EUROSOIL 2008 – EXCURSION 6A-pre-post-congress

"CHALLENGES IN SOIL WATER MANAGEMENT AND A PEDO-HISTORICAL SITE IN THE DANUBE VALLEY"

Peter STRAUSS[a], **Robert PETICZKA**[b], **Gerhard RENNERT**[c], **Eduard KLAGHOFER**[a] und **Gerhard TRNKA**[d]

[a] Federal Agency for Water Management, Pollnbergstrasse 1, 3252 Petzenkirchen
[b] University of Vienna, Institute of Geography and Regional Research, Universitätsstrasse 7, 1010Wien
[c] Amt der Niederösterreichischen Landesregierung, Abteilung Wasserbau, 3109 St. Pölten, Landhausplatz 1, Haus 3
[d] University of Vienna, Department for Prehistory and Early History, Franz-Klein-Gasse 1, 1190 Wien

1 GENERAL INTRODUCTION

The excursion is thought of being an informative mixture of topics related to soil - water management on the one hand and a pedo-historical presentation at a famous loess site on the other hand. Problems of soil water management will be discussed at the experimental station Petzenkirchen with demonstration of various field experimental setups (STOP 1). Practical problems of water management in the wine growing region of the Kamptal valley will be presented at STOP 3 at Langenlois. On the occasion of 100 years of discovery of the world famous "Venus of Willendorf" we will also present the famous loess site, where the statue was found (STOP 2). Last but not least, the products of the Kamptal region will be tasted at a local "Heuriger" (STOP 4).

1.1. Itinerary

We leave Vienna (8:30 a.m.) on the motorway A1 towards St.Pölten, the capital of the federal province of Lower Austria since 1986. We pass Melk, one of the most famous European monasteries of the baroque era and leave the motorway in Ybbs. After few kilometres we reach the Institute for Land and Water Management Research of the Federal Agency for Water Management at Petzenkirchen (10:00 a.m.). After lunch (12:00 - 13.30 p.m.) we cross the river Danube and proceed downstream along the Danube. Having past the city of Melk to our right we enter the UNESCO world cultural heritage of the 'Wachau', a well known Austrian valley with a landscape of high visual quality formed by the Danube river. The Wachau valley extends about 35 km from the city of Melk to the city of Krems and has been populated since thousands of years, which will be demonstrated at the example of our next stop at Willendorf (14:00 - 15:30 p.m.). We proceed along the Wachau valley until the city of Krems and further to the city of Langenlois, the biggest wine growing community of Austria (16:00 - 17:30 p.m.). After theoretical discussions on water management problems a practical exercise on food and wine quality will end the day (17:30 - 19:00 p.m.). We will be back in Vienna at about 20:00. A graphical representation of the excursion tour can be found in Figure 1.

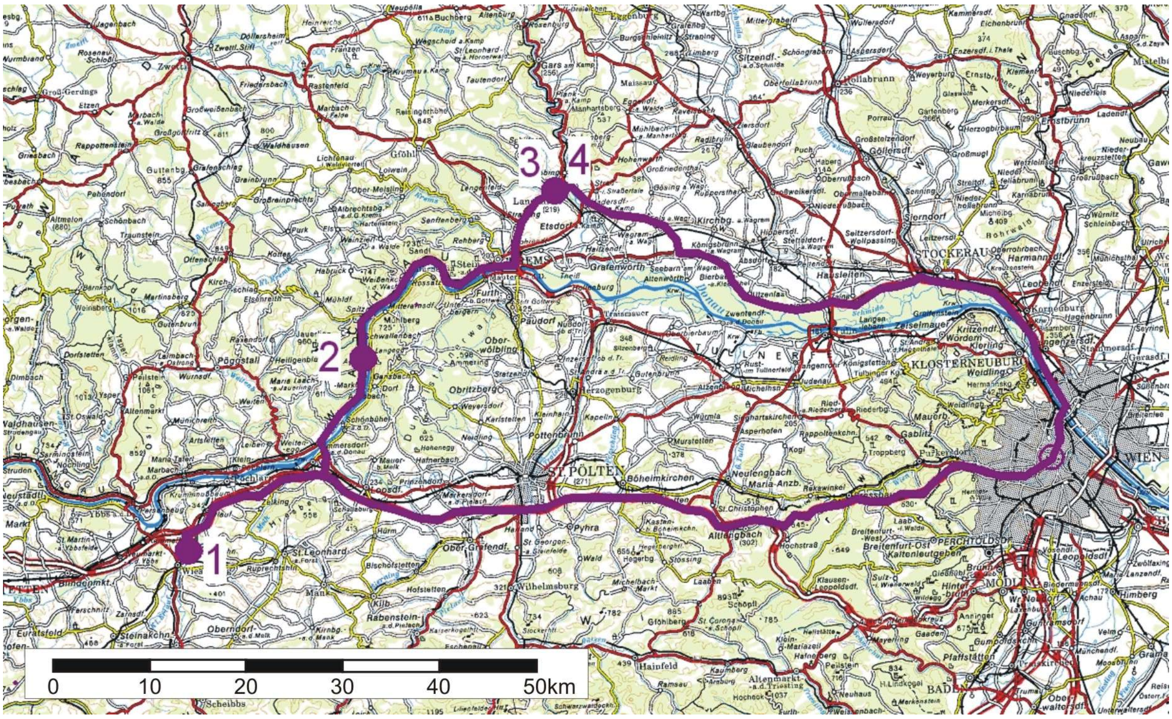

Figure 1: Itinerary of excursion, starting and ending in Vienna; stops are indicated with numbers.

1.2. Geology, soils and climate of the excursion area

Geologically the excursion area is mainly part of the Molasse zone of the alpine and Carpathian forelands, a basin filled with tertiary sediments, which filled the Parathetys, part of the ancient ocean Thetys. Towards the North the Molasse zone is bordered by the Austrian part of the Bohemian massif. The bohemian massif is a cristalline plateau where 15 - 30 km of rock have been eroded since paleozoic times. Towards the South the cristalline rocks flow below the Molasse zone and the bordering northern limestone Alps. The southern border of the Molasse zone is formed by the Flysch zone, with rocks mainly formed during the cretaceous, but in the area of the Viennese forest also formed during tertiary (DEL-NEGRO, 1977). The morphology of the excursion area has been formed significantly by aeolic and fluvial processes of the quartenary, which led to distinct terraces along the river systems. The river Danube plays a central role, being the second longest European river with a total length of more than 2800 km. The total watershed area amounts to almost 800.000 km^2 and the mean total flow rate at its estuary is about 6700 m^3s^{-1}. Within the region of the excursion area the mean flow rate amounts to about 1800 m^3s^{-1}. The origin of the Danube can be dated back to the tertiary. Since then the Danube changed its course several times until the beginning of the holocene era (DOMOKOS, 2000).

