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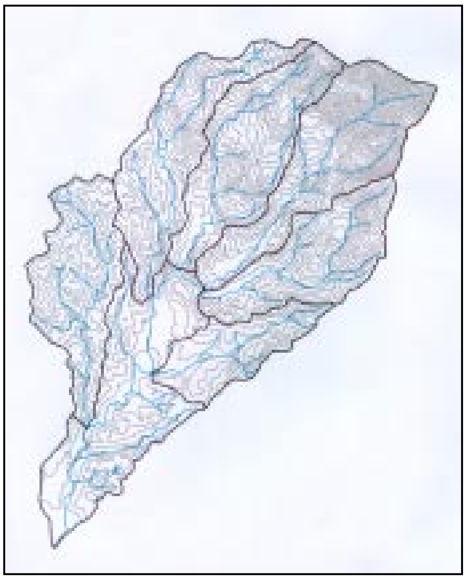
PREVENTION IN THE MOUNTAINS FOR PROTECTION OF THE VALLEYS

"Principles and guidelines for the environmental protection of drainage basins prone to flash floods. Experimental intervention in a pilot drainage basin" (Project reference number : B4-3040/97/734/JNB/C4)

Final Report:

EXPERIMENTAL INTERVENTION IN THE PILOT DRAINAGE BASIN OF CIVIGLIA TORRENT (Province of Massa and Carrara – Italy)



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1.) INTRODUCTION

In relation to the development of project "*Premo '98 – Prevention in the Mountains for Protection of the Valleys*" sponsored by European D.G. XI and aimed at the identification of a methodological approach for the analysis of medium-small basins prone to flash floods, this document is the conclusive study of the main territorial aspects of Civiglia basin, which represents a case study in order to put in practice the theoretic guidelines emerged in the development of project Premo.

The study of the Civiglia basin represents both a practical application of the indications emerged in the evolution of the project and the verification and refining, with a direct evaluation of an actual case, of the theoretical analysis.

This study is the prosecution of the preliminary analysis of Civiglia basin that was prepared in the first phase of project "Premo" in 1997-98. Information collected in that phase was integrated and examined in depth with analysis and field surveys that have consented to acquire a more complete information of the aspects directly or indirectly involved in the formation of flash alluvial events.

In particular, the analysis of territorial aspects has foreseen the acquisition of technical information from Scientific Bodies and Public Offices in charge in the management and control of this river basin. On the basis of collected information, the study has aimed at the integration of the available data or the preparation of an ex-novo collection of the incomplete data. This procedure has permitted to prepare an up-dated and significant data-base of the territorial characteristics of this basin and to compare correlated information in order to identify the causes responsible for the formation of recurrent alluvial events that involve the lower urbanized area of the basin (Terrarossa area).

In detail the study has been divided in a first step that prepares the up-dated data-base concerning the following aspects:

- Socio-economic aspects;
- Climatic and hydrological data;
- Geomorphology;
- Geology;
- Hydrogeology;
- Land use;
- Soils;
- Granulometry and sorting of alluvial deposits;
- Hydraulic structures;
- Ecological aspects;
- Hydraulic modelling;
- Critical hydraulic sections
- Law and prescription in force;
- Hazard conditions;

On the basis of the general territorial information, a diagnosis of the problems of Civiglia basin has been carried out. This analysis identifies the direct and indirect causes that produce hydraulic and morphological risk conditions within the studied basin.

In detail the following risk condition have been analyzed:

- Global risk conditions caused both by geomorphologic and hydrodynamics aspects.
- Hydraulic risk conditions in the Terrarossa area involved by recurrent alluvial events;

In relation to the analysis (territorial data) and diagnosis (risk conditions) of Civiglia basin, proposals of structural interventions and criteria for the management that could be put in practice in order to reduce the hydraulic risk conditions of the basin have been highlighted. These criteria concern the management of the valley flat areas, main torrents and the agricultural and forest territory.

A recording station to measure the discharges of Civiglia torrent in order to carry out an ex-post analysis of the effectiveness of interventions is foreseen for completion of this study.

Finally, all the territorial analysis and diagnosis carried out during the development of the study have been transferred on a Geographical Information System applying software used in the Regional Administration of Tuscany, called "Charta for Windows".

This GIS, in addition to the relevant assistance in the analysis and diagnosis processes of the project, represent a tool that can easily be up-dated or modified by the technicians that operate in this basin, in relation to the future territorial evolution of the Civiglia basin.

2.) GEOGRAPHICAL LOCATION

Civiglia basin extends itself in the territory of three different Communes (Licciana Nardi, Bagnone and Villafranca in Linigiana) located in the North–Western part of Tuscany within the Province of Massa and Carrara. Its territory belongs to the Lunigiana Valley and covers a total surface of 34.06 km^2 . The Civiglia torrent flows into the Taverone Torrent which is a left tributary of Magra River, the main water course in the Lunigiana area (Figure 2.a).

The basin is situated in the South-Western part of the Apennine watershed in an area characterized by hills with a range in elevations between 62 and 951 meters above sea level (m a.s.l.).

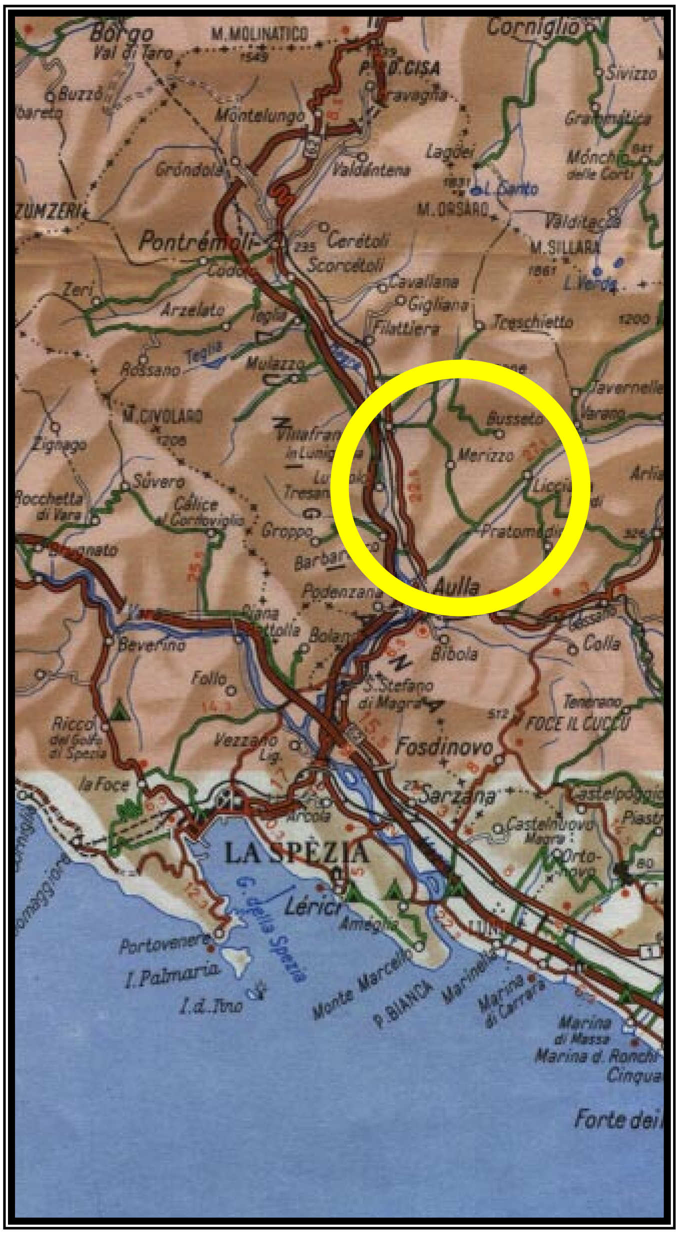


Figure 2.a - Location of Civiglia Basin

3.) SOCIO-ECONOMIC ASPECTS

3.1) Population

Socio–economic characterisation of this area has been made analysing the data of the population and commercial activities in census carried out by the ISTAT (National Statistical Agency) in October 1991 (Istituto Nazionale di Statistica – 1991).

The available data has permitted to carry out a detailed analysis of the geographical distribution of the population in each village while, as regards the typology of the commercial activities, the census data represents a comprehensive situation of each Commune. The homogeneity of the socio-economic characteristics of this area permits to draw some significant conclusions about the economic aspects of the Civiglia basin.

First of all it is important to highlight the evolutive trend of the population living in the basin. In detail, it is important to indicate the existence of two different evolutive trends between the Commune of Bagnone, characterized by a predominant hilly and mountainous territory, and the other two (Licciana Nardi and Villafranca) whose territory is lower in height.

During the last 16 years, in the first Commune, a decrease of 19% of the population has occurred because of difficulties implied in agricultural and urbanistic land uses while, in the other two communes, a mean increase of 7% of population has occurred in the large villages of the flat areas and along the principal road network.

The general evolutive trend of population in the three analysed communes is also highlighted by the distribution of people within classes of age. In fact, the Commune of Bagnone, because of the depopulation of hilly and mountainous areas, is characterised by preponderance of resident inhabitants more that 55 years old while in the other two communes, the existence of larger villages permits to maintain a normal distribution population within each age class.

As regards the entity and geographical distribution of the population, the following scheme (Table 3.1.a) shows population and buildings in each village within the basin.

Table 3.1.a - Census data of 1991

N.	Village	Population	Buildings
1	Groppo	63	141
2	Pieve	32	57
3	Vespeno	20	38
4	Castiglione	29	64
5	Lusana	43	60
6	Corvarola	26	32
7	Gabbiana	42	48
8	Cassolana	9	24
9	Villa di Panicale	71	41
10	Corte	41	16
11	Merizzo	71	114
12	Deglio	9	5
13	Panicale	64	44
14	Cortenovo	20	13
15	Amola	62	35
16	Fornoli	203	109
17	Castel di Monti	301	300
18	Terrarossa	939	378
	"Single buildings"	307	184
	Total	**2352**	**1553**

The analysis of the

previous data highlights a strong spreading of the population in small and very small villages (less than 20 people). The most populated villages (Castel di Monti, Terrarossa) have grown along the most important communication lines in the lower part of this basin.

As regards the total population, there is a degree of uncertainty because of the difficulty to identify the exact number of people living in single buildings located outside the villages. The value showed in the scheme has been determined calculating the density of the people living in single buildings in the three analysed communes multiplied by the surface of the Civiglia basin.

The calculation has determined a density of population for this hydrographic basin: of 69.0 people/km^2.

The comparison between total population and total existing buildings reveals a great number of the houses that are usually uninhabited. Actually, a high percentage of these buildings are occasionally used for a few days during the year for tourist purposes while, the remnant part is abandoned because of the depopulation phase occurred in mountainous area of Lunigiana in the last decades.

3.2) Economy

As regards the economic analysis of the Civiglia basin (Camera di Commercio, Industria, Artigianto, Agricoltura di Massa e Carrara - 1997), the activities have changed in the last decades from a predominant agricultural-forest typology to one of private business of small dimension and few employees.

The analysis of the statistical data of each Commune highlights the preponderance of building, retail sale, manufacturing and tourist activities. The hilly and mountainous morphology of the basin has also favoured the development of activities linked to the production and sale of wood and, at the same time, of the craft iron manufacturing that employs many people. Other kind of activities that employ a great number of people are represented by Public Offices and State schools.

The location of the larges part of these activities in the lower part of Civiglia basin has created an increase of number of pensioners in the mountainous area.

The typology of the economic activities previously analysed, shows that Civiglia basin presents poor economic resources that can only guarantee the existing economic conditions. In the last years, in the lower portion of the Civiglia basin (Terrarossa Area), an industrial and commercial–craft estate with many activities and employing many people was developed, with an increase of the total economic wealth of this area.

Finally, as regards the primary economic sector, a scant agricultural production in the alluvial plain and in the hilly areas, is practised only for domestic use because of the fragmentation of the land property.

4.) HYDROLOGICAL DATA

The climatic and hydrological characterisation of Civiglia basin has been carried out through the acquisition and elaboration of available pluviometric and thermometric data of five recording stations located near the boundary of the basin. All data were collected from the Hydrographic Office of Genoa (Ministero dei Lavori Pubblici - Servizio Idrografico di Genova - 1943-1992) that is in charge for the Lunigiana Valley. Data coming from another recording station of ARSIA, located inside the basin (village of Fornoli), have been analysed, but because of its short recording period, they are not used to define the mean peculiar pluviometric and thermometric characteristics of the basin.

The meteorological data analysed belong to the following stations:

- Arlia (494 m a.s.l. - discontinuous data between 1943-60);
- Aulla (120 m a.s.l. - discontinuous data between 1948-93);
- Bagnone (316 m a.s.l.- discontinuous data between 1945-90);
- Mazzola (449 m a.s.l. - discontinuous data between 1951-92);
- Villafranca in Lunigiana (130 m a.s.l.- 26 discontinuous data between 1946-92).

All the previous stations are equipped with pluviograph while just Arlia and Mazzola are able to record the atmospheric temperature (see Annexes).

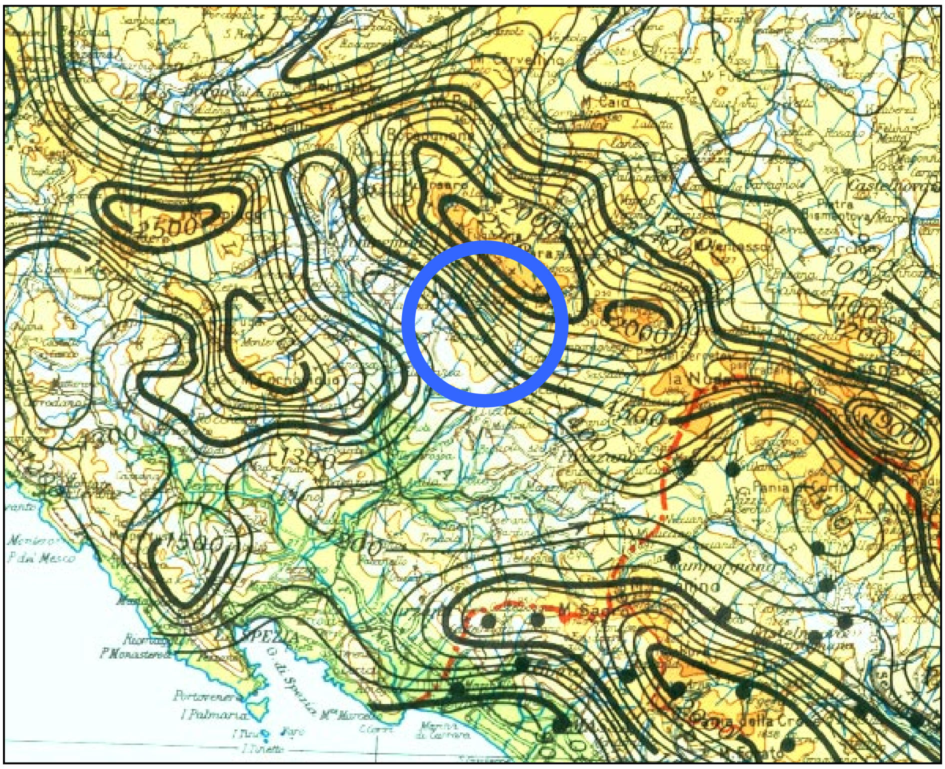


Figure 4.a - Mean annual rainfall (Ministero dei Lavori Pubblici - Servizio Idrografico dell'Arno di Pisa - 1971)

As regards general climatic conditions, Figure 4.a shows the mean annual rainfall distribution in the North-West portion of Tuscany Region, Lunigiana is characterised by a wet or almost-wet climate with a total mean annual rainfall that, on the eastern and western ridges that surround the valley, can exceed 2 000 mm, while the axial portion of this territory is characterised by lower rainfall values (mean value 1 300 mm).

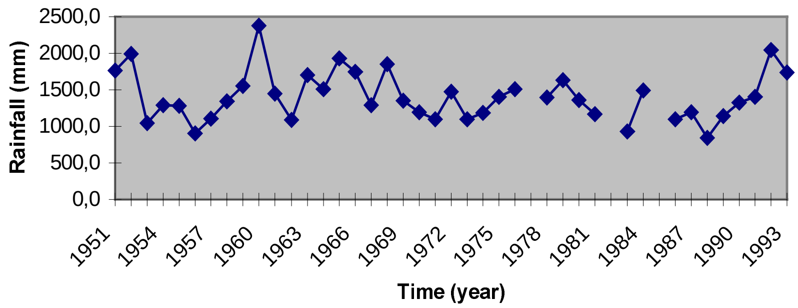
The pluviometric regime of this part of the territory is quite similar to the general climatic characteristics of Tuscany with long meteoric events concentrated during Spring and Autumnal periods while Summer dry periods (minimum of precipitation occurs in July) are interrupted by storm events.

Table 4.b - Total mean annual rainfall

Station	Value (mm)
Bagnone	1615.1
Villafranca	1719.3
Aulla	1501.6
Mazzola	1379.7
Arlia	1407.7

In detail, regardings Civiglia torrent, its basin is located in an area (axial part of the Lunigiana Valley) with values of mean annual precipitation that vary from 1 400 mm in the eastern part to 1 700 mm in the western part (Table 4.b). This difference is directly linked with the presence of a mountainous area on the western side of Lunigiana that causes the interception of a substantial portion of the rain brought by the most important atmospheric perturbances coming from West and South-West.

Figure 4.c - Villafranca annual rainfalls



A detailed overview of the total annual rainfall data stresses the occurrence of a wide range between the driest and wettest years with differences that exceed in many cases more that 1 000 mm (Figure 4.c). The highest value was recorded in 1960 in Bagnone with 2,570.6 mm while the lowest belongs to Arlia in 1988 with 840.4 mm.

On the other hand, it is not possible to identify a negative or positive evolutive trend of the mean annual total meteoric values.

Table 4.d - Mean monthly temperature

Month	Bagnone (C°)	Arlia (C°)
Jan	5.2	4.4
Feb	6.6	5.3
Mar	8.7	7.5
Apr	11.8	10.9
May	15.6	14.7
Jun	19.3	18.2
Jul	22.0	20.9
Aug	21.9	20.4
Sep	18.7	17.3
Oct	14.3	13.0
Nov	9.3	8.4
Dic	6.1	5.2

Regardings the thermometric aspects, the mean annual regime of Arlia and Bagnone, the only recording stations equipped with thermometer, are represented in Table 4.d.

Table 4.e - Extreme hourly rainfall events (mm)

Station	1 hour	3 hours	6 hours	12 hours	24 hours
Arlia	97.0	136.0	191.0	233.4	347.4
Aulla	60.0	108.0	143.0	188.0	207.6
Bagnone	58.0	98.0	117.3	151.0	160.6
Mazzola	52.6	61.8	88.2	140.8	171.2
Villafranca in lunigiana	71.0	104.0	132.0	199.0	222.0

Analysis of these data highlights the homogeneity of thermometric regime of this area with the highest value in July and the lowest temperature in January. Because of its mean South-Western exposition and of a low medium elevation, Civiglia basin benefits of a warmer climate in comparison with other zones of Lunigiana.

Small differences concerning mean monthly values which are higher in Bagnone than in Arlia. This aspect is correlated with the difference of elevation between the two stations (Bagnone 316 m a.s.l.. Arlia 494 m a.s.l.).

Also temperature values show a wide range between maximum and minimum recorded data. In particular, in the Bagnone station, the highest value has reached 40.8 °C while the lowest has decreased to –10.5 °C.

In order to complete the meteorological description of Civiglia basin, the hourly rainfall events were analysed. In particular, the extreme hourly rainfall events for the 1, 3, 6, 12 and 24 hours of each recording stations are reported in Table 4.e. The collected data show that this basin is involved by strong storm events that drop, in short time, a huge quantity of rain. In particular it is interesting to highlight the intensity value of short and very short precipitations (1, 3 hours). These values highlight the occurrence of rainfall events that are able to cause strong hydraulic and hydrogeological troubles within the basin.

In order to characterize completely the meteoric events that are able to produce alluvial events in the Civiglia basin, the meteorological analysis has also considered the statistical elaboration of recorded hourly rainfall values in order to define potential rainfall events in relation to their return time period (**Rt**).

Table 4.f - Statistical rainfall events in mm (Villafranca)

Rt	1 hour	3 hours	6 hours	12 hours	24 hours
10 years	54.9	85.4	108.8	159.9	197.3
50 years	71.9	110.6	139.4	211.8	257.1
100 years	79.1	121.2	152.4	233.7	282.5
200 years	86.2	131.8	165.2	255.5	307.7

Table 4.g - Statistical rainfall events in mm (Arlia)

Rt	1 hour	3 hours	6 hours	12 hours	24 hours
10 years	56.5	84.9	112.5	142.0	177.3
50 years	79.4	117.8	156.7	197.2	248.7
100 years	89.1	131.7	175.4	220.6	278.9
200 years	98.7	145.5	194.0	243.8	309.0

The statistical elaboration has been made with Gumbel’s method (Regione Toscana - Giunta Regionale - 1998) using, because of their long recording period (26 and 44 years) of hourly rainfall data, using Villafranca and Arlia's meteoric values. Results of this elaboration are represented in Table 4.f and 4.g.

Comparison of the two tables shows a difference between short and long meteoric events. Particularly, in the Arlia station, the total height of 1, 3 and 6 hour events are higher than Villafranca while the opposite condition can be highlighted for the 12 and 24 hours rainfalls.

Furthermore, comparing the recorded values with the statistical rainfall analysis, it is clear that, in the last decades, Civiglia basin was involved by storm events that, just in few cases, have overcome the return time period of 10 years. Overcoming of 50 years return time period is a very rare case. Exception to this evidence is the extreme recorded events of Arlia station that represents the strongest rainfall events of this area.

Despite of this analysis, Civiglia Torrent was involved during the last decades by frequent alluvial events that have cause damages in the Terrarossa area located in the lowest portion of the basin.

5.) GEOMORPHOLOGY

5.1) Morphological Aspects (Comune di Bagnone – 1998), (Comune di Liccina Nardi – 1998), (Comune di Villafranca in Lunigiana – 1998), (Università di Pisa - Dipartimento di scienze della Terra – 1988/89)

The examined torrent has its source in a hilly area located immediately South-West of the Apennine watershed that represents the main ridge of this portion of the regional territory.

Civiglia torrent shows a leaf shaped basin with the main direction towards North-East/South-West (see Figure 10.a) and has a total surface of 34.06 km^2 occupied mainly by hills of slight elevation (mean elevation of the basin 277 meters a.s.l.) and narrow valley floors (minimum elevation of the basin 62 meters a.s.l.) while in the North-western upper portion of the basin there are mountains that reach the maximum elevation of 951 meters a.s.l. .

The zoning of the total surface of this basin within classes of elevation, showed in Table 5.1.a, confirms the preponderance of hilly areas located between the elevations of 100 and 300 m a.s.l.:

Table 5.1.a – Percentile zoning of the total surface of the basin within classes of elevation (Regione Toscana - Giunta Regionale - 1985)

elevation classes (m)	0-99 m	100-199	200-299	300-399	400-499	500-599	600-699	700-799	>799 m
Surface (%)	5.2	37.1	26.7	11.3	7.5	5.6	2.8	2.3	1.4

The preponderance of hilly areas is also confirmed by the zoning of the total surface of the basin within classes of slope (Table 5.1.b):

Table 5.1.b – Percentile zoning of the total surface of the basin within classes of slope (Regione Toscana - Giunta Regionale - 1985)

Slope Classes (%)	0-9	10-19	20-29	30-39	40-49	50-59	> 59
Surface (%)	24.4	30.5	24.9	13.6	3.8	1.4	1.4

This situation derived from the morphological and geological evolution that involved this area in the beginning of the Pliocene-Pleistocene, when Lunigiana, in a phase of tectonic subsidence, was occupied by a lacustrine environment that caused the sedimentation of thick coherent and incoherent sediments. The subsequent erosion of these materials has formed the low sloped hills and terraced surfaces located in the medium-lower part of the basin. The erosive and sedimentation action of streams have also produced small and narrow alluvial plains along the most important torrents. In some cases, along Civiglia and Deglio torrents, the existence of natural sills (outcrop of rocky substratum) has caused the formation of the largest flat areas of the basin. On the other hand, the steepest areas are located in the upper portion of the basin where marly and calcareous-marly formations outcrop.

The two morphologically different parts of the basin are divided by tectonic elements (faults and overthrust) with mean trend from South-East to North-West. Along these lines, strong movements occurred during the Pliocene-Pleistocene period and produced the formation of the Lunigiana lacustrine habitat. In particular, in the middle part of the basin the tectonic evolution of the area has produced the formation of small graben with South-East to North-West direction.

5.2) Hydrographic network

Table 5.2.a - Morphometrical data of basin and main sub-basins

Torrent	Minimum elevation (m)	Maximum elevation (m)	Total length (km)	Surface (km^2)
Civiglia Torrent	62	755	13.58	34.06
Upper Civiglia	140	755	5.75	5.84
Carpena Torrent	77	272	5.26	4.54
Deglio channel	140	737	5.09	4.27
Ghiaia channel	110	510	6.37	4.94
Miona channel	95	316	3.77	2.70
Torchio di Bacco channel	136	721	5.34	5.23

The main torrent (Civiglia Torrent) has a total length of about 13.58 km and a medium direction from North-East to South-West that is frequently interrupted by sharp bends and by changes of direction towards South and South-East.

The most important tributaries are Miona, Deglio, Torchio di Bacco, Ghiaia channels, and Carpena Torrent. In the following table, sub-basin surface, total length and elevation of the upper and lower point above sea level of each torrent are specified (Table 5.2.a).

These morphological data stress the existence of small and very small sub-basins with a short and very short torrent and a high morphological gradient.

Analysis of the longitudinal profile of torrent bed (Figure 5.2.b and annex). highlights that the upper portion of the Civiglia torrent, Ghiaia, Deglio and Torchio di Bacco channels have a very steep course in relation to their location in the mountainous portion of the Civiglia basin. The other two streams (Carpena torrent and Miona channel), because of their location in the hilly portion of the basin, present a lower morphological gradient.

This aspect is directly linked to the different lithological resistance against erosion of the formations that are crossed by torrents and also by the presence of tectonic disturbances (faults and overthrusts) that have been surveyed in the basin.

Tectonic and lithologic influence cause a non-equilibrium profile of the previous streams. Instead, Carpena torrent and Miona channel, in relation to their lower maximum elevation and homogeneous rocky substratum, do not present sharp changes in their longitudinal profiles.

The planimetrical course of natural streams is also conditioned by the main tectonic directions that occur in rocky substratum. This aspect is evident in the middle portion of the basin where the most important tectonic trends, that have caused a tectonic subsidence of the Lunigiana valley have been surveyed. In detail, the 90° degree sharp bends of Civiglia torrent, Deglio and Ghiaia channels, follow the fractured zone produced by the subsidence displacement of rocky substratum.

The clear influence that tectonic activity occurred in the basin from the Miocene till the Pliocene-Pleistocene can be considered one of the most important factors that have produced the actual morphology of Civiglia basin.

Regardings the dynamics of hydrographic network, frequent but located erosive phenomena have been surveyed both in the torrent bed and along the banks. The first typology occurs in the upper portion of basin because of the steep morphological gradient of torrent beds. Destroyed or damaged river training works (check dams, sills, etc.) represent, in some cases, a contribution to the increase of the erosional action of the waters.

Bank erosional phenomena involve also torrent reaches of the lower portion of the hydrographic network situated in the incoherent lacustrine formations or in the alluvial materials. These phenomena have produced the undermining and destruction of longitudinal protection structures.

On the other hand, the field survey of the hydrographic basin did not show the presence of areas subject to strong surface erosional problems because the entire area of the basin is protected by an extensive vegetal covering. The surface of the basin is however subject to a normal erosional rate that, during the main flood events, produces transported solids that can deposit a large quantity of materials along the lower portion of torrent. In particular, aggradation of the lower part of the hydrographic network of this basin requires to put in practice a periodical work, by the Consortium of Mountain Communes of Lunigiana, in order to maintain the hydraulic transversal sections in the Terrarossa area.

On the basis of the direct analysis of erosive phenomena and comparison with the location of the largest active or dormant landslides, it is clear that the dynamic action of the water has produced in many cases the formation of slope instability conditions. In particular along Miona, Deglio Channels and also along small tributaries, the presence of landslides can be directly correlated with the bed or bank erosional phenomena.

5.3) Slope instability (Comune di Bagnone – 1998), (Comune di Liccina Nardi – 1998), (Comune di Villafranca in Lunigiana – 1998), (Università di Pisa - Dipartimento di scienze della Terra – 1988/89)

Concerning landslides, the morphological analysis of the basin has highlighted an dishomogeneous distribution of these phenomena with a preponderance in the lower portion of the basin where the incoherent and clayey lacustrine formation outcrops. Many active or dormant landslides together with wide debris areas are located along the great tectonic overthrust located in the North-East portion of the basin among the villages of Villa Panicale, Gabbiana and Castiglione. Along this tectonic element, the fractured rocky substratum has caused the formation of strong instability conditions on the steepest slopes.

