Precise Measurement of Water and Solute Transport in Soils

Lysimeter Systems for Climate Research, Water Management, Agronomy and Soil Science

UMS
measure to know

Dear Reader,
Dear Valued Customer,

True to the motto “It is our aim to give you the best possible support in your tasks“ it is our dedication to offer you the best technical solutions and excellent service. Because: Your need is to work with reliable, functional and low-maintenance measuring systems that supply you with precise results as a substantial data base for research, ecology and resource management.

Expressed by our slogan: UMS – measure to know.

With our experience of more than 20 years we are able to offer exceptional measuring and sampling instruments. Most products are manufactured by ourselves in our Munich premises. Other products are supplied by reliable partners worldwide. Based on this know-how and ability we can supply the solutions which our customers appreciate.

In this brochure we would like to introduce our Lysimeter systems for climate research, water management, agronomy and soil science. The fascination of these new Lysimeters due to their defined surface and volume is having controllable ecosystems with defined boundaries in the three phases solid, liquid and gasform, that give us conti-nuous, high resolution readings. We are at your disposal for planning, set-up, training, maintenance and longtime cooperation.

At this point I would like to express my thanks to my colleagues and friends at the Steering Committee of the Lysimeter Research Group. This panel of experts was ahead of time to recognize this fascination and challenge of Lysimetry and to initiate numerous innovations. As a result, we today can present the 3rd generation of UMS Lysimeters with the unique capability to realize studies in eco-systematic research with laboratory precision under field-identical conditions.

Enjoy reading! We are looking forward to new challenges as partner in your future projects.

Yours

Georg von Unold

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The fascination of Lysimetry

We are looking forward to work as a partner in your future projects

Content

Precisely measured soil data with high resolution – available at any time

In all our systems we place great importance on most advanced technology and a high degree of investment security.
On one hand we design customized solutions for our partners in research and industry. On the other hand we supply systems which have proven their reliability under various conditions all over the world.
The use of high-grade components and materials assures a maximum in system availability and data continuity.
Out of your ideas and visions, which are the guide-line for our systems, new fundamental scientific findings can be gained.

The fascination of Lysimetry
3rd generation UMS Lysimeter station for site remediation in solid, fluid or gaseous phase (University of Naples)

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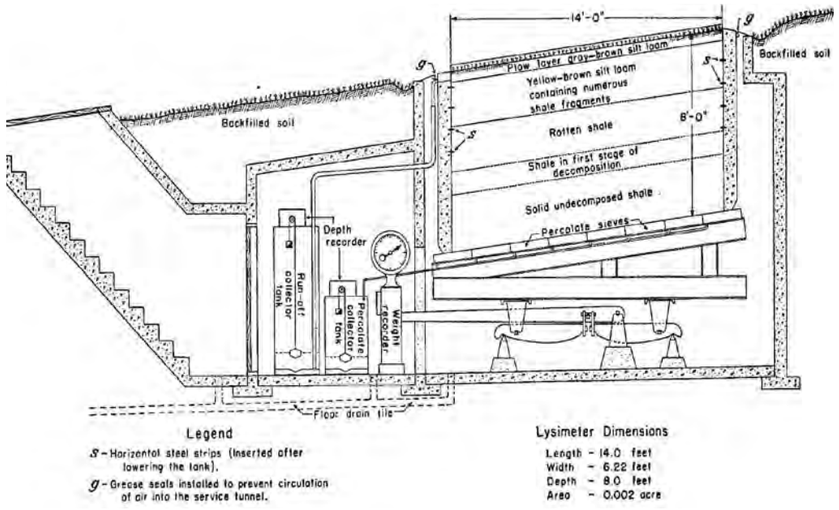
From a simple measuring tool to a highly developed monitoring system

Philippe de La Hire (1640-1718), mathematician who constructed Lysimeter, well-known for his nivellements in Versailles.