Concerning climate, the excursion area is located in a transitional zone between continental-pannonian (East) and oceanic (West) influences. **Table 1** gives some characteristics of two sites located at the Western and Eastern borders of the excursion area.

Table 1: Long term (1961-90) climatological characteristics for sites of the excursion area.

Station	Location		Precipitation Ø mm	Temperature Ø °C	Days > 5°C
Langenlois	15°41'	48°28'	457	8.9	231
Wieselburg	15°09'	48°07'	724	8.2	223

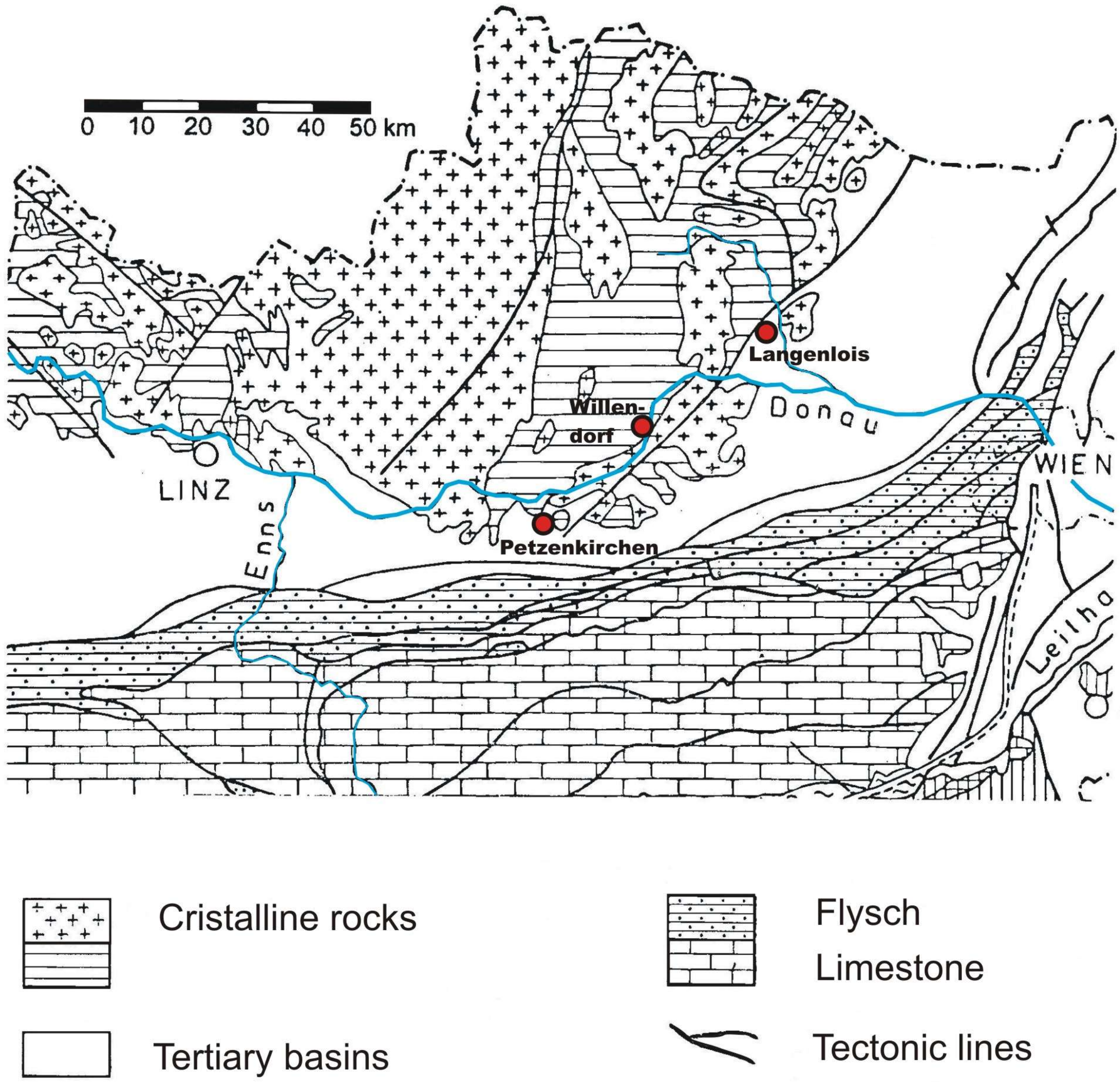

Figure 2: Geological representation of the excursion area.

Soils of the excursion area strongly dependant on the climatic framework of the region. In the Eastern parts of Austria soils of the Chernozem type are found, whereas - due to the climatic gradient within the excursion area, soils around stop 1 (Petzenkirchen) belong already to the Cambisol type.