The majority of surveyed landslides, especially where rocky formations outcrop, are usually in dormant conditions. On the other hand, active landslides usually occurred where clayey, shaly or debris formations outcrop.

The main active landslides of creeping type are surveyed in the middle portion of the basin within the Miona channel sub-basin. They are formed within the lacustrine sediments and move with a low velocity that can increase during the main meteoric events. Active or dormant landslides, in the steepest mountainsides, are/were usually generated by the river dynamics along torrent reaches with bed or bank erosional phenomena.

On the basis of informative analysis of territorial data, a census of both the total number of unstable and debris areas has been carried out. The elaboration stresses the presence of 251 zones with unstable or potential unstable morphological conditions with a total involved surface of 5 888 km^2. This unstable and potentially unstable formation cover more than the 17% of the total surface of the basin.

Table 5.3.a shows the distribution of the previous values among active, dormant and debris bodies. In particular the great number of dormant landslides that were surveyed homogeneously all over the basin is evident.

Table 5.3.a - Distribution of instability phenomena

Formation	Number	Surface (ha)
Debris	35	1.550
Active landslides	50	1.115
Dormant landslides	166	3.223

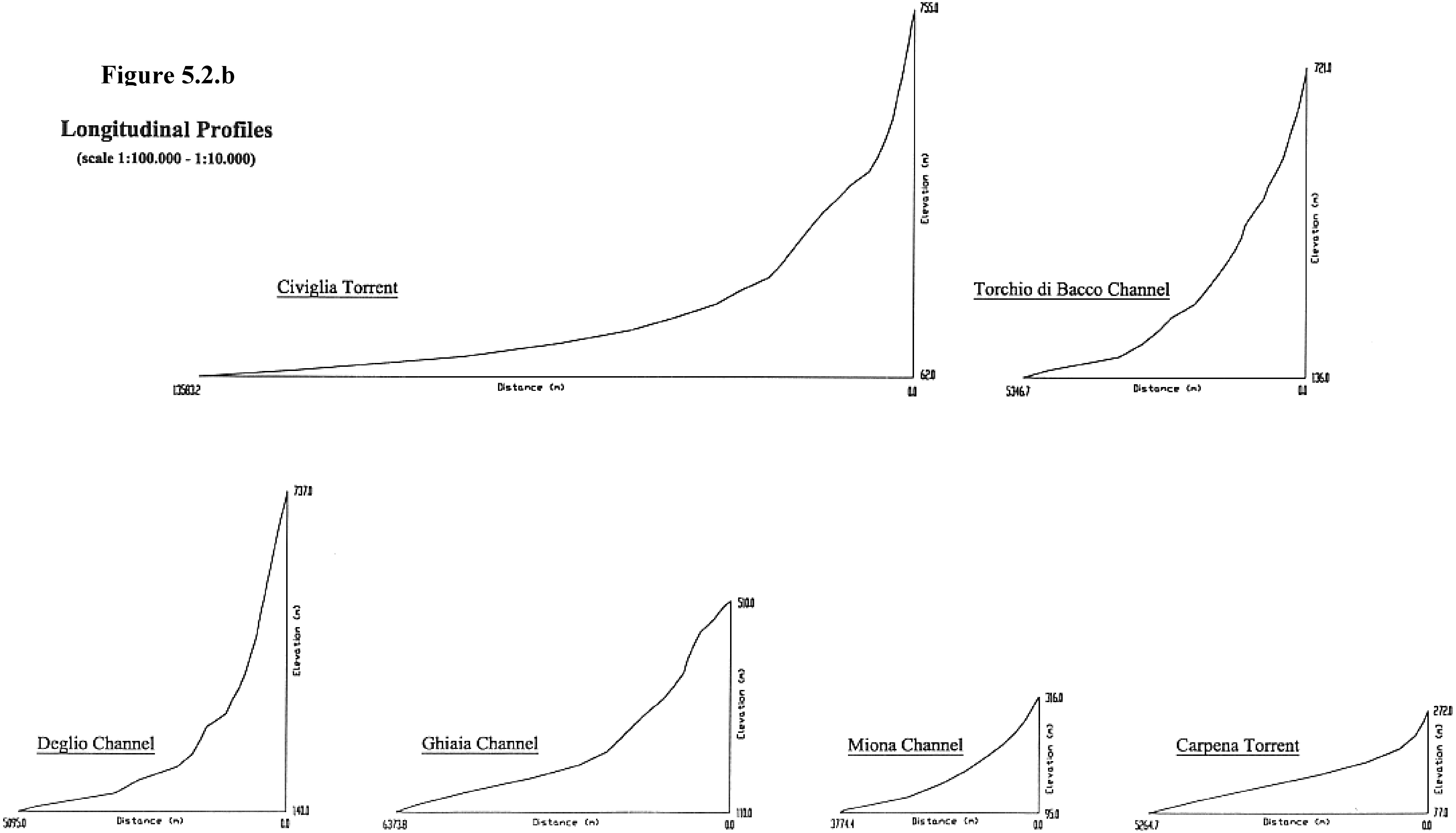
These data highlight the preponderance of active landslides within the fluvial-lacustrine incoherent formations of the middle part in the Civiglia basin. In particular, the sand-clayey and clay-sandy fluvial-lacustrine sediments are involved by the main instability phenomena surveyed in the basin. More than 28% of its outcrops are involved by actual or potential unstable conditions

Important instability conditions directly or potentially involve also urbanized areas and in particular the villages of Villa Panicale, Busseto and Gabbiana.

Figure 5.2.b

Longitudinal Profiles

(scale 1:100.000 - 1:10.000)



6.) GEOLOGY

The geological history of this area is similar to the tectonic and sedimentologic evolution of the northern Apennine Chain begun during the Noric-Rhaetic with a sedimentary phase that concluded in the upper Miocene when the main orogenetic phase that created the actual tectonic structure of the Apennine ridge began.

During the orogenetic phase, strong overthrusts among different formations occurred. An example of this phenomena is evident in the mountainous part of basin where the Ottone - S. Stefano Unit is located inside the Cretaceous Helminthoids Flysch.

Later, beginning from the lower Pliocene, this area was subjected to a tectonic subsidence that formed one of the largest graben existing within the Apennine Chain, where the formation of a lacustrine environment favoured the deposition of thick terrigenous coherent and incoherent formations. The tectonic displacement occurred along principal directions with trends from South-East to North-West (Apennine trend) and from North-East to South-West (anti-Apennine trend).

The old Pliocene-Pleistocene lake covers all the middle and lower portion of the Civiglia basin. In fact, because of the existence of evident distensive tectonic elements within the basin, this portion was lowered in comparison with the remnant portion of the basin.

The lacustrine phase that ended during the lower Pleistocene was replaced by a continental environment that has caused the erosion of previous lacustrine formations and the deposition of continental sediments, especially of fluvial type up to this day.

The rocky formations outcropping in the large part of the basin are prevalently composed by Upper Cretaceous-Paleocene marl, marly limestone, shale, and calcareous sandstone while Pliocene-Pleistocene lacustrine sediments with a granulometry range between clay and sand-pebble outcrop in the central part of the Civiglia basin. Narrow recent or terraced alluvial deposits are located in the main valley floor in the lower part of this basin.

The geological formations outcropping in the Civiglia torrent are the following (Comune di Bagnone – 1998), (Comune di Liccina Nardi – 1998), (Comune di Villafranca in Lunigiana – 1998), (Università di Pisa - Dipartimento di scienze della Terra – 1988/89):

Recent formations

- Debris - Deposits with heterogeneous granulometry usually made by homogeneous lithology (Quaternary);
- Bodies of active landslides (Quaternary);
- Bodies of dormant landslides (Quaternary);
- Recent and actual alluvial sediments (Holocene);
- Terraced alluvial sediments (Holocene);
- Alluvial fans (Holocene);

Fluvial-lacustrine sediments

- Fluvial-lacustrine sediments with preponderance of pebbles mixed with silt-sandy matrix (Villafranchiano);
- Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite) and rare interbeds of pebbles (Villafranchiano);

Ottone - S. Stefano Unit

- Helminthoids Flysch - Calcareous and marly calcareous turbids with marly and shaly interbeds (Upper Cretaceous);
- Polygenic breccias with shaly matrix and ophyolitic fragments (Upper Cretaceous);
- Base Complex - Dark-grey shales with rare silty marlstones. Within the formation chaotic calcareous and marly calcareous blocks (Upper Cretaceous);

Canetolo Unit

- Ponte Bratica Sandstones - Fine grained quartzose micaceous sandstones with interbeds of pelite and silty marlstones (Upper Eocene);
- Groppo del Vescovo limestones - Alternation of white and light grey torbiditic marly limestones, marlstones and shales (Paleocene);
- Alternation of dark grey shales, limestones, calcarenites and marly limestones (Upper Cretaceous).

In the following table (Table 6.a) the outcropping surface of each formation is specified. Analysis of these data shows the preponderance of calcareous and marly-calcareous Helminthoids Flysch formation that outcrops in more than 50% of the Civiglia Basin. Other important formations are represented by both the fluvial-lacustrine formations that cover a total surface of 6 006 km^2 (17.64%).

The outcrops of the remnant formations represent a small percentage within the total surface of the studied hydrographic basin.

Table 6.a - Surface of outcropping formations

Formation	Surface (km^2)	(%)
Debris	1.550	4.55
Active landslides	1.115	3.27
Dormant landslides	3.223	9.46
Recent and actual alluvial sediments	0.229	0.67
Terraced alluvial sediments	1.546	4.54
Alluvial fans	0.010	0.03
Fluvial-lacustrine pebbles mixed with silt-sandy matrix	1.951	5.74
Sand-clayey and clay-sandy fluvial-lacustrine sediments	4.055	11.90
Helminthoids Flysch	17.513	51.42
Polygenic breccias	1.121	3.29
Base Complex	0.072	0.21
Ponte Bratica Sandstones	0.076	0.22
Groppo del Vescovo limestones	0.017	0.05
Alternation of dark grey shales, limestones, calcarenites and marly limestones	1.582	4.65

7.) HYDROGEOLOGY

On the basis of lithological aspects of outcropping formations, the surface of Civiglia basin is divided into five classes of permeability. The definition of each class was made on the basis of qualitative parameters. During the field survey attention was paid into identification of natural springs in order to furnish a quantitative checking to the degree of permeability assigned to each formation. The density of natural springs within each different terrain represents an indirect way to quantify the underground circulation and its typology.

The geological formations outcropping in the Civiglia torrent are divided into the following classes:

High Permeable formation

- Alluvial fans;
- Recent and actual alluvial sediments.

These formations are characterized by a high permeability in relation to their coarse granulometry. The few quantity of clayey and silty matrix do not produce a relevant reduction of permeability.

Permeable formation

- Terraced alluvial sediments;
- Fluvial – Lacustrine sediments with preponderance of pebbles mixed with silt-sandy matrix.

Because of their coarse granulometry but also a significant matrix percentage inside, these formations are characterized by a minor but significant permeability in comparison with the previous formation. In relation to the large size of their outcrops, these formations represent the most important aquifer of the Civiglia basin.

Medium permeable formation

- Debris;
- Bodies of active landslides;
- Bodies of dormant landslides.

The presence of a high percentage of fine materials (matrix) causes a reduction of the permeability of these incoherent formations.

Low permeable formation

- Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite) and rare interbeds of pebbles;
- Helminthoids Flysch - Calcareous and marly calcareous turbids with marly and shaly interbeds;
- Ponte Bratica Sandstones - Fine grained quartzose micaceous sandstones with interbeds of pelite and silty marlstones;
- Groppo del Vescovo limestones - Alternation of white and light grey torbiditic marly limestones, marlstones and shales.

This group includes both incoherent and rocky formations. The lithological characteristics of these terrains (clay and shale) do not favour the underground water circulation. Local permeable conditions are located along the tectonic trends of rocky substratum.

Impermeable terrain:

- Polygenic breccias with shaly matrix and ophyolitic fragments;
- Base Complex - Dark-grey shales with rare silty marlstones. Within the formation caotic calcareous and marly calcareous blocks;
- Alternation of dark grey shales, limestones, calcarenites and marly limestones.

Preponderance of shale cause a low or very low permeability. Also, along tectonic trends of substratum, the underground flow water is very difficult.

On the basis of the previous classification, Civiglia basin shows a mean permeability that is clearly conditioned by the large outcrops of low permeable formations. They cover more than the 63% of the total surface and are homogeneously distributed all over the basin. In the following table (Table 7.a) the detailed distribution of each class of permeability is summarized.

Table 7.a - Distribution of permeability condition

Permeability	Surface (km^2)	(%)
High Permeable terrain	0.239	0.70
Permeable terrain	3.496	10.26
Medium permeable terrain	5.887	17.29
Low permeable terrain	21.662	63.60
Impermeable terrain	2.776	8.15

These data highlight that Civiglia basin does not present a significant underground water resource. The main aquifers of this area are located both along the alluvial flat areas and within the fluvial-lacustrine pebble formation outcropping in the middle hilly portion of the basin.

The qualitative analysis of permeability is confirmed by the distribution of natural springs. They are usually located within the formations characterized by medium permeability, permeability and high permeability conditions while springs located in low permeability or impermeability conditions are linked to the existence of fractured zone of rocky substratum along the main tectonic trends.

8.) LAND USE

Regarding the identification of land use within the Civiglia basin, an ex-novo stereoscopic analysis of aerial photos of this area was made. For this reason, the most up-dated photos (1995) have been collected from Regional Administration archives of Tuscany. The indications of stereoscopic analysis have been confirmed through a field survey of great part of basin.

Results of this analysis have highlighted the presence of many different land use typologies but also the preponderance of broad-leaved coppice that cover the most part of Civiglia basin. The other typologies of land uses represent small areas inside the wooded area in particular close to the villages or in the alluvial flat areas. In addition to the broad-leaved coppice, wooded areas are represented by broad-leaved and conifer woods, conifer-predominant woods, fruit chestnut groves and abandoned fruit chestnut groves. Their extension cover over 74% of the studied area and, on the basis of the following analysis, will increase in the next decades.

In Table 8.a. the extension of land uses is summarised grouping together the thick, thin and degraded type of each land use typology.

These data stress the great preponderance of broad-leaved coppice in comparison with the other soil uses (68.73%). Other significant land uses are represented by permanent meadows, abandoned fruit chestnut groves, cultivation sowable lands and vegetable gardens, that testify the presence of old economic activities linked to the agricultural-forestal utilisation of this area.

Urbanized areas have only a limited extension and cover a total surface of 45.08 ha (1.32%). Their distribution shows a concentration in the lower area of Civiglia basin (Terrarossa area) where, in the last decades, a strong urbanization of the alluvial plan occurred.

Table 8.a - Extension of land uses

Land use	Surface (ha)	(%)
Continuous urbanized area	34.19	1.01
Discontinuous urbanized area	4.28	0.12
Industrial or commercial area	6.61	0.19
Quarries	1.84	0.05
Simple sowable land	44.92	1.32
Arborized sowable land	5.58	0.16
Fruit and vegetable gardens	147.77	4.34
Vineyard	53.44	1.57
Olive grove	75.57	2.22
Naked pasture	29.61	0.87
Arborized or bushy pasture	83.19	2.44
Permanent meadow	343.66	10.09
Broad-leaved coppice	2341.02	68.73
Broad-leaved and conifer woods	3.18	0.09
Conifer-predominant woods	24.23	0.71
Fruit chestnut grove	11.22	0.33
Abandoned fruit chestnut grove	161.41	4.74
Bushes and shrubs	16.76	0.49
Stream	17.91	0.53

On the basis of qualitative land use data of 1954 and quantitative of 1978 (Regione Toscana - Giunta Regionale – 1985) (Table 8.b) compared with the 1995 updated information, Civiglia basin has progressively modified its typology of territorial use. In particular, this area has been subjected, during the last 51 years, to a large natural and artificial reforestation.

Wooded areas have replaced many agricultural zones that, in the past, characterized the medium-lower portion of the basin, in particular in flat areas and along the South, South-Western and South-Eastern slopes. The progressive depopulation of many villages and the change of the principal economic activities are the principal causes that have produced the evolution to the actual land use in the Civiglia basin.

Table 8.b - 1978 Tuscan Region land use data

Urbanized areas	1.9%
Agricultural areas	8.4%
Pastures and meadows	20.2%
Wooded areas	69.5%

9.) SOILS

During the study of Civiglia basin a provisional analysis of pedological types and of their location was prepared. The identification of soils has foreseen, as a first step, the analysis of principal landscape units and of the correlated soils. Then, on the basis of geological and land use data of territory, the basin was divided into different soil typologies. Together with the theoretical analysis, a direct survey of the basin coupled with measurements of pH, assessment of carbonate presence and description of natural and artificial cross sections of natural soils, have been carried out in order to refine the soil characterisation of the basin.

In detail, the following soil typologies were defined:

- Dystrict Eutrochrept - Deeper-than-100 cm evolved soils with ABwC profile, acid to sub-acid (pH < 6.5) reaction, less than 35% lithic frames, without carbonates within 100 cm. Unit located on sub-horizontal surfaces and little-eroded gentle slopes on talus, dormant landslide bodies, fluvial-lacustrine deposits and calcareous formations;
- Typic Eutrochrept - Deeper-than-100 cm evolved soils with ABwC profile, sub-alkaline (pH 7.5 – 8.1) reaction, less than 35% lithic frames, with carbonates within 100 cm. Unit located on little-eroded gentle slopes on calcareous- and marly-calcareous-predominant lithologies;
- Typic Udifluvent - Deeper-than-100 cm involved soils with AC profile, neutral to sub-alkaline (pH 6.5 – 8.1) reaction, occasionally more than 35% lithic frames. Unit located on valley bottom-sub-horizontal surfaces on recent and present alluvial deposits;
- Typic Udorthent - Approximately 100 cm-deep involved soils with AC profile, sub-acid to sub-alkaline (pH 5.5 – 8.1) reaction, 35% lithic frames. Unit located on slopes characterized by anthropic-origin terracing or on active landslide bodies;
- Lithic Udorthent - Less-than 50 cm-deep un-evolved soils with AC profile, predominant acid (pH<5.5) reaction, more than 35% lithic frames. Unit located on very steep, highly-eroded slopes on generally flyschoid substrata;
- Dystric Eutrochrept and Lithic Udorthent Complex;
- Less-than 50 cm-deep Dystric Lithic Udorthent association, with ABwC profile, acid to sub-acid (pH < 6.5) reaction, more than 35% lithic frames and Lithic Udorthent. Unit located on very steep, highly eroded slopes on non-calcareous flyschoid substrata;
- Deeper-than 100 cm, moderately-evolved TypicUdifluvent and Fluventic Eutrochrept association, with ABwC profile, neutral to sub-alkaline (pH 6.5 – 8.1) reaction, less than 35% lithic frames, and irregular, deep-related decrease in organic carbon content. Unit located on sub-horizontal, valley-bottom surfaces on recent and present alluvial deposits.

Analysis of Table 9.a describes the distribution of soil typologies within the basin. These data show the preponderance of three typologies of soil, that represent different evolutive conditions inside the basin. Dystrict Eutrochrept type is usually located in the lower portion of the basin on low steep slopes that permit the evolution of deep soils with sharp differentiated layers (ABwC).

Table 9.a - Surface of soil types

Soil	Surface (ha)	(%)
Dystrict Eutrochrept	1161.48	34.10
Typic Eutrochrept	74.31	2.18
Typic Udifluvent	36.87	1.08
Typic Udorthent	93.69	2.76
Lithic Udorthent	246.62	7.24
Dystric Eutrochrept and Lithic Udorthent Complex	1241.89	36.45
Dystric Lithic-Udorthent association	430.54	12.64
TypicUdifluvent-Fluventic Eutrochrept association	121.07	3.55

Dystric Lithic-Udorthent association, characterize the steep slopes of the upper forested portion of the basin. Significant erosional surface action of runoff waters that interest steep slopes favour the formation of thin soil with a high percentage of lithic fragments (>35%) while Dystric Eutrochrept and Lithic Udorthent Complex represents an intermediate evolutive stage influenced by the differentiated morphological and land use aspects of the middle portion of the Civiglia basin. The remnant typologies of soils are influenced by peculiar geological, morphological and land use characteristics of local areas.

10.) GRANULOMETRY AND SORTING OF ALLUVIAL DEPOSITS

The identification of sedimentological characteristics of alluvial transported materials was accomplished by means of a statistical analysis of dimension and distribution along the hydrographic network of (coarse) sediments (pebbles) in the actual alluvial deposits.

In particular, measurements of maximum size transported pebbles were made in 11 stations carrying out 20 measurements in each station (Figure 10.a – see Annex) distributed both along Civiglia torrent (6 stations) and on the principal tributaries (1 station in each stream). The geometrical definition of pebbles has foreseen the measurement of their three principal axis and the calculation both of roundness index using the formula of Krumbein and the definition of their morphological shape.

In Table 10.b the mean value of three main axis of pebbles that were measured in each station and the roundeness index have been reported.

Table 10.b - Mean dimension of maximum pebble sediments and roundeness index

Torrent	Max. axis (cm)	Med. axis (cm)	Min. axis (cm)	Roundness
S. 1 - Civiglia T.	13.06	9.57	5.58	0.675
S. 2 - Civiglia T.	15.51	11.50	5.49	0.624
S. 3 - Civiglia T.	18.55	12.33	6.72	0.609
S. 4 - Carpena T.	21.52	14.16	5.89	0.551
S. 5 - Civiglia T.	37.17	26.02	13.03	0.620
S. 6 - Miona C.	17.80	13.11	7.36	0.688
S. 7 - Civiglia T.	30.16	19.00	12.63	0.644
S. 8 - Civiglia T.	63.95	46.97	34.95	0.733
S. 9 - Del Deglio C.	28.42	20.44	11.38	0.667
S. 10 - Torchio di Bacco C.	31.74	23.96	13.79	0.683
S. 11 - Ghiaia C.	32.20	21.60	10.87	0.616

These data stress the decrease of downstream mean axial dimensions of maximum transported coarse sediments along Civiglia torrent. Local alterations of this trend are correlated to different sediment contributions of tributaries.

Regarding the data elaborated for other principal tributaries, the measurement stations were located in the lower portion of stream at the end of the steepest portion of the torrent. Mean maximum dimensions of pebbles can be easily correlated with the morphometric aspects of each sub-basin. In detail, the mean maximum dimension of transported pebbles are directly influenced by the surface of sub-basin, length and mean slope of corresponding torrents. In fact these parameters work together to the formation of strongest flood events that permit the movement of bigger sediments.

On the basis of data of measured dimensions, a definition of roundness index of pebbles and a morphological analysis of mean shape of transported materials have been carried out. The definition of roundness index was calculated applying Krumbein formula (Ricci Lucchi F. - 1980):

$$\psi = [(b * c)/a^2]^{1/3}$$

where:

ψ = Krumbein roundness index;
a, b, c = maximum, medium, minimum pebbles axial dimensions.

Analysis of Table 10.b, together with the previous one, highlights that roundness of pebbles in the Civiglia torrent decreases downstream together with the maximum size of sediments. This aspect can be correlated with the morphological evolution of transported materials that, because of abrasion of pebbles during movement, favours the formation of a hydrodynamic stable shape. In fact Figure 10.c (Zingg diagram) shows that the preponderance of measured alluvial sediments present a flat shape (b/a > 0.67, c/b < 0.67). Formation of flat shape sediments is also conditioned by the characteristics of rocky substratum that, in great part of the basin, is represented by the layered marly and calcareous Helminthoids Flysch formation that usually gives origin to pebbles with a primary flat shape.

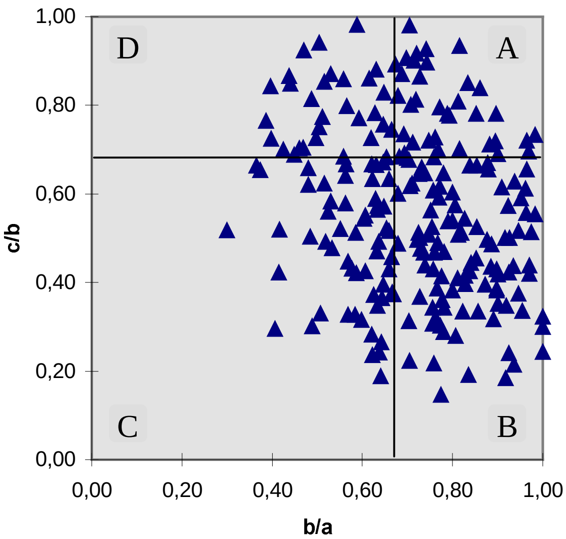


Figure 10.c – Krumbein diagram

A = Spherical shape (16%);

B = Flat shape (44%);

C = Ovoid shape (24%);

D = Elongated shape (16%).

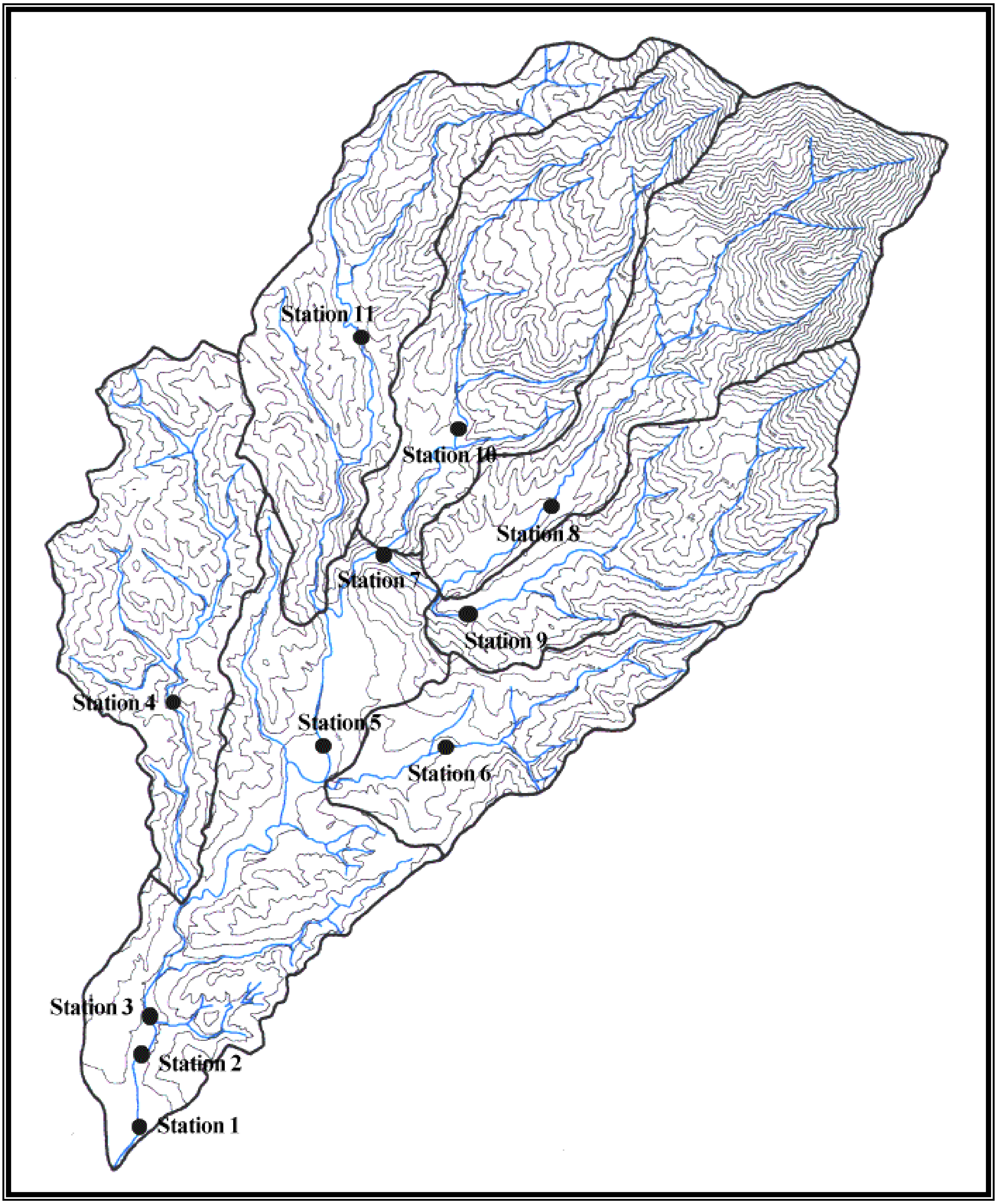


Figure 10.a – Distribution of pebble measurement stations

11.) HYDRAULIC STRUCTURES

Concerning the hydraulic structures existing within the Civiglia basin, this study has done the census of typology and maintenance conditions of transversal and longitudinal works carried out along the main torrents. This work was based on a first census of these structures made in 1991 (Regione Toscana – Comunità Montana della Lunigiana - 1991). These data were updated to the present with a survey of the great part of existing works and with a research in the Public Offices in charge for the hydraulic management of Civiglia Torrent in order to obtain any kind of information regarding typology, year of construction and condition of these structures.