Coshocton-Lysimeter in 1937: Already at that time lysimeter innovations enabled precise determination of the water balance and leachate of substances into the groundwater.

Originally Lysimeters were only used for measuring leachate. Thanks to innovative technology UMS Lysimeters today are precision tools for environmental monitoring research projects like climate research, water management, agronomy, soil science or site remediation.

Modern day UMS Lysimeters – now in their 3rd generation – monitor the hydraulic and thermal conditions of the surrounding field. Their sophisticated measuring, sampling, controlling and regulating instrumentation monitors the real field situation.

Soil water is the decisive parameter for mass balance determination. For studies on groundwater recharge or mass transport or for metabolism research it is significantly important to have a field-identical water regime inside the Lysimeter.

For climate research or analysis of microbial activities UMS Lysimeters offer thermodynamic comparability between field and Lysimeter.

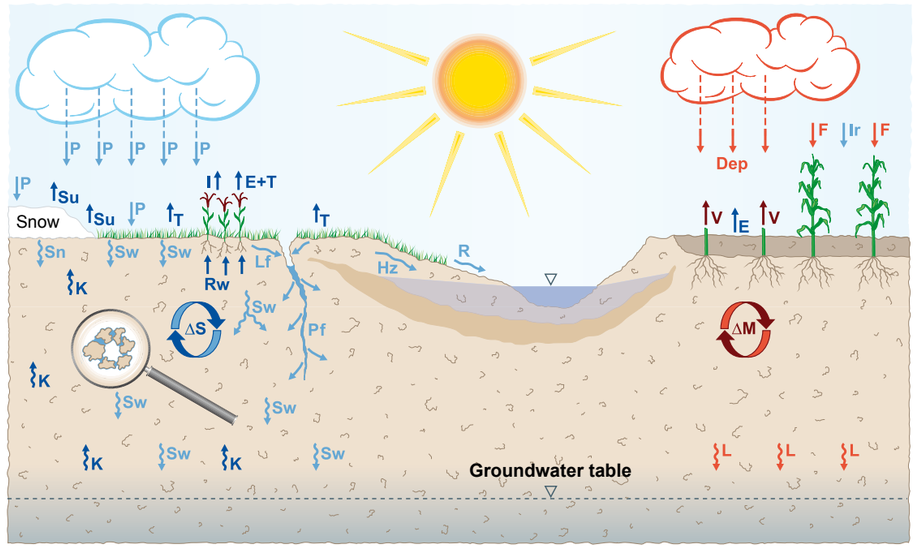
Both aspects are important for many tasks, as well as considerations in research regarding:
- conventional cultivation,
- snow coverage during winter operation,
- high substance conversion after snow melt.

Whether your field of activity is soil science, climate research, water management, agricultural research or remediation of contaminated sites, modern UMS Lysimeters contribute the essential monitoring results.
Today high-precision sensors are available that for example reveal the smallest amount of precipitation as dew and frost.

High-resolution data loggers store short-interval readings over extended periods of time to visualize details of ongoing processes, mass conversion or solute transport.

Loggers store readings internally or on USB sticks. As an option, the logger can transmit the data into a network by Ethernet or server/web server via GSM or GPRS. Thus, you can bring together data from numerous UMS Lysimeter sites, which then are available as a common and substantial data base for a research network.

Precise water and substance balances



ΔS = Water content changes
- Hz Interflow
- Lf Lateral flow
- Ir Irrigation
- P Precipitation (total)
- Pf Preferential flow
- R Runoff
- Sn Snowmelt water
- Sw Seepage water

- E Evaporation
- I Interception
- K Capillary water
- Rw Root water uptake
- Su Sublimation
- T Transpiration

ΔM = Mass changes
- Dep Deposition (atmos.)
- F Fertilizer
- L Leachate

- V Vegetation loss

Water balance formula: (P + Ir) - (I+ET + Sw) = ΔS

Substance balance formula: Dep + F - V - L = ΔM

Soil water as well as input and output parameters of water and substance balance

UMS Lysimeters offer precise and detailed data from the "black box" soil. Lysimeters with high-precision weighing systems are the modern tool for studies where soil water and mass transport must be determined precisely under field-identical conditions.