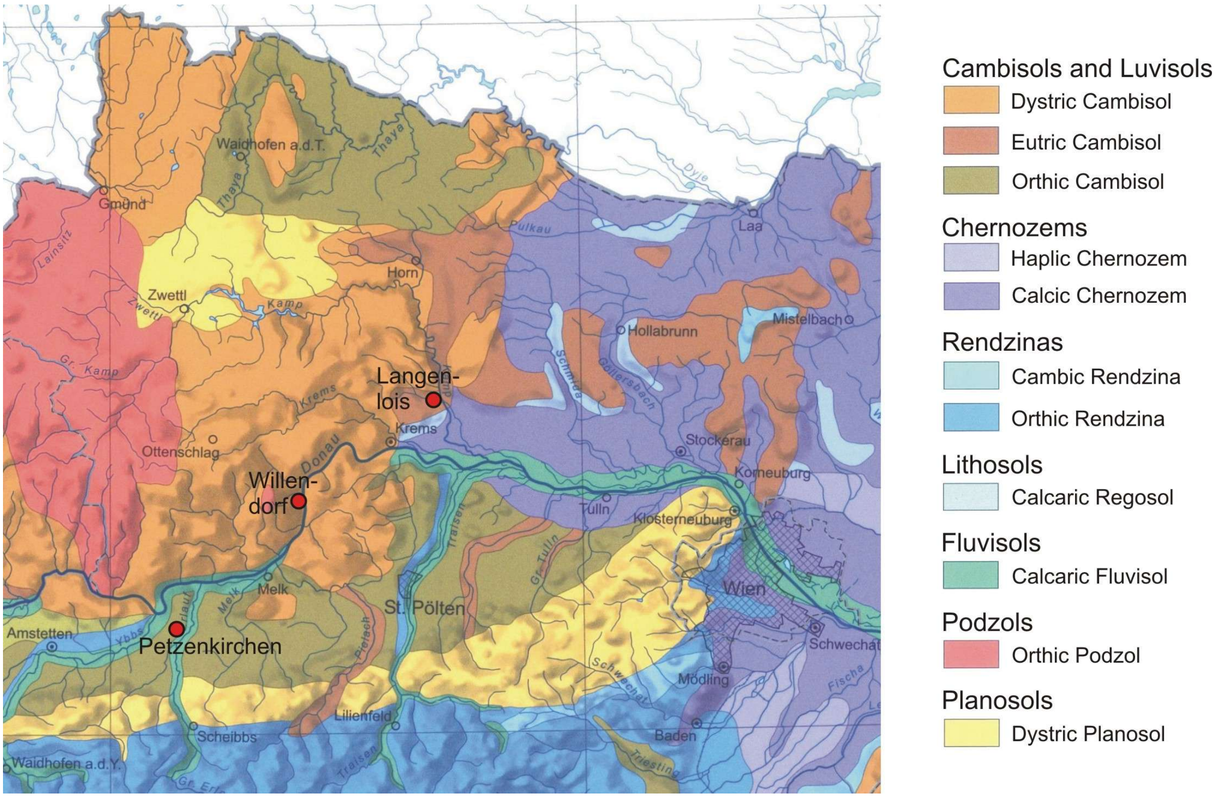

Figure 3: Spatial representation of soils of the excursion area (PETICZKA & POSCH, 2004).

2 METHODS

2.1 Soil physical analyses

Soil texture has been analysed with the pipette method according to ÖNORM L1061-2 (2002). Water retention capacity was analysed using ceramic plates (pF) according to ÖNORM L 1063 (2006). Saturated hydraulic conductivity was measured according to ÖNORM L 1065 (1988). Soil bulk density was measured according to ÖNORM L 1068 (2005). Total iron and dithionite extractable iron were determined after MEHRA & JACKSON (1960).

2.2 Soil chemical analyses

Organic carbon was analysed with the method of wet combustion according to ÖNORM L 1081 (1999), $CaCO_3$ was measured volumetrically with the Scheibler method described in ÖNORM L1084 (2006).

3 EXCURSION STOPS

3.1 STOP 1:

INSTITUTE FOR LAND AND WATER MANAGEMENT RESEARCH, FEDERAL AGENCY FOR WATER MANAGEMENT

3.1.1. Description of institute activities

The Institute for Land and Water Management Research is part of the Austrian Agency for Water Management, which belongs to the Ministry for Agriculture, Forestry, Environment and Water Management. It has been founded in 1936 as an experimental station for water management with focus on soil drainage. Since then, the focus of activities has changed significantly. Nowadays, the core of the institute's activities is research with the aim of reducing contamination of ground and surface waters by pollutants and erosion. As a support for the various activities in the field of soil-water relationships the institute maintains laboratory devices with main emphasis on measurement of soil physical parameters such as texture, density, hydraulic conductivities, soil water retention curves or aggregate stabilities. The results from research and project-related studies are basis of our consultancy activities which are used by federal administration and policy units, private organizations and individuals. The institute's activities are grouped into 4 departments:

Land use & Land management

In the context of protection of groundwater the department focuses on the development and introduction of methods for the evaluation of land use and land management and develops strategies for an environmental friendly and sustainable land use.

Groundwater Protection

The department develops suitable measures to prevent entering of pollutants such as nitrate, pesticides or heavy metals into the groundwater. To develop these measures field experiments, simulation models such as STOTRASIM and measured soil analytical data are used.

Soil Water Balance & Groundwater Recharge

Long-term monitoring of the soil water status of different sites using automated weather and soil moisture stations as base for testing and calibrating models on soil water balance is done. The model SIMWASER, which has been developed at the institute, is used to estimate the effects of management or land use changes like reforestation on groundwater recharge, especially in dry areas. Experimental Field Sites: to improve the data basis for modelling are maintained.

Small Watershed Hydrology & Erosion

Measurement and modelling of soil erosion and nutrient transport in watersheds is a main focus of activities within this department. Based on knowledge about soil and nutrient movement measures for the protection of surface water are proposed. Experiments are designed for various spatial and temporal scales from rainfall simulation experiments and plot sized experimental setups up to small watersheds.

3.1.2. Presentations at the institute

3.1.2.1. Water movement in soil

Flow in micro columns

Micro columns are used to determine unsaturated hydraulic conductivities of soil (**Figure 4**) by measuring water content and pressure distribution simultaneously at various positions within a soil column. To facilitate water flow samples an upward flow is initiated after complete saturation. From these continuously measured data, important soil water characteristics such as unsaturated hydraulic conductivity and pF can be obtained in much shorter time as compared to traditional measuring equipment.