Census of hydraulic structures was carried out dividing all the existing works in check dams, sills, cliff and traditional bank protection structures without discriminating the constructive typologies within each class. On this basis, a synthetic summary of number, typology, and their working order is showed in Table 11.a.

Table 11.a - Hydraulic structures conditions

Structure	Maintenance conditions		
	Efficient structures	Visible damages	Destroyed structures
Check dam	8	7	6
Sill	1	-	-
Cliff	2	-	-
Bank protection	57	176	140

These data highlight the great number of longitudinal protection bank structures existing along the hydrographic network. Preponderance of longitudinal protective works in comparison with transversal structures stresses the importance of bank erosional phenomena within the studied basin. Analysis of hydraulic works map shows that they are distributed homogeneously along the main torrents.

These longitudinal works are usually carried out (in particular, in the hilly and mountainous portion of the basin) with dry or cemented stone walls. They testify an ancient construction to reduce local erosive conditions of flowing water or to stabilize landslides. In few cases these works were built, during the last decades, in gabions or concrete structures. They are located along the urbanized torrent reaches, coupled with other hydraulic works or to protect unstable slopes.

Regardings surveyed check dams, some of these structures were put in practice, during last century, in order to furnish hydropower to the ancient mills or to reduce located erosional action of torrents while the recent structures were put in practice to stabilise large landslides on steep slopes.
Analysis of previous data put in evidence the bad maintenance conditions of the great part of counted structures. Many works present now heavy damages that cause their complete inefficiency.

On the basis of information collected from the Public Offices in charge for the hydraulic management of Civiglia basin, during the last decades new hydraulic structures or maintenance of the existing ones have not been carried out in the medium and upper portion of hydrographic network. The absence of maintenance action has caused damages or destruction of many longitudinal or transversal structures. In some cases, intact structures, built in the last decades, are completely ineffective because the undermining or going around of flowing waters.

Maintenance of longitudinal hydraulic structures has been put in practice only in the Terrarossa area because of the recurrent floods events that have involved this urbanized area. In this reach of Civiglia torrent, in the last years, longitudinal protective structures with concrete walls, gabions and cliffs were carried out.

Finally, a recurrent reshaping action of the torrent bed is in action because of the aggradation phenomena that occur in this area.

12.) ECOLOGICAL ASPECTS

The general ecological aspects of Lunigiana are influenced by its geographical location, that represent a connection between the North-European and Alpine Regions and the Mediterranean habitat. This particularity has produced the existence of many different floristic types during the quaternary when warm and cold climatic conditions alternated (Boll. Mus. St. Nat. Lunigiana Vol. 6-7 Num. 1-2 – 1988), (Centro Aullese di Ricerche e di Studi Lunigianesi - 1980).

The peculiar morphological characteristics of Lunigiana valley have allowed the conservation of both Mediterranean and Alpine species. Differentiation in the ecological aspects is favoured by the presence of shoreline and mountainous ridge to produce the coexistence, in short space, of different conditions. Typical is the existence of sclerophille vegetation in one slope and mesophile on the other. Finally, the isolation of this area has favoured the differentiation of endemic species.

This diversified ecological condition has favoured the colonization of variegated terrestrial, aquatic and aerial faunal species. The human presence has caused, in some areas, the reduction of faunal living species. In particular, along the axial portion of the valley, the presence of many urbanized areas has caused the escape, and in some cases, extinction of living species. Fortunately, the presence of large inhabited hilly or mountainous area has favoured the conservation of a considerable faunal heritage.

In detail, the ecological-vegetation aspects of the Civiglia basin are clearly influenced by the morphological characteristics of the basin and, in particular, by the altimetrical difference between the valley floor and the mountains and by the orientation of the mountainside in relation to the sun exposure. The large part of the basin is covered by heliophilous broad-leaf trees and, in particular, by oak species and chestnuts (in some cases black hornbeam).

The wooded area can be divided in two vegetal formations, in relation to the mean temperature and the elevation: thermophile and mesophile woods.

Thermophile woods

This vegetal formation occupies the lower portion of the hydrographic basin under the elevation of 600 meters a.s.l. . The most widespread species, prevalently ruled with coppice, are represented by:

- Turkey oak;
- Durmast;
- Manna-has;
- Black hornbeam;
- Holm-oak.

The most widespread herbaceous species are:

- Globularia punctata;
- Brachypodium pinnatum;
- Teucnum chamedris;
- Mellittis mellissophyllum;
- Litospermum perpureus - ceruleum;

Mesophile woods

- This vegetal formation is prevalently made by a composition of :
- Black and white hornbeam;
- Turkey oak;
- Chestnut;
- Maple;
- Sorb;
- Laburnum;
- Hazel.

The different sun exposure of the mountainsides causes a strong differentiation concerning the number of tree species. A high variety of species has been surveyed on the mountainsides exposed toward North while a small number of species are present on the mountainsides exposed toward South with the preponderance of Turkey Oak, Durmast and Black Hornbeam.

Regarding the faunal aspects of Civiglia torrent the principal aspect regarding the aquatic, amphibian, mammalian and avian species are synthetically described.

Aquatic and amphibian species

- Chub (Leuciscus cephalus);
- Vairone (Leuciscus souffia);
- Eel (Anguilla anguilla);
- Barber (Barbus barbus);
- Trout (Salmo trutta);
- River crab (Potamon edule).

Amphibian species:

- Two species of toad (Bufo bufo spinosus, Bufo viridis);
- Many species of frog (Rana esculenta, Rana graeca, Rana dalmatina, Rana temporaria);
- Tree frog (Hyla arborea);
- Many species of triton (Triturus alpestris apuanus, triturus cristatus carnifex, Triturus vulgaris meridionalis);
- Two species of salamander (Salamandra salamandra, salamandrina terdina);

Reptile species

- Two species of lizard (Lacerta sicula, Lacerta muralis);
- Green lizard (Lacerta viridis viridis);
- Two species of grass snake (Natrix natrix helvetica, Natrix tessellata);
- Coluber (Coluber viridiflavus viridiflavus);
- Viper (Vipera aspis aspis).

Avian species

Migratory birds coming from North-European and arctic regions:

- Two species of heron (Ardea cinerea, Ardea purpurea);
- Little egret (Egretta garzetta);

- Lapwing (Vanellus vanellus);
- Woodcock (Scolapax rusticula);
- Snipe (Gallinago gallinago);
- Stilt (Himantopus himantopus);
- Wild duck (Anas platyhynchos).

Sedentary species:

- Starling (Sturnus vulgaris);
- Redbreast (Erithacusrubecula);
- Blackcap (Sylvia atricapilla);
- Blackbird (Turdus merula);
- Bunting (Emberiza calandra);
- Skylark (Alauda arvensis);
- Hooded crow (Corvus corone cornix);
- Greenfinch (Chloris Chloris);
- Three species of woodpecker (Picus viridis, Dendrocopos major, Sitta europaea);
- Titmouse (Parus palustris);
- Great tit (Parus major);
- Jay (Garrulus glandarius);
- Cuckoo (cuculus canorus);
- Pheasant (Phasianus colchicus);
- Partridge (Perdix Perdix);
- Tawny owl (Strix aluco);
- Barn owl (Tyto alba);
- Owl (Athene noctua);
- Kestrel (Falcus tinninculus);

Mammalian species

- Roe (Capreolus capreolus);
- Fallow deer (Dama dama);
- Wild boar (Sus scropha);
- Fox (Vulpes vulpes);
- Stone marten (Martes foina);
- Weasel (Mustela nivalis);
- Badger (Meles meles);
- Squirrel (Sciurus vulgaris);
- Dormouse (Glis glis);
- Five species of rat and mouse (Rattus rattus, Rattus norvegicus, Apodemus sylvaticus, Mus musculus, Evotomys nageri);
- Four species of shrew (Sorex minutus, Sorex arenus, Sorex samniticus, Neomys fodies);
- Two species of mole (Talpa caeca, Talpa Europaea);
- Hedgehog (Erinaceous europeus);

13.) HYDRAULIC MODELLING

Regarding the hydraulic modelling of the Civiglia torrent, the calculation of the discharge values of the basins in the Terrarossa area subjected to recurrent flooding with different return time periods, has been evaluated. The elaboration is based on the extreme rainfall events for 1, 3, 6, 12 and 24 hours time period in Arlia and Villafranca recording stations.

Elaboration of the expected rainfall events (in mm) as a function of different return time periods has been prepared on the basis of Gumbel's statistical analysis. In the following schemes (Tables 13.a, 13.b), the extreme events have been reported for 10, 15, 25, 50, 75, 100 and 200 years return time period:

Table 13.a - Expected rainfall events in Villafranca recording station (mm)

Rt (years)	1 hour	3 hours	6 hours	12 hours	24 hours
10	54.94	85.40	108.86	159.94	197.31
15	59.29	91.86	116.70	173.23	212.65
25	64.68	99.86	126.42	189.70	231.67
50	71.90	110.58	139.44	211.79	257.16
75	76.10	116.82	147.01	224.62	271.98
100	79.07	121.23	152.37	233.71	282.47
200	86.22	131.84	165.25	255.55	307.68

Table 13.b - Expected rainfall events in Arlia recording station (mm)

Rt (years)	1 hour	3 hours	6 hours	12 hours	24 hours
10	56.56	84.89	112.51	141.98	177.34
15	62.43	93.32	123.84	156.14	195.64
25	69.70	103.77	137.88	173.69	218.34
50	79.44	117.78	156.71	197.22	248.76
75	85.10	125.92	167.65	210.90	266.44
100	89.11	131.68	175.40	220.57	278.95
200	98.74	145.53	194.02	243.84	309.03

On the basis of the previous values, the exponential functions that represent the rainfall events as a function of their duration have been elaborated for the 10, 15, 25, 50, 75, 100 and 200 years return time periods (Table 13.c). These return times periods have been chosen to verify the hydraulic cross sections in the Terrarossa area.

Table 13.c - Functions of rainfall probability (mm)

Rt (years)	**Villafranca**	**Arlia**
10	$Y = 54.94\ t^{0.411}$	$Y = 56.56\ t^{0.362}$
15	$Y = 59.29\ t^{0.411}$	$Y = 62.43\ t^{0.362}$
25	$Y = 64.68\ t^{0.411}$	$Y = 69.70\ t^{0.362}$
50	$Y = 71.90\ t^{0.412}$	$Y = 79.44\ t^{0.362}$
75	$Y = 76.10\ t^{0.412}$	$Y = 85.10\ t^{0.362}$
100	$Y = 79.07\ t^{0.412}$	$Y = 89.11\ t^{0.362}$
200	$Y = 86.21\ t^{0.413}$	$Y = 98.74\ t^{0.362}$

On the basis of the previous data, a quantitative reconstruction of the expected discharge values of the Civiglia torrent at Terrarossa area has been prepared. First step for the calculation is the definition of the concentration time of the basin located upstream Terrarossa. In detail, the concentration time has been calculated applying the Giandotti formula which was prepared for hilly and mountainous basins in the Apennine ridge (Table 13.d).

Giandotti's formula takes into consideration some morphometric parameters of the basin:

$$Ct = 4 \sqrt{S} + 1.5\ L / 0.8 \sqrt{H_m}$$

where:

C_t = concentration time (hour);
S = total surface of basin (km^2);
L = length of main torrent (km);
H_m = mean elevation of basin related to the hydraulic section examined (m).

Table 13.d - Calculation of the Concentration Time

	Terrarossa area
S (km^2)	34.06
L (km)	13.58
H_m (m)	229
C_t (hours)	**3.74**

In relation to the calculated concentration times, the critical rainfall events for the Civiglia basin for 10, 15, 25, 50, 75, 100 and 200 years return times have been computed (Table 13.e) assuming that the critical rainfall has a period equal to the concentration time of the entire basin (Terrarossa area: 3.74 hours):

Table 13.e - Extreme rainfall events (mm)

Rt (years)	Villafranca	Arlia
10	96.18	91.24
15	104.15	100.67
25	114.02	112.36
50	127.26	128.04
75	134.96	137.15
100	140.40	143.60
200	153.50	159.10

On the basis of the previous extreme rainfall events, the values of discharge of the Civiglia torrent at Terrarossa have been calculated with the Giandotti's formula (rational formula). Because of the similarity of the extreme rainfall data of the two pluviometrical recording stations, the mean value has been applied in the mathematical formulation.

The Giandotti's formula calculates the discharge of the basin assuming that the critical rainfall was uniform inside the basin. This condition can be assumed for a medium-small size basin like the Civiglia basin.

$$Q = 0.278\ CIA$$

where:

Q = outflowing discharge (m^3/s);
C = ratio between outflow and inflow;
I = rainfall intensity (mm/hour);
A = Surface of the basin (km^2).

Regarding the ratio between outflow and inflow, the hydraulic studies made in past for Civiglia basin indicate a mean value of 0.5. In the present hydraulic analysis, a **0.6** ratio between outflow and inflow is applied, in order to verify the worst hydrological conditions.

The calculated data are shown in the following scheme (Table 13.f):

Table 13.f - Extreme Discharges Data at Terrarossa

Rt (years)	Discharge (m^3/s)
10	140.8
15	154.4
25	170.6
50	192.4
75	205.1
100	214.0
200	235.6

14) CRITICAL HYDRAULIC SECTIONS IN TERRAROSSA AREA

In order to identify the critical sections of Civiglia torrent in the Terrarossa area, a verification of the hydraulic effectiveness of seven torrent sections has been made. In particular, seven transversal hydraulic sections have been reconstructed and, for each one, the maximum discharge value has been calculated and compared with the expected discharge data as a function of the 10, 15, 25, 50, 75, 100 and 200 years return time meteoric events (Figure 14.a - see annex).

In detail, sections 4, 5, 6 are bounded by artificial embankments built with concrete, gabions or cliff while sections 1 and 7 do not present artificial banks. Sections 2 and 3 are located on the railway and road bridges.

The verification of the hydraulic sections has been made applying the formula:

$$\mathbf{Q = A\ V}$$

where:

Q = discharge (m^3/s);
A = surface of the hydraulic section (m^2);
V = velocity of current (m/s).

The velocity of the flowing water during flood events was given by Chèzy's formula:

$$\mathbf{V = C\ (R\ i_f)^{1/2}}$$

where:

C = roughness index;
R = hydraulic radius (m);
i_f = slope of the torrent bed.

The roughness index has been determined applying Gauckler-Strickler's formula:

$$\mathbf{C = (1/n)\ R^{1/6}}$$

The parameter **"n",** was determined on the basis of the indication of three authors, Kutter, Bazin and Manning. The calculated discharge of all cross sections has been computed applying the values of each author. The maximum discharge is the mean of the calculated values of each author. For sections 1, 2 (railway bridge), and 3 (road bridge), the total discharge is represented by the sum of two separated flow sub-sections.

In Table 14.b, the previous parameters and the mean maximum discharge data are summarized:

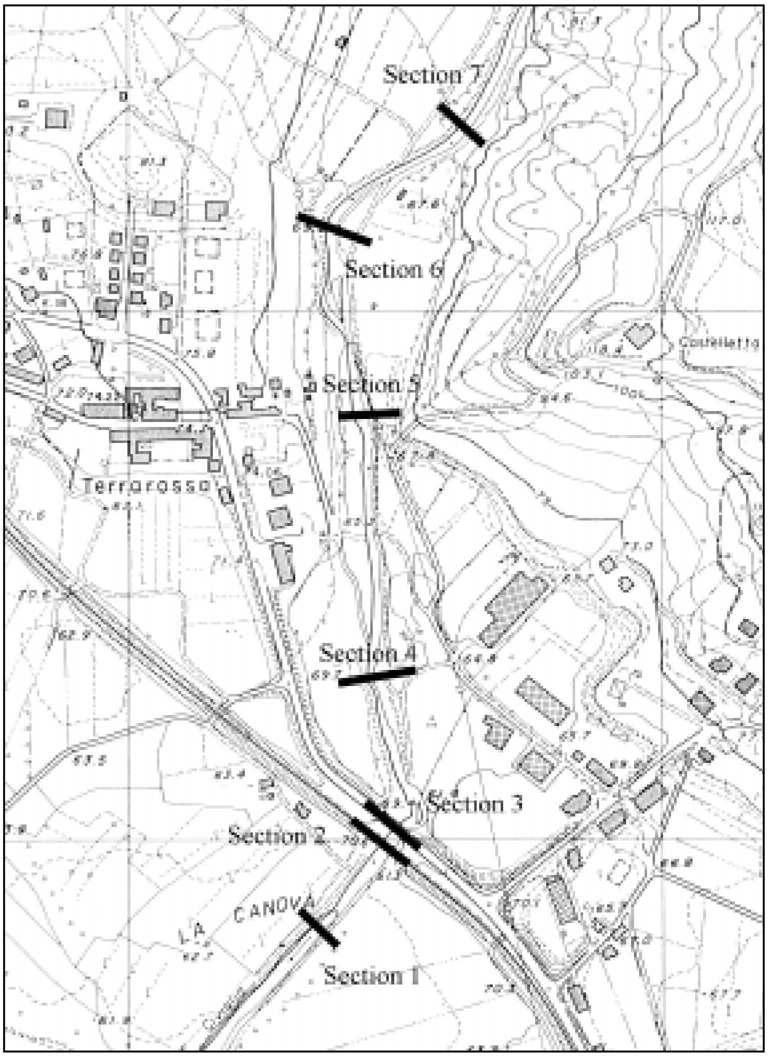


Figure 14.a – Location of the verified hydraulic sections

Table 14.b - Hydraulic analysis of the transversal torrent sections

Section	Slope (%)	Surface (m^2)	Wet perimeter (m)	R	n Kutter	n Bazin	n Manning	C Kutter	C Bazin	C Manning	Vel. (K) (m/s)	Vel. (B) (m/s)	Vel. (M) (m/s)	Qmax. (K) (m^3/s)	Qmax. (B) (m^3/s)	Qmax. (M) (m^3/s)	Q mean (m^3/s)
1a	0.0059	2.70	5.10	0.53	2.40	1.85	0.032	23.264	24.558	28.107	1.300	1.373	1.571	3.511	3.706	4.241	**3.82**
1b	0.0059	33.40	26.20	1.27	2.40	1.85	0.032	31.994	32.973	32.540	2.775	2.860	2.822	92.674	95.511	94.258	**94.15**
2a	0.0059	49.80	22.80	2.18	2.00	1.75	0.030	42.494	39.833	37.969	4.824	4.522	4.310	240.233	225.189	214.650	**226.69**
2b	0.0059	31.00	18.90	1.64	2.00	1.75	0.030	39.038	36.764	36.199	3.840	3.617	3.561	119.047	112.115	110.391	**113.85**
3a	0.0059	35.00	16.00	2.19	2.00	1.75	0.030	42.513	39.849	37.978	4.830	4.527	4.315	169.038	158.449	151.010	**159.50**
3b	0.0059	32.00	15.30	2.09	2.00	1.75	0.030	41.965	39.365	37.695	4.662	4.373	4.187	149.174	139.933	133.997	**141.03**
4	0.0059	46.00	25.60	1.80	2.20	1.80	0.031	37.861	37.135	35.568	3.898	3.824	3.662	179.325	175.884	168.462	**174.56**
5	0.0059	65.00	36.80	1.77	2.20	1.80	0.031	37.660	36.952	35.466	3.844	3.772	3.621	249.891	245.197	235.336	**243.47**
6	0.0059	42.00	26.50	1.58	2.20	1.80	0.031	36.397	35.806	34.832	3.520	3.462	3.368	147.821	145.421	141.465	**144.90**
7	0.0059	38.00	21.60	1.76	2.20	1.80	0.031	37.613	36.910	35.443	3.832	3.760	3.611	145.617	142.895	137.215	**141.91**

Comparing the calculated maximum discharge of the hydraulic sections in the Terrarossa area with the total discharge of the basin calculated on the basis of the rainfall events with 10, 15, 25, 50, 75, 100 and 200 years return time periods it is clear the inefficiency of some hydraulic sections for flood events with a return time even equal to 10 (Table 14.c).

These data are in accordance with the recurrent flooding events that have occurred in the last decades.

Table 14.c - Comparison among the discharge of hydraulic section and the extreme flood events

Terrarossa area								
Extreme flood events (m^3/s) - Rt (years)							Hydraulic Section	Q mean (m^3/s)
10	15	25	50	75	100	200		
140.8	154.4	170.6	192.4	205.1	214.0	235.6	1	98.0
							2	340.5
							3	300.5
							4	174.5
							5	243.5
							6	144.9
							7	141.9

In detail, sections 6 and 7 are unable to contain discharge with a return time period equal to 10 years and section 4 is just able to contain a flood with a return time period lower than 50.

In the following Figure 14.d, the comparison between the areas subjected to recurrent flood events and the zone bounded by the Regional Decree of Tuscany 230/94 is represented. The scheme highlights that almost the entire area subjected to alluvial events is included in the limits “A1” and “B” of that decree (see next Chapter – Law and prescription in force).

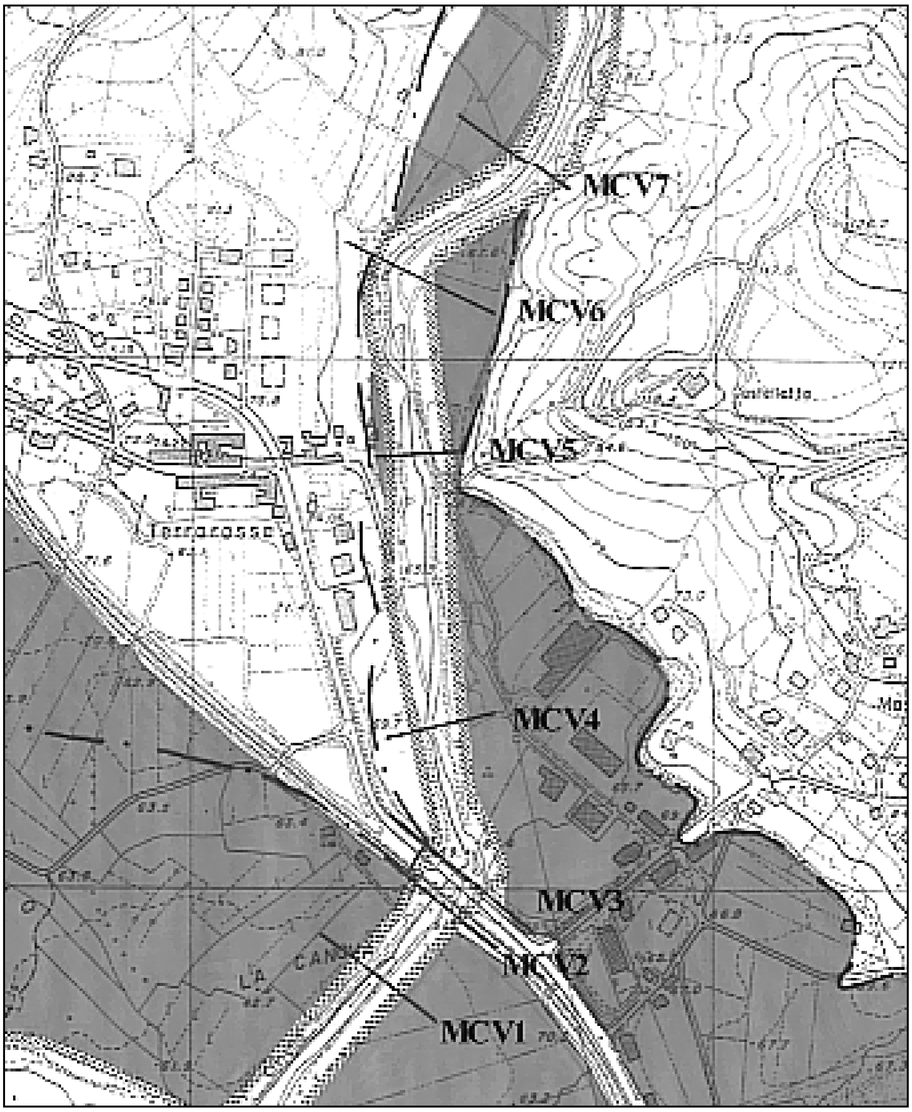


Figure 14.d – Legislative bonds of Regional Decree 230/94

Legend

A1 area of Regional Decree 230/94

B area of Regional Decree 230/94

Areas subjected to recurrent flood events

MCV Analyzed hydraulic sections

15.) LAW AND PRESCRIPTIONS IN FORCE

From the legislative point of view, Civiglia basin is subject to a series of state and regional Laws regarding different sectors of soil defence and the environmental and ecological respect of the territory.

State laws

Regarding State Laws, Civiglia hydrographic basin is subject to the following Laws:

- R.D. 3267/1923 - This Royal Decree establishes prescriptions regarding the prevention of unstable conditions deriving from the carrying out of structural interventions in wooded areas. Hydrogeological bond covers great part of the hilly and mountainous areas of the basin. The carrying out of structural interventions inside these areas must be authorised by the State Forestal Body;
- L. 431/1985 (Galasso's Law) - This Law establishes prescriptions regarding the landscape protection of the territory of relevant ecological value. It concerns many aspects of landscape defence. The Civiglia basin is involved by the following aspects:
  - respect of woods and forest (point c);
  - respect of areas for civic use (point h). These areas comprehend part of the Civiglia basin that are considered of public interest;
  - respect of areas of archaeological interest (point m). This point identifies the zone that could be potentially interested by archaeological researches;
- Decree of President of Republic 285/90 - Cemeterial bound - It establishes a zone of respect around cemeteries of 100 meters of radius.

Regional laws

Regarding the Regional Legislation, the following Laws involve the territory of the Civiglia basin:

- R.L. 52/1982 - Regional Law about protected areas. It identifies the regional territory subjected to environmental and ecological protection. The upper portion of the Civiglia basin is comprehended in the "A" category, that concerns the areas with an extensive landscape and environmental interest;
- D.C.R. 230/94 - Regional Council Resolution about hydraulic risk protection. The resolution establishes prescriptions, restrictions and directives concerning the construction of buildings and the management of the town planning plan, fixing the boundaries, on geometrical criteria, of hydraulically homogeneous areas in relation to distances from the rivers specified by the law.

  In detail, the limits specified in the regional legislation wide that in the "A1" area, comprehending the torrent bed and an area 10 meters wide, the modifications of the town planning plan for the construction of new buildings or morphological changes are forbidden. The only permitted modifications are those concerning the construction of hydraulic works, crossing structures, water derivation, etc, that do not increase the hydraulic risk condition of the torrent bed.

  In the "B" area, comprehending an inner area of 10 meters and an outer including the zones with an elevation upper, at most, 2 meters above the torrent bank with a maximum extension of 300 meters width, the modifications of the town planning plan for the construction of new buildings or morphological changes can be made only if the hydraulic safety is certified by the carrying out of hydrological-hydraulic analysis of the torrent basin with a return time flooding period of, at least 200 years.

16.) HAZARD CONDITIONS

The identification of the hydraulic risk conditions in Civiglia basin has been performed crossing the different information deriving from geology, geomorphology and torrent dynamics. In addition the hydraulic risk condition in the Terrarossa area has been considered.

The applied methodology is synthesized in the following scheme (Figure 16.a):

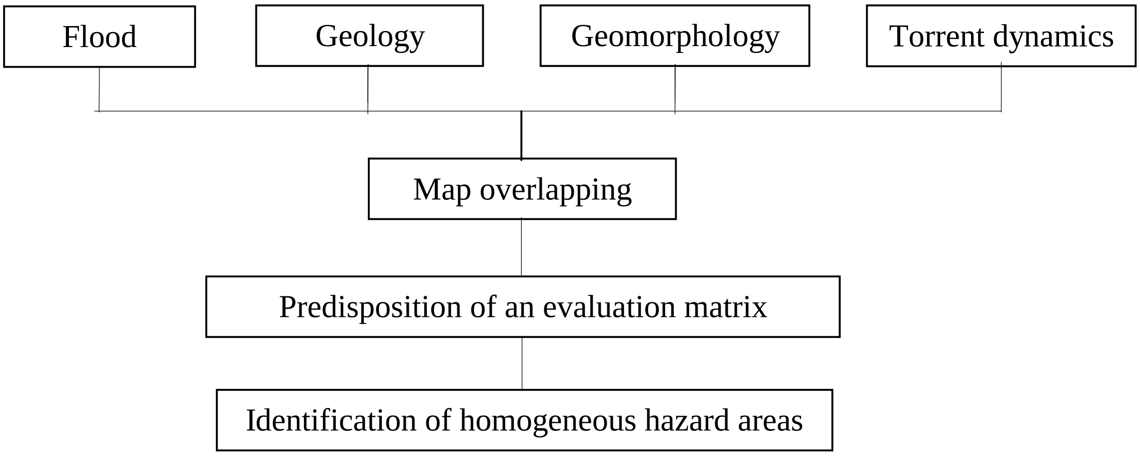


Figure 16.a – Methodological Scheme

On the basis of all the collected information, the main risk conditions surveyed in Civiglia basin are linked to the existence of hydraulic problems that involve the lower portion of the main torrent (village of Terrarossa), which presents insufficient hydraulic sections as to guarantee the flow of the most important water discharges generated by intense storm events.