Highly accurate weighing techniques offer new applications.
Knowledge about water flow is the basis for all studies about soil water and mass balances.
UMS Lysimeters equipped with precision weighing systems measure water flows in the soil by weighing and calculating water input and output over the time.
UMS technology has the capability to weigh Lysimeter columns with a mass of up to 6000 kilograms. It measures those soil columns with an accuracy of 100 grams which corresponds to a precipitation or water column of 0.1 mm. The resolution is even10 grams or 0.01 mm precipitation.
Thus, UMS Lysimeters are exceptionally suitable for the measurement of all types of precipitation like rain, dew, rime and snow. And most of all, the precipitation is measured just as it really occurs in the surrounding field – right on the soil surface.

And, as not only the Lysimeter weight, but also the leachate output is measured in the gram range, UMS Lysimeters can be used for calibration of groundwater recharge models.

Finally, UMS Lysimeters can confirm predictions regarding climatic change by supplying substantial data. An example of this is the TERENO-SoilCan project, for which soil columns were cut at several locations and then brought to a location with different new climatic conditions for surveying.

The mesocosmos of soil, vegetation and micro-organism inside the Lysimeter is exposed to a natural yet different climate. Thus, any effects due to climate change on soil, plants, water balance, CO_2 und O_2 dynamics can already be measured today.

Our customers appreciate the innovative solutions planned down to the last detail

Our expertise in selecting, cutting and extraction of soil columns
To get significant data for a field, catchment area or region it is necessary to select a representative location. In case the soil profile shows barrier layers, lenses of clay or extreme coarse horizons a new spot for the soil column extraction should be chosen. Otherwise, these specific characteristics must be considered in the conception as well as in the data interpretation.

Taking soil probes at the chosen extraction spot

Quality assurance with the UMS cutting method
As each soil is unique, it is essential to have experience in the cutting of Lysimeter soil columns. In the past 20 years, UMS has extracted hundreds of soil columns all over the world, and in many types of soil: typical farmland, permafrost, forests, rubble plains or alpine habitats, nearby or as far as China.

Following are some examples how the UMS cutting method ensures the quality of your future measuring data:

- We do inspection borings by hand or machine to find out if rocks, roots, cavities or other disturbances might require preventive measures.
- We assure the quality by continuous observation of the cutting process.
- We use tools to cut exactly perpendicular (a method by UMS which is under protection by the utility model).
- We use newly developed cutting edges made of a special steel which has minimised friction. This prevents soil compaction inside the Lysimeter column.
- We remove by hand stones or roots beneath the cutting edge so they cannot produce cavities or grinded grooves on the soil column.

The quadruple hydraulic press in action

Cutting with the UMS cutting edge: Non compacting and gap free

Precise and gentle shear-off procedure
The bottom of the soil column is sheared off with a polished cutting plate. The plate's specially shaped cutting edge together with a hydraulic drive allows careful and accurate shearing.

Precise and gentle shear-off procedure

Soil conserving lifting and rotation method
After the soil column is cut and sheared off it is lifted and turned upside down.
The UMS method has four particular advantages:
1. The lifting force is applied evenly and close to the balance point to prevent column deformation. The soil body is kept safe and free of deformation.
2. The Lysimeter cylinder is not deformed when lifted as the induced load torque is reduced to a minimum. The load is extensively distributed from the short bolts over the large-sized welded on base plate.
3. The round bolts allow the easy, smooth and safe rotation of the whole cylinder. This saves costs by reducing the efforts for installation as well as for maintenance when the Lysimeter needs to be lifted.
4. The integrity of the soil body is assured by the safe and easy handling.
5. The filled Lysimeters are transported on trucks with special air suspension to ensure that the soil column remains undisturbed. The height of the soil column is checked for quality assurance.