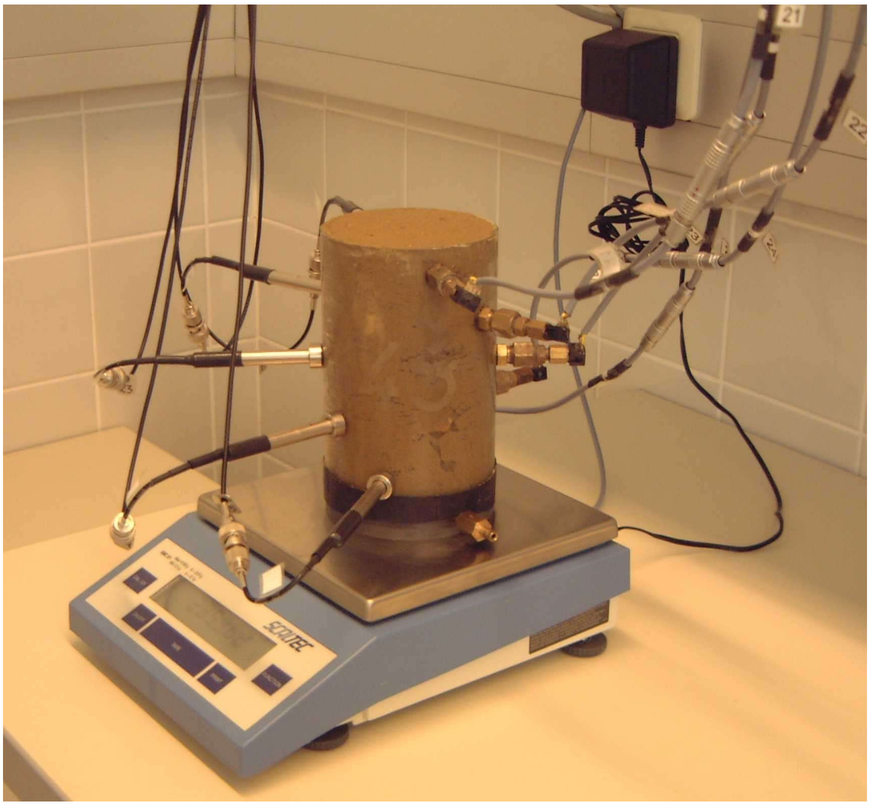

Figure 4: Equipment to determine soil unsaturated hydraulic conductivity.

Flow in macro columns

Numerous data exist on infiltration down to a depth of 1.5-2 m. These data have been sampled using lysimeters or soil water measurements combined with soil pressure information. Information obtained is used to calibrate and validate soil hydrologic models which are used as tools for hydro-pedologic issues. In contrast, measurements of soil water movement in deeper soil layers are rare. Using principles of water movement in unsaturated soils according to the well know Richards equation, infiltrating water needs several months to arrive at depths of 6 - 12 m in soils with high gravel content. This is often controversial to gauge measurements. Applying kinematic waves as infiltrating principle may lead to better agreement between measurements and modelling results. However such approaches also need calibration and validation. Therefore, an indoor soil column (5 m depth, 0.5 - 1 m diameter), filled with coarse fluvial material below a depositional layer of about 1m is under construction. Constructional details and first results will be discussed during the presentation of the physical model.

Rainfall simulation unit

The use of artificial rainfall is a common method to study the interaction of soil, soil bounded agrochemicals and water. Since long term the institute has used various types of rainfall simulators. The presently used rainfall simulator (STRAUSS et al., 2000) is built up in a modular design. Each element consists of 3 fulljet ½ HH40WSQ nozzles, mounted on support bars at a height of 2.6 meters. The plot size for a simulator with 4 elements is 11 m by 2 m. Water flux is controlled by pressure control and intermittent spraying. Because the spraying time for the 3-way valves is controlled electronically, it is possible to use variable rainfall intensities for rainfall simulation. Testing of the simulator showed that uniformity of the spray pattern for the selected nozzles was 90% according to the widely used Christiansen uniformity index. The median volumetric drop size of the artificial rainfall was measured being 1.95 mm at a water pressure of 25 kPa. Velocity of a drop of this size reaches around 90% of its terminal velocity. (**Figure 5**)

Figure 5: Rainfall simulator in action.

3.1.2.2. Soil profile: Soil type according to WRB: (stagnic) Cambisol

Location

Lower Austria, Petzenkirchen; coordinates (Gauss Krueger), M34, 662402, 5335154; altitude 228 asl

Climate

Transition between oceanic and continental zone

Temperature

Mean monthly temperature (°C)

Period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
1981-1990	-1.5	-0.3	5.3	10.3	15.7	17.8	20.4	19.8	15.4	10.1	3.6	0.7	9.8
1961-1990	-1.8	0.3	4.2	9.3	14.0	17.1	18.7	18.2	14.5	9.2	3.6	-0.2	8.9

Precipitation

Mean monthly rainfall amounts (mm)

Period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
1981-1990	40	40	44	47	69	82	105	78	63	45	41	46	700
1961-1990	39	41	45	58	75	93	99	80	53	44	48	49	724

Relief: Footslope, slope 11%, Landuse/vegetation: Grassland

Soil profile description

Horizon	**A**	**AB$_v$**	**B$_{1v}$**	**B$_{2og}$**	**D**
Depth (cm)	0-25	25-45	45-80	80-110	>110
Texture	sL/L	sL	sL	sL	sL
Coarse Material	-	-	-	-	<5%
Colour (moist)	10 YR 4/3	10 YR 4/4	10 YR 5/6	10 YR 5/6	10 YR 6/8
Carbonate	-	-	-	-	-
Mottles	-	-	-	Single undistinct	Single undistinct
Concretions	-	-	Few single Mn	Several single Mn	Several single Mn

Figure 6: Soil profile stagnic Cambisol.

Texture

Horizon	A	ABv	B_{1v}	B_{2og}	D
			%		
> 2 mm	0	-	0	-	-
2-0.630 mm	1.8	-	1.3	-	-
0.630-0.200mm	3	-	2.5	-	-
0.200-0.063 mm	18.9	-	53.4	-	-
0.063-0.020 mm	31.3	-	12.7	-	-
0.020-0.0063 mm	14.3	-	4.5	-	-
0.0063-0.002 mm	5.8	-	2	-	-
< 0.002 mm	24.9	-	23.6	-	-

Bulk density and saturated hydraulic conductivity

Horizon	A	AB_v	B_{1v}	B_{2og}	D
Bulk density ($g \cdot cm^{-3}$)	1.43	1.59	1.56	-	-
K_{sat} ($m \cdot d^{-1}$)	0.3	0.09	0.16	-	-

Water content at different pressures (pF in Vol%)

Horizon	A	ABv	B_{1v}	B_{2og}	D
	%				
0	50.3	-	42.9	-	-
60	35.7	-	34.3	-	-
100	34.9	-	33.2	-	-
800	31.4	-	28.8	-	-
3000	24.0	-	24.8	-	-
15000	20.7	-	18.8	-	-

Organic Carbon

Horizon	A	ABv	B_{1v}	B_{2og}	D
	2.0	-	0.5	-	-

3.1.2.3. Watershed monitoring station

The watershed in Petzenkirchen has a size of 66 ha and is used to deal with several scientific topics. These can be divided into soil erosion problems, nutrient pressure on surface waters and relations between land use and flow generation. Figure 6 shows the Petzenkirchen watershed.