This situation has caused in past times much economic damage to civil buildings and productive-commercial activities.

This zone is still without any kind of hydraulic defence structures to contain flood waters in the torrent bed and for this reason it is necessary to prepare a defence plan for the reduction of hydraulic risk.

The hydraulic risk is increased by the presence of obstacles that hinder the flow of flood water. In particular, the present of two bridges could represent a further risk condition because of the vegetal materials carried by the water during the most important flood events (trunks, branches) that may cause the formation of temporary dams in the two sections previously described.

The impermeability of geological formations outcropping in the major part of the hydrographic basin concurs to the increase of the ratio between outflow and inflow and consequently the value of the main flood discharges. Furthermore, during the most important alluvial events, the terminal part of the torrent bed is involved by an aggradation phenomena, because of the sedimentation of transported terrigenous materials caused by reduction of the morphological gradient of the lower torrent reaches. This phenomena leads to the problem of having to periodically clean up and reshape the torrent bed after every important flood event.

In addition to the hydraulic problems, Civiglia torrent is affected by widespread unstable conditions that affect the steepest slopes and that are generated or increased by bed or bank erosive phenomena along the main torrents. Instability conditions are also present in some areas not directly involved by the river dynamics where Pliocene clayey sediments outcrop. On the basis of direct analysis, the surveyed erosive phenomena represent a natural evolution processes of a morphologically active territory. In relation to its extensive vegetal covering, Civiglia basin is not very affected by relevant problems of surface erosion.

In detail, the larger landslides areas are located within the Miona sub-basin close to the village of Castel di Monti and Molesana di Sotto. Other important (actual or potential) unstable areas are found in the upper portion of the basin involving directly the villages of Villa Panicale, Busseto and Gabbiana. Typology of surveyed unstable areas are usually represented by low speed movements directly linked to the saturation of fine material during the most important rainfall events.

On the basis of this study, Civiglia basin can be considered as an example of a hydrographic basin lacking in significant hydrogeological troubles (erosion, landslides) but affected by hydraulic problems caused both by intense pluviometrical events and by the ineffectiveness of flow sections.

17) BASIN MANAGEMENT

In order to reduce the hydraulic risk condition in Civiglia basin a proposal for the global managment of the basin has been prepared through the identification of guidelines and prescriptions for the territorial management of the basin .

In detail, indications of land use and non-structural prescriptions have been identified both in the valley flat areas and on the slopes. The two different spheres of management are correlated with different problems connected with the formation and the evolution of floods.

The valley flat areas are directly involved in the destructive effects of strongest flood events. For this reason, their managment requires mostly the identification of structural and non-structural interventions that are able to reduce the hydraulic risk conditions. On the other hand, slopes exist in the areas where the surface runoff and then the channelized flow origins.

On this basis, the management of a torrent basin subjected to alluvial events is a combination of intervention (passive and active measures) both in the valley flat areas, that could be usually urbanized, and also on the areas of water flow formation.

17.1) Management of the valley floors

On the basis of the morphological aspects of the valleys and characteristics of the torrents, the larger valley flat areas have been classified in relation to the actual and potential hydraulic risk conditions caused by the strongest alluvial events. In detail, these areas have been divided in the following classes:

1. Flat Valley floors that are morphologically protected also against the strongest alluvial events (alluvial terraces). Sometimes, structural interventions have to be put in practice in order to protect the natural banks from erosive phenomena;
2. Flat valley floors with a significant slope that, in relation to peculiar geomorphological aspects, could be involved by the strongest alluvial events or by the occurrence of mass transports. These areas, that up to now have been used for agriculture or meadows, could be interested by the preparation of punctual structural interventions for their hydraulic safety;
3. Flat valley floors with a slight slope that, in relation to the natural evolution of the torrent dynamics during alluvial events, must be bound with prescriptions in order to avoid land uses that are not compatible with the occurrence of recurrent flood events. These areas, that up to now have been used for agriculture and meadows, could be left to the natural evolution of the torrent bed and for the identification of active or passive control of floods. Small interventions for protection of peculiar situation could be put in practice with bioengineering works;
4. Flat valley floors with a slight slope where the construction of new buildings could be authorized after the hydraulic safety of these areas through the preparation of adequate structural interventions for the reduction of the hydraulic risk is guaranteed;
5. Fluvial pertinence area in which it is not admissible the realization of building structures.

The analysis of the previous classes highlights the existence of different conditions in relation to the hydraulic risk.

Up to now the great part of the valley flat areas are lacking in buildings. Only in the Terrarossa area, the urban development occurred during the last decades causing the formation of hydraulic risk conditions. In the other valley flat areas, the previous prescriptions can be considered in future before the preparation of management plans for the urbanistic development of this basin.

Particular attention must be paid to the areas that could be used for the construction of structural and non structural interventions (torrent pertinent areas), in order to assure a hydraulic protection of Terrarossa area.

17.2) Management of torrents

Analysing the hazard conditions, hydraulic works and torrent dynamics aspects showed in the annexed thematic maps, a series of technical prescriptions concerning the planning of structural interventions have been identified in order to protect the banks and slopes subjected to effective and potential hazard conditions linked to river dynamics.

These indications identify preliminary typologies of intervention for the arrangement of the hydrographic network. Preparation of detailed planning of structural intervention must be foreseen in a following in-depth planning phase that have to take into consideration the local aspects of the torrent bed of each stream. In particular, the interventions for the arrangement of the hydrographic network must be planned preparing a general project of intervention for each sub-basin.

The cross analysis of the previous information has favoured the identification of homogeneous areas where to put in practice specific typologies of intervention. The identification of the interventions has favoured the application of bioengineering works in the torrent reaches that, in relation to the hydraulic and morphological conditions, are not subjected to extreme torrent dynamics conditions or to strong instability phenomena. Traditional structural interventions in concrete have been proposed to solve peculiar hazard conditions that also directly involve urban settlements or the stabilization of the worst unstable areas.

In some cases, the combination of the two classes of interventions has been proposed to solve peculiar conditions linked to located instability conditions in torrent reaches where the application of bioengineering works is not able to arrange a stable condition of the bed.

Finally, the map furnishes indications of the intervention that must be rearranged and the location of new check dams in order to assure the stability of the main villages involved by instability conditions.

17.3) Agriculture and forestry measures

On the basis of the territorial information analyzed in the previous chapters and, in detail, through the indication concerning the land use, permeability and slope, the critical map for the runoff propensity of Civiglia basin has been prepared.

Applying GIS, an overlapping of the previous information has permitted the identification of homogenous units concerning the formation of runoff during rainfalls. In particular, on the basis of bibliographical information and a direct survey of the basin, a weight has been given to each territorial information (classes of land use, permeability and slope). The given weights vary from 0 to 10.

On the basis of the information on the propensity to runoff of the entire basin, a final map concerning agricultural and forestry measures of the Civiglia basin has been prepared. The applied methodology is synthesized in the following scheme (Figure 17.3.a):

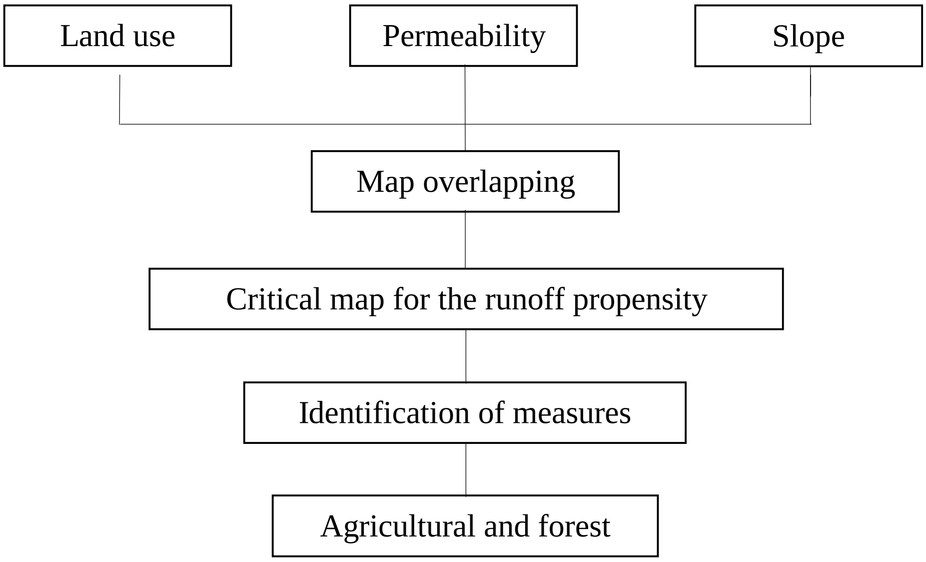


Figure 17.3.a – Methodological Scheme

Analyzed parameters (Tables 17.3.b, 17.3.c and 17.3.d)

Table 17.3.b – Land use information

Codex	Land use		Weight
U1	Continuous urbanized area		Not considered
U2	Discontinuous urbanized area		Not considered
U3	Industrial or commercial area		Not considered
U4	Extractive area		Not considered
S1	Simple sowable land		9
S2	Arborized sowable land		8
S3	Cultivation sowable land and market gardens		6
L1	Vineyard		7
L2	Olive grove		7
P1	Naked pasture		4
P2	Arborized or bushy pasture		3
P3	Permanent meadow		5
B11	Broad-leaved coppice	Thick	1
B12		Thin	4
B13		Degraded or open	4
B21	Broad-leaved and	Thick	1
B22		Thin	4

B23		Degraded or open	4
B31	Conifer-predominant	Thick	1
B32		Thin	4
B33		Degraded or open	4
C1	Fruit chestnut grove		3
C2	Abandoned fruit chestnut grove		5
N11	Bushes and shrubs	Thick	2
N12		Thin	4
A1	Stream		Not considered

Table 17.3.c – Hydrogeological information

Weight	**Codex**	**Hydrogeology**	**Type**
1	HP	High Permeable Terrains	Alluvial fans
			Recent and actual alluvial sediments
3	P	Permeable Terrains	Terraced alluvial sediments
			Fluvial-lacustrine sediments with preponderance of pebbles
4	MP	Medium Permeable Terrains	Debris
			Bodies of active landslides
			Bodies of dormant landslides
7	LP	Low Permeable Terrains	Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite)
			Helminthoids Flysch – Calcareous and calcareous turbids with marly and shaly interbeds
			Ponte Bratica sandstones – Fine grained quartzone micaceous sandstobnes with interbeds of pelite and silty marlstones
			Groppo del Vescovo limestones – Alternation of white and light grey torbiditic marly limestones, marlstones and shales
10	IM	Impermeable Terrains	Polygenic breccias with shaly matrix and ophyolitic fragments
			Base Comlex – Dark-grey shales with rare silty marlstones within the formation caotic calcareous and marly calcareous blocks
			Alternation of dark grey shales, limestones, calcarenites and marly limestones

Table 17.3.d – Slope information

Weight	**Slope (%)**
0	0 –7
1	8 –25
4	26 – 50
8	75 – 100
10	> 100

On the basis of the weight given to each class of the analyzed territorial information (land use, permeability, slope), a global index, equal to the total sum of each parameter has been identified.

The previous global indexes has been grouped into three classes, which have permitted to divide the basin in homogeneous zones. In the following table, the three classes are identified (Table 13.3.e):

Table 13.3.e – Runoff Global Index

Classes	Global index
1	0 - 9
2	10 - 16
3	17 - 25

The previous classes represent variable conditions of the propensity to runoff during rainfalls. In detail.

- **Class 1 (surface 1 565.82 ha)** - low influence on surface runoff formation (particular prescriptions are not required);
- **Class 2 (surface 1 699.33 ha)** - medium influence on surface runoff formation (application of cultural and conservative measures are required);
- **Class 3 (surface 135.84 ha)** - High influence on surface runoff formation (application of cultural and strictly conservative measures are required);

The final results of this analysis identify a good propensity of Civiglia basin against the formation of runoff during meteoric events. In fact the larger part of the basin is cover by wooded surface composed for the 66% of the total amount by thick broad-leaved coppice.

The thick broad-leaved coppice woods represent 40% of class 1. Class 2 extends over about 50% of the entire basin and comprehend thick broad-leaved coppice (53%), abandoned fruit chestnut grove (7%), meadows and pastures (21%), sowable land (10%) and the remnant part (9%) by other typology of land use.

This class includes, the most important agricultural land forestry measures in relation to its largest extension within Civiglia basin and its capability to strongly influence the hydrologic regime of the basin.

Great importance holds the definition of the rules for cultivation of the broad-leaved coppice in relation to the great extension of this typology of land use. By the same token, the meadows and pastures require a peculiar attention both for their large extension and for the potential creation of erosive and hydrogeological unstable conditions.

18.) EX POST EVALUATION

Predisposition of an ex-post evaluation of the hydraulic data of the basin, in relation to the future application of structural and non-structural interventions that could be able to modify the extreme discharge value in the Terrarossa area, has required to locate, in the lowest portion of the basin (closely downstream to the recurrent flooded area), a recording station for the hydraulic (discharge, stage) and meteorological parameters (rainfall, temperature).

This recording station is inserted in the Tuscan Regional network for the recording of agricultural-meteorological data managed by (ARSIA).

In detail, the recording station is located on the downstream side of the road bridge (National Road 62) that bond toward South-East the recurrent flooded area of Terrarossa (MCV 3 - see Figure 14.a).

The recording station is composed by the following parts:

- Box containing the electronic devices;
- Box containing the batteries;
- Solar panels and aerial for the radio-transmission of the recorded data;
- Hydrometrical sensor;
- Pluviometrical sensor;
- Termometrical sensor.

The recorded data can be applied to prepare useful correlation among the territorial aspect of the basin (geology, land use, etc.) and the hydrological and hydraulic characteristics of the torrent (extreme rainfall events, concentration time, discharge values, etc.).

Interesting correlations can be identified between the intensity of rainfall events and the potential occurrence of flood events in the Terrarossa area. In particular, the data of the new station together with the other installation located near Fornoli (managed also by ARSIA), could be used to identify the critical rainfall threshold for the occurrence of flood events.

Furthermore, the new installation can be employed to alert population and active the civil protection machine before the occurrence of floods in the Terrarossa area.

19.) GEOGRAPHICAL INFORMATION SYSTEM (GIS)

The previous territorial information has been implemented on a GIS that allowed to analyzed, manage and update the collected information. The applied system, called Charta for Windows, is used in the Regional Administration of Tuscany for the management of the informative archives. The principal technical aspects of the system are next explained.

Cartha for Windows is an integrated GIS able to manage vector data bases, alfanumeric information, images and generic raster data as the digital terrain model (DTM). It runs under MS-Windows and has a modular configuration allowing to manage cartographic applications, image georeferencing and processing, computer photointerpretation and DTM applications.

The minimum information unit on Cartha for Windows is the geographic object, described by geometric form, attributes, relations with other objects, documentary images and texts. Geographic objects are managed by a proprietary GIS engine, while the linked alphanumeric attributes are managed by a standard relational data base integrated to Cartha for Windows. Geographic data are managed without coverage or map sheet limits.

The system supplies a full set of functions for acquisition, editing, updating, display and restitution and query of geographic data. Vector data acquisition may occur from video photointerpretation, from digitization or import from other systems.

Cartha for Windows talks with the other systems through the most common vector and raster data formats as DXF, ARCINFO, MOSS TIFF, BMP, ESA, ERDAS, etc.

Preparation of query operations, running on interactive mode, produces a list of references to the objects of the geographic data base. This list may be used to plot a thematic map or to define the domain of a raster operation like a supervised classification. Cartha for Windows allows to customise the data base structure.

All graphic aspects of a geographic data base and thematic images as color, line pattern, hatch, fonts, symbols, legends, etc., may be defined by an interactive editor. The graphic display of objects may vary as function of the values of a particular attribute. Output on standard MS Windows printers and plotters is supported. The map layout may be designed by an interactive editor.

The digital terrain model (DTM) can be used in morphology analysis. Cartha for Windows allows the insolation simulation, slope, aspect, view field simulation and realistic perspective projections.

Application of the GIS to Civiglia Basin has required the preparation of DTM through the scanning of topographic map in scale 1:10 000 and 1:5 000. All the other territorial information has been digitalized and georeferenced to the model (see Annex – Geographical Information System).

20.) INTERVENTIONS FOR THE HYDRAULIC SAFETY OF CIVIGLIA BASIN

20.1) Retention basin (Italian proposal)

On the basis of the indications highlighted in the previous Chapters and the general information of the entire basin, a proposal of structural interventions to be put in practice in Civiglia Basin must be focused on the reduction of the flood peak with active flood control interventions.

The proposed solution foresees the construction of a retention basin with a check dam with fixed outlet in the area of Gragnolesa where the morphological conditions of the valley present a favourable site. In particular, this site is characterized by a large flat zone closed downstream by a narrow valley. This kind of intervention could permit the storage, during main alluvial events, of a significant volume of water, reducing the discharge in the Terrarossa torrent reach in accordance with the hydraulic efficiency of torrent bed.

Figure 20.1.a shows the location of the proposed retention area within the basin.

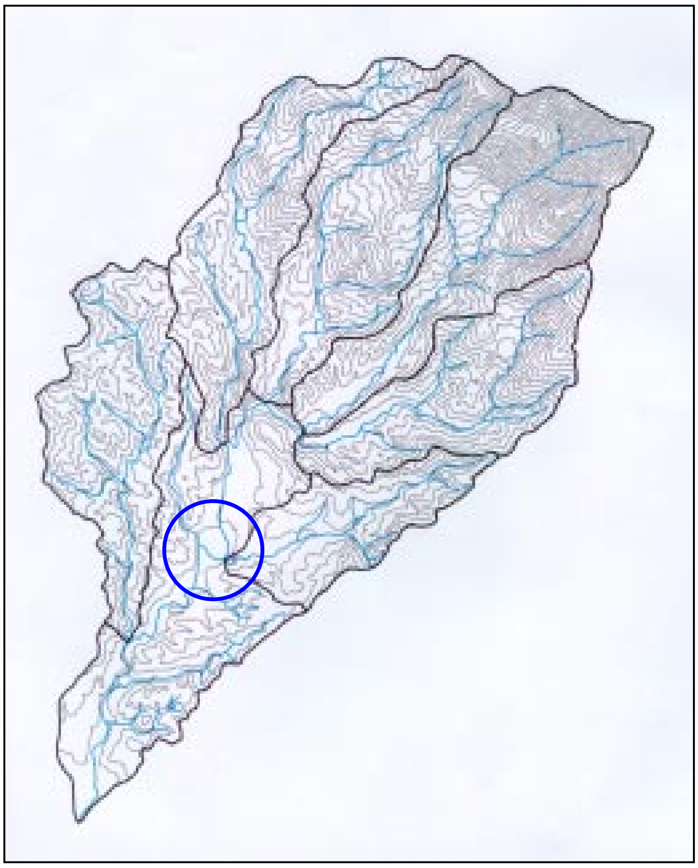


Figure 20.1.a – Location of the proposed intervention (scale 1:50 000)

In order to store an appreciable volume of flood water, the proposed check dam with a fixed outlet should be almost 9.0 meters high. Referring to the contour-line of 98 m a.s.l.. the transversal structure will close the valley with a width of 75-100 meters. On this basis, the flat zone located upstream could store a maximum volume of about 570 000 m^3 of water (Figure 20.1.b).

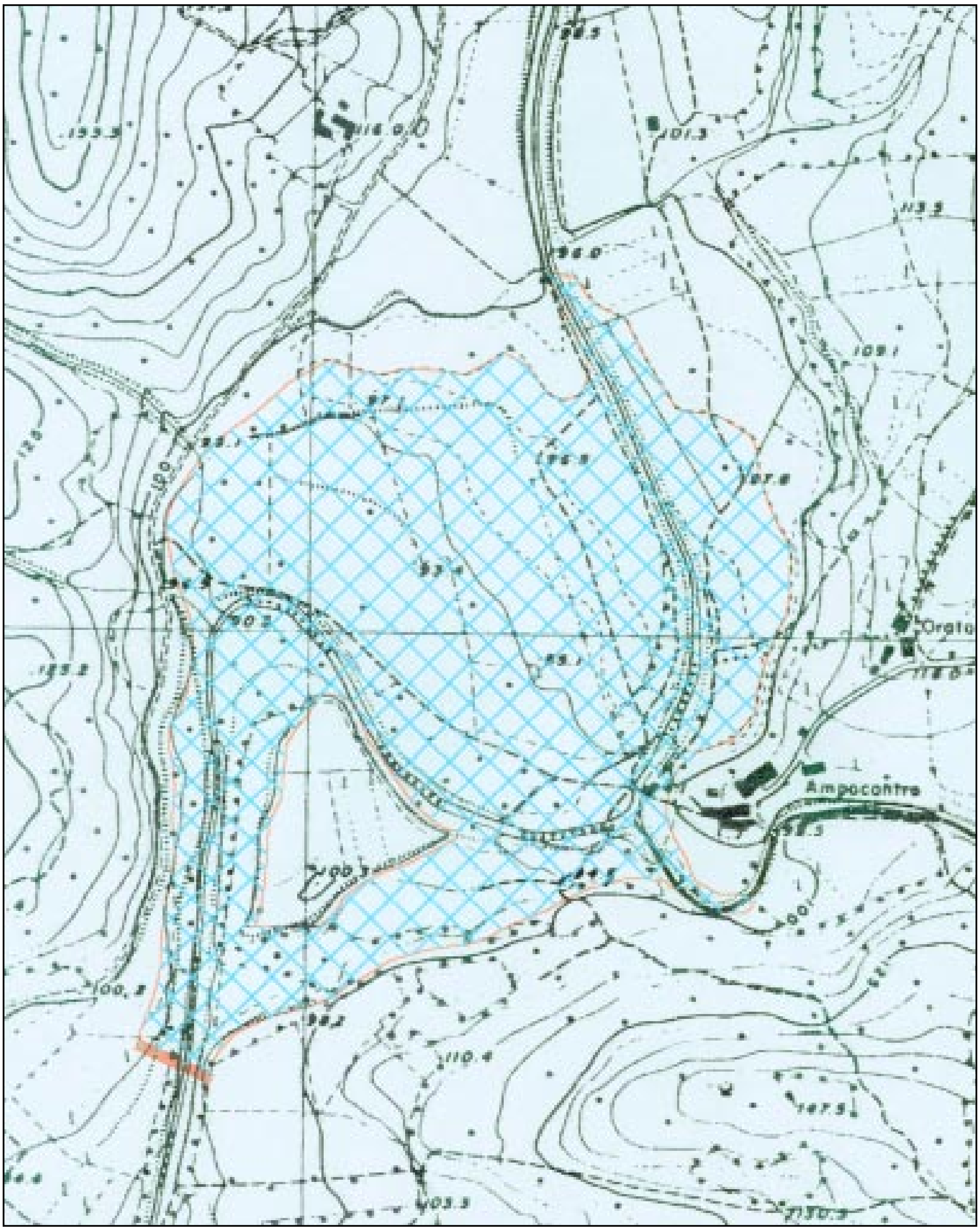


Figure 20.1.b – Extension of the retention areas (scale 1:5 000)

The structures could be carried out with an earth-fill embankment with the outlet(s) made of concrete.

Choice of this type of structural interventions is able to influence in a positive way the water discharge of the entire basin of Magra river. Preparation of some retention basins along the principal tributaries of Magra river could represent a solution for the reduction of the hydraulic risk conditions in the main Lunigiana valley.

20.1.1) General features

In the following pages, the peculiar territorial characteristics of the chosen area are described. The analysis has foreseen the predisposition of in deep investigations through the execution of direct field surveys.

On this basis, a detailed cartography (1:10 000) of each topic in this area has been prepared.

GEOLOGY

Regarding the geological aspects of the identified site for the construction of a temporary retention basin, a detailed survey of this area has singled out the outcrop of the following formations (Figure20.1.1.a):

Recent formations

- Recent and actual alluvial sediments with preponderance of pebbles and sand (Olocene);
- Terraced alluvial sediments (Olocene);

Fluvial-lacustrine deposits

- Fluvial-lacustrine sediments with preponderance of pebbles mixed with silt-sandy matrix (Villafranchiano);
- Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite) and rare interbeds of pebbles (Villafranchiano)

Ottone-S. Stefano unit

- Helminthoids Flysch-calcareous and marly calcareous turbidites with marly and shaly interbeds (Upper Cretaceous)

Detailed surveys of this area has allowed to define the structural and stratigraphical statement of the outcropping formations and the reconstruction of interpretative geological underground section (Figure 20.1.1.b).

Analysis of the geological map at the scale 1:10 000 identifies the existence of a lowered tectonic structure (graben) that favoured the formation of the flat alluvial area. Two main tectonic distensive trends bind the Gragnolesa area on the West and South-West sides.

The occurrence of main tectonic trends clearly influenced the sharp bending of the torrent.

GEOMORPHOLOGY AND TORRENT DYNAMICS

The peculiar geomorphological aspects of this area are represented by the alluvial terraced structures that are clearly identifiable in the flat area (Figure 20.1.1.c). The erosive action of the Civiglia torrent, that has interested the alluvial incoherent sediments after the ending of the lacustrine depositional phase, has caused the formation of subsequent orders of terraces. Their evidence is partly obscured by the agricultural activity that has hidden many morphological aspects.

Occurrence of a large plateau, located on the eastern part of the analyzed area, testifies the ancient depositional surface of the lake that developed in Lunigiana during the Villafranchiano period.

