoderma adspersum*, *Ganoderma resinaceum*, *Pleurotus ostreatus*, *Laetiporus sulphureus* etc. are saprophytes (Appendix II.2.).

**Vertebrates**

**Mammals** – the fauna of mammals is very similar fauna to the previous habitat.

**Birds** - characteristic species for this habitat are Cetti's Warbler (*Cettia cetti*) and Penduline Tit (*Remiz pendulinus*). Many other species use willow trees for breeding and protection, and commonest are Nightingale (*Luscinia megarhynchos*), Robin (*Erithacus rubecula*), Blackcap (*Sylvia atricapilla*) and few others. Many migratory species, especially herons (Ardeidae) use willows as roosting places.

**Reptiles** - the most common species are Grass Snake (*Natrix natrix*) and Dice Snake (*Natrix tesselata*).

**Amphibians** - species composition is similar to that of the Plane belts, but some species, especially Lake Frog (*Rana ridibunda*) and Southern Crested Newt (*Triturus carnifex*) are more common.

**Invertebrates**

Daily butterflies are well represented in this habitat. Most common species are: *Plebejus argyrognomon, Lycaena tityrus* and *Leptots pirithous*.

**Distribution**: This biotope is common for almost all lowland rivers in Macedonia.

In the area of the road corridor well preserved willow forest are presented at the lower flow of river Vardar, especially the district of village Marvinci, Prdejci, Grchishte etc. (see Habitat map-Appendix I.4.).

### V.1.4.4. Belts of willows along the rivers and streams

**Reference to Habitat Directive:** *Salix alba* and *Populus alba* galleries
**Reference to Palaearctic Habitats:** 44.1412 Eu-Mediterranean white and crack willow galleries

Stands of the community that characterise the previous biotope are preserved as narrow belts along the streams and rivers. These belts are more common than well-developed woodlands. Poorer floral composition and often lack of some characteristic elements characterises them.

In the area of the road corridor it is distributed almost along the whole river Vardar flow and some channels as well. It is usually altering with *Platanus* belts or woodlands and *Tamarix* shrublands (see Habitat map-Appendix I.4.).

### *V.1.4.5.* Shrublands of Tamaris and *Salix amplexicaulis*

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24.32 Vegetated river sand banks

This biotope represents mostly the heliophylous shrubland dominated by *Tamarix parviflora* and *Salix amplexicaulis*. These shrub species are forming the specific plant community named as **Tamarici-Salicetum amplexicaulis** (Kárpáti 1962) Em 1967. It is developing on the sandy and gravely river drifts in the range of *Platanus orientalis* community. The stands are flooded during the spring period.

In the herb layer *Lycopus europaeus*, *Equisetum arvense*, *Juncus articulatus*, *Mentha longifolia*, *Agrostis alba* etc. are common. Numerous annual species from the neighbouring grassland areas are can be often meet.

Lignicolous fungi are represented by very specific species growing on Tamarix spp. such are: the saproparasitic species *Inonotus tamaricis*, than *Peniophora tamaricicola* etc.

Animal composition of the shrublands of *Tamarix* and *Salix amplexicaulis* is mixture of the different types of fauna of the neighbouring communities and it is very similar with the fauna of the Plane communities and willow woodlands, but much poorer. It is due to the small surface that the community is distributed on. Disjunctive distribution is another reason for the present situation.

**Vertebrates**

**Mammals** – the fauna of mammals is very similar to the previous habitat.

**Birds** - there are no characteristic bird species in the Tamarisk growths, although there is one rare (Masked Shrike, *Lanius nubicus*). Among the common species are Blackbird (*Turdus merula*) and Whitethroat (*Sylvia communis*). Also, there are no permanently present rare bird species on the sandbanks, but occasionally Glossy Ibis (*Plegadis falcinelus*) and other species might appear. Among the commonest here are Ringed Plover (*Charadrius dubius*) and Common Sandpiper (*Actitis hypoleucos*), while on migration and during wintering Grey Herron (*Ardea cinerea*) and Little Egret (*Egretta garzetta*) are also common.

**Reptiles** - there are no characteristic reptiles for this habitat type. The commonest species is Grass Snake (*Natrix natrix*).

**Amphibians** - again, there are no characteristic species. Number of frogs (Lake Frog *Rana ridibunda*, Balkan Stream Frog *Rana graeca*) can be found on the river banks, while European Tree Frog (*Hyla arborea*) in the Tamarisk growths.

**Invertebrates**

Following species of Odonata are characteristic and more abundant: *Onychogomphus forcipatus, Orthetrum cancellatum* and *Libelulla depressa*. The composition of the ground beetle fauna is consisted of riparian species such as *Bembidion* spp., *Asaphidion caraboides balcanicum, Tachyura diabrachys, Chlaenius* spp. as well as species of open sandy habitats: *Cicindela campestris, Amara aenea* etc.

Daily butterflies *Lysandra coridon, Lycaena vigaureae, Pontai chloridicae, Lcaena thersamon* and *Iolana iolas* are the most frequent in this habitat.

**Distribution**: Tamaris shrubland biotope is regularly distributed in the lower and middle Vardar valley together with valleys of main Vardar tributaries: Crna Reka, Bregalnica, Pchinja etc.

The best preserved Tamaris shrublands along the E5 highway corridor are distributed on frequently flooded large Vardar drifts in the vicinity of the villages Davidovo and, Miravci (see Habitat map-Appendix I.4.).

### V.1.4.6. Sandy areas with different density of herb plant cover and small bushes of *Tamarix spp.*

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24.32 Vegetated river sand banks

This biotope is representing very specific type of grassland that is developing on the river Vardar banks or smaller permanent river islands. The ground is represented by sandy or gravely soil or the soil is in the process of formation. These areas are flooded from time to time and the wetland shrubland or forest vegetation can not be established.

The vegetation is not covering the whole ground, it is sparse and represented by herb species, mainly Gramineae, than many pioneer plant species adapted to sandy ground from Polygonaceae, Chenopodiaceae and other families. The presence of small, young Tamarix spp. sprouts is also giving the physiognomy of this biotope.

Insects are represented mainly by the Carabidae species that are adapted to the living conditions in such biotopes. *Dyschiriodes sp*., *Tachyura diabrachys*, *Siagona europaea* and *Cicindela campestris olivieria* are typical and very characteristic inhabitans of this biotope. Odonata and butterfly species are the same ones as those mentioned in the description of shrublands of *Tamarix* and *Salix amplexicaulis* (Chapter V.1.4.5.).

The most characteristic birds of this biotope are *Phalacrocorax carbo, Motacilla flava, M. alba, Chradrius dubius, Ciconia ciconia, Ardea cinerea, Tringa ochropus* etc. The above-mentioned species are very common on the sandy riverbanks.

**Distribution**: This kind of biotope is characteristic for the river Vardar valley and lower flow of its tributaries. It is more or less common biotope, although restricted at the territories already mentioned.

The investigated highway corridor, passes through the lower flow of river Vardar which is the part of the river where conditions (slow water flow, wide flat river terraces etc.) for establishing of this kind of biotope are the most abundant (see Habitat map-Appendix I.4.).

### V.1.4.7. River banks represented by sandstone cliffs

**Reference to Habitat Directive:** No specific reference

**Reference to Palaearctic Habitats:** No specific reference

Most of the riverbanks in the area of the road corridor are either glacis or rarely firm limestone cliffs. On some places loose sandstone cliffs, cut by the action of the river, are presented. They are not very high (usually several metres), distributed mostly along the sharp bends of the river.

Usually these places are not covered by vegetation, since they can undergo frequent changes due to the water erosion. They are very suitable as nesting places for some birds such are Crag Martin *Riparia riparia* and Bee Eater *Merops apiaster*.

**Distribution**: This kind of biotop is very rare in Macedonia. It is present on some places along upper part of Vardar valley, river Pchinja and Kriva Reka valleys and some other places.

In the area of the road corridor it is also rare habitat. It is distributed along the left bank of the river Vardar –the section between villages Josifovo and Marvinci. In that area, there are some banks of sandstone cliffs several hundred metres long (see Habitat map-Appendix I.4.).