The total area of the watershed is composed of arable land (88 %), pasture (5 %), forest (5 %) and paved land (2 %). The present soils are gleyic Cambisols(50 %), Pseudogleys (30 %) and Cambisols (20 %). Figure 7 gives an overview about the distribution of soils in and around the watershed area.

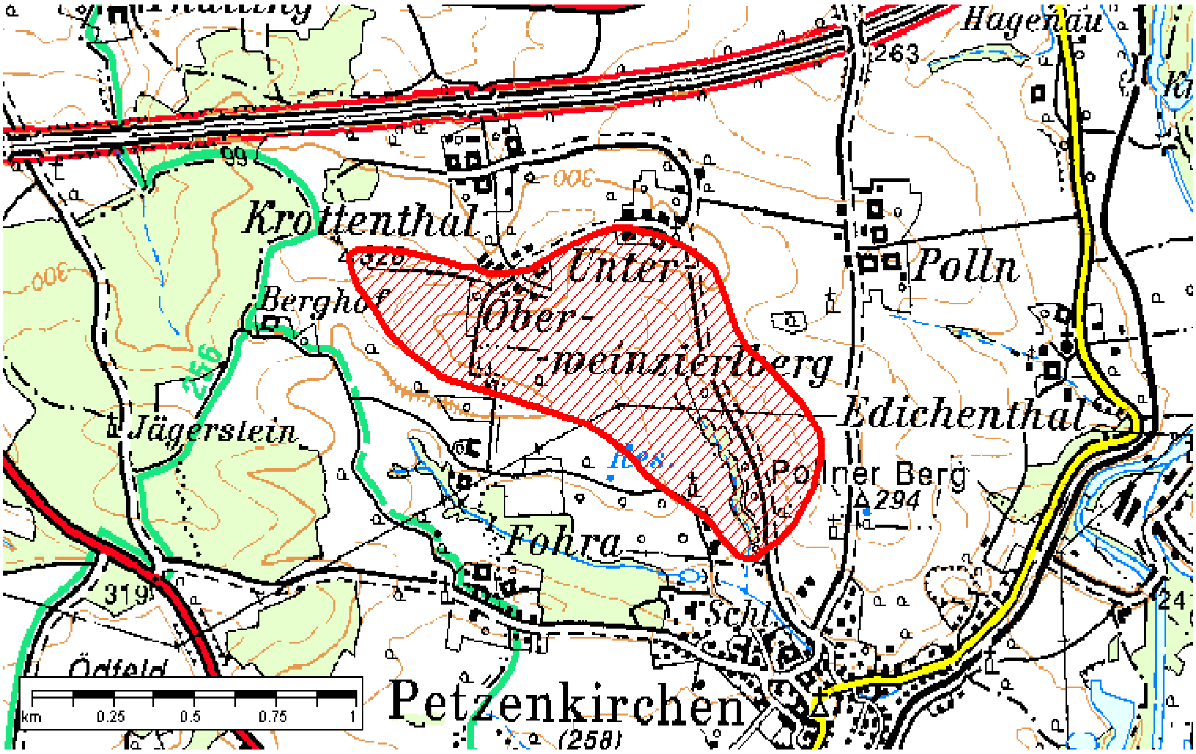

Figure 7: Watershed Petzenkirchen.

Figure 8: Spatial representation of different soil types in the Petzenkirchen watershed (brownish = Cambisols, greenish = Pseudogleys, blueish = Gleysols).

For the monitoring of the watershed discharge was measured since the earliest years of the institute (1946). From 1946 to 2001 a Thompson weir combined with continuous water depth recording using plotting paper was used. In 2001 an H-flume in combination with an ultrasonic probe was used to measure discharge. In 2005 the ultrasonic probe was replaced with a pressure probe. The monitoring station can be seen in **Figure 9**.

Figure 9: H-flume with pressure probe and additional devices at the watershed outlet.

Additionally to discharge, rainfall data with high temporal resolution are recorded (Balance system of OTT). In May 2007 an additional infra-red precipitation device (Parsivel, OTT) was installed to obtain information on type of precipitation (from drizzle to hail) and drop size distribution. In addition a research program with the aim of flow separation using isotopic data was started. Therefore a rainfall split sampler was developed to obtain isotopic information at different rainfall event times.

Beside quantitative measurements also water quality data are collected since 2001. At one hand, this is done with automatic flow proportional water samples, which are analysed in our laboratory for sediment concentration, electric conductivity, chloride nitrate and ammonia. These discontinuous measurements are used to calibrate and control our continuously measuring systems for turbidity (Tetracon, YSI; ViSolid, WTW), For particular periods there is also information available for total phosphorus concentrations. The data obtained are used to gather a better insight into the interaction between watershed hydrolgoy and sediment transport as well as validation of transport models.

Table 2 gives some basic data on watershed characteristics.

Table 2: key data of the Petzenkirchen watershed.

mean annual discharge (since 1990):	3	$l \cdot s^{-1}$
highest observed discharge (since 1990):	>400	$l \cdot s^{-1}$
lowest observed discharge (since 1990):	1	$l \cdot s^{-1}$

Figure 10 gives an example of typical rainfall - runoff responses including two different types of sediment concentration measurement at the watershed outlet.