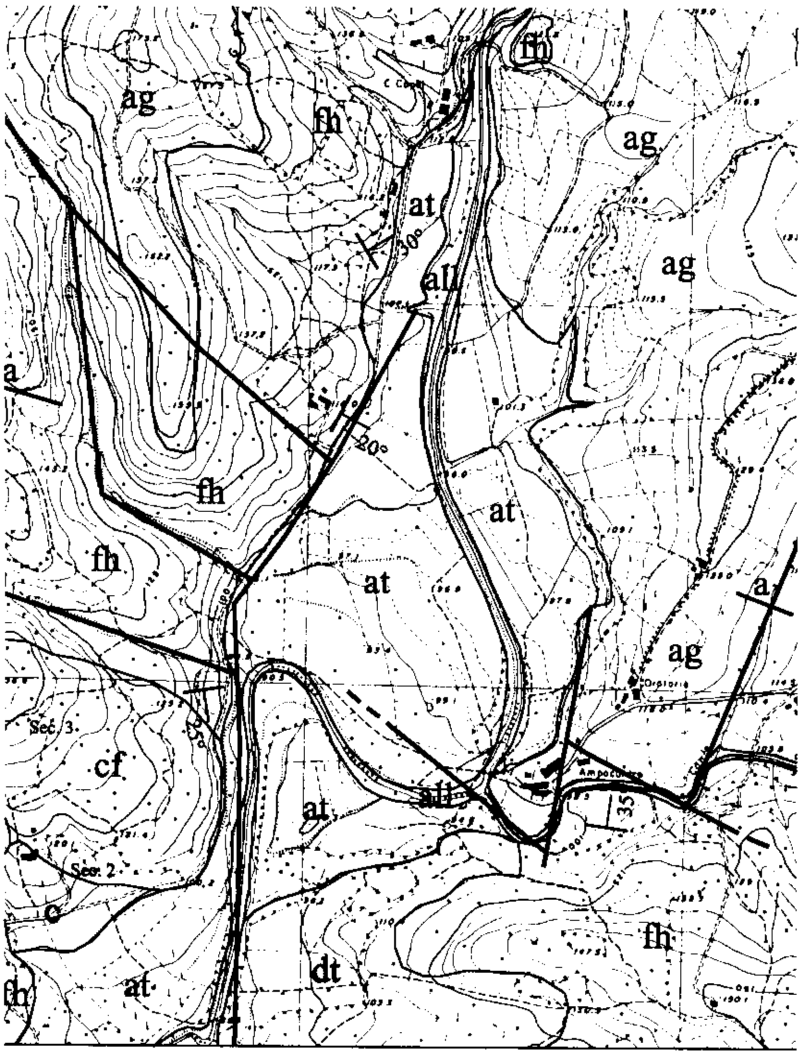


Figure 20.1.1.a - Geology

LEGEND

all	Recent and actual alluvial sediments with preponderance of pebbles and sand (Olocene);
at	Terraced alluvial sediments (Olocene);
c	Alluvial fan (Olocene);
dt	Debris (Olocene)
cf	Fluvial-lacustrine sediments with preponderance of pebbles mixed with silt-sandy matrix (Villafranchiano);
ag	Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite) and rare interbeds of pebbles (Villafranchiano)
fh	Helminthoids Flysch-calcareous and marly calcareous turbidites with marly and shaly interbeds (Upper Cretaceous)

Faults

35° Dip and inclination of bedding

a Cross section

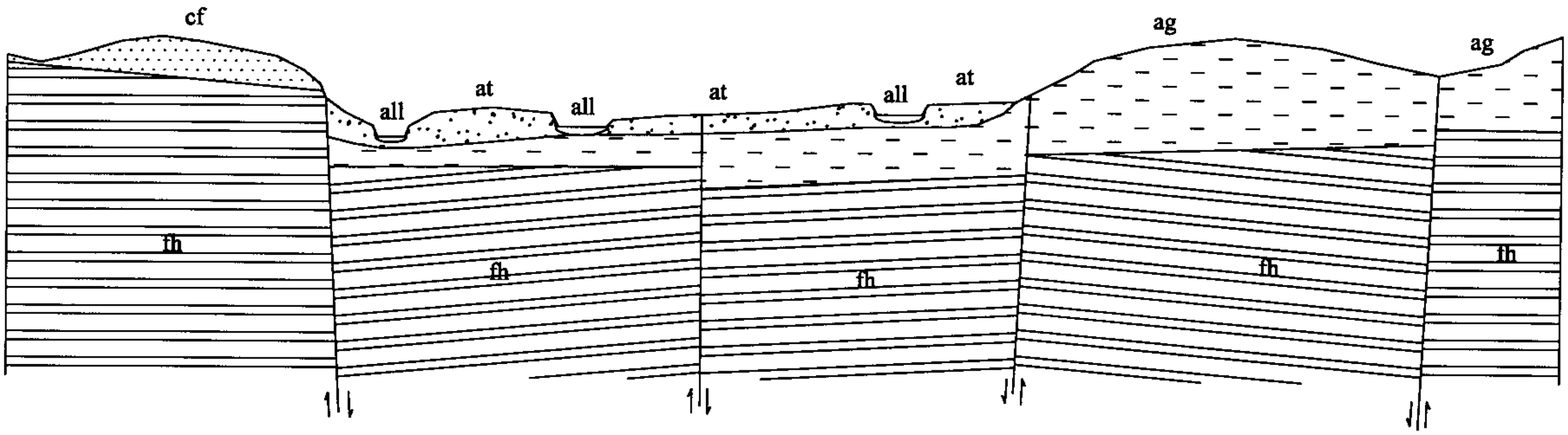


Figure 20.1.1.b - Geological underground section

LEGEND

all — Recent and actual alluvial sediments with preponderance of pebbles and sand (Olocene);

at — Terraced alluvial sediments (Olocene);

cf — Fluvial-lacustrine sediments with preponderance of pebbles mixed with silt-sandy matrix (Villafranchiano);

ag — Sand-clayey and clay-sandy fluvial-lacustrine sediments with vegetal remains (lignite) and rare interbeds of pebbles (Villafranchiano)

fh — Helminthoids Flysch-calcareous and marly calcareous turbidites with marly and shaly interbeds (Upper Cretaceous)

Faults

Instability phenomena have been surveyed on the slopes that surround the retention basin area. These landslides are all dormant. Furthermore, soil-creeping phenomena have been detached on the lacustrine formations where the slopes present a significant steepness.

Particular attention has been paid to the identification of the instability phenomena and the potential unstable conditions, in order to prevent the formation of new landslides or the re-activation of the dormant ones during the flooding time, both in the site of construction of the dam and in the remnant portion of the retention basin. Comparison between the extension of retention area and the unstable zones testify that no potential unstable areas are involved in the area of the proposed retention basin.

This part of the Civiglia torrent is characterized by the presence of diffuse bank erosional phenomena that cause instability conditions. In particular, small and very small active instability points are located on the steep banks of the torrent where the erosive action of the water causes the formation and rejuvenation of instability conditions.

Erosive action is more intense in the outer side of the torrent bend producing the formation of vertical natural banks. Furthermore, the erosional action caused the destruction of pre-existing longitudinal structures of bank protection made with cemented stones.

The direct survey of this part of Civiglia torrent does not show the existence of any typology of longitudinal or transversal hydraulic structures.

Detailed analysis of the torrent has highlighted the existence of depositional areas with formation of fluvial bars that cause the widening of the torrent bed. Deposition of transported materials is favoured by the reduction of the morphological gradient of this part of the torrent bed (0.01%) that is located immediately downstream of the steep portion of the hydrographic network.

HYDROGEOLOGY

On the basis of the qualitative indications identified in the previous report concerning the “General Study of Civiglia Basin”, the formations outcropping in the valley are characterized by permeable (terraced alluvial sediments) and high permeable conditions (recent and actual sediments) (Figure 20.1.1.d).

The rocky substratum (Helminthoids Flysch) and the sand-clayey/clay-sandy fluvial-lacustrine sediments, outcropping on the slopes present, also in relation to the cleavage of rocks, have a medium permeability.

On the basis of the information coming from the analysis of the geological analysis, the studied area is characterized by the existence of an underground water flow that occurs mainly in the sub-surface incoherent sediments.

Absence of wells within the studied area does not permit the detailed reconstruction of the underground water surface. In relation of the morphological aspects of this zone, the underground water movement should be parallel to the mean axial trend of the valley. Furthermore, Civiglia torrent, because of its lowered and incised position in the alluvial sediments, will represent the drainage axis of the valley.

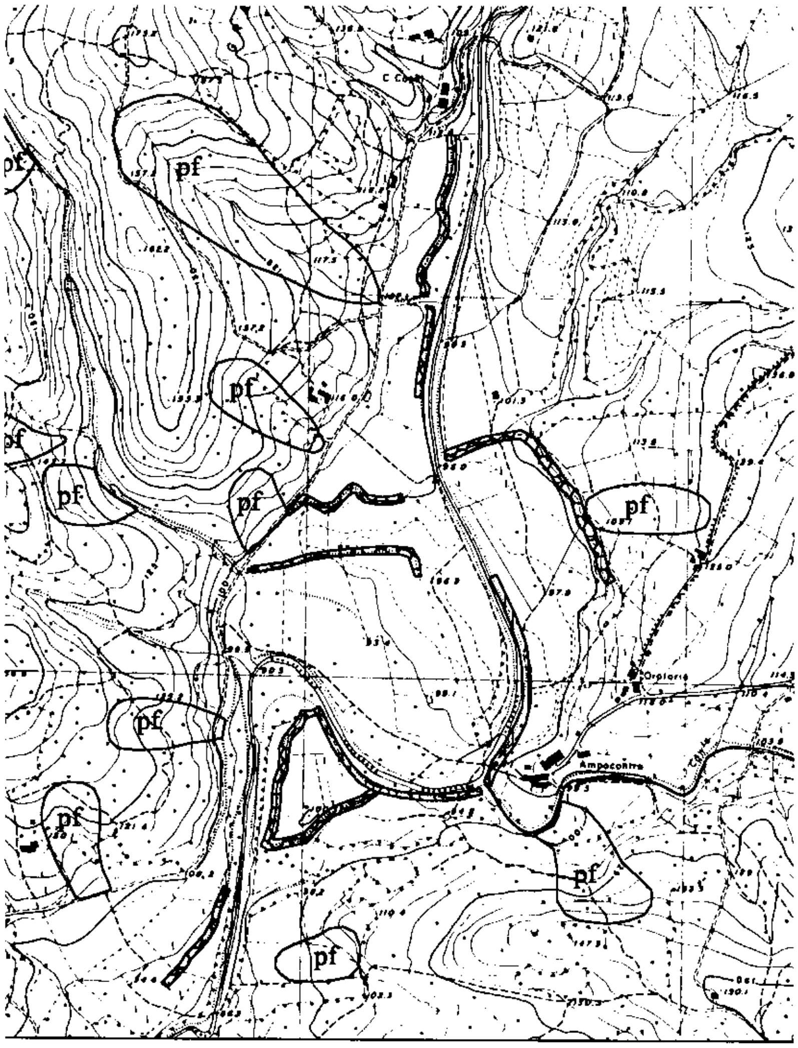


Figure 20.1.1.c - Geomorphology and torrent dynamics

LEGEND

Torrent banks subjected to erosional phenomena with formation of small local landslides (collapse)

pf Bodies of quiescent or paleo-landslides

Border of alluvial terrace

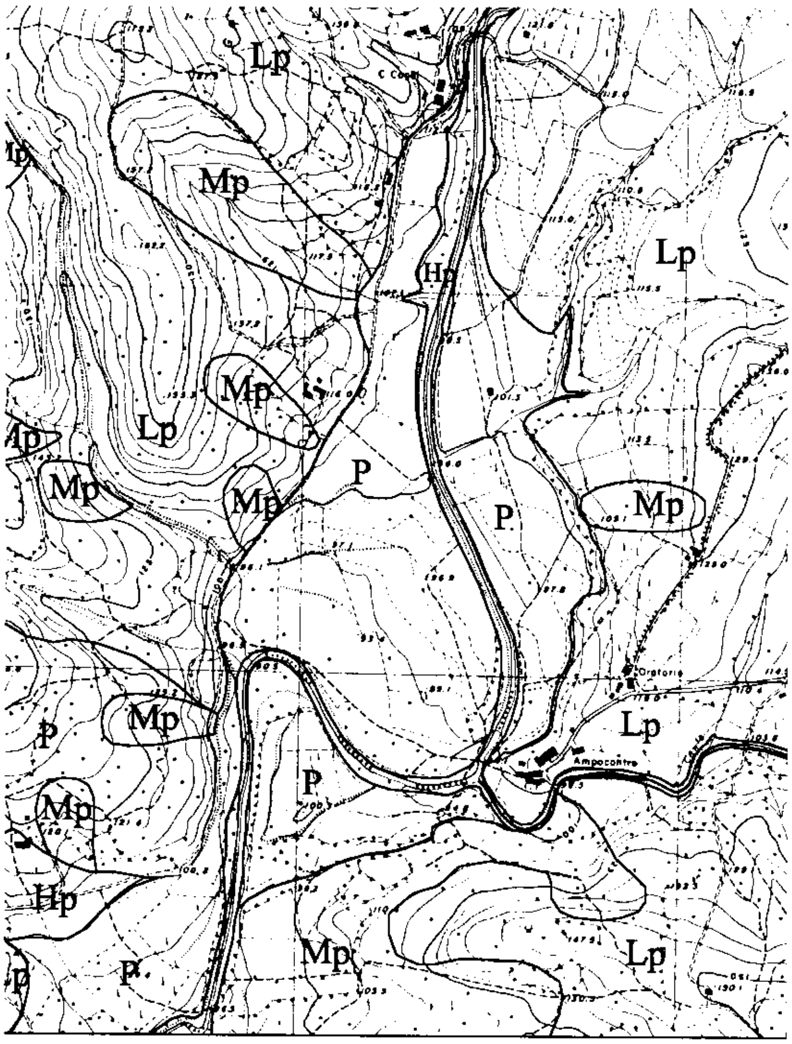


Figure 20.1.1.d - Hydrogeology

LEGEND

Hp	High permeable formations
P	Permeable formations
Mp	Medium permeable formations
Lp	Low permeable formations

LAND USE

The land use of this area has been reconstructed through the analysis of aerial photos of 1995 and direct field survey (Figure 20.1.1.e). On this basis, an up-dated identification of land use typologies has been prepared regarding both the retention zone and the adjoining slopes.

In detail, the analyzed area is characterized by the presence of:

- permanent meadow;
- broad-leaved coppice;
- Simple sowable land.

Permanent meadows characterize the flat area while broad-leaved coppice are on the slopes. Simple sowable land are present in the North part of the studied area with reduced morphological gradient.

No urbanized (continuous or discontinuous) or industrial-commercial settlement are present in the zone identified for the construction of the retention basin. Furthermore little agricultural activity is present in the alluvial flat area.

The presence of these typologies of land uses favours the location in this site of this kind of structural intervention because of the compatibility of the land use typologies with the occurrence of temporary flooding events.

SOIL

On the basis of the geological, geomorphological and land use data, the analysis of soils has been prepared. In the studied area, the presence of the following types of soil has been singled out (Figure 20.1.1.f):

- Typic Eutrochrept – Deeper than 100 cm evolved soils wit AbwC profile, sub-alcaline (pH 7.5-8.1) reaction, less than 35% lithic frames, with carbonates within 100 cm;
- Lithic Udorthent – Less than 50 cm-deep involved soils with AC profile, predominant acid (pH<5.5) reaction, more than 35% lithic frames;
- Deeper-than 100 cm, moderately-evolved Typic Udifluvent and Fluventic Eutrochrept association, with AbwC profile, neutral to subalcaline (pH 6.5-8.1) reaction, less than 35% lithic frames, and irregular, deep-related decrease in organic carbon content.

In the alluvial area, the low morphological gradient favours the formation of deep evolved soils while reduced values of soil depth have been surveyed on the adjoining slopes.

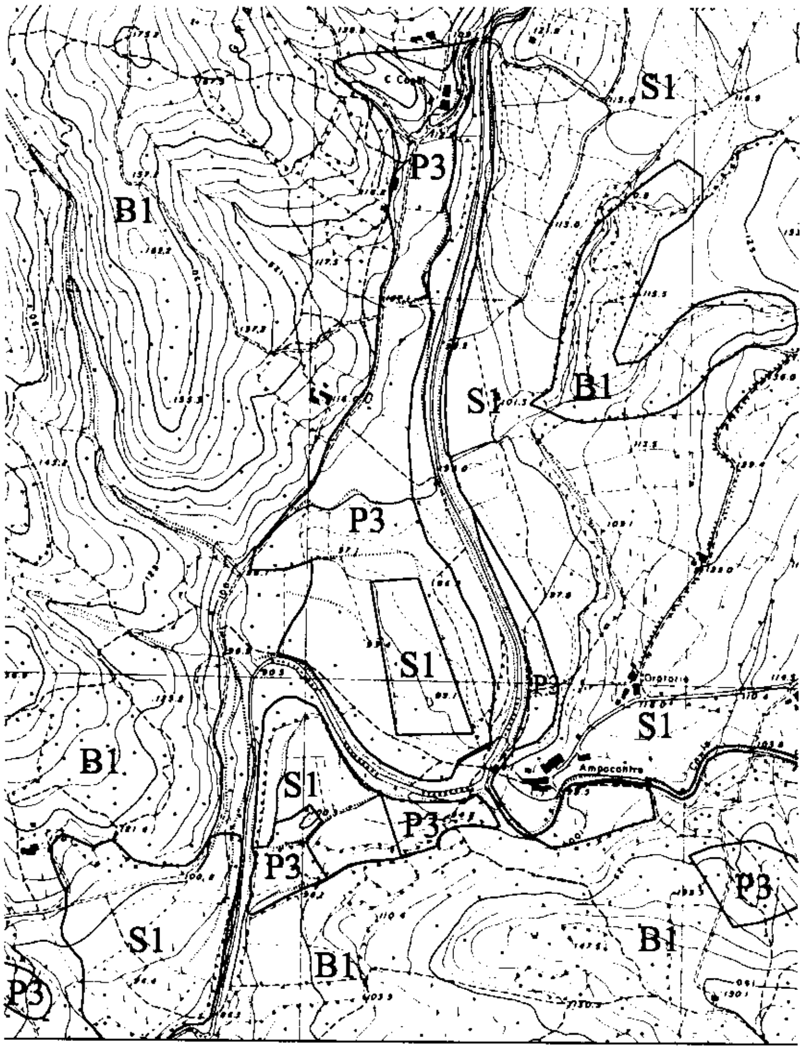


Figure 20.1.1.e - Land Use

LEGEND

P3	Permanent meadow
B1	Broad–leaved coppice
S1	Simple sowable land

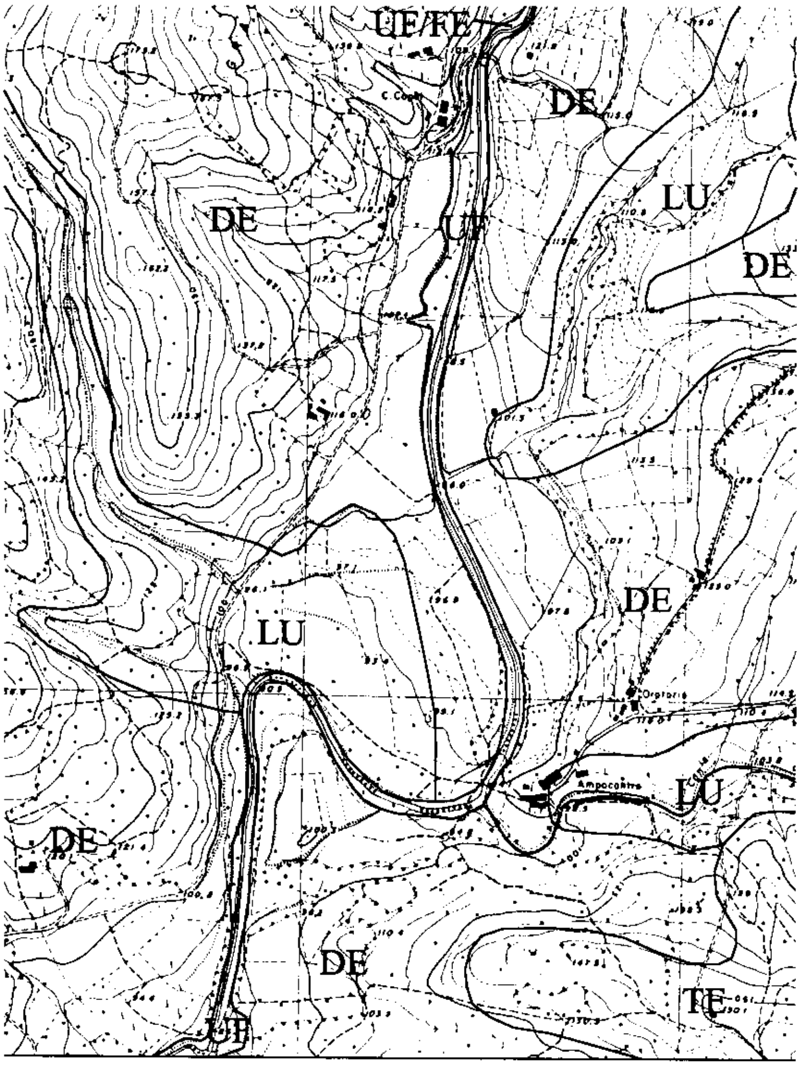


Figure 20.1.1.f - Soils

LEGEND

DE — Dystrict Eutrochrept – Deeper than 100 cm evolved soils with ABwC profile, acid to subacid (pH<6.5) reaction, less than 35% lithic frames, without carbonates within 100 cm. Unit localized on sub–horizontal surfaces and little eroded gentle slopes on talus, dormant landslide bodies, fluvio–lacustrine deposits and calcareous formation;

UF — Typic Udifluvent – Deeper than 100 cm unevolved soils with AC profile, neutral to subalcaline (pH 6.5 – 8.1) reaction, occasionally more than 35% lithic frames. Unit localized on valley bottom sub–horizontal surfaces on recent and present alluvial deposits;

TE — Typic Eutrochrept – Deeper than 100 cm evolved soils wit AbwC profile, subalcaline (pH 7,5–8,1) reaction, less than 35% lithic frames, with carbonates within 100 cm;

LU — Lithic Udorthent – Less than 50 cm–deep involved soils with AC profile, predominant acid (pH<5,5) reaction, more than 35% lithic frames;

UF/FE — Deeper–than 100 cm, moderately–evolved Typic Udifluvent and Fluventic Eutrochrept association, with AbwC profile, neutral to subalcaline (pH 6,5–8,1) reaction, less than 35% lithic frames, and irregular, deep–related decrease in organic carbon content.

20.1.2) Hydraulic modelling

On the basis of the hydraulic analysis prepared in the Chapter 13, the discharge values in the torrent reach identified for the carrying out of the retention basin has been prepared (Gragnolesa area). The calculation of the concentration time has been carried out applying Giandotti's formula (see Chapter 13).

On the basis of the morphometric parameters of the sub-basin delimited by the retention structure, the concentration time is reported in the following table (Table 20.1.2.a):

Table 20.1.2.a - Calculation of the concentration time

	Gragnolesa area
S (km^2)	25.50
L (km)	10.36
H_m (m)	213
C_t (hours)	**2.95**

Applying the extreme rainfall events calculated in Chapter 13 (see Table 13.e). the values of discharge of Civiglia torrent in Gragnolesa area have been computed with Giandotti's formula (see Chapter 13).

Also in this case, a **0.6** ratio between outflow and inflow is applied in order to identify the worst hydrological conditions for the formation of flood events. The calculated data, for 10, 15, 25, 50, 75, 100 and 200 years return time period, are shown in Table 20.1.2.b:

Table 20.1.2.b - Extreme Discharge Data at Gragnolesa

Rt (years)	**Discharge (m^3/s)**
10	116.8
15	127.7
25	141.2
50	159.3
75	169.8
100	176.3
200	195.1

Comparing the calculated maximum discharge of the hydraulic sections in the Terrarossa area with the discharge of the entire basin calculated on the basis of the rainfall events with 10, 15, 25, 50, 75, 100 and 200 years return time period, it is clear that some hydraulic sections are inefficient for flood events with a return time equal to 10 (Table 20.1.2.c). These data are in accordance with recurrent flooding events that have occurred in the last decades.

For this reason, the proposed intervention should be able to reduced the flowing water during the strongest flood events storing the surplus of water in the retention basin.

In order to quantify the water that should have to be stored, the simplified hydrogram of flood events with 10, 15, 25, 50, 75, 100 and 200 years return time period has been prepared for the discharge data computed for the Civiglia torrent in the Gragnolesa area (Figure 20.1.2.d).

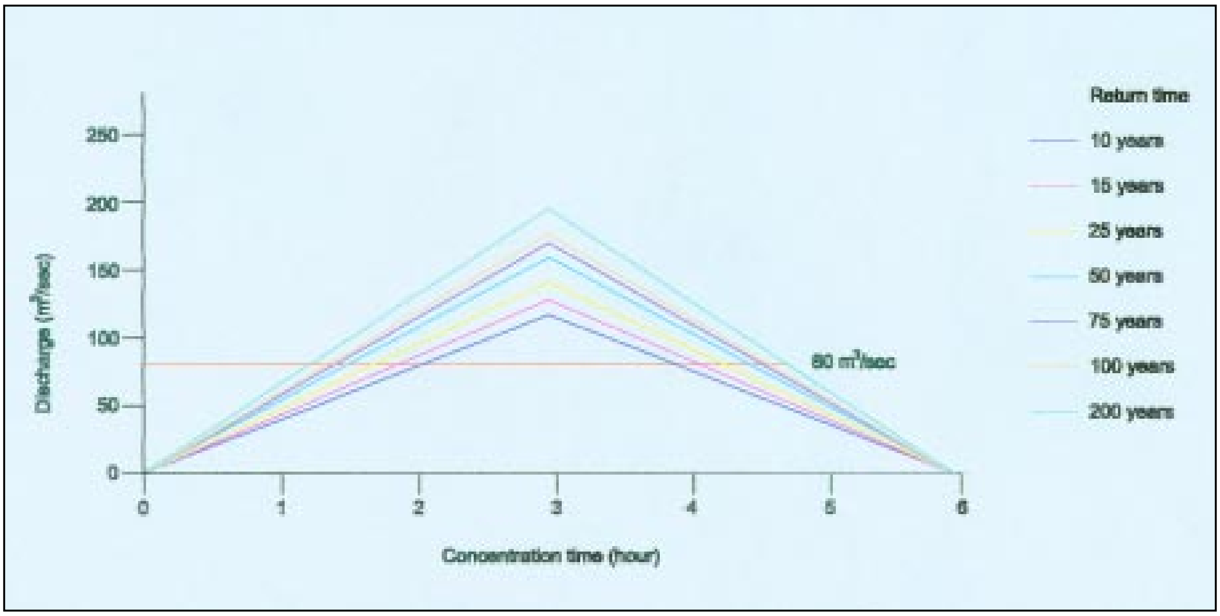


Figure 20.1.2.d – Simplified hydrograms for each return time period

On the basis of the hydraulic effectiveness of the water course in the Civiglia area, in order to avoid the occurrence of flood events, the discharge that could be released by the proposed intervention must not exceed 80 m^3/s. Release of a maximum discharge of 80 m^3/s will require to store in the retention basin a volume of (Table 20.1.2.e):

Table 20.1.2.e - Volume of water stored in the retention basin

Rt	**Water surplus (m^3)**
10	123 140
15	189 236
25	280 784
50	419 084
75	504 316
100	558 500
200	720 986

Comparing these data with the total volume of the proposed retention basin (570 000 m^3), it is clear that this kind of intervention could reduce the hydraulic risk conditions in Terrarossa area for flood events with 100 years return time period.

Table 20.1.2.c - Comparison among the discharge of hydraulic section and the extreme flood events in Terrarossa and Gragnolesa area

Terrarossa area							Hydraulic Section	Q mean capacity (m^3/s)	Gragnolesa area						
Flood events (m^3/s) for each return time period (years)									Flood events (m^3/s) for each return time period (years)						
10	**15**	**25**	**50**	**75**	**100**	**200**			**10**	**15**	**25**	**50**	**75**	**100**	**200**
140.8	154.4	170.6	192.4	205.1	214.0	235.6	1	98.0	116.8	127.7	141.2	159.3	169.8	176.3	195.1
							2	340.5							
							3	300.5							
							4	174.5							
							5	243.5							
							6	144.9							
							7	141.9							

20.1.3.) Technical analysis

In the following sub-chapter, the structure typology, annexed interventions and other qualitative considerations are faced.

STRUCTURE TYPOLOGY

Predisposition of a retention basin will require the construction of a transversal check dam with a fixed outlet that will close the entire transversal section of the main valley.

In detail, the proposal foresees to prepare a dam with an height of 9.0 meters (maximum elevation 98 m a.s.l.) that could create a retention basin with a maximum volume of 570 000 m^3.

On the basis of the previous detailed map, where the location of the proposed structure is identified, the transversal work will be 75-100 m wide.

The proposed structure can be constructed with an earthfill embankment with an irregular trapezoidal transversal section. In particular, the upstream side of the embankment could be prepared with a lower slope than the downstream side in order to prevent the collapse of the structure during the lowering of water level in the retention basin.

The inner structure of the dam can be arranged with a many-layer section through the predisposition of an impermeable or low permeable covering (clays and silty-clay materials) on the upstream side of the structure while, in the downstream side, permeable materials can be arranged in order to reduce the inner pressures generated by the water flow inside the structure and to avoid its collapse or breaking up during the filling of the retention basin.

In the following scheme (Figure 20.1.3.a), a preliminary proposal of the transversal hydraulic structure is represented.

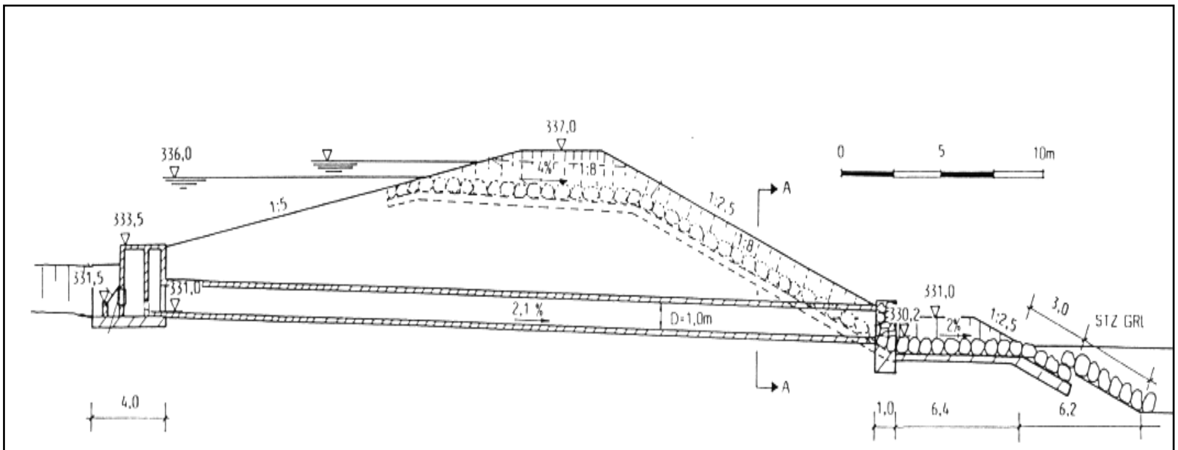


Figure 20.1.3.a – Cross section of a preliminary scheme of the proposed intervention (Amt der Steinrmarkischen Landesregierrung – Fachabteilungsgruppe Landsbaudirektion – Fachabteilung IIIa – Wasserwirtschaft – 1994)

FOUNDATION SITE

The identified site should guarantee a good foundation regarding the maximum pressure that could be applied and the corresponding subsiding of the underground sediments.