## V. 2. OPEN TERRAIN - GRASSLANDS OF NATURAL ORIGIN

The grasslands in the area of highway corridor are not characteristic vegetation type. This region is either covered by zonal *Quercus coccifera* shrubland or it is turned into arable fields after clearing of shrubland. Thus, very small area in the road corridor is represented by grassland, and only small parts of it have natural origin. Most of the grasslands are formed after temporal abandonment of the fields.

More or less natural type of grasslands in the area along the road corridor is developing either close to the river Vardar (the possibility of frequent flooding does not allow development of final vegetational stage) or close to the settlements and roads.

### V.2.1. DRY GRASSLANDS

**Reference to Habitat Directive:** 6220 * Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*

**Reference to Palaearctic Habitats:** 32.D22 East Mediterranean – pre-desert scrub
34.5 Mediterranean xeric grasslands
34.532 Helleno-Balcanic short grass and therophyte communities

This grassland type has been formed by devastating larger areas of natural vegetation (pseudomaquis), mainly close to the populated places or along main traffic lines. It is represented by areas covered by herb vegetation surrounded by kermes oak shrubland of different degradation stages. The dominant plant association of dry pastures in the pseudomaquis is **Tunico-Trisetetum myrianthi** Mic. 1972. These pastures are consisted of therophyte plant species which dry-out in the beginning of the summer.

**Helianthemo-Euphorbietum thessalae K. Micevski** develops in the clearings of Coccifero-Carpinetum orientalis on rocky sites. Only a small number of plant species

can be found: *Euphorbia thessala, Alyssum minimum, Alyssum murale, Tunica saxifrage, Moenchia graeca, Aethionema graeca, Trifolium stellatum* etc.

The floral composition of the typical grassland which marks the physiognomy of this biotope in pseudomaquis shrubland is very similar to that from the surrounding sparse shrubland. Thermophyllous species are dominating. The presence of some small shrubs (either degraded *Quercus coccifera* or other species like *Cistus villosus* etc). is common. Many tall herb species with thorny habitus (*Eryngium campestre*, *Cirsium spp*., *Echinops spp*. etc.) are also characteristic.

The vegetation of the grasslands developing close to the roads is usually represented by floral elements of the neighbouring biotopes (mostly pseudomaquis type), but the important characteristic is that ruderal plants are commonly found there.

The fungal composition is very similar to open terrains in shrubland. The mycorhizal species are very rare, and grassland species are dominating. *Pleurotus eringii*, *Agaricus spp*., *Lepiota spp*., *Stropharia spp*. etc. are more representative.

**Vertebrates**

**Mammals** - This habitat is characterized by large mammal diversity. Most common species are: Wolf, Brown Hare, Red Fox, Golden Jackal, European Ground Squirrel, Red Fox etc.

**Birds** - As this habitat is with only small surface, there are not many characteristical bid species. Commonest are Crested Lark (*Galerida cristata*) and corn Bunting (*Miliaria calandra*), but many other species are coming from the neighbouring habitats for foraging. Some raptor species, such as Buzzards and Kestrels, should be also mentioned.

**Reptiles** - this habitat is very rich with species (15 in total), and with some very important ones. Common are some lizards and many snake species (*Coluber caspius*, *Elaphe quatourlineata* etc.)

**Amphibians** - there are only two species regularly found in this habitat, but several others probably can be found coming from neighbouring habitats. Commonest is the Green Toad (Bufo viridis).

The representatives of fauna are the same as for pseudomaquis forests of different types of development and degradation. It should be outlined that the orthopterans and hemipteran species are much more abundant. Daily butterflies species are very frequent in this habitat.

**Distribution**: these habitats are not very common in the Republic of Macedonia, as they are connected to pseudomaquis. They are distributed in the lowlands in the lower sections of river Vardar (the other sections of the river Vardar and its tributaries' valleys are characterized by specific hill pastures' biotope in the zone of *Carpinus orientalis* and *Quercus pubescens* forests).

Some of the areas representing this habitat type in the projected highway corridor are distributed along the existing roads and especially railroad line, but they are usually very small and not typical. More typical biotopes of this type are distributed in the area close to village Smokvica and Miletkovo (see Habitat map-Appendix I.4.).

## V. 3. ROCKY AREAS

## V.3.1. ABOVEGROUND HABITATS

Rocky and stony areas are characterised by extremely low biological production, but are very important for biodiversity of certain area. The mineral composition of the rocks and extreme ecological conditions offer unfavourable habitat, and present plant and animal communities are adapted to this habitat.

Rocky and stony sites are common biotope in the upper part of the road corridor, especially the canyon part of Demir Kapija gorge. Typical rocky sites are presented in the beginning of the gorge, while smaller rocky and stony habitats are frequent through the entire road corridor, both alternatives.

### V.3.1.1. Sparse *Phillyrea media* shrubland

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** No specific reference

Phillyrea (*Phillyrea media*) shrublands on smaller rocky and stony sites are quite regular through the whole Demir Kapija gorge. They are especially frequent on the left (eastern) slopes of the gorge. Usually they are of very small dimensions and mostly they are not marked on the Habitat map-Appendix I.4. The most extensive sites representing this biotope are distributed at the beginning of the gorge. Specific characteristic for this biotope is regular existence of unstable ground represented by moving stones (scree).

Cliffs and rocks of Demir Kapija canyon are sparsely vegetated by several shrub species. *Phillyrea media* is dominant species in the ravines of the canyon. However, Greek Juniper shrubs (*Juniperus excelsa*) are typical on the bare rocks of the canyon, together with shrubs of *Rhamnus* sp., *Prunus webbii*, *Ficus carica* and some other species. However, only *Phillyrea media* forms distinct shrubby communities on the rocks and cliffs of the Demir Kapija canyon. Other sites of this biotope are surrounded or sparsely covered by C**occifero-Carpinetum orientalis** Oberd. 1948 emend. Ht. 1954 association, which was described under sparse pseudomaquis habitat type (Chapter V.1.1.1.2.).

Very sparse *Phillyrea media* shrubland, together with Pubescent oak and Oriental hornbeam forms separate plant association - **Phillyreo-Carpinetum orientalis** Em 57. This community in the Republic of Macedonia is developing only on the rocky places and bare rocks. It represents climax vegetational stage conditioned by the high inclination and stony ground. Bedrock is usually represented by limestone and serpentinete. *Quercus pubescens* is dominating in the tree layer, but *Carpinus orientalis* is also frequent. In the shrub layer the most common are: *Phillyrea media*, *Pistacia terebinthus*, *Coronilla emeroides*, *Jasminum fruticans*, *Prunus webbii, Quercus coccifera* etc. The herb layer is characterized by Mediterranean species: *Asparagus verticillatus*, *Carex distachya*, *Anemone blanda*, *Oryzopsis virescens*, *Arrhenatherum palaestinum* etc.

The latest community in the area of the project interest is only distributed in the limestone canyon Demir kapija. It is very rare community in Macedonia as well.

### V.3.1.2. Chasmophytic vegetation on cliffs and rocks

**Reference to Habitat Directive:** Eastern Mediterranean screes (not relevant habitat for Macedonia)

**Reference to Palaearctic Habitats:** 61.4 Eastern Mediterranean screes (not relevant habitat for Macedonia)
62.4 Limestone bare inland cliffs
62.1A131 Balkan range *Ramonda* cliffs

The beginning of the Demir Kapija gorge (0,9 km in length, see Habitat map-Appendix I.4.) is represented by very high cliffs and steep rocks, which are vertical on some places, and it has typical canyon-like shape with different karst formations. There are nine caves and many crevices, ledges etc.

Several plant associations develop on the rocks in the highway corridor area:

a) **Centaureo-Ramondietum nathaliae Rizovski prov.** – it develops in the shadowed crevices of the limestone rocks. It can be found on the both sides of Vardar River in Demir Kapija canyon as well as the higher parts of Krastovec. The most important plant species are *Ramonda nathaliae, Centaurea campylacme, Arenaria filicaulis, Saxifraga hederacea, Poa bivonae, Cachrys alpine, Vesicaria utriculata* etc.

b) **Stachyo-Inuletum aschersonianae Rizovski prov.** – the physiognomy of the association is determined by *Inula aschersoniana*. It develops on the west slopes of Krastavec, in the areas covered by Paliuretum submediterraneum. The list of plant species contains *Stachys horvaticii, Ceterach officinarum, Dianthus armerioides, Sedum ochroleucum, Sedum dasyphyllum, Melica transsilvanica, Allium pulchelum, Galium purpureum, Alyssum orientale, Minuartia glomerata, Draba elongata* and *Achillea ageratifolia*.