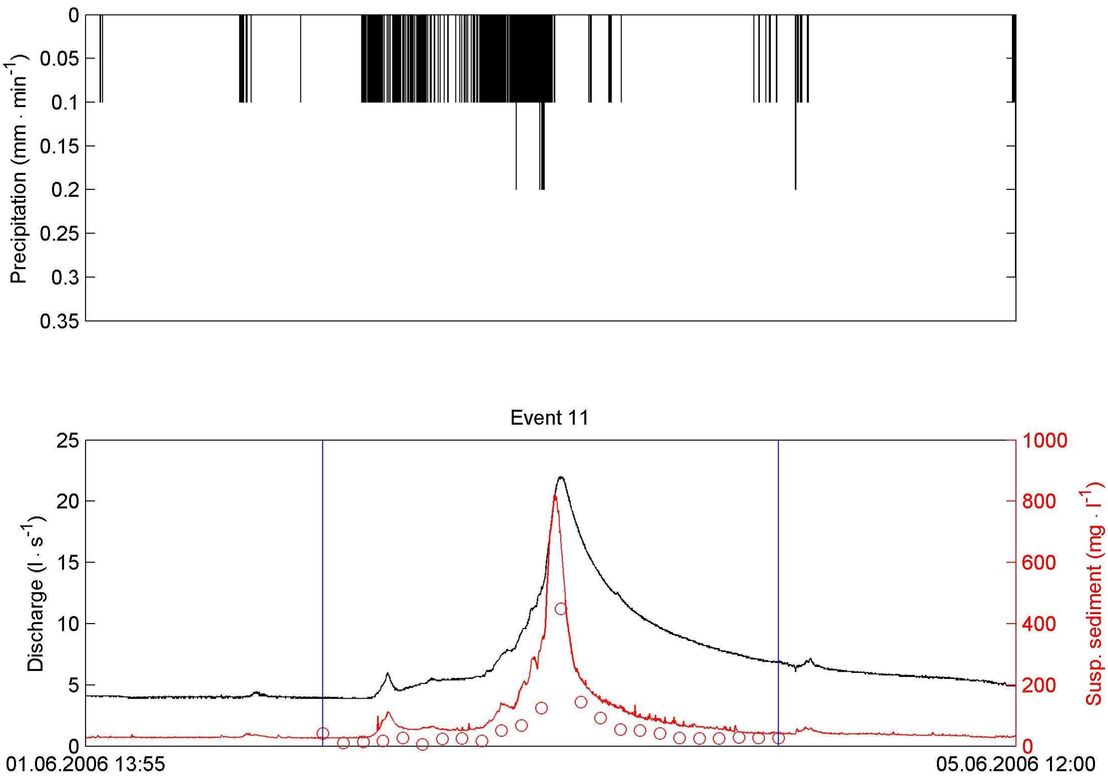

Figure 10: Rainfall intensity, discharge, continuous sediment concentration (Visolid, WTW) and flow proportional sediment concentrations (gravimetrically measured) for a typical event of Petzenkirchen catchment.

3.2 STOP 2: THE VENUS OF WILLENDORF

The Venus of Willendorf, also known as the Woman of Willendorf, is an 11.1 cm high statuette of a female figure. It was discovered in 1908 by archaeologist Josef Szombathy at a paleolithic site at Willendorf. As of 1990, following a revised analysis of the stratigraphy of its site, it has been estimated to have been carved 24,000–22,000BC.

It is carved from oolithic limestone that is not local to the area, and tinted with red ochre. The Venus is not a realistic portrait but rather an idealization of the female figure. Her vulva, breasts, and swollen belly, are heavily pronounced, suggesting a strong connection to fertility. Her tiny arms are folded over her breasts. The figure has no visible face, her head being covered with circular horizontal bands of what might be rows of plaited hair, or a type of headdress.

http://www.xtec.es/~aguiu1/calaix/057venusdewillendorf.htm

Since this figure's discovery and naming, several similar statuettes and other forms of art have been discovered. They are collectively referred to as Venus figurines, even though they pre-date the mythological figure of Venus, and are not thought to be representations of that goddess. Like many prehistoric artefacts, the cultural meaning of these figures may never be known. Archaeologists speculate, however, that they may be emblems of security and success, fertility icons, pornographic imagery, or even direct representations of a Great Goddess or Mother Goddess or various local goddesses. The female figures, as part of Upper Palaeolithic portable art, appear to have no practical use in the context of subsistence. They are mostly discovered in settlement contexts, both in open-air sites and caves; burial contexts are much rarer. The apparent obesity of the figures strongly implies a focus on fertility as, at the time of their construction, human society had not yet invented farming and did not have ready access to rich or plentiful foodstuffs. An image of excess weight may have symbolized a yearning for plenty and security. The statue's feet do not allow it to stand on its own. Due to this it has been speculated that it was meant to be held, rather than simply looked at. Nevertheless, the widespread theories concerning a possibly fertility cult or a Mother Goddess are entirely speculative and cannot be scientifically evaluated. The original statuette can be seen as part of the collection of the 'Naturhistorisches Museum' in Vienna. In terms of archaeology and anthropology, the Willendorf site is most interesting also because of the identification of nine successive layers of human settlement, covering a time span from 45.000 to 23.000 before present.

Figure 10 gives an overview on the different strata and anthropogenically influenced layers of the loess profile, where the Venus of Willendorf has been found.