Up to now, on the basis of the surface information, it is not possible to identify how deep the rocky substratum is. For this reason, during the subsequent planning phase, it will be necessary to prepared in-deep reconstruction of underground cross sections and geo-technical characteristics of the natural sediments.

The reconstruction of a detailed transversal underground section of the site of intervention has to be defined in order to avoid extreme differential subsiding that can cause the deformation of the earthfill structure, favouring the water flow inside the dam and the formation of inner water pressure.

In relation to the high permeability that characterizes the alluvial sediments outcropping in the proposed site, structural interventions must be prepared in order to reduce the pressure of underground waters under the transversal structure. In particular, the pressure of underground waters will reach its highest value during the filling up of the retention basin causing a significant water flow under the dam.

For this reason, two different solutions could be put in practice for the reduction of water pressure and assure the stability of the dam:

1. the predisposition of a drainage system of the underground flowing water in the downstream part of the structure, in order to reduce the water pressure under and also inside the earthfill transversal structure;
2. the predisposition of transversal impermeable barrier with clay or concrete structures in order to limit the flow of underground water.

OUTLET STRUCTURE

In relation to the strong dynamics action of the flowing water, the outlet structure for the discharge of the flood waters must be built with a concrete structure.

The size and number of the outlets, on the basis of the previous hydraulic modelling, will be planned in order to permit the outflow of a maximum discharge of 80 m^3/s as a function of the hydraulic effectiveness of the lower part of Civiglia torrent.

Figure 20.1.3.b - Example of protective grid (Amt der Steinrmarkischen Landesregierung – Fachabteilungsgruppe Landsbaudirektion – Fachabteilung IIIa – Wasserwirtschaft – 1994)

The concrete structures have to be protected upstream by a grid in order to prevent the obstruction of the outlets by the floated material and assure their effectiveness for the entire duration of the flood. On the basis of the experiences seen during the project, the protective structure (grid) can be prepared with a sloped surface in order to favour the floating of the transported materials (in particular vegetal cutting, trunks, shrubs, etc.) and avoid the occlusion of the outlets. An example of this structure is exemplified in the Figure 20.1.3.b.

The transversal retention structure will be planned with an emergency device for the discharge of the flood water in case of occlusion of the outlets. The emergency device can be constructed on the top of the transversal structure and protected with covering structure in concrete or stones in order to resist to the erosive action of the flowing waters.

SCREEN DAMS

In order to reduce the flow of transported materials inside the retention basin, it will be necessary to plan screen dams along the main torrent reaches which are tributary of the retention basin.

These works can be prepared with concrete and iron transversal structures located before the outflow of the torrents in the retention area.

After each flood event, these structures have to be cleaned in order to guarantee their effectiveness for the subsequent floods.

Together with the previous structural interventions that reduce the transported vegetal materials, a sedimentation pool inside the retention area must be planned in order to favour the deposition of the rocky transported materials. Preparation of a low energy area within the retention basin will permit the storage of coarse sediments avoiding their deposition close to the retention structure. Removing of transported materials must be put in practice after each significant flood events.

PRESCRIPTIONS AND LAWS IN FORCE

Regarding the laws and prescriptions in force in the area identified for the predisposition of the proposed interventions, three legislative bounds appear (Figure 20.1.3.c and Figure 20.1.3.d):

- Royal Decree 3267/23 – "*Rearrangement of legislation about woods and mountainous areas*";
- State law 431/85 – "*Obligations affecting environment*" point g (woods and forests);
- Decree of the Regional Council 230/94 – "*Actions against hydraulic risks*"

NON-STRUCTURAL INTERVENTIONS

Construction of the proposed structural intervention have to be coupled with non-structural interventions as it concerns the retention basin area. In relation to the occurrence of recurrent flooding events, the retention basin must be kept clear from civil or public constructions (urbanization).

The town planning plans of the local Administration involved have to be modified in order to identify this areas free from land use typologies that are not compatible with storage of flood water.

Prescription and regulation must be prepared in order to put in practice a correct management of the wooded areas located close to the retention basin in order to reduce the transport of vegetal materials that could obstruct the outlet of the transversal hydraulic structure.

COST

On the basis of the technical aspect of the proposed structural intervention a estimated cost of this work could be 370 000 Euro plus VAT and technical expenditures.

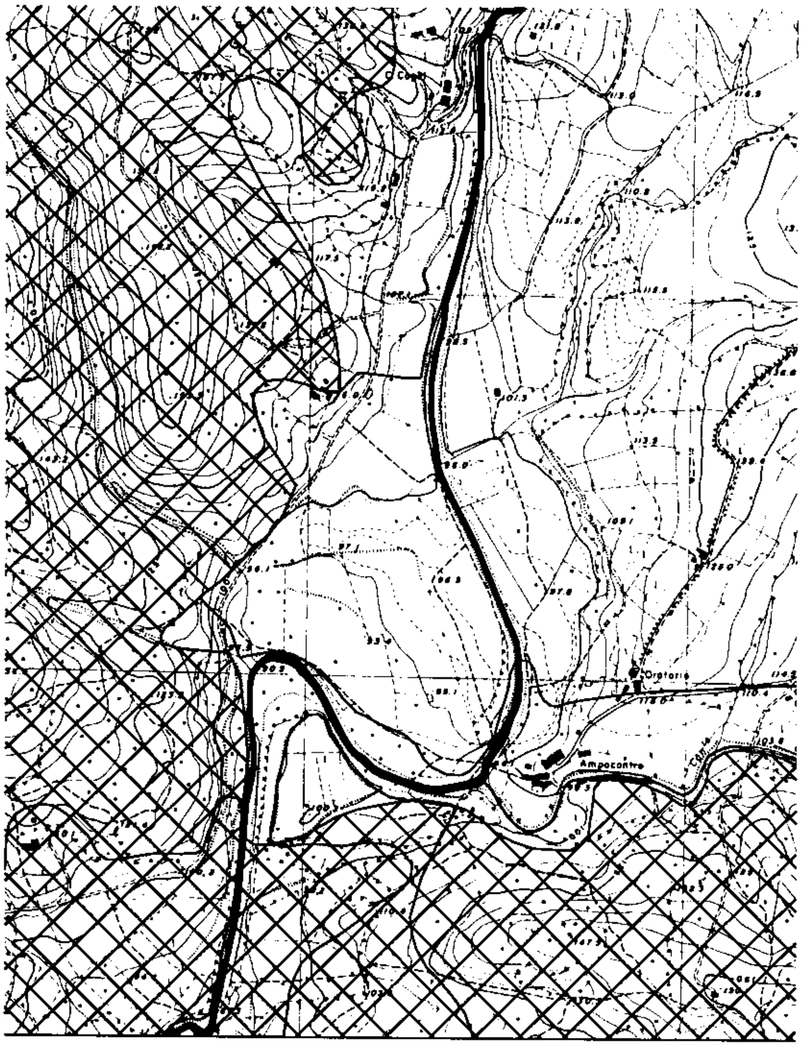


Figure 20.1.3.c - Prescriptions and laws in force

LEGEND

Royal Decree 3267/23 - "*Rearrangement of legislation about woods and mountainous areas*";

Decree of the Regional Council 230/94 - "*Actions against hydraulic risks*"

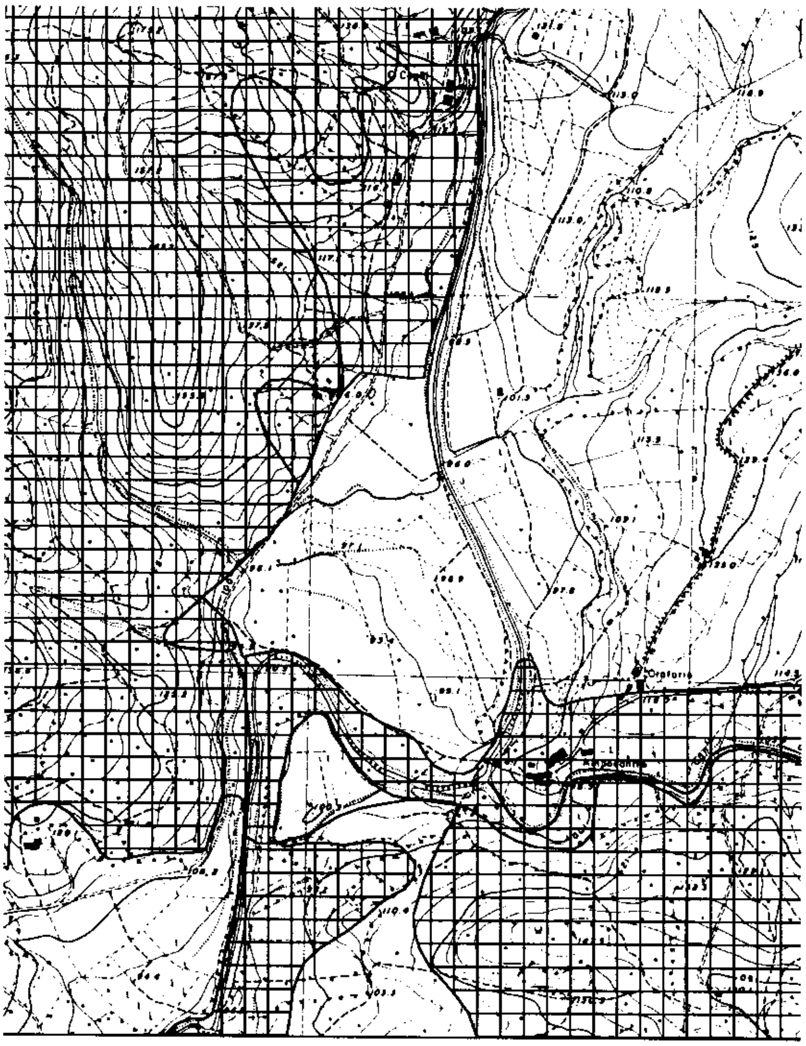


Figure 20.1.3.d - Prescriptions and laws in force

LEGEND

State law 431/85 – "*Obligations affecting environment*" **point g (woods and forests);**

20.2) Austrian proposal for the protection of the civiglia basin against floods

Description of the problem:

- Danger of floods in an urban and an industrial area in Terrarossa, near Aulla;
- Deposition of bed load material upstream of a road bridge and a railway bridge (both with a central pillar) in the area of the industrial site.

Data relating to the project:

Terrarossa area

Annex	Application of principles and guidelines for flash flood mitigation in the Civiglia basin (Province of Massa – Italy).
Base map:	scale 1: 5 000
Cross-sections:	(MCV 1-7) 1:200

Gragnolesa area

Annex:	Intervention for the hydraulic safety of the Civiglia basin.

Possible solutions to the flood problem affecting the Terrarossa area:

1st Alternative	2nd Alternative	3rd Alternative	4th Alternative
Acquisition of endangered objects and transfer of activities to areas that are not subject to the risk of floods.	Insurance of endangered objects against damage caused by floods.	Construction of dikes and masonry revetment walls along the banks for the protection of endangered objects Removal of bed load material depositions upstream of the road bridge.	Construction of a flood retention basin in the surroundings of Gragnolesa area.
Passive flood protection		*Active flood protection*	

Further alternatives cannot be worked out at the present stage of planning because of the lack of direct knowledge of the territory and more detailed information.

Alternatives 1 and 2 do not require further consideration from a water management point of view. Their implementation depends primarily on socio-political, economic and infra-structural aspects. In this context, any decision must be taken at a political level, although comparison with the costs for the implementation of alternatives 3 and 4 would provide a useful starting point.

Notes on Alternatives 3 and 4:

Alternative 3:

Technically, the construction of dikes and masonry revetment walls along the banks from the road bridge up to the valley narrowing at cross section MCV 5 is not a problem. Length of river segment: about 400m.

- Raising of river bed on the left bank (dike or revetment wall) up to 1.5 m (= calculation on the basis of base plan and cross sections) and integration of revetment walls on the right bank. Security level: HQ_{200} (= as required by the Italian counterpart)
- Evaluation of the effects of shifting flow retention from the left bank to the right bank (see objects and lower course).
- Analysis of bed load situation and, if necessary, construction of sediment control dams in the upper course outside inhabited areas.
- Consideration of the damming effect generated by the central pillars of the two bridges with respect to both flood discharge and bed load transport.
- Removal of bed load material depositions upstream of the road bridge focussing especially on questions of public interest.
- Construction of an access way to the river bed.
- Extensive acquisition of land along the river.
- Adoption of security measures against drop.

Costs (prices relate to the period of April 1999 in Austria -):

	Euro
• Construction of a flood retention dam on the left bank Length = 400m, width of crown: 3.5m Slope 1:2 and 1:3 Average height of the dam: 1.25m Control measures on the water side Dam crown surmounted by roadway Including acquisition costs	155 000
• Integration of revetment wall on the right bank Length = 150m, width of crown: 0.5m Average height of revetment wall: 0.5m	36 000
• Removal of bed load material depositions about 1 000m^3	7 000
• Drainage of surrounding land	7 000
• Sediment control dam in the upper course for about 2 000 m^3	218 000
• Contingencies and rounding up	22 000
	445 000

Planning expenses are not included in this estimate.

Authorizations required according to Austrian law:

- Water law (federal law);
- Railway law (federal law);
- Law on the promotion of hydraulic engineering works (federal law);

If state subsidies are resorted to, expenses could be shared as follows (HQ_{100}):

50 – 60%	Federal Ministry of agriculture and forestry;
30%	Province of Styria;
10 – 20%	Beneficiary, (Commune).

Upkeep must be continually provided by the beneficiary.

Upkeep of flood control structures:

- Mowing crown and slopes of the dam
- Taking care of eventual bank vegetation
- Removing bed load material depositions from the torrent bed if they reduce the security level.

Alternative 4:

The construction of flood retention basins requires the availability of land and the presence of favourable topographical conditions. In the area of Granolesa there is an ideal location for the construction of a flood retention basin.

Basic principles of the Project:

- Base flow and storage capacity should be calculated with respect to security requirements further downstream. It has been estimated that the location of the retention basin would encompass 60 – 70% of the basin of the Civiglia torrent.
- The construction of the flood retention basin should enable to minimize intervention on the lower course.
- Two possible solutions should be evaluated as to the construction of the basin:
  1. Basin in the river bed:
     minimal interference with the environment;
     higher risk of siltation and therefore more expensive upkeep;
     construction of sediment control dam should be considered.
  2. Basin in a side branch:
     no interruption of flow continuity;
     almost no interference with bed load transport;
     dam can be erected with material excavated locally during construction of by-pass channel;
     more expensive components for dam construction.
- Conservation of natural river (meander) in the area of the retention basin;
- Permanent road access to retention basin to be included in the planning;
- Extensive acquisition of land, if possible, otherwise payment of one-time-only indemnities (out of the construction fund) for economic drawbacks suffered by the owners of the pieces of land that cannot be acquired;
- Both upstream and downstream of the retention basin installation of both a hydrographer and a mechanical hydrographer is recommended.

Costs (prices relate to the period of April 1999 in Austria -):

• Retention basin in Gragnolesa area with earth dam, storage capacity about 250 000 m^3. • Storage surface about 60 000 m^2 • Max. storage water level 7.5m	2 000 000 – 2 400 000

Planning costs are not included in this estimate.

Although its construction costs are clearly the highest, alternative 4 should be taken into consideration for the following reasons:

- From a general water management point of view it has a balancing effect on the river regime of the Civiglia torrent (it could possibly be used as a reservoir for industrial water and groundwater enrichment)
- It contains the flood peak and minimizes potential risks for the Terrarossa area
- It reduces upkeep costs downstream of the retention basin
- It can serve as a pilot project to gather information as to the working of flood retention basins.

Authorizations required according to Austrian law:

- Water law (federal law)

Among other things, the appointment of a basin surveillant and a basin overseer is required

- Law on environmental protection (regional law)
- Forestry law (federal law)

if woods or forests are affected

- Law on the promotion of hydraulic engineering works (federal law)

if state subsidies are resorted to, expenses could be shared as follows (protection of the Terrarossa area against HQ_{100}):

50 – 60%	Federal Ministry of agriculture and forestry;
30 - 40%	Province of Styria;
5 - 10%	Beneficiary, (Commune).

Upkeep must be continually provided by the beneficiary.

Upkeep and servicing of the flood retention structures:

- Constantly checking correct function of the dam
- Servicing mobile elements of bottom outlet and bypass
- Removing depositions of bed load material and wood
- Mowing crown and slopes of the dam
- Taking care of eventual vegetation on the land-side of the dam
- Taking security measures against human drop.

Further notes:

The discharge hydrographer that is to be installed in Civiglia torrent should not be placed at the level of the road bridge, but at the level of the railway bridge, since in the event of flood, the current here is smoother with the result that measurements are more accurate. The automated discharge control system should be integrated with a mechanical hydrographer which has to be accessible to overseers.

To have a better overview of the situation, the flood stages referring to HQ_{10}, HQ_{50}, HQ_{100} and HQ_{200} should be added to cross sections MCV 1-7 and adjusted according to the altitude lines of the base plan.

21.) CONCLUSIONS

This study represents a practical application of the guidelines and principles for flash flood prevention that have been highlighted in the final document of project “Premo 98”. This study case has been chosen in relation to the surface of the basin (medium-small size catchment) and the recurrent flood events that occur in the lower portion of the basin.

Civiglia basin was analyzed in all its territorial aspects in order to define the causes and phenomena that are responsible of the formation of flash flood events in the Terrarossa area where, in the last decades, civil, industrial and commercial–craft estate have been constructed in a naturally recurrent flooded area.

The information was implemented on a GIS that is able to represent, analyze and elaborate the territorial characteristics of the basin.

In detail, Civiglia basin represents a typical example of a basin with no significant hydraulic or hydrogeological problems (intensity of erosive and landslides phenomena) and with the presence of extensive vegetal covering that assures a protection to the basin and a reduction of runoff propensity of the basin.

Despite of these aspects, the occurrence of extreme rainfall events and the peculiar altimetrical trend of the main torrents produce the suddenly concentration of flowing water and the formation of high flood waves that cannot be contained by the present hydraulic transversal section in Terrarossa area.

For these reasons, Civiglia basin represents a common example in European countries where the presence of human settlements in river or torrent pertinent areas is usually identified.

On the basis of the inter-relation among causes and natural aspects of the basin, different potential solution to the alluvial problems have been identified.

The proposed interventions represent some of the possible options for hydraulic problems of basins subjected to flash floods. Coupled with the proposed intervention, guidelines and principles for the correct management of the valley floor, hydrographic network and slopes will be able to assure the reduction of the hydraulic risk conditions.

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NNEXES

- PLUVIOMETRICAL DATA;
- THERMOMETRICAL DATA;
- GRANULOMETRY MEASUREMENTS;
- GEOGRAPHICAL INFORMATION SYSTEM;
- HYDRAULIC CROSS SECTION AT TERRAROSSA (SCALE 1:500)

THEMATIC MAPS (SCALE 1:25 000):
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SHADED RELIEF
INSOLATION
SLOPE
POPULATION DENSITY AND GENERAL FEATURES
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MANAGEMENT OF THE HYDROGRAPHIC NETWORK
MEASURES IN AGRICULTURE AND FORESTRY IN FUNCTION OF RUNOFF CLASS

LONGITUDINAL PROFILES (SCALE 1:25 000 – 1:2 500)

PLUVIOMETRICAL DATA OF ARLIA (mm)							
Year	**1 hour**	**3 hours**	**6 hours**	**12 hours**	**24 hours**		**Annual rainfall**
1946							
1947							
1948	34.0	53.4	60.8	68.6	69.2		
1949	33.8	39.0	42.6	64.0	88.8		
1950	43.6	53.2	63.8	69.4	69.4		
1951	50.0	84.6	104.6	104.6	104.6		1 765.0
1952	53.0	86.0	139.0	182.0	222.8		1 988.4
1953	25.0	34.4	40.2	43.6	89.0		1 046.6
1954	32.0	50.2	53.8	105.0	110.4		1 290.2
1955	20.0	29.6	37.6	55.2	78.6		1 281.6
1956	17.2	26.0	39.6	40.0	41.2		902.7
1957	21.4	43.0	45.4	53.6	75.4		1 107.6
1958	17.4	26.2	40.4	53.2	71.0		1 343.8
1959	41.0	54.0	82.0	135.4	163.6		1 556.8
1960	67.0	92.0	105.8	138.6	141.2		2 377.1
1961	26.0	37.8	45.0	52.0	73.2		1 447.6
1962	24.2	38.2	48.2	56.6	68.2		1 089.3
1963	31.0	38.4	65.0	81.4	115.0		1 699.3
1964	52.8	62.6	77.6	111.6	133.8		1 509.1
1965	97.0	99.4	105.2	112.6	124.6		1 929.3
1966	22.6	42.8	57.4	87.4	108.0		1 744.8
1967	27.8	33.6	40.4	59.4	79.6		1 290.6
1968	69.0	96.8	120.0	127.0	134.0		1 854.6
1969	20.8	42.0	83.8	128.4	154.8		1 353.4
1970	23.8	39.0	41.2	49.4	69.4		1 193.6
1971	11.8	20.0	39.0	52.6	66.0		1 099.8
1972	43.0	77.0	99.0	156.0	183.2		1 475.0
1973	26.0	56.0	93.0	118.6	123.4		1 099.8

1974	22.0	29.2	31.0	47.8	54.8		1 185.8
1975	18.0	32.0	43.0	73.4	102.4		1 407.6
1976	40.0	75.2	109.4	113.1	113.3		1 512.0
1977	26.4	39.8	63.6	67.6	106.8		
1978	18.4	32.6	47.0	65.0	74.8		1 398.8
1979	24.6	30.4	43.0	55.8	80.0		1 630.2
1980	20.2	38.6	64.6	96.6	124.6		1 358.6
1981	17.8	39.2	62.8	73.4	76.0		1 170.8
1982	50.0	136.0	191.0	233.4	347.4		
1983	19.0	41.0	47.2	50.4	63.8		927.2
1984	21.6	38.6	40.4	47.0	58.8		1 492.4
1985	23.6	35.0	44.4	46.2	59.8		
1986	16.8	23.6	36.2	46.6	57.0		1 092.4
1987	30.4	53.8	71.2	84.6	87.0		1 189.0
1988							840.4
1989	32.2	322	42.2	55.8	62.4		1 140.0
1990							1 328.8
1991	77.0	126.0	130.0	151.0	168.4		1 402.5
1992	42.0	49.0	70.0	91.0	123.0		2 043.4
1993	38.0	62.4	72.6	80.2	100.8		1 741.2

Mean value
1 407.7

PLUVIOMETRICAL DATA STATION OF AULLA (mm)							
Year	**1 hour**	**3 hours**	**6 hours**	**12 hours**	**24 hours**		**Annual rainfall**
1943	15.6	30.2	32.0	44.0	61.0		
1944							
1945							
1946							
1947	25.0	34.0	52.0	89.0	97.0		
1948							
1949	45.6	46.8	61.4	76.8	112.6		
1950	23.4	40.2	48.2	55.2	65.6		1 279.4
1951	26.0	33.8	45.8	70.8	110.0		1 267.2
1952	60.0	108.0	143.0	188.0	207.6		1 722.1
1953	51.0	70.0	72.0	73.2	108.6		1 821.0
1954	27.2	53.0	83.0	106.2	115.8		1 140.8
1955	32.2	44.2	57.0	87.6	93.2		1 691.2
1956	20.4	42.0	56.0	72.2	90.0		1 335.8
1957	57.2	73.2	83.2	97.0	131.0		1 415.6
1958	26.0	53.0	73.0	76.0	93.4		1 660.4
1959	58.4	72.0	86.2	113.2	148.4		1 598.0
1960							1 585.6
1961							
1962							
1963							
1964							
1965							
1966							
1967							
1968							
1969							

1970							
1971							
1972							
1973							
1974							
1975							
1976							
1977							
1978							
1979							
1980							
1981							
1982							
1983							
1984							
1985							
1986							
1987							

Mean value
1 501.6

PLUVIOMETRICAL DATA OF BAGNONE (mm)

Year	1 hour	3 hours	6 hours	12 hours	24 hours		Annual rainfall
1945							1 082.3
1946							1 414.0
1947							
1948							
1949							1 363.5
1950							1 385.5
1951							2 186.7
1952							2 115.8
1953							1 215.2
1954							1 743.5
1955							1 512.0
1956							1 227.4
1957							1 437.7
1958							1 683.6
1959							1 853.2
1960							2 570.6
1961							1 913.3
1962							1 351.4
1963							1 882.1
1964	37.0	80.0	89.8	108.0	150.4		1 711.8
1965							1 904.8
1966	32.0	44.0	58.4	71.0	104.5		1 665.9
1967	40.0	73.0	94.0	120.0	140.6		1 296.5
1968							2 124.9
1969	40.0	74.0	91.0	128.0	152.6		1 690.4
1970	58.0	98.0	115.6	151.0	151.2		1 795.4
1971	23.6	26.0	48.0	67.8	73.2		1 264.4
1972	38.0	70.4	95.2	105.0	135.0		1 713.5
1973							1 177.9

1974	38.0	53.8	56.0	63.8	63.8		1 226.3
1975	31.0	36.7	48.0	79.0	103.6		1 545.0
1976	31.9	72.7	117.3	122.2	122.2		1 697.0
1977	31.8	50.0	80.8	112.6	160.6		1 967.0
1978	19.2	32.0	48.8	62.2	73.6		1 310.6
1979	28.0	34.0	46.6	60.4	89.4		2 136.6
1980	32.2	54.8	88.2	108.2	124.6		1 316.1
1981	39.6	72.4	95.0	110.0	119.6		1 217.9
1982							1 838.3
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							1 221.6
1991							

Mean value
1 615.1

PLUVIOMETRICAL DATA OF MAZZOLA (mm)							
Year	**1 hour**	**3 hours**	**6 hours**	**12 hours**	**24 hours**		**Annual rainfall**
1947							
1948							
1949							
1950							
1951							2 095.2
1952							1 733.8
1953	32.0	52.6	54.4	62.2	98.4		971.0
1954	21.0	37.4	57.0	67.6	74.4		1 348.6
1955	32.6	48.2	48.4	48.2	74.2		1 179.2
1956							890.2
1957							1 045.0
1958							1 156.4
1959	52.6	61.8	88.2	140.8	171.2		1 514.0
1960	37.2	47.0	70.4	95.6	104.8		2 156.8
1961	26.6	47.0	50.0	73.0	86.0		1 378.6
1962	31.2	38.2	46.0	55.6	75.4		1 137.0
1963	44.0	60.0	64.4	77.4	113.2		1 665.4
1964	46.0	60.0	68.2	93.6	107.4		1 402.6
1965	33.0	44.8	64.4	88.4	110.6		1 760.2
1966	35.0	55.0	72.8	84.0	126.6		1 565.0
1967	35.4	41.6	50.0	61.4	72.4		1 070.4
1968							
1969							
1970							1 268.8
1971	39.0	45.4	46.0	64.0	82.2		1 225.6
1972	26.8	40.0	50.8	69.0	98.4		1 370.6
1973	28.6	60.0	83.6	134.4	149.4		1 039.8
1974	18.0	24.0	40.0	51.4	54.8		1 162.2
1975							1 544.4
1976							1 606.8
1977							1 842.9
1978	28.4	34.6	52.0	89.0	116.2		

1979	23.8	40.8	58.2	68.8	93.8		1 965.6
1980	19.8	43.2	69.4	106.2	134.4		1 189.8
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							1 056.3
1990							1 074.2
1991							
1992							973.2