The physiognomy of the habitat is defined by the shape and appearance of the rocks, while plant cover has only sporadic role, as it was mentioned above (Photo 27). The main characteristic for plant composition is not their biomass, but presence of rare and endemic species, like *Lilium heldreichii*, *Kitaibelia vitifolia*, *Dianthus cruentus ssp. turcicus*, *Allyssum desertorum*, *Alyssum minutum* etc. It gives this habitat very high biodiversity importance in national and international scale.

For more detailed description of flora and fungi see Appendix II.1. and II.2.

Appart from important plant species that grow in the two habitats mentioned above, there are many important animal species as well.

**Vertebrates**

**Mammals -** several bat species (*Barbastella barbastellus, Pipistrellus savii, P. pipistrellus, Myotis mystacinus. M. myotis, Tadarida teniotis*) found their shelter in the crevices of the cliffs and rocky areas along the investigated area. Wolf, Brown Hare, Red Fox, Golden Jackal, European Ground Squirrel etc, are commonly found in this habitat.

**Birds -** there are many important bird species found in this habitat, especially on the cliffs of Demir Kapija Gorge. The list includes many birds of prey, among which globally threatened Lesser Kestrel (*Falco naumanni*) might still breed here, then Egyptian and Griffon Vultures (*Neophron percnopterus*, *Gyps fulvus*), Golden Eagle (*Aquila chrysaetos*), Long-legged Buzzard (*Buteo rufinus*), Peregrine (*Falco peregrinus*), Lanner (*Falco biarmicus*) and other species with limited distribution, like Rock Nuthatch (*Sitta neumayer*), Blue Rock Thrush (*Monticola solitarius*), Alpine Swift (*Apus melba*), etc. the cliffs has formerly hosted the most important Griffon Vulture colony in the country, which has now almost completely disappeared.

**Reptiles** - the most characteristic species are Erhard's Stone Lizard (*Podarcis erhardii riveti*) and Kotschy's gecko (*Cyrtopodion kotschyi*), but Nose-horned Viper (*Vipera ammodytes*) and Leopard Snake (*Elaphe situla*) are also common.
**Amphibians** - European Green Toad (*Bufo viridis*) finds shelter under the rocks and in crevices during the daytime period. There are no other abundant species, but Balkan Stream Frog (*Rana graeca*) can be also found.

*Photo 27. Chasmophytic vegetation on cliffs of Demir Kapija canyon*

**Invertebrates**

Invertebrates are represented by orthopteroids, beetles and butterflies that inhabit the neighbouring shrub communities. The following species can be mentioned as characteristic ones: *Acrida hungarica, Oryctes nasicornis, Megopis scabricornis, Gnaptor spinimanus, Cyphogenia lucifuga, Iphiclides podalirius, Aglais urticae, Vanessa cardui, Artogeia manni, Myrmeleon formicaris* and some other species.

For more detailed description of animal composition see Appendix II.3. and II.4.).

In the area of the road corridor it occupies only the cliffs at the beginning of the Demir Kapija gorge (see Habitat map-Appendix I.4.).

## V.3.2. UNDERGROUND HABITATS

Natural underground habitats can be found in the limestone area of the Demir Kapija canyon and Krastavec hill. This habitat type is represented by the caverns in the limestone and several (known) caves.

### V.3.2.1. Endogean habitat (caverns)

**Reference to Habitat Directive:** No specific reference

**Reference to Palaearctic Habitats:** No specific reference

Caverns in the limestone are important for the existence of the endogean species while the caves are important for cave-dwelling species. However, the fauna species of caverns and caves is mixed and thus it can not be presented separately.

So far, we are aware of the presence of two endogean species (*Syro* sp.-Opiliones and *Cyphoniscus markoi*) which occurs in the soil caverns around Markova Cheshma locality (Photo 28). Since no other data are available for the caverns habitat in the highway corridor area, it can not be described properly.

*Photo 28. Markova Cheshma – in the vicinity of the fountain is the locality of two endogean species (Cyphoniscus markoi and Syro sp.)*

### V.3.2.2. Caves (Bela Voda cave)

**Reference to Habitat Directive:** 8310 Caves not open to the public
**Reference to Palaearctic Habitats:** 65.41 Troglobiont invertebrate temperate caves

There are about 10 caves in the limestone complex of Demir Kapija and Chelevechka Reka gorge. Most of them are very short caves used by bats as their shelter. Out of these caves, Bela Voda (955 m) is the longest and the most important.

The cave Bela Voda is inhabited by a number of invertebrate species as well as extraordinary high number of bat species. Sometimes, some reptile and amphibian species may be found at the entrance of the cave (*Elaphe situla, Rana graeca*). The animal species of Bela Voda cave can be divided in three groups (troglobionts – exclusive cave dwellers; troglophylls – species that inhabit caves and other cold and wet places and trogloxens – species that feed outside of the cave and hide in the caves, tunnels, mines etc. such as bats and butterflies).

*Photo 29. Cave cricket Dolichopoda remyi*

*Photo 30. Snail of the family Zonitidae in Bela Voda cave*

*Photo 31. Isopod species in Bela Voda cave*

*Photo 32. Nesticus sp. – troglophilous spider in Bela Voda cave*

*Alpioniscus vardarensis,* and *Mladenoniscus belavodae* (*in litt.*) are endemic species of Isopoda known from the Bela Voda cave only and represent troglobiontic species. Another strict endemic species from Bela Voda cave is troglobiont *Choleva macedonica* (Cholevidae, Coleoptera).

The cave cricket *Dolychopoda remyi* (Photo 29) is troglophyllous species known from some caves in northern Greece and south Macedonia. There are other troglophylls such as *Scutigera sp*. (Myriapoda), *Nesticus* sp. (Araneae, Photo 32), terrestrial snails (Photo 30) and some isopods (Photo 31).

Insects of family Staphylinidae and Diptera (Limoniidae, flies and mosquitoes and other insects which are not real cave dwelling insects - they are mostly feeding on the guano of the bats) are trogloxenic species.

There are 18 bat species that are registered in Bela Voda cave (Nastov A. & Petkovski S., 2004). Most frequent ones are: *Rhinolophus ferrumequinum, R. hipposideros, Miniopterus schreibersi, Pipistrellus pipistrellus, Myotis myotis, M. blithii* etc. Greatest number of individuals is using this cave as a summer roost, however two species found shelter in this cave in the winter period: *Miniopterus schreibersi* and *Myotis myotis*. Following bat species are restricted to the Bela Voda cave: *Eptesicus seroticus, Myotis emarginatus, Pipistrellus nathusii, Rhinolophus blasii, R. mehellyi, Barbastella barbastellus, Plecotus austriacus* and *Tadarida teniotis.*

Beside these already known species of animals, very probably there are other animal species, such as representatives of Leptodirinae-Cholevidae and endogean Carabidae.

The fact that Bela Voda cave is third longest cave in the Republic of Macedonia along with its rich fauna, makes its protection necessary. Every disturbance of the stabile conditions in the cave could have negative consequences on the cave fauna.

# V. 4. WETLANDS/WATER HABITATS

## V.4.1. RIVERS AND STREAMS

There are several types of water bodies in the area of interest. The proper typology according to Water Framework Directive (WFD) is ongoing process in Macedonia. Preliminary results from these investigations will be used for the purposes of this study.

### V.4.1.1. Rivers (approximately wider than 5 m)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24. Rivers and streams
**Reference to Water Framework Directive (EEC 60/2000):** lowland medium/small river type

Water flows that can fulfil the aforementioned criteria for "river" in the area of the road corridor are Vardar and Boshava rivers. Vertebrate fauna that is present in this habitat is more or less the same in large rivers and streams. Thus, it is presented in the following text.

**Vertebrates**

**Mammals** - Typical mammal species that inhabit bigger rivers are: Southern water shrew (*Neomys anomalus*), Muskrat (*Ondatra zibethicus*), European water vole (*Arvicola terrestris*), Southern vole (*Microtus rossiaemeridionalis*) and Coypu (*Myocastor coypus*).