The UMS lifting and rotating method prevents a deformation of the soil body and eliminates the development of gaps inside the cylinder – an essential quality criterion for receiving substantial data.

Safe lifting of a Lysimeter with a weight of a few tons

Safe rotation of the Lysimeter without deformation

Field-identical water regime with UMS Lysimeter technique
A main point of criticism against Lysimeters has always been the difference between the "water regime" in the field and inside the Lysimeter.
In conventional gravity Lysimeters the leachate is just drained out of the bottom of the Lysimeter. In reality variable matric potentials, which are the driving force for water flow, occur in the field.
In rainy seasons or wet periods the field's soil water is pulled towards the lower groundwater. This does not happen inside the Lysimeter as the potential on the very bottom is zero. As a result the Lysimeter has more moisture than the field.
In dry periods, depending on the soil type, capillary suction causes the water in the field to rise. As this is not the case in the conventional Lysimeter the soil in the Lysimeter remains drier than the soil in the field.

In UMS Lysimeters this problem is solved by measuring and comparing the matric potential in both, the bottom of the Lyismeter and in the field at the same depth. If the Lysimeter has more moisture, water is sucked out the Lysimeter through the suction cups rake. If the Lysimeter is drier, water is injected.
This technique is installed in all UMS Lysimeters since 2004 with great success.

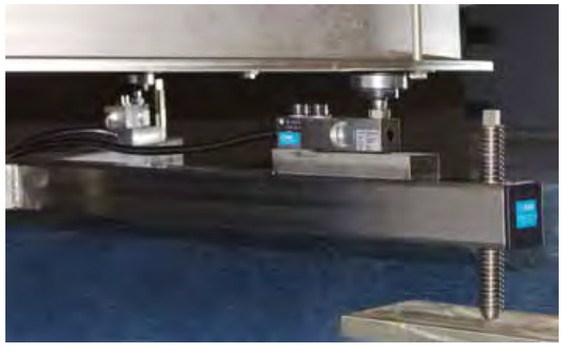
Installation of the suction cups rake

The lower part of a Science-Lysimeter just equipped with instruments

Our customers appreciate the innovative solutions planned down to the last detail

Precision weighing for reliable mass balances
Measuring small changes of a large load under field-identical conditions: this innovative technology is what makes UMS Lysimeters so valuable.
For UMS Lysimeters this means:
- Measurement of the soil column mass with an accuracy of 100 grams which corresponds to a precipitation or water column of 0.1 mm. The resolution is even 10 grams or 0.01 mm precipitation.
- Leachate is measured with an accuracy of 10 grams and a resolution of 1 gram.

The precision weighing system in UMS Lysimeters allows the highly accurate measurement of mass increase and decrease in the Lysimeter. Thus, water balance parameters rain, dew, frost, snow and evapotranspiration are determined with highest resolution.
Already the first UMS Lysimeters were placed on three weighing cells. This minimizes measurement errors due to a shift of the load caused by wind and reduces the statistical error. The weighing cells offer highest accuracy, they are hermetical sealed and, as other parts, made of durable stainless steel. Measuring the leachate discharge is even more precise as leachate is collected and weighed in a separate tank.
With the special design the weighing system excludes transverse forces (patent pending).
Another advantage is the easy and quick replacement and calibration of the weighing cells.


Precision weighing cells with transverse force free load transmission


Inspection of the sensor installation

Field-identical temperature dynamics
All chemical and microbial processes are temperature dependent, as well as hydraulic processes. When designing a Lysimeter it is of great importance that the temperature dynamics of the field are transferred to the Lysimeter as efficient as possible.
The well rings are made of porous concrete. Thus, the evaporation enthalpy creates a thermal equilibrium between Lysimeter soil and the surrounding field – adequately from the soil surface down to the bottom.
The bottom side is equipped with a high thermal conductivity heat exchanger which re-establishes the thermal conduction usually interrupted in conventional Lysimeters.