Mean value
1 379.7

PLUVIOMETRICAL DATA OF VILLAFRANCA (mm)							
Year	**1 hour**	**3 hours**	**6 hours**	**12 hours**	**24 hours**		**Annual rainfall**
1946							1 311.2
1947							1 999.9
1948							1 893.7
1949							1 473.2
1950							1 611.3
1951							2 238.1
1952							2 193.5
1953							1 182.0
1954	38.0	51.2	96.2	149.8	221.2		2 033.8
1955	28.0	50.4	53.2	74.2	95.6		1 494.2
1956	31.0	42.6	42.6	54.0	66.2		1 322.2
1957	40.2	81.0	90.0	90.2	98.4		1 641.6
1958	33.2	60.0	70.8	72.6	116.4		1 751.8
1959	71.0	93.0	106.4	199.0	214.8		2 000.2
1960	47.0	76.0	127.0	151.0	158.4		2 712.6
1961	36.0	50.6	87.0	129.0	156.0		1 776.4
1962	14.8	37.0	54.4	77.8	98.2		1 421.5
1963	36.4	51.0	67.6	84.6	154.6		2 162.4
1964	54.0	81.2	104.0	177.0	222.0		1 928.0
1965	60.0	88.6	95.0	99.0	137.8		2 109.4
1966	62.4	87.6	90.6	158.4	195.4		2 099.2
1967	37.6	56.6	81.0	106.6	136.2		1 766.4
1968	41.0	86.0	104.8	112.6	126.0		2 194.0
1969	22.0	35.0	47.0	81.0	119.0		1 366.4
1970	50.0	104.0	132.0	187.0	212.2		1 905.6
1971	37.2	43.0	67.6	98.4	107.8		1 547.2
1972	34.0	59.2	70.0	124.0	175.0		1 972.4
1973							1 168.5
1974	50.6	56.0	67.2	74.0	80.8		1 363.7
1975							1 522.0
1976	33.9	54.5	60.0	85.3	97.6		1 426.2
1977	27.8	50.0	80.0	89.6	146.0		
1978	19.4	35.6	52.8	66.2	81.0		
1979	31.0	40.0	60.8	86.4	110.0		1 558.6

1980	28.6	50.4	73.2	92.6	144.6		
1981	16.8	36.8	43.8	72.4	82.2		
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							1 408.2
1991							1 252.8
1992							1 365.6

Mean value
1 719.3

TERMOMETRICAL DATA OF ARLIA (C°)																
	Gen	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dic**		**Mean**	**Max**	**Min**
1951	6.1	6.9	7.0	11.4	14.3	19.4	21.3	21.0	19.4	12.4	10.0	5.5		12.9	31.5	-10.0
1952	3.4	4.7	7.7	13.2	16.4	21.4	24.9	21.4	16.0	12.9	7.0	5.2		12.9	36.8	-4.0
1953	3.0	3.5	7.9	12.5	17.2	17.6	22.4	21.7	18.6	14.7	8.7	7.4		13.0	33.5	-5.0
1954	1.7	2.8	8.6	11.0	15.0	19.4	19.9	19.3	17.7	12.0	8.6	7.1		12.0	32.3	-8.2
1955	6.4	6.1	6.3	12.3	16.3	19.4	22.1	20.6	17.4	13.0	7.4	7.5		12.9	34.0	-2.5
1956	6.4	-1.7	6.3	9.3	16.4	17.1	21.6	21.3	17.9	11.7	6.8	4.6		11.5	35.0	-9.0
1957	4.0	6.6	8.8	11.9	14.2	19.7	21.7	22.8	17.3	14.2	9.4	5.5		13.0	35.5	-2.5
1958	4.7	6.5	5.2	9.3	16.8	18.6	21.3	21.7	18.1	12.8	9.4	6.3		12.6	34.7	-4.0
1959	4.1	6.4	9.7	10.9	15.1	20.1	22.9	21.1	16.8	11.9	7.7	6.4		12.8	32.6	-4.0
1960	4.3	5.4	8.3	11.4	15.9	20.4	19.9	19.5	15.4	11.8	9.6	5.7		12.3	32.0	-6.0
1961	4.0	6.8	8.5	13.5	14.9	18.8	21.2	21.5	20.4	14.5	9.2	5.7		13.3	33.6	-5.0
1962	6.3	5.1	5.0	11.8	13.9	18.4	20.9	22.3	18.4	14.4	7.8	3.5		12.4	33.3	-6.2
1963	1.6	2.2	6.7	11.9	15.5	17.4	21.8	19.8	17.7	13.3	11.3	3.6		12.0	32.8	-7.8
1964	4.4	6.1	7.3	11.1	15.8	19.9	21.1	20.4	18.0	12.1	9.0	5.4		12.6	32.8	-6.0
1965	4.4	3.1	7.9	9.9	13.8	17.5	19.8	19.5	15.9	14.0	9.1	6.2		11.8	34.5	-5.6
1966	2.4	8.8	8.2	11.5	15.7	19.3	19.3	19.2	18.0	14.8	6.5	4.6		12.4	35.0	-5.4
1967	4.0	5.3	9.1	10.5	14.4	17.2	22.3	21.1	16.9	14.5	9.7	4.6		12.5	33.6	-6.9
1968	3.2	6.4	8.4	12.2	15.3	17.7	20.2	18.3	16.3	13.5	8.9	3.9		12.0	33.6	-9.5
1969	3.3	3.2	6.8	10.3	15.0	16.4	20.1	20.0	17.3	13.9	9.3	3.2		11.6	33.1	-7.0
1970	5.9	5.1	5.4	9.7	13.0	18.8	20.6	20.5	18.7	12.7	9.2	4.0		11.9	34.0	-7.5
1971	4.5	5.8	2.8	12.2	15.3	16.5	21.4	22.4	17.2	12.2	7.3	5.3		11.9	33.8	-9.2
1972	4.2	6.7	9.1	10.1	13.3	16.6	20.3	18.8	13.8	11.8	8.7	5.4		11.6	33.6	-2.6
1973	4.6	5.4	7.1	8.8	15.4	18.8	20.2	21.6	18.5	12.7	8.0	4.3		12.1	32.7	-5.0
1974	5.7	7.1	8.4	10.3	13.7	17.8	19.8	21.7	16.7	8.1	7.4	5.3		11.9	36.0	-3.1
1975	6.3	5.8	7.0	11.0	14.2	16.4	20.6	20.2	18.2	11.8	7.3	5.0		12.0	31.7	-4.5
1976	4.1	6.4	6.3	10.1	14.9	18.7	20.8	17.5	14.3	12.6	7.6	4.8		11.5	31.4	-7.6
1977	5.5	6.8	8.8	9.1	13.4		19.1	17.8	15.0	13.8	7.7	4.9		11.0	29.8	-3.4
1978	4.4	5.4	8.6	9.1	13.0	16.7	19.0	21.9	17.3	13.0	7.7	5.8		11.8	31.5	-4.8
1979	3.1	5.8	8.0	9.1	14.8	19.5	20.6	19.9	17.0	13.3	7.3	5.7		12.0	33.0	-9.5
1980	4.0	6.6	7.2	8.7	13.0	15.9	18.0	20.1	18.0	12.9	7.3	3.8		11.3	33.0	-7.0
1981	2.8	4.7	8.6	12.7	13.7	18.2	19.4	20.0	16.8	13.4	7.6	4.3		11.9	35.0	-7.0
1982	6.2	5.8	7.1	11.6			21.2	18.5	18.3	12.5	9.9				36.0	-5.5
1983	5.0	3.3	8.7		14.4	17.1	24.1	20.5	19.5	14.3	8.0	4.7			38.5	-4.5
1984	4.2	3.8	6.6	10.3	11.1	16.6	20.4	19.4	15.7	13.6	9.6	5.9		11.4	33.0	-6.5
Mean	**4.4**	**5.3**	**7.5**	**10.9**	**14.7**	**18.2**	**20.9**	**20.4**	**17.3**	**13.0**	**8.4**	**5.2**		**12.2**	**33.6**	**-6.0**

TERMOMETRICAL DATA OF BAGNONE (C°)

	Gen	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dic		Mean	Max	Min
1951	5.9	6.5	7.2	11.3	14.5	20.1	22.4	22.4	20.7	11.8	9.8	4.5		13.1	32.2	-1.1
1952																
1953	2.4	3.5	7.5	12.4	16.7	17.7	23.2	21.9	18.7	14.2	7.5	7.2		12.9	33.0	-5.3
1954	0.9	3.3	8.7	11.1	15.4	20.3	19.4	19.9	19.3	13.5	9.0	7.0		12.4	33.0	-5.3
1955	6.2	5.0	6.1	11.7	15.9	19.8	24.0	21.9	18.3	13.4	8.2	7.4		13.2	36.2	-6.0
1956	5.7	0.5	8.0	10.1	16.0	17.8	23.0	23.0	20.2	13.6	7.7	6.4		12.7	39.2	-10.1
1957	5.1	8.7	10.0	12.2	15.0	21.5	22.2	22.4	18.6	16.4	10.8	6.6		14.2	39.5	-5.1
1958	6.0	8.2	6.8	10.0	18.5	19.4	23.0	23.8	20.2	14.7	10.9	7.8		14.1	**40.8**	-7.0
1959	5.8	8.5	10.4	11.8	16.0	21.3	24.6	24.0	18.4	13.9	8.7	6.6		14.1	38.8	-6.0
1960	4.6	7.5	9.4	11.4	15.0	18.8	20.0	19.7	16.1	12.9	8.7	5.3		12.5	34.0	-5.9
1961	3.4	8.4	9.3	12.8	13.2	19.1	20.4	21.8	18.7	13.8	7.9	5.1		12.8	36.8	-7.0
1962	5.8	4.8	4.6	11.4	13.8	18.4	20.5	22.4	17.6	13.4	6.4	1.6		11.8	34.0	-9.0
1963	1.2	3.2	7.4	11.3	15.5	17.6	22.1	21.0	18.1	14.9	11.0	4.5		12.4	34.5	**-10.5**
1964	4.9	7.2	8.6	12.7	17.3	20.1	21.1	19.1	18.8	13.4	9.7	5.1		13.2	35.0	-6.5
1965	4.7	3.0	8.3	11.0	14.7	17.9	20.0	21.8	16.5	13.8	8.8	6.4		12.3	36.0	-6.0
1966	2.6	9.4	8.7	12.7	16.7	20.8	18.9	20.4	18.5	16.2	6.9	4.2		13.0	35.8	-7.0
1967	4.3	5.4	9.2	10.7	13.7	17.5	24.5	23.1	16.8	15.6	10.0				36.8	-8.5
1968		8.3	8.1	12.8	15.5	18.6	20.9	17.8				5.0				
1969	6.4	4.5	9.0	12.2	17.5	17.4	23.2	22.3	19.6	15.8	11.7	5.0		13.7	37.0	-6.5
1970	7.1	7.1	8.2	12.0	15.0	20.6	21.6	22.4	21.0	14.9	11.1	5.7		13.9	36.5	-7.0
1971	6.0	8.3	6.7	14.1	16.9	18.2	22.1	24.2	17.5	14.6	8.6	7.6		13.7	37.2	-7.0
1972	5.8	8.1	10.5	12.7	15.2	19.2	22.4	21.8	16.2	14.3	10.8	7.3		13.7	38.0	-3.5
1973	6.8	7.2	9.4	10.8	16.8	20.9	22.4	23.9	20.1	15.5	9.4	6.2		14.1	37.2	-6.5
1974	7.2	8.9	10.3	12.6	15.6	19.2	21.9	24.0	19.2	10.3	9.2	5.7		13.8	38.1	-5.0
1975	7.5	7.3	8.8	12.7	16.1	18.2	23.9	22.4	20.6	14.5	9.2	7.2		14.1	35.5	-5.5
1976	5.6	7.4	8.9	12.1	16.6	20.8	23.0	20.2	16.5	14.6	10.1	6.8		13.5	36.0	-8.5
1977	6.9	9.0	11.1	11.8	15.1	18.3	21.7	20.1	17.8	15.7	10.8	6.6		13.7	33.0	-4.0
1978	6.3	6.6	10.4	9.5	14.5	19.0	21.1	21.9	18.9	15.4	9.1	7.3		13.3	34.5	-6.5
1979	4.4	7.4	9.4	11.1	15.9	20.9	22.0	21.8	18.4	14.3	8.9	7.6		13.5	36.5	-9.5
1980	5.7	8.7	8.8	10.7	14.3	17.5	19.6	22.7	18.8	14.3	8.8	5.6		13.0	35.0	-8.0
1981	4.2	5.4	11.0	13.4	14.6	20.0	20.7	22.1	19.3	15.3	9.5	6.5		13.5	35.5	-8.0
1982	7.6	6.5	8.5	12.1	15.9	20.5	24.7	21.9	20.9	14.0	11.2	7.4		14.3	37.0	-4.5
Mean	**5.2**	**6.6**	**8.7**	**11.8**	**15.6**	**19.3**	**22.0**	**21.9**	**18.7**	**14.3**	**9.3**	**6.1**		**13.3**	**36.2**	**-6.7**

PEBBLES AXIAL DIMENSION

Station 1				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	18.20	17.50	10.70	0.827
2	14.30	10.00	6.80	0.693
3	16.40	12.40	3.80	0.560
4	17.60	12.00	8.20	0.682
5	11.60	8.40	4.30	0.645
6	12.10	9.20	4.30	0.646
7	19.80	14.80	7.50	0.657
8	14.90	11.40	4.40	0.609
9	11.90	9.70	6.80	0.775
10	12.50	9.20	4.30	0.633
11	10.40	6.40	5.50	0.688
12	11.00	10.60	5.90	0.803
13	11.00	10.30	2.20	0.572
14	14.60	7.00	4.60	0.533
15	11.80	9.10	5.60	0.715
16	14.60	5.80	4.20	0.485
17	9.80	8.10	4.40	0.719
18	10.00	7.20	6.60	0.780
19	12.10	8.80	7.60	0.770
20	16.00	13.00	6.60	0.695
Mean	13.06	9.57	5.58	0.675

Station 2				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	16.80	12.90	9.00	0.744
2	13.30	12.90	5.40	0.733
3	17.90	11.60	9.60	0.703
4	21.30	13.50	7.60	0.609
5	25.00	22.50	9.40	0.697
6	17.40	9.60	5.00	0.541
7	14.20	13.00	6.50	0.748
8	15.00	9.50	3.30	0.518
9	20.60	14.00	11.50	0.724
10	12.50	7.40	5.70	0.646
11	12.90	10.40	2.90	0.566
12	13.00	12.30	4.60	0.694
13	15.00	7.60	2.50	0.439
14	18.20	10.70	10.50	0.697
15	15.50	9.40	4.00	0.539
16	11.20	7.70	6.70	0.744
17	15.00	6.10	1.80	0.365
18	12.10	12.10	3.90	0.686
19	18.70	18.70	5.60	0.669
20	14.00	14.00	3.40	0.624
Mean	15.51	11.50	5.49	0.624

STATION 3				
	1^{st} axis (cm)	2^{nd} axis (cm)	3^{rd} axis (cm)	Krumbein roundeness index
1	20.20	11.40	7.60	0.597
2	17.60	15.00	11.70	0.827
3	19.20	18.00	11.30	0.820
4	27.40	17.90	12.20	0.663
5	23.00	14.80	5.40	0.533
6	21.20	18.50	7.30	0.670
7	19.00	15.40	6.30	0.645
8	23.00	12.20	7.10	0.547
9	22.40	17.50	8.20	0.659
10	18.20	12.00	7.60	0.651
11	23.50	20.60	10.20	0.725
12	25.40	9.50	6.20	0.450
13	15.50	10.90	3.40	0.536
14	16.80	16.20	10.60	0.847
15	16.80	7.90	7.30	0.589
16	13.70	8.50	2.40	0.477
17	14.70	7.30	5.30	0.564
18	18.40	9.00	2.70	0.416
19	14.60	12.00	4.00	0.608
20	13.30	6.70	6.30	0.620
Mean	18.55	12.33	6.72	0.609

STATION 4				
	1^{st} axis (cm)	2^{nd} axis (cm)	3^{rd} axis (cm)	Krumbein roundeness index
1	25.00	16.00	3.00	0.425
2	16.20	10.50	6.00	0.621
3	23.50	15.20	6.00	0.549
4	22.10	15.00	7.30	0.607
5	23.50	15.10	4.00	0.478
6	20.50	16.00	4.60	0.559
7	20.70	15.70	3.40	0.499
8	34.50	22.00	5.30	0.461
9	31.80	24.60	3.60	0.444
10	29.10	14.10	7.10	0.491
11	24.50	11.50	8.10	0.537
12	18.80	15.70	3.00	0.511
13	24.20	12.70	7.10	0.536
14	27.80	21.00	7.20	0.581
15	17.60	15.00	6.80	0.691
16	18.80	12.50	9.30	0.690
17	17.30	13.20	4.20	0.570
18	18.50	7.70	4.00	0.448
19	17.80	10.00	6.40	0.587
20	14.10	11.00	7.10	0.732
Mean	21.52	14.16	5.89	0.551

STATION 5				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	25.40	16.40	11.00	0.654
2	23.10	16.80	8.40	0.642
3	22.40	15.00	5.60	0.551
4	23.50	13.80	5.80	0.525
5	21.20	11.00	5.40	0.509
6	19.70	11.20	5.00	0.525
7	33.40	17.80	8.50	0.514
8	27.70	18.40	8.40	0.586
9	23.50	16.70	10.40	0.680
10	40.30	30.50	18.50	0.703
11	49.00	38.00	15.70	0.629
12	56.00	35.00	13.00	0.525
13	48.00	19.00	16.00	0.509
14	52.50	42.00	16.00	0.625
15	37.00	28.00	12.00	0.626
16	41.50	31.50	21.50	0.733
17	28.50	28.00	15.50	0.811
18	33.00	30.50	7.30	0.589
19	38.50	35.00	21.50	0.798
20	43.50	19.50	13.40	0.517
Mean	37.17	26.02	13.03	0.620

STATION 6				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	19.80	12.50	11.00	0.705
2	22.20	14.00	9.30	0.642
3	16.50	12.00	4.40	0.579
4	22.50	16.40	7.80	0.632
5	23.20	16.50	11.80	0.713
6	16.50	16.00	7.00	0.744
7	22.30	15.70	3.50	0.480
8	15.60	14.90	5.00	0.674
9	17.10	11.40	4.30	0.551
10	21.00	12.30	6.30	0.560
11	17.60	13.00	8.40	0.706
12	18.60	13.90	10.00	0.738
13	16.80	12.00	10.80	0.771
14	15.60	14.00	5.40	0.677
15	20.40	12.70	3.00	0.451
16	16.50	8.50	5.30	0.549
17	20.50	19.40	10.00	0.773
18	14.90	11.20	6.30	0.682
19	15.80	11.10	7.50	0.693
20	12.00	10.00	8.50	0.839
Mean	17.80	13.11	7.36	0.668

STATION 7				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	30.50	30.00	22.00	0.892
2	19.80	16.40	6.50	0.648
3	23.90	14.30	4.50	0.483
4	22.70	17.40	8.50	0.660
5	21.20	13.40	6.30	0.573
6	26.00	20.50	16.00	0.786
7	35.00	16.10	11.30	0.530
8	26.00	20.80	11.20	0.701
9	22.80	17.60	14.00	0.780
10	28.00	20.50	13.50	0.707
11	33.00	14.00	9.80	0.501
12	25.50	16.00	12.50	0.675
13	24.00	13.50	7.80	0.568
14	19.50	14.50	13.00	0.791
15	33.00	29.00	19.00	0.797
16	37.50	16.50	14.00	0.548
17	58.00	35.00	19.00	0.583
18	33.00	17.00	14.50	0.609
19	27.00	17.00	10.00	0.616
20	34.00	19.00	13.00	0.598
Mean	30.16	19.00	12.63	0.644

STATION 8				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	49.50	35.00	28.00	0.737
2	58.00	36.00	24.00	0.636
3	51.00	45.00	32.00	0.821
4	44.50	32.00	26.00	0.749
5	42.50	41.00	29.50	0.875
6	41.00	39.00	23.00	0.811
7	63.50	41.00	31.00	0.681
8	50.00	45.00	31.00	0.823
9	47.00	31.00	16.00	0.608
10	51.50	35.00	21.00	0.652
11	55.00	37.00	33.00	0.739
12	48.00	41.00	21.50	0.726
13	51.00	27.00	23.50	0.625
14	49.00	34.00	23.50	0.693
15	99.00	83.00	55.00	0.775
16	62.00	45.00	29.00	0.698
17	118.00	73.00	53.00	0.653
18	65.00	49.50	36.00	0.750
19	71.00	50.00	49.00	0.786
20	92.00	75.00	70.00	0.853
Mean	63.95	46.97	34.95	0.733

STATION 9				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	33.30	28.50	9.50	0.625
2	20.70	19.00	3.50	0.537
3	26.00	9.50	6.30	0.446
4	21.50	12.00	10.30	0.644
5	19.10	16.00	6.80	0.668
6	21.00	18.80	13.50	0.832
7	20.30	16.10	12.50	0.787
8	22.00	8.50	6.50	0.485
9	30.00	27.00	9.50	0.658
10	31.20	15.00	9.30	0.523
11	40.50	23.00	7.50	0.472
12	21.30	18.70	12.50	0.802
13	40.30	31.50	10.80	0.594
14	42.50	27.80	14.50	0.607
15	31.80	23.50	10.30	0.621
16	30.30	21.40	13.20	0.675
17	38.00	26.50	24.00	0.761
18	16.00	13.00	10.50	0.811
19	18.00	15.50	13.00	0.854
20	25.00	20.50	10.50	0.701
media	28.42	20.44	11.38	0.667

STATION 10				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	39.00	35.00	15.00	0.701
2	26.50	20.00	10.50	0.669
3	22.30	20.00	15.60	0.856
4	27.00	25.00	12.50	0.754
5	35.10	31.50	12.00	0.674
6	39.00	38.00	19.50	0.787
7	34.00	26.40	9.50	0.601
8	26.00	23.00	10.00	0.698
9	26.50	23.50	11.40	0.725
10	27.80	21.50	6.50	0.565
11	29.20	18.50	10.60	0.613
12	34.60	22.80	9.80	0.571
13	22.30	20.60	11.80	0.788
14	33.80	27.20	15.60	0.719
15	32.20	14.10	12.20	0.549
16	25.00	17.30	12.70	0.706
17	32.50	20.20	12.80	0.626
18	24.40	18.80	11.10	0.705
19	47.50	46.00	32.00	0.867
20	43.00	22.00	17.00	0.587
Mean	31.74	23.96	13.79	0.683

STATION 11				
	1st axis (cm)	2nd axis (cm)	3rd axis (cm)	Krumbein roundeness index
1	33.00	20.00	11.00	0.587
2	40.50	16.80	7.10	0.417
3	32.00	26.50	11.00	0.658
4	24.00	20.50	13.60	0.785
5	38.00	27.40	13.60	0.637
6	24.00	17.80	16.50	0.799
7	26.50	22.30	9.90	0.680
8	25.10	23.20	9.80	0.712
9	25.00	14.40	6.20	0.523
10	26.20	14.80	11.80	0.634
11	18.40	16.40	5.20	0.632
12	37.40	18.20	14.80	0.577
13	29.80	27.40	9.50	0.664
14	37.40	11.20	5.80	0.359
15	24.60	12.40	9.30	0.575
16	38.00	35.50	15.50	0.725
17	43.20	27.50	13.50	0.584
18	24.50	19.60	11.80	0.728
19	54.00	31.50	10.30	0.481
20	28.50	22.50	12.10	0.695
Mean	32.20	21.60	10.87	0.616

Name:	Aspect
Description:	Slope direction
Type:	Raster map
Classification:	
Legend:	North. Northeast, East, Southeast, South. Southwest, West, Northwest
Actual scale/resolution:	5 meter
Production:	
Source:	Digital Terrain Model
Source scale/resolution:	5 meter
Date:	
Format:	ArcInfo Grid (16 bit matrix)
Coordinate system:	UTM
Associated data:	-

Name:	Demography
Description:	Population numbers and distribution located on urban centroids
Type:	Point vectorial map
Classification:	
Legend:	name and inhabitants number: tens, hundreds
Actual scale/resolution:	1:25 000
Production:	
Source:	demographic data
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	

1. General Features Map

Description:	Civiglia basin map with background, general information concerning the main villages, the road network and municipalities boundaries
Actual scale/resolution:	1:25 000
Coordinate system:	UTM

Data Set:	Demography
Description:	Population numbers and distribution located on urban centroids
Type:	Point vectorial data set
Classification:	Context
Legend:	Inhabitants number
Production:	Representation of administrative boundaries for each municipalities
Source:	Municipal documents
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Associated data:	Demographic tables

Data Set:	Municipalities Boundaries
Description:	Municipalities boundaries
Type:	Line vectorial data set
Classification:	Structural
Legend:	Municipalities
Production:	Representation of administrative boundaries for each municipalities
Source:	Municipal documents
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Associated data:	-

Data Set:	Road Network
Description:	This map contains general indications concerning the road network
Type:	Line vectorial data set
Classification:	Structural
Legend:	
Production:	Main road network has been identified on the basis of the existing cartography
Source:	Existing cartogaphy
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Associated data:	-

Pluviometrical Map

Description:	Analysis of climatic and meteoric data and rainfall statistical analysis in order to define the potential meteoric events in relation to different return times
Actual scale/resolution:	1:25 000
Coordinate system:	UTM
Data Set:	Pluviometrical Stations
Description:	Pluviometrical recording stations location
Type:	Point vectorial data set
Classification:	Support or Inventory
Legend:	Mean pluriennal rainfall
Production:	-
Source:	Data recorded by the State Office in charge for the collection of meteorological data
Source scale/resolution:	1:25 000
Date:	Most recent data: 1993
Format:	PC ArcInfo Coverages
Associated data:	Measured values tables
Data Set:	Rainfall
Description:	Mean annual isohyets
Type:	Line vectorial data set
Classification:	Derived
Legend:	Mean annual
Production:	Pluviometrical stations location isohyets
Source:	Pluviometrical stations
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Associated data:	

Hydrographic Network Map

Description:	This map contains the representation of the main streams and the delimitation of six sub-basins
Actual scale/resolution:	1:25 000
Coordinate system:	UTM

Data set:	Hydrographic Network
Description:	Analysis of the main morphometric aspects
Type:	Point vectorial data set
Classification:	Inventory or Support
Legend:	The legend shows the typologies of the existing hydraulic works grouping together the longitudinal protective structures (check dam, sill, bank protection structures, cliff); furthermore, with different color has been represented their maintenance conditions (efficient structures, structures with damages, structures with heavy damages)
Production:	The predisposition of ths data set has been carried out with the collection of an existing census of hydraulic works made in 1991, updated with field survey in 1998
Source:	Existing census of hydraulic works made in 1991, updated with field survey in 1998
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Associated data:	Description documents and photographs

Name:	Hydrographic Network
Description:	Hydrographic network
Type:	Line vectorial map
Classification:	
Legend:	Primary and secondary network
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	None

Data set	Basins Boundaries
Description:	Sub-basins boundaries
Type:	Polygon vectorial map
Classification:	Structural
Legend:	Six main sub-basins
Actual scale/resolution:	1:25 000

Production:	On the basis of the length and surface of their cathcment; these sub-basins cover the entire upper portion of the Civiglia basin

Source:	Hydrographic Network, Contours, Elevation Points
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	UTM
Associated data:	-

Hydraulic Works Map	
Description:	This map contains the location and description of the existing longitudinal and transversal hydraulic structures
Actual scale/resolution:	1:25 000
Coordinate system:	UTM
Data set:	Hydraulic Works
Description:	location of the hydraulic structures
Type:	Point vectorial data set
Classification:	Inventory or Support
Legend:	The legend shows the typologies of the existing hydraulic works grouping together the longitudinal protective structures (check dam. sill. bank protection structures. cliff); furthermore, with different color has been represented their maintenance conditions (efficient structures, structures with damages, structures with heavy damages)
Production:	The predisposition of ths data set has been carried out with the collection of an existing census of hydraulic works made in 1991, updated with field survey in 1998
Source:	Existing census of hydraulic works made in 1991, updated with field survey in 1998
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Associated data:	Description documents and photographs

Name:	Contours
Description:	Elevation contours
Type:	Line vectorial map
Classification:	Derived information
Legend:	Elevation: meter, with equidistance of 25 and 50 meters
Actual scale/resolution:	1:25 000
Production:	Directly derived from Digital Terrain Model
Source:	Digital Terrain Model
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	None

Name:	Control Stations location
Description:	Predisposition of a measuring system of the flood discharges in the torrents and of the rainfalls for the calibration of the model with strategic control stations distributed throught the basin
Type:	Point vectorial map
Classification:	Inventory information
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Measured values tables

Name:	Deforestation Evolution
Description:	Simplified land cover map tracing the regression of the forest cover
Type:	Polygon vectorial map
Classification:	Support
Legend:	Forest cover density
Actual scale/resolution:	1:25 000
Production:	
Source:	Orthophotomaps
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	None

Name:	Digital Terrain Model
Description:	Digital model of landform data represented as point elevation values, also called digital elevation model
Type:	Raster map
Classification:	Derived or Support
Legend:	Elevation: meter
Actual scale/resolution:	5 meter
Production:	
Source:	Digital data existing in Regional Administration of Tuscany
Source scale/resolution:	1:5 000
Date:	
Format:	
Coordinate system:	
Associated data:	None