**Birds** - there are no characteristic breeding bird species along Vardar and Boshavica Rivers. Several species can be found during migration and wintering, of which commonest are Cormorant (*Phalacrocorax carbo*) and Mallard (*Anas plathyrhynchos*), while Teal (*Anas crecca*), Pintail (*Anas acuta*) and Garganey (*Anas querquedula*) can be occasionally found on migration. Kingfisher (*Alcedo atthis*) and Dipper (*Cinclus cinclus*) are common species found in the winter period.

**Reptiles** - two water turtles, European Pond Terrapin (*Emys orbicularis*) and Caspian Turtle (*Mauremys caspica*) are the most important reptilian species in the rivers, the second one being with restricted distribution in Macedonia (found only south of Demir Kapija and around Dojran Lake).

**Amphibians** - different species, and especially their larvae (tadpoles) can be found in the rivers. This includes frogs (*Rana ridibunda*, *Rana graeca*), toads (*Bufo bufo*, *Bufo viridis*, and Yellow-bellied Toad *Bombina variegata*), newts (*Triturus vulgaris*, *Triturus cristatus*), etc.

### V.4.1.1.1. River Vardar

River Vardar springs out in the area of Shar Planina Mt. near the village Vrutok and mouths into the Aegean Sea in Greece. The total length of the river Vardar from spring to the mouth is 388 km of which the length of the river in Macedonian territory is 300,7 km. Vardar River is the main river in Macedonia. The catchment of the river Vardar is the biggest in Macedonia and drains 80% of the territory (approximately 20.500 $km^2$). Total surface of Macedonia is 25 713 $km^2$, with the highest point 2764 m.a.s.l. on Korab Mountain, the highest point in the Vardar catchment is Titov Vrv with the altitude 2748 m.a.s.l., the lowest point, 44 m.a.s.l., in Macedonia and hereby the lowest point in the Vardar catchment is near Gevgelija. Land use in the watershed is approximately 16% of arable land, 26% is covered by pastures and 37% is covered by forests. Data about land use are very important mostly for hydrological assessment, where this data are used for calculation of specific runoff.

In the area of the road corridor, river Vardar has about 45 km length. It is characterised by faster flow in the upper part of the corridor (Demir Kapija–Udovo). There are steep slopes rising on some places directly from the river banks. In the region of Demir Kapija, actual wetted width in the water level is 75 m, it is a large river type. The cross section profile is natural, and variation in depth is high. The river channel is single braided channel with sinuous curving. The river valley for this part of river is wide U-shape valley. Migration barriers are not present here. The vegetation in riparian zone and floodplain zone is natural. In this survey unit there are presented lateral and middle bars and riffles. The bed substrates are: boulders, cobbles, gravel, sand and mud. The variation in width is high. The presence of flow types is various: broken standing waves, unbroken standing waves, rippled, smooth and no perceptible flow. The mean annual long-term discharge is 126 $m^3 \cdot s^{-1}$ calculated for reference period 1951-2000.

Vascular vegetation that gives the physiognomy of the river banks and of the water close to the banks, is not well-developed due to the fast flow and pollution coming downstream from Skopje and Veles region. Anyway, there are some plant species related to the water ecosystem especially from the right side of the river. These are *Myriophyllum spicatum*, *Polygonum hydropiper*, *Ranunculus trichophyllus*, *Myosotis scorpioides* etc. Stony bad enables development of populations of *Cladophora spp*, during summer, and rich epilithic diatoms communities and cyanophytes, during winter and spring. In addition eutrophic diatom species *Cyclotella menghiniana*, *Navicula capitatoradiata*, *Nitzschia palea* etc. have greatest abundance, indicating the high level of saprobity.

Fish community in this part is dominated by *Alburnoides bipunctatus*, *Barbus peloponnesius* and *Leuciscus cephalus*. The total number of species recorded for this area is 11.

At the lower part of the river, near village Smokvica, actual wetted width in the water level was 90 m. The bankfull width was 110 m. The river is of large river type, the survey length is 1000 m and survey sub-unit lengths are 200 m. The variation in depth is high. The river channel is single and braided. The river Vardar flows in this part through imperceptible river valley. Migrations barriers are not presented here. Many bars and islands are presented there. Bed substrates characteristic for this place are: cobbles, gravel and mud. Variation in width is very high. Types of flow are: broken standing waves, smooth and no perceptible flow. The natural hydrological regime is

influenced by wastewater discharging and by surface water abstraction. The mean annual long-term discharge is 135 $m^3 \cdot s^{-1}$.
The vegetation in riparian zone is natural. The form of the floodplain area is not changed and it is natural or semi-natural open land. This part of the river is characterised by intensive agricultural area around the river. Among other vascular plant species associated with water *Veronica anagalis-aquatica*, *Veronica beccabunga*, *Stelaria aquatica*, *Lycopus europaeus*, *Myosotis scorpioides*, *Alisma plantago-aquatica*, *Phragmites communis*, *Rumex cristatus*, *Polygonum hydropiper*, *Ranunculus repens* etc.
The composition of algal communities in the lower part of the river Vardar in the investigated corridor has the same characteristic species as the upper part, although characterised by a much slow flow and muddy bad. The composition of the fauna of river Vardar and its tributaries is very characteristic due to the occurrence of species with southern distribution.
Mayflies are represented by many species, many of them endemic and very rare. Very interesting, but unfortunately, unreliable information is about the occurrence of *Lethroceris patruelis* in the River Vardar and its tributaries.
Batrachofauna is represented by *Rana ridibunda* and *Rana graeca,* which were quite common along the projected highway corridor. Ornithofauna of the banks of river Vardar is presented in Chapter V.4.1.1.
Fish fauna is dominated by *Rhodeus amarus, Alburnoides bipunctatus, Barbus peloponnesius* and *Pseudorasbora parva*. The last was for the first time recorded in river Vardar in period 1996-1998 as an introduced species. It was supposed that its population will decrease, but the last investigation show that it is still present in the river Vardar. Additionally, another introduced species was recorded *Ameiurus nebulosus* during 1998. In that period the population of *A. nebulosus* was low and was supposed that it has no chances for increase of its populations. During the last investigation, this species was not recorded.

### V.4.1.1.2. River Boshava

According to its basic characteristics, river Boshava is completely different in respect to Vardar and Anska Reka. It has characteristics of a mountain river along the largest part of its flow, i.e. very fast flow, stony bed, and mostly clean water (oligosaprobic). At the lowest part, before its mouth in the river Vardar it becomes more similar to Vardar by all characteristics, due to the human influence from Demir Kapija town. Namely, the last 2 km of the river are passing through or next to the town. In this region channel plan form is sinuous and the channel is single. Variation in depth is high for the whole survey unit.

In this part of river these bed elements are dominant: bars and riffles and lateral bars as teh most significant. Characteristic bed substrates are: cobbles, gravel, sand and mud, but the presences of waste material (building waste, PET flasks etc.) are significant, which negatively influences the score. The variation in width is significant; ratio of the maximum and minimum width is 3, what reflects the significant changes in flow dynamics, what is reflected in flow types. The flow types are: unbroken standing waves, rippled, smooth, no perceptible flow, broken standing waves. Artificial bed elements in this survey unit were mostly created by parts of building waste (concrete panel). The riparian vegetation is also influenced by the solid waste, although natural plant communities are present on the right side of the river bank. The bank stabilization is not

willful, but there is the artificial material on the bank, which practically serves as stabilization. The profile of the cross section is also changed. The form of floodplain area is not changed and floodplain is used for agriculture.

*Cladophora glomerata* is dominant macrophyte species in the river, which is covered by epiphytic diatom communities. Diatom epiphytic assemblages are composed by cosmopolitan diatom taxa as *Navicula tripunctata*, *Diatoma vulgaris*, *Gomphonema olivaceum*, although some not very common taxa like *Mastogloia smithii var. lacustris, Stauroneis agrestis* and *Navicula lesmonesis* are recorded in Boshava diatom community.