When completely surrounded by the field's soil the Lysimeter obtains a field-identical temperature profile

Sealing the rim gap
The gap between Lysimeter cylinder and collar is properly sealed to prevent the intrusion of rain, melting water or stones. This reliably eliminates a former cause of error.

In addition the circulation of air caused by thermal effects is reduced. This sealing of the rim gap was first implemented 15 years ago, but was improved since then and now in no way influences the weighing precision.


A installed sealing lip on a Hydro-Lysimeter just being prepared

Snow – a interfering factor?
Snow and snow melt are important, not only in alpine regions. With UMS Lysimeters you can directly measure the water equivalent of snow and the snow cover growth by weighing. This is achieved by a special rotating blade which cuts a small gap into the snow cover straight over the Lysimeter rim. With this gap the Lysimeter is weighable again, and snow fall or melting processes cause little disturbance, utility patented.


Precise measurements even in winter

Simple maintenance and easy replacement of sensors
Sensors can be replaced without lifting the Lysimeter through a service hatch in the collar. The weighing cells are not fixed to the bottom side of the cylinder but are hooked sideways. Thus, they can be replaced easily (patent pending).


The careful installation with flanged fittings makes maintenance easier

Careful selection of material and material processing
UMS Lysimeter vessels are made of a special stainless steel and are manufactured only by skilled specialists with advanced welding experience. The narrow tolerances and the passivated welding seams must pass a strict quality control. The construction's dimensions and stability are verified and tested to guarantee long-term operation of the system.
UMS Lysimeters are placed inside concrete well rings which have a thermal transmission comparable to the soil. They are designed to withstand geodynamic pressures and assure stability for years. A proven design for long-term precise weighing!


Stainless steel construction for extended durability

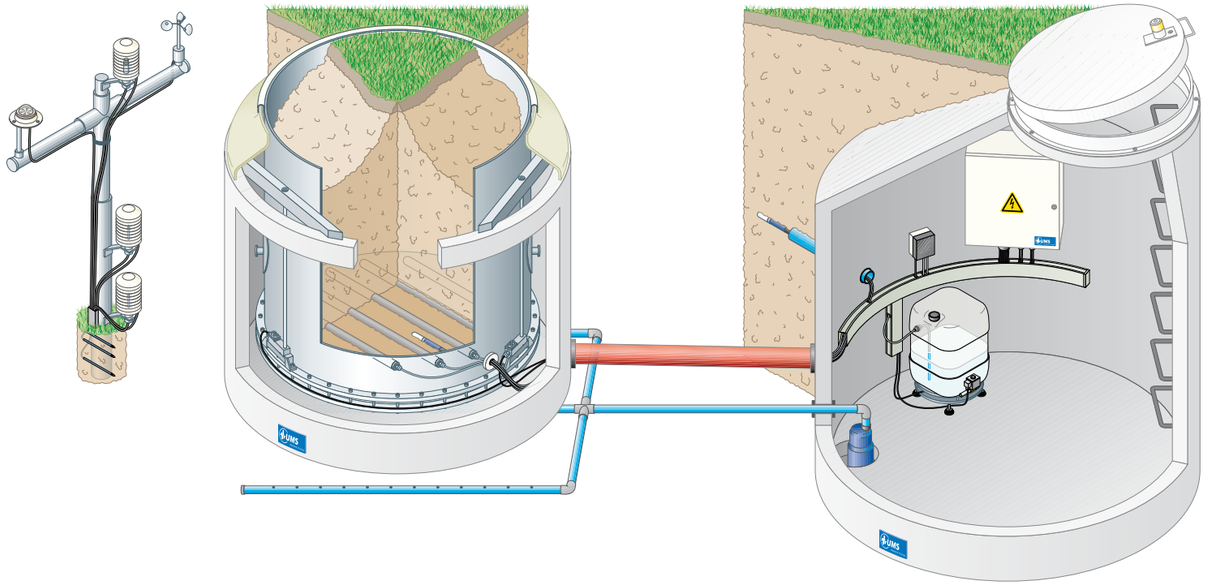
UMS know-how for customized solutions
The UMS team has more than 20 years of experience and consists of graduated engineers, geoscientists, master craftsmen and technicians having skills in
- soil physics,
- electronics,
- precision mechanics,
- metal working.