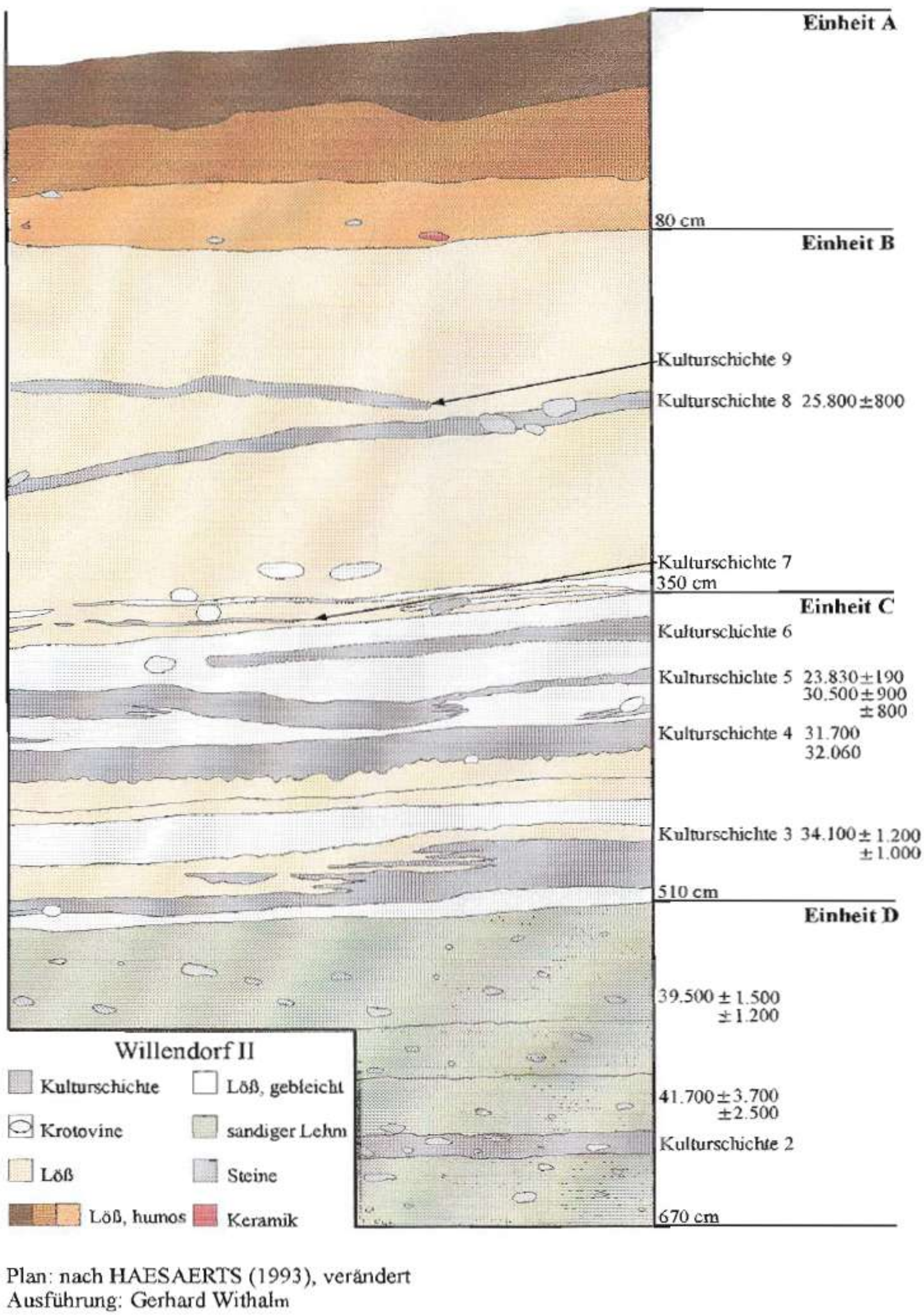

Figure 11: Loess profile, where the Venus of Willendorf has been found. 'Einheit' characterizes the different units of the profile, 'Kulturschichte' is anthropogenically influenced layer, 'Keramik' spots to place where the Venus has been found.

Figure 11 gives a description of the numbering and different sampling depths for soil analysis.

Proben-bezeichnung	lfd. Nr.	Tiefe in cm
V1	1	0-10
1a	2	10-20
V2	3	20-30
2a	4	30-40
V3	5	40-50
3a	6	50-65
V4	7	65-75
4a	8	75-90
V5	9	90-100
V6	10	100-110
6a	11	110-130
V7	12	130-140
7a	13	140-150
V8	14	150-160
8a	15	160-175
V9	16	175-185
V10	17	185-195
10a	18	195-200
V11	19	200-210
11a	20	210-215
V12	21	215-225
12a	22	225-240
V13	23	250-260
13a	24	260-270
V14	25	270-280
V15	26	280-290
15a	27	290-300
V16	28	300-310
16a	29	310-330
V17	30	330-340

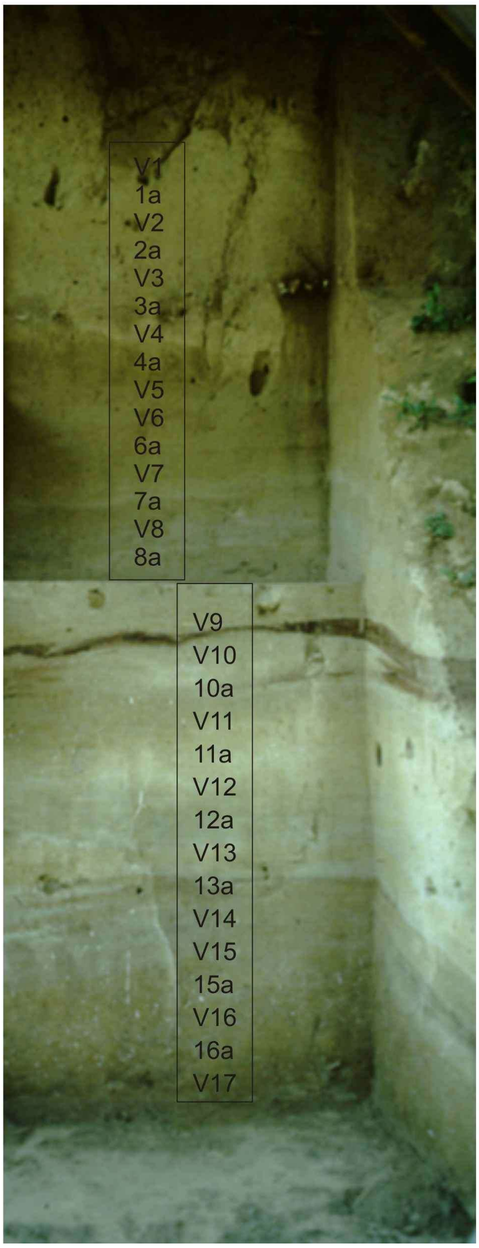

Figure 12: Sample numbering and sample depths (left side) and location of the soil samples in profile (right).

An interpretation of the stratigraphic situation of the Willendorf profile is difficult due to its special geomorphological position in a slope leading to a slow movement. This movement is even increased due to strongly different textural properties of the various layers. It can therefore be concluded, that strong overlays and superimpositions have taken place.

Table 3: Textures, colour, carbon contents, total Fe and dithionite soluble Fe of the different soil layers at the Willendorf site.