#### V.4.1.1.3. River Anska (channel in the area of the highway corridor)

River Anska Reka is located in the southern part of Macedonia. It is a left tributary of river Vardar with total length of 22 km. The catchment area is 18 $km^2$. In the lower part of the river several sublacustrine springs are recorded. The river channel is single and sinuous. For this river unit the presence of bed elements is not characteristic. It is presented here only by small lateral bars and in one survey sub-unit also by riffles. Bed substrates are: cobbles, gravel, sand and mud. In two surveyed sub-units boulders are also present. The variation in width is high; ratio of the maximum and minimum width is 2,2. Types of flow are: broken standing waves, unbroken standing waves, rippled, smooth. The riparian vegetation is modified.

The water is turbid during wet season, as a result of erosion from surrounding agricultural land. The river is highly impacted by eutrophication from agriculture that enables massive development of macrophytes. Macrophytes are present during the whole year. The most dominant species during summer period are *Potamogeton fluitans*, while in part with very slow flow *Lemna minor* is covering the water surface. During spring time, the most dominant macrophyte species is green alga *Cladophora glomerata*. Such composition of macrophytes enables intensive development of epiphytic diatom communities. Diatoms composition is represented by eutrophic diatom species as *Cymbella tumida, Ulnaria ulna, Cocconeis pediculus, Hippodonta capitata*, *Gomphonema capitatum* etc.

### V.4.1.2. Streams (approximately narrower than 5 m)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24.14 Epipotamal streams
24.15 Metapotamal and hypopotamal streams
**Reference to Water Framework Directive (EEC 60/2000):** lowland calcareous streams

The area of road corridor is not characterised by well-developed hydrographical network.

The most of the dales that slopes down to Vardar valley are dry throughout the larger part of the year, especially those from the upper part of the projected highway road corridor (Demir Kapija–Udovo). The most of the streams flowing into river Vardar in the lower section of road corridor (Udovo–Gevgelija) do not enter the flat part of the valley, since they are captured and transported by network of channels to the fields.

The following streams with permanent flow can be registered in the highway corridor area:

- **Left tributaries of Vardar**: Chelevechka Reka, Vodosir, Gradeshka Reka, Mushtenica and Arazliska Reka
- **Right tributaries of Vardar**: Stara (Klisurska) Reka, Golema Javorica, Mala Javorica, Simonska Reka, Selishte Potok, Petrushka Reka and its tributaries (Kalica, Gabreshka Reka and Varnica) and Dukovec.

However, the most important permanent and larger waterflows (streams) are Chelevechka Reka, Petruska Reka, Golema Javorica and Mala Javorica.

**Vertebrates**

**Mammals - the** composition of species is identical as in the rivers.

**Birds** - there is one characteristic and common species dependent on the streams, Grey Wagtail (*Motacilla cinerea*), breeding in small numbers along streams in the region.

**Reptiles** - there are no important species, but some snakes (*Natrix natrix*, *Natrix tesselata*) and probably turtles (*Emys orbicularis*, *Mauremys caspica*) can be found.

**Amphibians** - the composition of species is identical as in the rivers.

### V.4.1.2.1. Chelevechka (Iberliska) Reka

This stream is left tributary of river Vardar, with mouth in the region of Demir Kapija canyon (the beginning of Demir Kapija gorge). At the lowest flow Chelevechka Reka is passing through the water gap, cut in Jurassic limestone cliffs and thus separating two tunnels of existing motor road (Photo 33).

Along the Chelevechka Reka dale very well preserved plane (*Platanus orientalis*) forests (proclaimed as protected area–Monument of Nature) is developed. Although the brook looks like pure natural clean rivulet, it is highly eutrophicated in its lower flow. The eutrophication comes as a result of strong farming and other anthropogenic influences from village Chelevec. The lowest part, directly before confluence, the stream is polluted by solid waste from passengers that stopped on parking place between two tunnels.

The diatom composition is mainly consisted of eutrophication tolerant species as taxa from genera *Nitzschia* (*N. hungarica*, *N. dissipata*, *N. sigmoidea* etc.) and *Navicula* (N. tripunctata and N. trivialis). The bottom of the stream is mainly covered with *Cladophora glomerata* and *Spirogyra* spp. what enables good substratum for epiphytic growth of diatom species.

The fauna of Chelevechka Reka is not so diverse due to the pollution of its water. *Anodonta cygnaea* is common in the Chelevechka Reka. *Potamon fluviatilis* (Crustacea) was registered on the banks of Chelevechka Reka. Odonata species composition near the water stream is similar to one of other water flows. The most common species are: *Sympetrum sanguineum, Sympetrum flaveolum* and *Orthetrum brunneum*.

During the spawning period different fish species, enters the rivulet in large numbers and, spawn there.

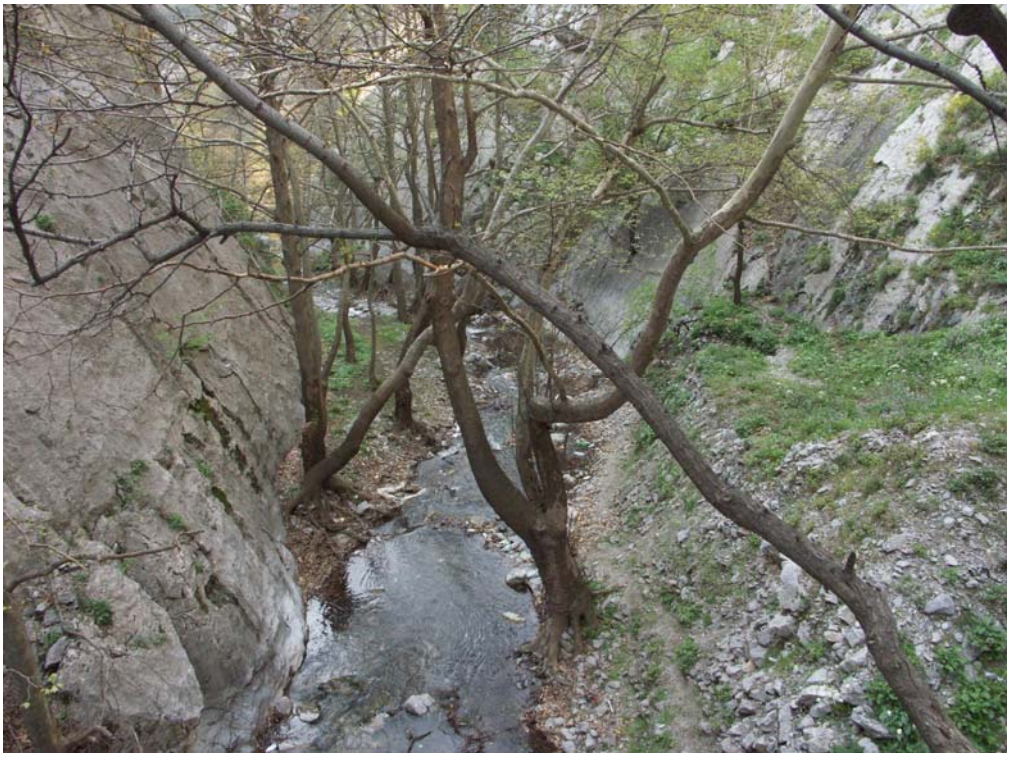


*Photo 33. Chelevechka Reka gorge*

### V.4.1.2.2. Petrushka Reka

This stream is right tributary of river Vardar with mouth in the region between villages Miletkovo and Miravci. According to its hydrobiological characteristics this stream is typical oligosaprobic rivulet, with stony bed, fast flowing waters, and rich epilithic algal communities (Photo34. 35 and 36). It is characterized by high conductivity (over 600 µS/cm). Along the rivulet very well developed sites of Oriental plane are presented (See Habitat map-Appendix I.4.). Before entering the plane, the water from Petrushka Reka is dammed, and during the driest period almost no water is reaching Vardar.

The diatom composition is quite different from all other investigated water flows, and characterised by typical oligotrophic species like: *Amphipelura pelucida*, *Encyonema caespitosum, Cymbella neocistula, Cymbella lange-bertalotii* and many others. Among recorded diatom species in Petrushka Reka, several species are rare in the flora of Macedonia: *Diploneis margenstriata*, *Gomphoneis ohridana, Gomphonema sp*.