UMS advises and supports you in planning, designing, constructing and finally in training your team in start-up and maintenance.

Beside complete solutions and Lysimeter stations with one to 60 Lysimeters, or complete, web server based networks we also supply single components, sensors or 1-channel-loggers.


Multiple use: Lysimeter removed and replaced

Measurement of water balance parameters and weather data considering soil surface and soil water properties



The Meteo-Lysimeter with weather station and service well

RS200
rain sampler

Weather station of a
Meteo-Lysimeter

Customized weather station with Lysimeter (between trees and access hatch)

With the Meteo-Lysimeter you measure the essential parameters of energy and water balances in soils and its interface to atmosphere with highest precision.

Your task is to develop water balance models and to calculate potential evapotranspiration.
The Meteo-Lysimeter precisely measures precipitation, evapotranspiration and leachate. For this, the Lysimeter weighs in the gram range a certain mass of soil with a defined surface over an extended period of time and supplies you with precise data of
- water input like rain, dew, frost or snow,
- water output by evapotranspiration and leachate, and
- the change of soil water content.

Together with additionally measured meteorological data you can develop water balance models and determine potential evapotranspiration (ET_0).

Advantages of the UMS system solution
The key benefits of the Meteo-Lysimeter are:
1. You receive highly resolved and precise data of precipitation, evapotranspiration and leachate by direct measurement of soil weight and water weight.
2. The “true“ field evapotranspiration is determined, which really takes place on the respective soil surface under certain climatic and water conditions.
3. Also leachate amount and composition are gained under field-identical conditions, and stored for later analysis inside the easily accessible service well.
4. Precipitation is measured directly on the soil surface considering real wind conditions, soil moisture and vegetation. A relatively large 1 square meter surface gives you the best possible precipitation data.
5. UMS Lysimeters supply information about the true water conversion processes taking place on the surface down to a selectable soil depth, with additional information about air humidity and temperature, solar radiation and wind.

Other advantages
- Field-identical water regime;
- Field-identical temperature regime in the Lysimeter;
- ET_0 as continuously recorded reading calculated with the 12 cm grass cover algorithm;
- Connection to Ethernet, remote control by GSM or GPRS;
- An optional tool for snow measurement automatically offers additional information about the water equivalent of snow;
- Standard Lysimeter height is 1.5 meters. If required a height of up to 2 meters is available.
- The evapotranspiration determination is done by weight measurement, not by evapotranspiration models.