No.	Colour Munsell	Texture in %			Texture Type	$CaCO_3$ %	Fe_{tot} $mg \cdot kg^{-1}$	Fe_d $mg \cdot kg^{-1}$
		Sand	Silt	Clay				
1	2.5Y 5/4	19.2	66.4	14.4	sU	35.0	9531	173
2	2.5Y 6/4	18.4	66.4	15.2	tU	29.9	8866	156
3	2.5Y 5/4	18.9	65.1	16.0	tU	26.0	9533	174
4	2.5Y 5/4	19.8	67.7	12.5	sU	23.6	10004	185
5	2.5Y 5/4	18.4	65.2	16.5	tU	24.4	8692	198
6	2.5Y 5/4	19.2	65.1	15.7	tU	24.0	9125	204
7	2.5Y 4/4	17.0	63.4	19.5	tU	23.2	8749	216
8	2.5Y 6/4	19.5	61.1	19.4	tU	22.1	9614	204
9	2.5Y 5/4	18.3	61.9	19.8	tU	18.9	8631	206
10	2.5Y 5/3	19.3	61.7	19.0	tU	19.3	10598	198
11	2.5Y 5/3	16.0	64.8	19.2	tU	23.6	12655	194
12	2.5Y 5/3	16.0	67.1	17.0	tU	18.0	9545	215
13	2.5Y 5/3	16.7	62.4	21.0	tU	19.1	6851	206
14	2.5Y 5/3	17.3	63.4	19.3	tU	17.0	5369	136
15	10YR 3/4	16.0	65.2	18.8	tU	17.4	5864	163
16	10YR 3/4	20.7	70.4	8.9	sU	17.0	8652	145
17	2.5Y 5/3	17.2	63.7	19.0	tU	11.2	8638	163
18	2.5Y 5/3	15.1	57.6	27.3	UL	13.9	7841	160
19	2.5Y 5/3	16.9	62.8	20.3	tU	17.8	6598	164
20	2.5Y 5/3	16.4	61.8	21.8	tU	20.3	6683	182
21	5Y 5/3	18.0	61.1	20.9	tU	19.2	9531	184
22	5Y 5/3	15.5	65.6	18.9	tU	20.1	11363	177
23	5Y 5/3	14.5	67.1	18.4	tU	17.6	12664	176
24	5Y 5/3	16.9	65.0	18.0	tU	14.1	13311	218
25	5Y 5/2	10.9	68.6	20.5	tU	6.8	10660	215
26	5Y 5/2	16.3	61.3	22.3	tU	7.2	9524	181
27	2.5Y 5/3	17.8	54.4	27.8	L	8.3	7427	213
28	2.5Y 5/3	19.2	55.2	25.6	UL	8.3	9214	241
29	2.5Y 5/3	20.2	56.2	23.6	tU	7.7	10458	233

This can be confirmed by the fact, that the soil profile is quite inhomogeneous also with respect to its content in Fe. Despite the difficult morphological situation the profile offers some interesting aspects in the field of palaeopedology and sedimentology. In the whole profile the chemical und physical parameters are very similar, so that any significant palaeosol cannot be detected. Pedogenesis therefore could only be very weak and the signals are blurry. The strongest signals can be found in the samples 22 to 27 were we find decreasing values of carbonates and high values for the relationship Fe_{tot}/Fe_d. As a conclusion the profile of Willendorf is much more interesting by regarding the paleolithic situation than it is in the field of paleopedology.

3.3 STOP 3: DRIP IRRIGATION FACILITY AT KÄFERBERG - STEINHAUS, COMMUNITY OF LANGENLOIS

Main reasons for setting up the drip irrigation facility was deemed to be improvement of the soil water balance positively influencing grape yield and quality. In addition a permanent grass cover in vineyards became possible and a contribution towards preservation of the characteristic landscape was done. The area covered by the facility is about 95 ha of vineyards. **Figure 13** gives an overview on water deficits at the example of a dry year (1992). In 1992, total rainfall amounted to 238 mm and the deficit between water needed and available water was 192 mm. Using drip irrigation, 90 mm can be applied. Compared to other forms of irrigation drip irrigation exhibits a significantly higher effectiveness because water arrives directly at the roots of the grapevine, thereby reducing superficial runoff and erosion. In addition local humidity is not influenced which contributes to reducing fungal diseases. Soils within the facility can be described as Anthrosols from loess. They have a low water capacity and summer rain can be stored only partially. The maximum weekly water amount to be stored is about 25 mm. Stand density is 3600 grapevines$\cdot$ha^{-1}. Drip feeds have a capacity of 1.6 l$\cdot$h^{-1}. The facility is divided into 12 departments which are irrigated up to 12 hours maximum.

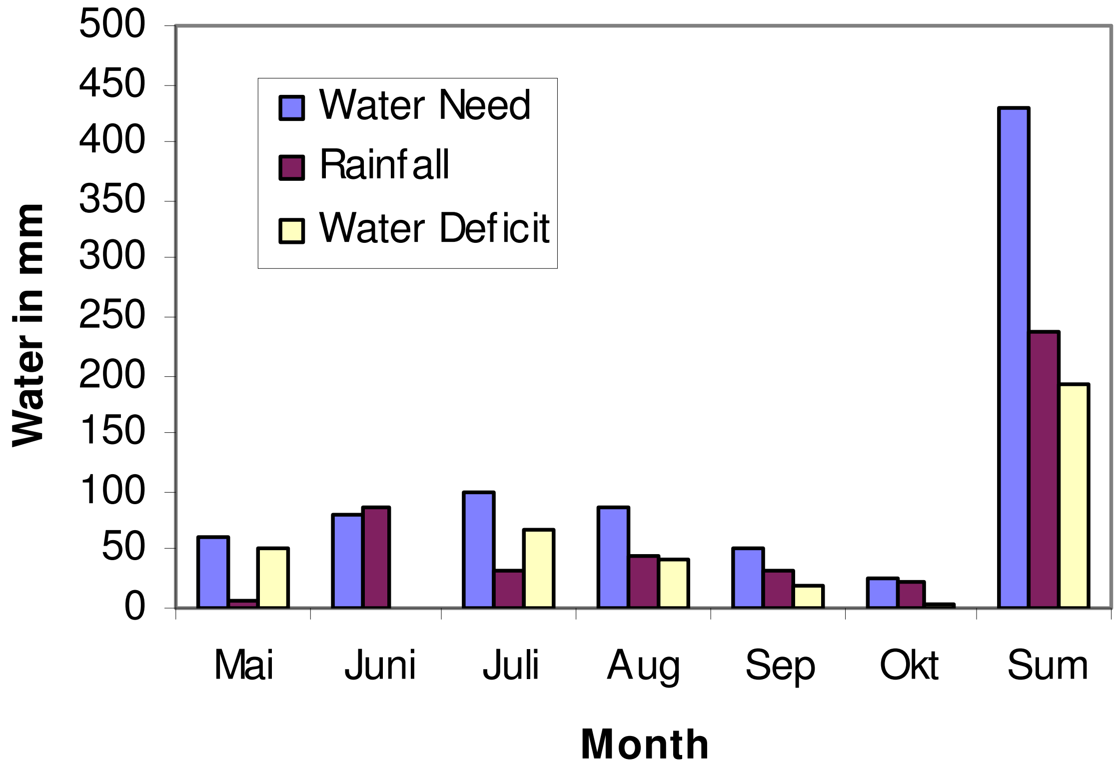

Figure 13: Comparison between rainfall amounts and water need of vineyards for the dry year 1992.

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