*Photo 34. Confluence of Petrushka and Stara Reka*

*Photo 35. Petrushka Reka near village Miletkovo*

*Photo 36. Algal community in Petrushka Reka*

### V.4.1.2.3. Golema Javorica and Mala Javorica

These streams are right tributaries of the river Vardar. According to their hydrobiological characteristics these stream are typical oligosaprobic rivulets, with stony bed, slow flowing waters, and rich epilithic algal communities (Photo 37 and 38). Along the both streams very well preserved plane (*Platanus orientalis*) forests are presented. The cannopy cover is about 50%. In the lower part of the streams, several characteristic species were recorded *Campylodiscus hybernicus*, *Diploneis krammeri*, *Gomphonema sp*., previously recorded in few streams on Mountain Kozuf. The diatom composition in upper part is dominated by typical oligotrophic species like *Gomphonema amoenum, Meridion circulare, Diploneis fontanella, Amphipleura pelucida* etc.

*Photo 37. Mala Javorica stream*

*Photo 38. Golema Javorica stream*

### V.4.1.3. Streams which are usually dried up during the summer (ravines)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24.16 Intermittent streams

These streams characterise numerous ravines in the road corridor region on the left and right slopes of river Vardar valley. The water flow exists only during the humid period of the year (See Habitat map-Appendix I.4.). They have high water level after snow melting in early spring, and a half of the year (more or less) these streams are characterised by dry bed. That is the reason these streams do not have great importance as water ecosystems. But, the ravines through which they flow are regularly covered by denser or sparser plane forests or belts, thus strongly differing from surrounding pseudomaquis or agricultural habitats.

### V.4.1.4. Streams with water flow only during the rainy period (gullies)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 24.16 Intermittent streams

The most important characteristic for this biotope is shallow, stony, eroded diches cut by running waters during heavy rains. They are distributed mostly on the left slopes of the river Vardar valley in the region of sparse pseudomaquis biotope (Section Demir Kapija –Udovo; see Habitat map-Appendix I.4.).

They are characterised by poor, very sparse plant cover, mainly pioneer species due to the permanent erosive processes. Numerous animal species are coming from neighbouring biotopes (pseudomaquis).

#### V.4.1.4.1. Thermal waters/springs

Thermal water is spatially connected with the neo-tectonic fissure structures in the Vardar zone or with the transversal fissure marginally located in the depressions. The main hydrothermal systems are located in the east and northeast of the country in the crystalline rocks of Macedonian-Serbian massive and are characterized by low TDS (total dissolved solids) and low corrosion activity. A number of geothermal areas composed by separate fields were discovered as a result of investigations from more than 50 prospecting and operating wells with a depth from 40 to 2100 m.
The following geothermal zones are exploited in the area of interest:

1. Geothermal zone Gevgelija:
   - Twenty two wells with depth of 30-850 at the Smokvica field. The most productive stratum was found in the range of 350-500 m. The total discharge of four wells was 180 l/s, the average wellhead temperature (WHT) was 65 $^{o}$C.
   - The field Negorska Banja was investigated by means of a few wells. The total discharge of thermal water of 80 l/s at 51$^{o}$C was obtained by pumping from two wells from a depth of 600 m.

There is one geothermal project in this area consisted by two parts. The first part is the system of geothermal heating for 22.5 hectare of stationary greenhouses from the Smokvica field (15 MWh). The second part is a system of geothermal heat supply of a hotel complex that includes the heating of rooms, hot water supply and balneology. The thermal water is transmitted from the field Negorci (10 km from Smokvica).

The diatom composition is highly specific to this type of waters: *Denticula elegans, Nitzschia thermalis, Achnanthidium thermale, Nitzschia vitrea, Mastogloia smithii*.

### V.4.1.5. Channels

**Reference to Habitat Directive:**
**Reference to Palaearctic Habitats:**

According to the WFD *Article 2(8)*: *"Artificial water body means a body of surface water created by human activity"*. A key question in order to differentiate between AWB and HMWB is the meaning of the word "created" as used in Article 2(8). More specifically, the question is whether "created" refers to creating a new water body from previously dry land (e.g. a canal), or whether it could also denote a water body that has changed in category (e.g. river into a lake as a consequence of damming, or coastal water into a freshwater lake due to reclaiming).
The Guidance for identification of water bodies interprets an AWB "as a surface water body which has been created in a location where no water body existed before and which has not been created by the direct physical alteration or movement or realignment of an existing water body". Note, this does not mean that there was only dry land present before. There may have been minor ponds, tributaries or ditches which were not regarded as discrete and significant elements of surface water. Where an existing water body is modified and moved to a new location (i.e. where previously there was dry

land) it should still be regarded as a HMWB and not an AWB. The same applies to water bodies that have changed category as a result of physical modifications; such water bodies (e.g. a reservoir created by damming a river) are to be regarded as HMWB and not as AWB.

The irrigation schemes are complex engineering systems consisting of numerous facilities widely dispersed in space. They consist of basic structures (dams, intakes, pumping stations, main and group canals), secondary and tertiary network and irrigation equipment. The main conveyers are usually the open concrete canals, or pressurized pipelines. The secondary and tertiary network usually consists of pipelines, made of different material, while the network of the older schemes, or there where specific crops are grown (rise), consist of concrete or earth made open canals.

In the area of interest there are 20 Irrigation Systems (IS) with the area of 12.277 ha (Table 12). The largest IS are Udovo-Valandovo with area of 3.624 ha and Boshavica 1.935 ha (Fig. 6).

Tab. 12. *List of Irrigation Systems in area of interest*

| **No.** | **Code** | **Irrigation system** | **Irrigation area (ha)** | **River of water source** | | |
|---|---|---|---|---|---|---|
| | | | | **0** | **1** | **2** |
| 80 | III.0b-1 | Boshavica | 1.935 | Vardar | | |
| 81 | III-1 | Pepelisho Pole | 1.600 | | Boshava | |
| 82 | III.1a-1 | Demir Kapija | 300 | Vardar | | |
| 83 | III-2 | Gradec | 264 | Vardar | | |
| 84 | III-3 | Udovo-Valandovo | 3.624 | | (Stara) | Petruska |
| 85 | III.3a.0a-1 | Petrushka Reka | 100 | | Stara | |
| 86 | III.3a-1 | Miravci | 100 | | Vardar | |
| 87 | III-4 | Grchishte I and II | 423 | | Vardar | |
| 88 | III-5 | Smokvica I and 2 | 110 | | Vardar | |
| 89 | III-6 | Prdejci | 200 | | | |
| 90 | III.6a-1 | Kovanska, Sermeninska Reka | 200 | | Vardar (wells) | |
| 91 | III-7 | Vinojug | 150 | | Vardar | |
| 92 | III-8 | Gjavato | 1.340 | | | |
| 93 | III.8a-1 | Paljurci | 800 | | | |
| 94 | III8b-1 | Konska Reka | 571 | | Vardar | |
| 95 | III-9 | Sehovo | 200 | | Vardar | |
| 96 | III-10 | Granica | 120 | | | |
| 97 | III10a-1 | Pod anot | 120 | | Vardar (wells) | |
| 98 | III-11 | Avlakjot | 40 | | | |
| 99 | III-12 | Keramidnica | 80 | | Vardar | |
| SUM | | | 12.277 | | | |