Name:	Ecological Aspects
Description:	Description of the principal ecological aspects of the basin and of the hydrographic network, and identification of the most important ecological aspects to protect
Type:	Polygon vectorial map
Classification:	Inventory
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Descriptive documents and photographs, Technical report

Name:	Elevation Points
Description:	Elevation Points
Type:	Point vectorial map
Classification:	Support
Legend:	Elevation: meter
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	None

Name:	Erosion and Sedimentation Torrent Reaches
Description:	Identification of the torrent reaches with erosion-sedimentation phenomena
Type:	Line vectorial map
Classification:	Support information
Legend:	Stream reaches subjected to bank erosional phenomena, stream reaches subjected to bed erosional phenomena, stream reaches subjected to sedimentation phenomena
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Flood Events
Description:	Delimitation of the areas involved by past flood or alluvial events
Type:	Polygon vectorial map
Classification:	
Legend:	Date
Actual scale/resolution:	
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	

Name:	Geology
Description:	
Type:	Polygon vectorial map
Classification:	Support
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	New information collected during the development of the study
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Global Risk
Description:	Analysis of the different risk conditions existing in the hydrographic basin
Type:	Polygon vectorial map
Classification:	Derived
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Granulometric Analysis Stations location
Description:	Samples to the realization of quick granulometric analysis along the torrent courses
Type:	Point vectorial map
Classification:	
Legend:	Date
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Measured values tables, Technical Report

Name:	Headwaters
Description:	
Type:	Polygon vectorial map
Classification:	Derived
Legend:	
Actual scale/resolution:	1:25 000
Production:	Strahler first order reaches
Source:	Hydrographic network, Contours, Elevation points
Source scale/resolution:	1:25 000
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	None

Name:	Hydraulic Defence Structures
Description:	location and description of the existing hydraulic defence structures
Type:	Point vectorial map
Classification:	Inventory
Legend:	Type of structure: chek dam, sill, bank protection structure, cliff Maintenance conditions: efficient structures, efficient structures with visible damages, destroyed structures
Actual scale/resolution:	1:25 000
Production:	Field data collection
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Hydrogeology
Description:	
Type:	Polygon vectorial map
Classification:	Derived
Legend:	Permeability: impermeable, lowly permeable, medium permeable, Permeable, highly permeable Springs
Actual scale/resolution:	1:25 000
Production:	
Source:	New information collected during the development of the study
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Insolation
Description:	
Type:	Raster map
Classification:	
Legend:	11.00 a.m. June 21th 1999
Actual scale/resolution:	5 meter
Production:	
Source:	Digital terrain model
Source scale/resolution:	5 meter
Date:	
Format:	
Coordinate system:	
Associated data:	None

Name:	Land Use
Description:	Land use map - isto mais parece land cover
Type:	Polygon vectorial map
Classification:	Support
Legend:	Continuous urbanized area, discontinuous urbanized area, industrial, industrial or commercial area, extractive area, simple sowable land, arborized sowable land, cultivation sowable land and market gardens, abandoned sowable land, vineyard, olive grove., naked pasture, arborized or bushy pasture, permanent meadow, broad-leaved coppice (thick, thin, degraded or open), broad-leaved and conifer wood (thick, thin, degraded or open), conifer-predominant wood (thick, thin, degraded or open), fruit chesnut grove, abandoned fruit chesnut grove, bushes and shrubs (thick, thin), stream
Actual scale/resolution:	1:25 000
Production:	
Source:	New information collected during the development of the study
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Land Use Evolution
Description:	
Type:	Polygon vectorial map
Classification:	
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	

Name:	Laws and Prescriptions
Description:	Identification of the subjected areas to the state and regional laws in force
Type:	Polygon vectorial map
Classification:	Inventory
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	State and regional laws
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Laws regulations documents, Technical report

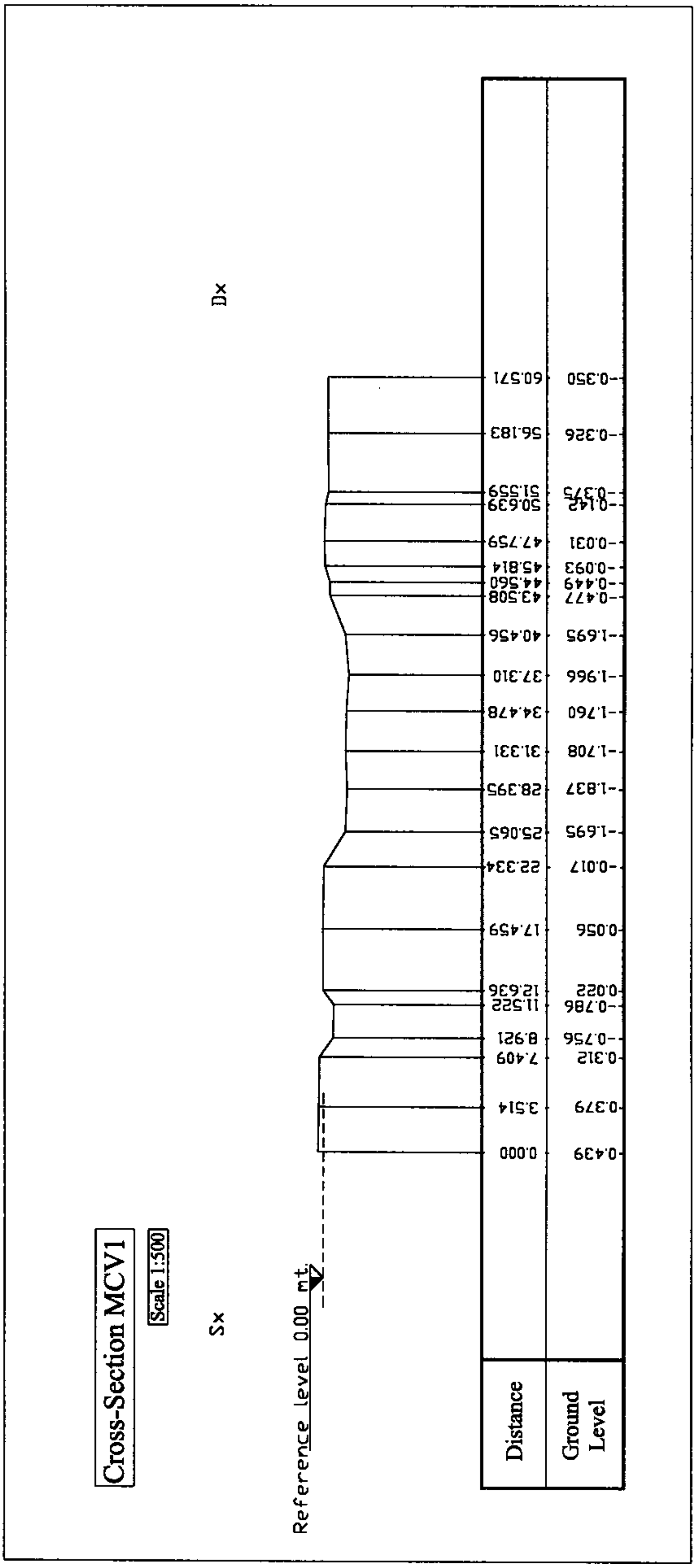
Name:	Management of the Flood Plane and Valley Bottoms
Description:	
Type:	Polygon vectorial map
Classification:	
Legend:	
Actual scale/resolution:	
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Reports

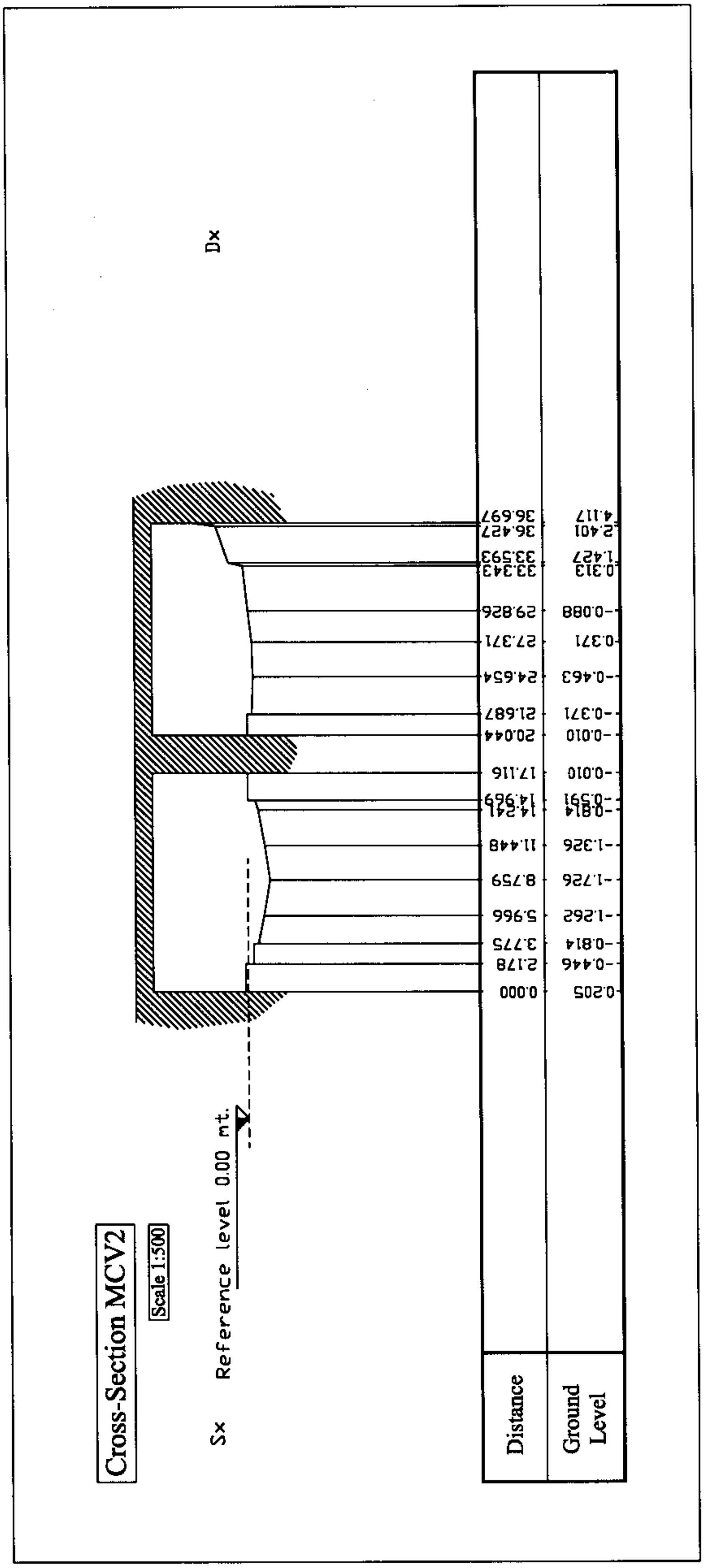
Name:	Slope
Description:	
Type:	Raster map
Classification:	
Legend:	Slope: percentagem
Actual scale/resolution:	5 meter
Production:	
Source:	Digital terrain model
Source scale/resolution:	5 meter
Date:	
Format:	
Coordinate system:	
Associated data:	None

Name:	Soils
Description:	Identification of the soils characteristics in relation to the geological, geomorphological and land use aspects
Type:	Polygon vectorial map
Classification:	Support
Legend:	
Actual scale/resolution:	1:25 000
Production:	
Source:	
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	Technical report

Name:	Urban Land Use
Description:	Simplified land use map representing the zoning, economical types and evolution of land urban use; this data is probably splited in various dates
Type:	Vectorial (polygon) map
Classification:	
Legend:	Use density: high density (impervious zone > 60%), average density (impervious zone 30-60%), low density (impervious zone 10-30%); economical activities, date
Actual scale/resolution:	1:25 000
Units:	
Production:	
Source:	Land Use Map
Source scale/resolution:	
Date:	
Format:	PC ArcInfo Coverages
Coordinate system:	
Associated data:	

HYDRAULIC CROSS SECTION AT TERRAROSSA (SCALE 1:500)

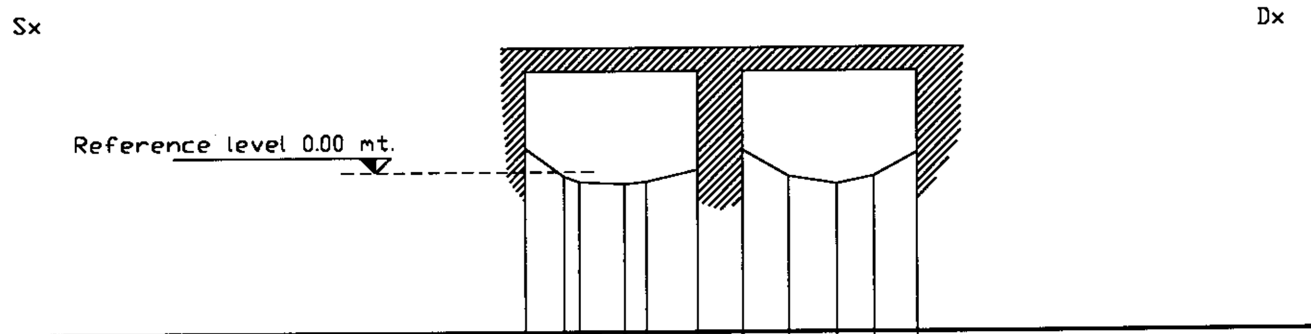




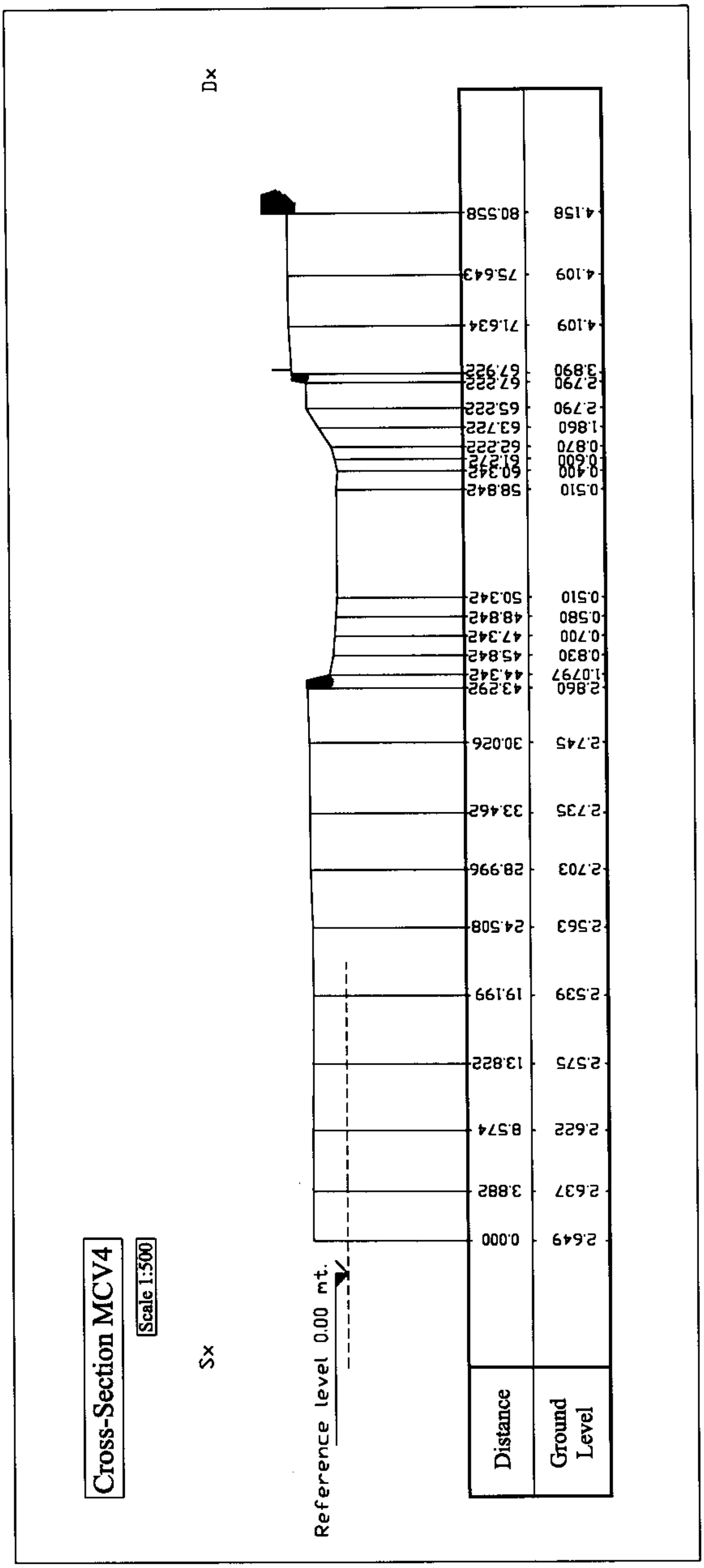
Cross-Section MCV2
Scale 1:500
Sx
Dx
Reference level 0.00 mt.
Distance
Ground Level
0.000
2.178
3.775
5.966
8.759
11.448
14.241
14.969
17.116
20.044
21.687
24.654
27.371
29.826
33.343
33.593
36.427
36.697
0.205
-0.446
-0.814
-1.262
-1.726
-1.326
-0.814
-0.591
-0.010
-0.010
-0.371
-0.463
-0.371
-0.088
0.313
1.427
2.401
4.117

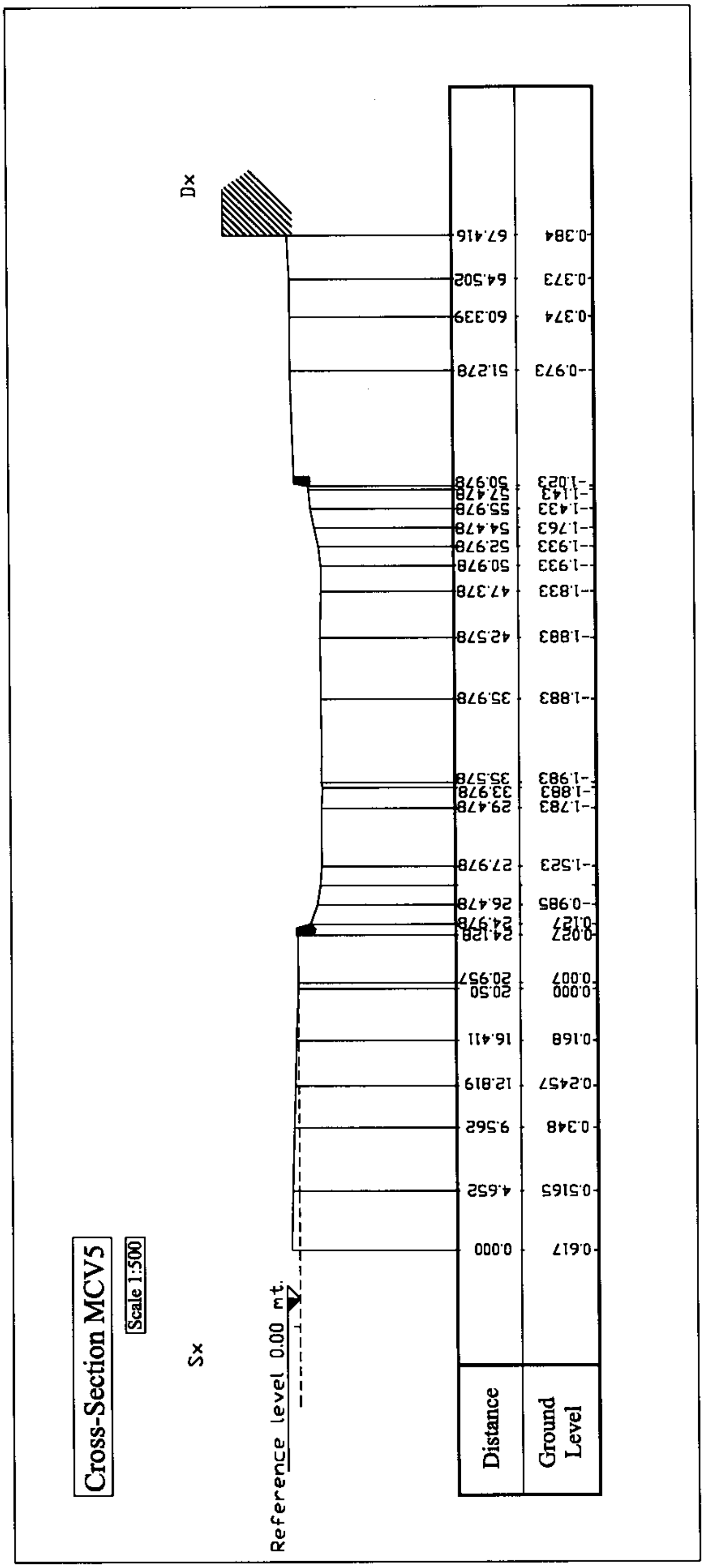
Cross-Section MCV3

Scale 1:500



Distance	0.000	2.588	3.589	6.618	8.079	11.473	14.437	17.460	20.591	23.037	25.908
Ground Level	1.553	-0.317	-0.659	-0.809	-0.659	0.115	1.436	-0.338	-0.842	-0.338	1.225

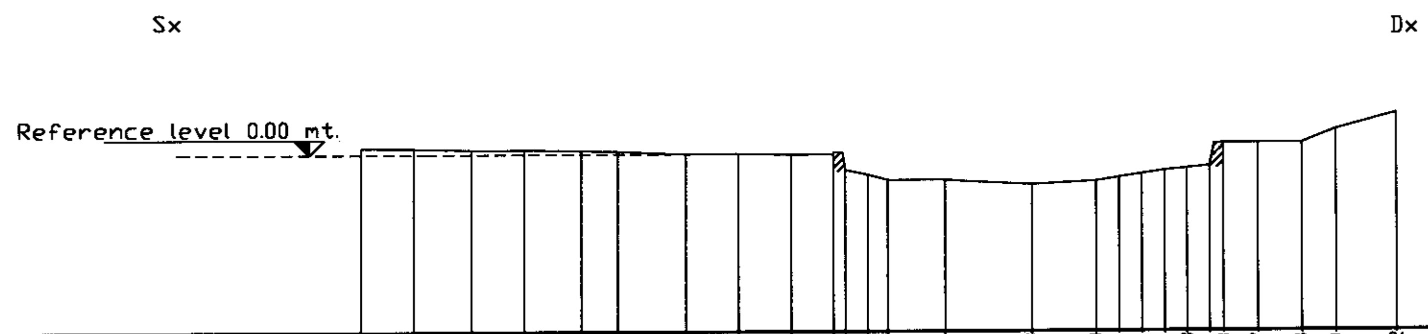

Cross-Section MCV4
Scale 1:500
Sx
Dx
Reference level 0.00 mt.
Distance
Ground Level
0.000
3.882
8.574
13.822
19.199
24.508
28.996
33.462
30.026
43.292
44.342
45.842
47.342
48.842
50.342
58.842
60.342
62.222
63.722
65.222
67.222
67.922
71.634
75.643
80.558
2.649
2.637
2.622
2.575
2.539
2.563
2.703
2.735
2.745
2.860
1.0797
0.830
0.700
0.580
0.510
0.510
0.400
0.600
0.870
1.860
2.790
2.790
3.890
4.109
4.109
4.158



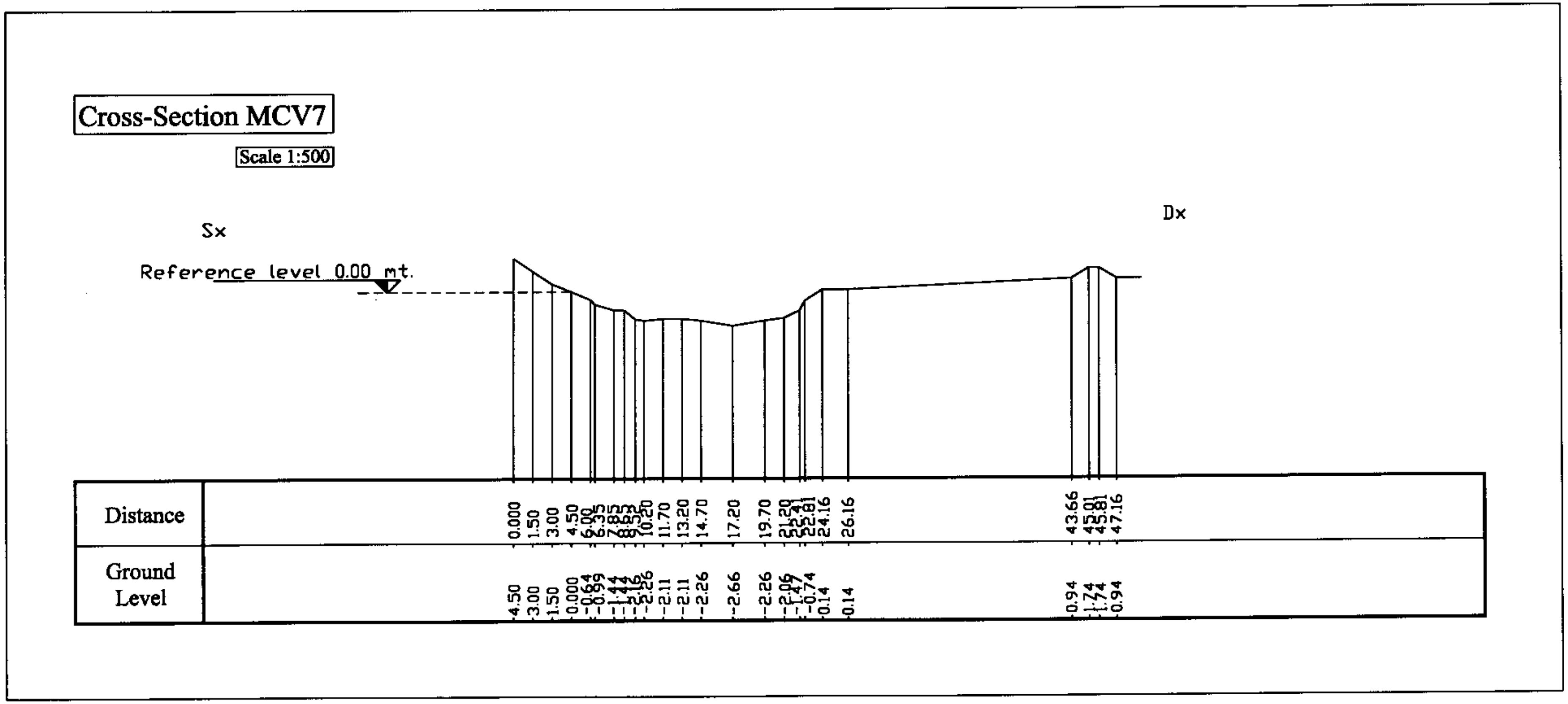
Cross-Section MCV5
Scale 1:500
Reference level 0.00 mt.
Sx
Dx
Distance
Ground Level
0.000
4.652
9.562
12.819
16.411
20.50
20.957
24.128
24.978
26.478
27.978
29.478
33.978
35.578
35.978
42.578
47.378
50.978
52.978
54.478
55.978
57.478
50.978
51.278
60.339
64.502
67.416
0.617
0.5165
0.348
0.2457
0.168
0.000
0.007
0.027
0.127
-0.985
-1.523
-1.783
-1.883
-1.983
-1.883
-1.883
-1.833
-1.933
-1.933
-1.763
-1.433
-1.143
-1.023
-0.973
0.374
0.373
0.384

Cross-Section MCV6

Scale 1:500



Distance	Ground Level
0.000	0.442
3.488	0.3908
7.285	0.3028
10.773	0.285
14.546	0.230
16.973	0.1907
21.468	0.000
24.956	0.014
28.443	-0.06
31.223	-0.04
32.023	-1.09
33.523	-1.39
34.833	-1.73
38.633	-1.73
44.383	-2.05
48.633	-1.85
50.133	-1.62
51.633	-1.38
53.133	-1.16
54.633	-1.01
56.133	-0.87
57.033	0.63
59.327	0.63
62.234	0.63
64.520	1.504
68.552	2.553


Cross-Section MCV7
Scale 1:500
Sx
Dx
Reference level 0.00 mt.
Distance
0.000
1.50
3.00
4.50
6.00
6.35
7.85
10.20
11.70
13.20
14.70
17.20
19.70
21.20
22.81
24.16
26.16
43.66
45.01
45.81
47.16
Ground Level
4.50
3.00
1.50
0.000
-0.64
-0.99
-1.44
-1.44
-2.26
-2.11
-2.11
-2.26
-2.66
-2.26
-2.06
-1.47
-0.74
0.14
0.14
0.94
1.74
1.74
0.94