tially decreased due to dilution because of heavy rain. During the following discharge decrease the concentrations increased accordingly to outflow of less diluted base flow.

Another tracer pulse appeared after 900 hours approximately, between December 1 and 2 slightly after the low water pulse due to rain on November 26 and 29 (20 mm) which was not strong enough to flush the tracer. More probably this is a secondary pulse due to washing off the Uranine from Slapenski Ledenik after the rain on November 19. This pulse required about 300 to 400 hours to reach the spring; this gives the velocity of 20 to 25 m/s and according to higher water level it is slightly higher than was the velocity during the first pulse. The following peaks of the tracer pulse curve appeared in December together with water pulses; they are obviously the result of pushing of dyed water from the underground after 1300 to 1800 hours since the injection. Similar phenomenon was recorded at previous water tracing in August 1995. The last traces after 4600 hours confirmed that water is retained in the Vipava aquifer for at least half a year. Similar conditions were stated during water tracing of the Pivka and Stržen near Postojna in 1988 (HABIČ 1989).

7.3. WATER PROTECTION MEASURES (J. JANEŽ)

7.3.1. Introduction

The first attempts to protect karst water between the valleys of the Vipava, Soča and Idrijca started 25 years ago when the professional foundations and proposition of protection of the recharge area of Podroteja spring near Idrija was being prepared. The decree did not pass. In the early 80' the Karst Research Institute ZRC SAZU, Postojna prepared the professional foundations and the communes Nova Gorica and Ajdovščina passed the communal acts to protect the springs Mrzlek, Vipava and water storage of Čepovan-Lokve water supply. The Mrzlek recharge area was protected by the act issued at Nova Gorica but not at Ajdovščina commune. The Vipava recharge area was protected by the Ajdovščina commune but only the area covered by its own commune while the part that administratively belongs to Postojna was not protected.

Insufficient local and partial measures animated the initiative to prepare a full range of professional foundations for uniform protection of the entire karst aquifer of Banjšice, Trnovski Gozd, Nanos and Hrušica and the recharge areas of all the concerned springs. These foundations were being prepared from 1988 to 1993. The first phase of the project was concluded, including geography, geology, karst springs, hydrogeology, speleology, surface and underground pollution, threat to waters, plan of protection with proposed protection areas and protection measures. The second phase aimed to the abatement of pollution and future land use management, was not achieved.

7.3.2. Physico-chemical and biological threat to karst superficial and underground waters

7.3.2.1. General criteria

Threat to karst waters depends on ecological burden and natural sensitivity (vulnerability) of the aquifer. The first one is controlled by different forms and varying degree of industry, thus it represents active and latent sources of pollution and may be diminished by better hygienic organisation of the environment. Vulnerability of a karst aquifer depends on superficial infiltration (rate and velocity), hydrogeological conditions of the aquifer that control way and time of underground drainage, quantity of water and rate of dilution and stage of environment deterioration that was already reached (JANEŽ 1995).

Classification of recharge areas according to different degrees of vulnerability is used to determine the protection areas. Definition of the true burden is urgent for a sensible approach and sensible order at sanitation of pollution.

7.3.2.2. Vulnerability

The vulnerability of an aquifer may be defined, without considering the distribution of pollution sources, by hydrogeological properties of terrain; it means that underground water below more permeable areas is more threatened than below less permeable ones. Anthropogeneous factors, as for instance population at a given time or land use of the aquifer surface do not impact on vulnerability except when man and his interventions had essentially changed the natural conditions (for example wood cutting can substantially increase the soil erosion etc.).

The vulnerability of an aquifer or a degree of pollution danger may also be defined by possibilities of intervention in case of pollution. By intervention one may prevent:

- spreading of harmful substances over the surface and their in vasion into aquifer
- preventing the access of accidental spills into water supply system, to user respectively.

We have taken into account only such possibility of intervention in case of pollution that is controlled by natural circumstances and conditions, mostly hydrogeological and not by anthropogeneous impacts as is momentary urbanisation/population of karst surface or organisation of water management.

Using the above mentioned criteria we divided the entire region between the Soča, Vipava and Idrijca into areas of catastrophic, great, medium and little vulnerability.

The areas of catastrophic vulnerability are those where there is practically no possibility nor time in case of pollution to prevent the harmful substance access into water supply system. Areas of great vulnerability belong to such regions where there is practically no possibility to prevent the access of harmful substance into aquifer, but there is a certain time to prevent the access into water supply system. They include the entire karst recharge area of a water source having exclusively underground drainage of precipitation. In the areas of medium vulnerability there is more chance to prevent the access of harmful substance either into aquifer or into water supply system. As medium vulnerable areas are treated the regions consisting of medium to bad permeable rocks, dolomitic and some flysch areas in particular. The areas of little vulnerability offer in case of pollution a true time and possibility to react and prevent the access into aquifer. They include the surface on impermeable beds with exclusively surface drainage of the precipitation.

7.3.3. Overview of way and degree of protection

7.3.3.1. General criteria

The extent of protected area is defined for the conditions of high hydrological levels (the fastest discharge, the highest water level, the widest surface of recharge area). Protection measures are totalled - a measure implemented for a wider protection area applies to all the areas within.

1. This protection area includes the surface of the catastrophic vulnerability area where there is in case of pollution practically no possibility to prevent the access of harmful substance into water supply system. It is divided into two parts; zone 1 a means enclosure around the water storage which prevents intentional water pollution; in zone 1 b all the activities that may threaten the water quality and quantity are restricted.
2. This protection area with a severe regime covers the area of great vulnerability where there is practically no possibility to prevent the access of harmful substance into aquifer, however there is a certain time to prevent the access into water supply system. It includes karst recharge area of the water source. The area is aimed to be protected by severe sanitary measures against organic biological pollution.
3. This area with sanitary regime includes the area of medium vulnerability with some time available to prevent the access of harmful substance either into aquifer or into water supply system (rocks of medium or bad perme-

ability). The area is aimed to protection against intensive organic biologic pollution.

4. This protection area bears a soft regime and includes the area of little vulnerability where there is still time and possibility to prevent the access of harmful substance into aquifer in case of pollution (surface on impermeable beds). The area is aimed to be protected against the unconventional pollution by permanent, non-degradable substances.

7.3.4. Verifying the protection areas related to recent water tracing tests

The achieved water tracing tests from 1993 to 1996 show the following:

- the principle of uniform protection of the entire region showed to be correct. The conservation of one area (Belo Brezno and vicinity of Golaki, for instance) remains the same without regard whether the water flows to Mrzlek or Hubelj.
- According to water tracing results the classification of all the limestone terrains in the second protection area with severe regime of protection was correct.
- Water tracing tests in Mrzli Log and Malo Polje showed that it would be probably necessary to protect the area of sinking streams on dolomite and flysch more severely and include them into the second protection area.