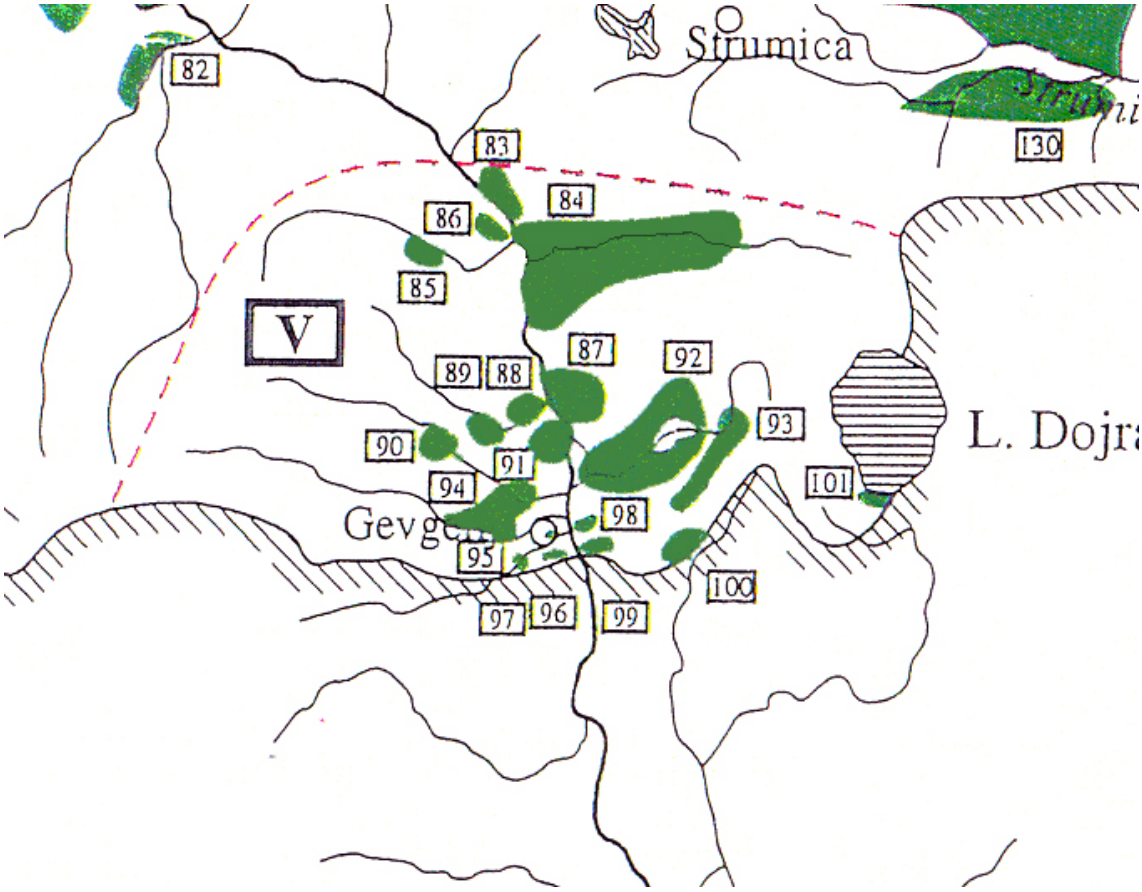



*Fig. 6. Irrigation systems in the south-east Macedonia*

In the area of interest, higher impact is expected on open channels from Anska Reka. The water quality of this irrigation system is under great influence of agricultural land. Massive development of aquatic macrophytes is noticeable during summer period, where *Cladophora glomerata* is the most dominant. Several diatoms as typical eutrophic indicators are present in epiphytic communities (see description of Anska Reka).

Water fauna of the channels is very similar to one of the stagnant water biotopes. The most representative inhabitant of channels is *Mauremys caspica rivulata*, a reptile with south range of distribution. Ornithofauna and enthomofauna is almost identical with the fauna mentioned in the description of stagnant water biotopes.

**Vertebrate fauna for rivers (excluding fish)**

**Mammals** - Typical mammal species that inhabit larger rivers are: Southern water shrew (*Neomys anomalus*), Muskrat (*Ondatra zibethicus*), European water vole (*Arvicola terrestris*), Southern vole (*Microtus rossiaemeridionalis*) and Coypu (*Myocastor coypus*).

**Birds** - there are no characteristic breeding bird species along Vardar and Boshavica Rivers. Several species can be found during migration and wintering, of which commonest are Cormorant (*Phalacrocorax carbo*) and Mallard (*Anas plathyrhynchos*), while Teal (*Anas crecca*), Pintail (*Anas acuta*) and Garganey (*Anas querquedula*) can be occasionally found on migration. Kingfisher (*Alcedo atthis*) and Dipper (*Cinclus cinclus*) are common species found in the winter period.

**Reptiles** - two water turtles, European pond terrapin (*Emys orbicularis*) and Caspian Turtle (*Mauremys caspica*) are the most important reptilian species in the rivers, the second one being with restricted distribution in Macedonia (found only south of Demir Kapija and around Dojran Lake).
**Amphibians** - different species and especially their larvae (tadpoles) can be found in the rivers. This includes frogs (*Rana ridibunda*, *Rana graeca*), toads (*Bufo bufo*, *Bufo viridis*, and Yellow-bellied Toad *Bombina variegata*), newts (*Triturus vulgaris*, *Triturus karelini*), etc.

**Vertebrate fauna for streams (excluding fish)**
**Mammals - the** composition of species is identical as for the rivers.
**Birds** - there is one characteristic and common species dependent on the streams, Grey Wagtail (*Motacilla cinerea*), breeding in small numbers along streams in the region.
**Reptiles** - there are no important species, but some snakes (Natrix natrix, Natrix tesselata) and probably turtles (*Emys orbicularis*, *Mauremys caspica*) can be found.

**Amphibians** - the composition of species is identical as in the rivers.

## V.4.2. STAGNANT WATER BIOTOPES

The biotopes representing the area along or around the slow moving water are not very frequent in the area of the road corridor. Usually they are represented with swampy areas in the scope of the river arms and reed belts along the rivers or channels.

### V.4.2.1. Swampy reed biotope in sparse willow stands

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** No specific reference

This kind of biotope in the investigated road corridor is occupying areas covered by sparse willow grows, usually old and tall stems, continuing into Tamaris shrubland. Such places are almost exclusively in the frame of the river Vardar arms, where the water flow is very slow or the water is almost stagnant. Usually, they are not dried up during the summer period.

The physiognomy of the habitat is marked mainly by the well developed and dense reed (*Phragmites australis*) grows mixed with *Typha latifolia* and *Typha angustifolia*, *Scirpus lacustris* etc. (Photo 39). The willow (*Salix alba*, *Salix fragilis*), poplar (*Populus nigra*, *Populus tremula*) and often plane (*Platanus orientalis*) trees are also sparsely present. Early summer period is characterized by presence of different colours owing to intensive blossoming of *Butomus umbelatus*, *Iris pseudoacorus*, *Alisma plantago-aquatica* etc. The lower stratum is built of different swamp species from genera *Juncus*, *Carex*, *Mentha*, *Lycopus*, *Polygonum* and others. The water surface is completely covered by *Lemna* spp.

The constant humidity in this biotope provides very suitable conditions for permanent growing of diverse plant species offering rich and divers habitat, food and shelter niches for vast number of animal species from all groups.

Dominant animal groups inhabiting this biotope are the semiaquatic and subaquatic groups of insects and waterfowels. Odonata, Plecoptera and Ephemeroptera are the representatives of the semiaquatic insects. The most abundant species of Dragonflies

(Odonata) are *Crocothemis erythraea, Lestes dryas, Calopteryx splendens, Libelulla depressa* and *Sympetrum sanguineum*.

Species of the beetles (Coleoptera) that were registered as characteristic ones are *Potamonectes griseostriatus, Rhantus sp.* and *Gyrinus caspius*. Order Hemiptera is represented by *Corixa spp*., *Sigara spp., Gerris lacustris, Gerris sp., Notonecta glauca*, most of them very common and widely distributed in other parts of Macedonia. All of the mentioned insect species are living in the ponds and small rivers in the investigated area.

*Photo 39. Swampy reed biotope in sparse willow stands*

*Rana ridibunda, Rana graeca, Bombina variegata* and *Natrix natrix* can be mentioned as common species of these ecosystems - representatives of batrachofauna and herpetofauna.

As it could be expected, the waterfowels are the most characteristic and important animal groups for these biotopes. *Nycticorax nycticorax, Ixobrychus minutus, Fulica atra*, *Acrocephalus arundinaceus* inhabit exclusively the reed communities. Some other bird species looking for their prey such as *Ardea cinerea* and *Ciconia ciconia* may be found in the shallow waters of the biotope. *Phalacrocorax carbo* and some other common species (*Remiz pendulinus, Parus major, Parus caeruleus, Luscinia megar-rhynchos, Picus viridis, Oriolus oriolus, Columba palumbus* etc.) are using the tree canopies as resting, feeding or nestling place (See Appendix II.3.3.).

It is comparatively rare habitat in Macedonia due to the melioration activities after the World War II due to which it is endangered habitat type in Macedonia (NBSAP).

Swampy reed beds are rare in the area of the project interest as well, it covers insignificant surface in the road corridor so it is not very important for overall assessment of highway construction impacts.

### V.4.2.2. Reed belts (*Phragmites australis*)

**Reference to Habitat Directive:**
**Reference to Palaearctic Habitats:**

The reed stands in the projected road corridor does not represent the typical reed biotope in the most cases. They are developing as narrow belts along the slow flowing water in channels and some river Vardar arms. Such reed stands usually represent the fragments of the **Scirpo-Phragmitetum** W. Koch 1926 swamp plant association (as in the previous habitat). This kind of biotope is much poorer from the floral and faunal point of view, compared to the previous one.

### V.4.2.3. Reservoirs

According to the Water Framework Directive (WFD), the overall goal for surface waters is that a Member States should achieve "good ecological and chemical status" in all bodies of surface water by 2015. Some water bodies may not achieve this objective for different reasons. Under certain conditions the WFD permits to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB) according to Article 4(3) WFD. HMWB are bodies of water which, as a result of physical alterations by human activity, are substantially changed in character and cannot, therefore, meet "good ecological status" (GES).
Specified uses of water bodies generally result in pressures that might impact the status of the water body. In the context of HMWB and AWB identification and designation process, changes to hydromorphology resulting from "physical alterations" are relevant [Art. 2(9)]. Physical alterations include alterations in the morphology and hydrology of the water regime (compare glossary and step 6). For example, the most common physical alterations include dams and weirs, which disrupt the river continuum and cause alterations of the hydrologic and hydraulic regime. The dams, according to their importance, size, complexity of problems to be resolved during their design and construction, their impact on the environment etc., are included among the most important water management facilities.
In the area of interest there is one HMWB – Kalica Reservoir (Fig. 40) which is used for irrigation purposes. The dam is build as rock fill, made of local material. During field investigations the water level was decreased and the water remains only in the deepest parts of the reservoir. The bottom is covered with large amount of organic sediment. On this substrate large-celled diatoms are predominant in the epipelic community and represent the most important primary producers. Most dominant diatom species are *Pinnularia rupestris*, *Surirella biffrons*, *Caloneis amphisbaena*, *Cymbopleura amphycephalla*, *Cymbella affinis*. Such diatom composition indicates oligo-mesotrophic conditions of the water with moderate to high electrolyte content. This finding is in concordance with measurements of the basic chemical parameters.

Due to high variation of the water level, aquatic macrophytes and riparian vegetation are completely absent. This situation is characteristic for reservoirs with high variability of the water level.

*Photo 40. Reservoir Kalica – used for irrigation purposes and fishing*

### V.4.3. SPRINGS AND WELLS

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 54.11 Soft-water springs

Springs and wells are not numerous in the area of the road corridor but their significance as water resources is great (Photo 41 and 42). They are marked on the Habitat map (See Appendix I.4.).

*Photo 41. Fountain near Mala Javorica stream*

*Photo 42. Spring on Golema Javorica stream*

*Photo 43. Vegetation of the spring habitat (fountain Ilinden)*

Apart from the socio-economic value they have biological value as well. Permanent ecological conditions in springs enable establishing of specific biocoenoses with restricted distribution only to the small springs area (Photo 43). The algal and animal

species in springs are oligosaprobic organisms. Very often rare or endemic species are presented and thus, springs are worth for conservation from biodiversity point of view as well (not only as a water resource).

The situation with wells is very similar.

## V. 5. ANTHROPOGENIC HABITATS

This chapter deals with the anthropogenic habitats such as urban and rural settlements as well as plantations of conifers and deciduous trees and agricultural land (fields, orchards, vineyards, fallow fields).

### V.5.1. WOODLANDS AND PLANTATIONS

Plantations in the highway corridor area cover small surfaces. Most of them can be found near the settlements and along the existing motor way and railway.

#### V.5.1.1. Broadleaf plantations

Black locust (*Robinia pseudoacacia*), Canadian poplar (*Populus* X *canadensis*) and high-stemmed *Populus nigra* cultivars represent the broadleaf plantations in the highway corridor. Along the railway some small stands of *Ailanthus glandulosa* can be found. However, the latter can be included in the ruderal sites.

**Vertebrates**

**Mammals -** Mammal fauna in this habitat consists of species typical for forest: wild cat (*Felis sylvestris*), Yellow -necked mouse (*Apodemus flavicolis*), wood mouse (*Apodemus sylvaticus*). However, highly flexible species can be found in this habitat also: Red Fox, Wolf, Badger, Wild Boar etc.

**Birds** - Only small number of bird species breed in this habitat, although many more visit it from the neighbouring habitats. Typical species are Warblers (Sylviidae) and Tits (Paridae).

**Reptiles** - also, all species found here are coming from the neighbouring habitats..

**Amphibians** - There are no characteristic species of Amphibians in this habitat type, although some species are more abundant here than in the surrounding habitats (Toad *Bufo bufo*, Fire Salamander *Salamandra salamandra*).

##### V.5.1.1.1. Pure stands of Black locust's (*Robinia pseudoacacia*)

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 83.324 Locust tree plantation

The Black locust's stands are planted on small areas. They are very open and ground vegetation is well developed and it is similar to that of the neighbouring grasslands. Many ruderal elements are present in the Black locust's stands because of their proximity to the roads and settlements.

The forest-like stands of this biotope are rare in the investigated road corridor, but belts of Black locust along the roads and especially the railway line are more common, since the Black locust was planted for erosion prevention.

Black locust's biotope is characterised by the presence of some lignicolous fungi, which are not common in other biotopes that were already mentioned, such are *Phellinus robiniae*, *Phellinus torulosus*, *Ganoderma resinaceum* etc. Quite common terricolous fungal species in this biotope are edible mushrooms of *Macrolepiota procera* and several *Agaricus* species.

Fauna of Black locust's stands is not specific and represents a mixture of the thermophyllous species inhabiting neighbouring localities.

**Distribution**: Black locust's forests and woodlands are widespread in the Republic of Macedonia due to the fast growing characteristics of the species and great resistance to unfavourable conditions. Many areas were afforested in order to prevent eolian and alluvial erosion processes.

In the investigated road corridor the best Black locust's stands are distributed in the beginning of the road corridor (before Demir Kapija canyon), than on several localities next to the river Vardar in the area of Demir Kapija gorge. Localities in the lower part of the valley are smaller and less significant (see Habitat map-Appendix I.4.). The best stands of Black locust's belts are distributed along the railway line from Miravci to Miletkovo (see Habitat map-Appendix I.4.).

### V.5.1.1.2. Stands with *Populus spp.*

**Reference to Habitat Directive:** No specific reference
**Reference to Palaearctic Habitats:** 83.3212 Other poplar plantations

Individual poplar trees growing along the rivers and channels are not included in this biotope, since they are integral part of the willow habitats. Planted poplar stands are distributed on very small areas in the area of project interest, usually not creating forest type of vegetation, except for the very few plantations of Canadian poplar (*Populus* X *canadensis*). Very often individual Lombardian poplar trees (*Populus* cv *italica* - pyramidal form of *Populus nigra*) are planted on the field or acre boundaries.

The stands are usually open and ground vegetation is well developed. It is very similar to that from neighbouring grasslands or other communities.

The poplar forest biotope is characterised by the presence of some lignicolous fungi which are common for planted old Italian poplar trees, such are: *Ganoderma adspersum*, *Pleurotus ostreatus*, *Agrocybe aegerita* etc.

Generally, the fauna of these stands does not have some specific features and it is not rich in species. Mammal fauna is very similar to the one in the oak forest.

The following species of daily butterflies are characteristic and more abundant: *Everes decoloratus, Inachis io* and *Pontia edusa.*

**Distribution**: Poplar plantations are widespread in the Republic of Macedonia. They are intensively planted due to their high and fast biomass production. Many field and garden edges in Macedonia were planted with Italian poplar in order to prevent wind blowing and to produce shade for farmers.

In the investigated highway corridor the largest stands of Canadian poplar are distributed close to the river Vardar in the district of Davidovo. The small stands of Canadian poplar and Lombardian (Italian) poplar, as well as tree belts, are evenly distributed throughout the whole corridor.