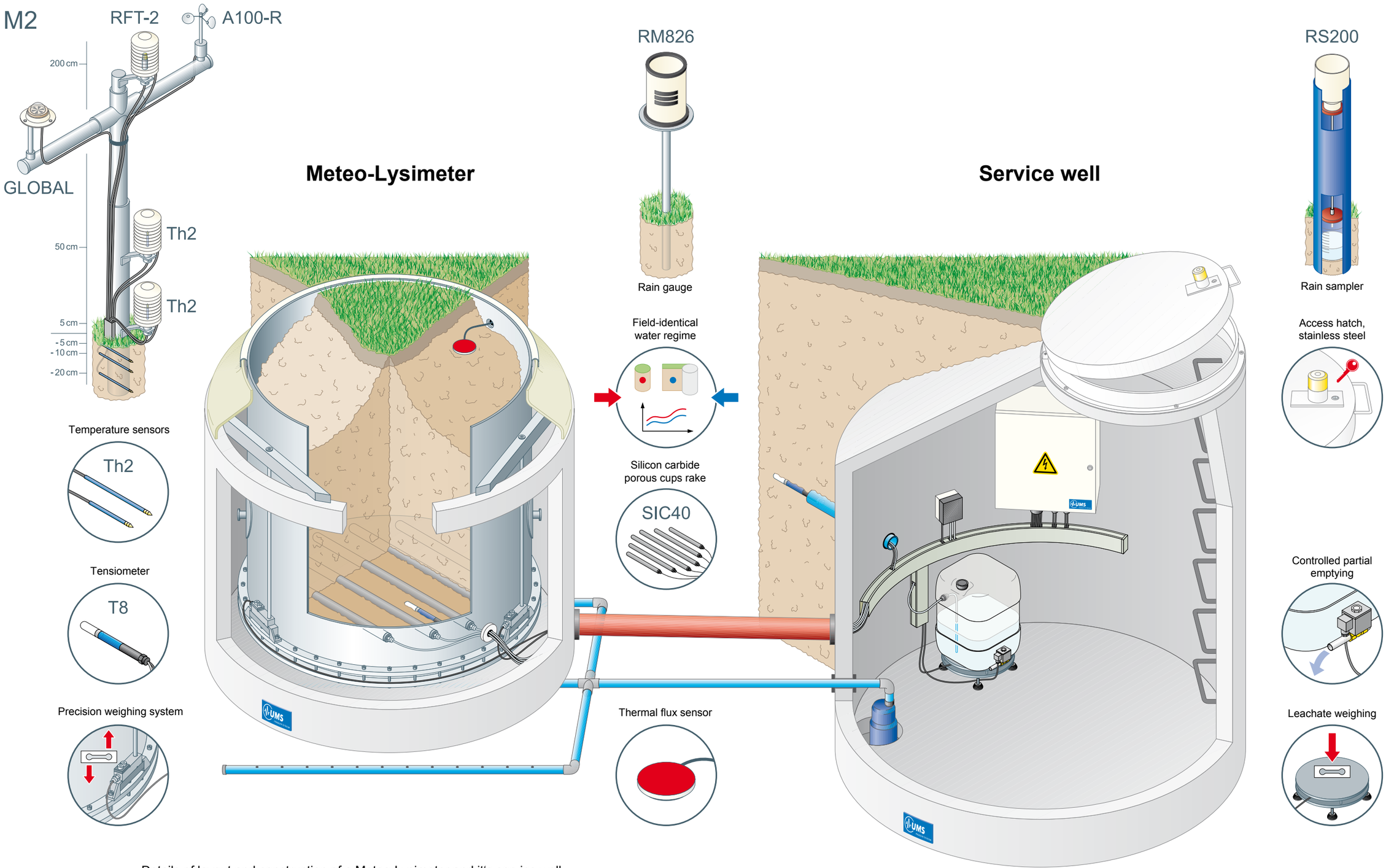
All from one source
We configure the Meteo-Lysimeter according to your needs, take care of the complete installation of your station, and support you with extensive training and documentation.

Content of supply
- UMS Lysimeter cylinder with silicon carbide porous cups rake
- Precision weighing system
- 2 pcs. T8 Tensiometers for regulation and supervision
- Weighable 60 l leachate tank with controlled partial emptying to 40 l
- Enclosure MBR-1 with data logger DT80, reverse flow peristaltic pump and power supply unit
- Lysimeter concrete well shaft
- Service well shaft (Ø 2.35 m; height 2.3 m)
- Float switch pump with drainage system

Weather station including:
- RFT-2 air humidity sensor, calibrated at 97% rH
- Th2 temperature sensors: -20, -10, -5, +5, +50, +200 cm
- Thermal flux sensor in 20 cm
- GLOBAL pyranometer
- RM826 rain gauge
- 4 pcs. RS200 rain samplers
- A100-R wind speed sensor
- M2 mast with sensor mounts

Technical Information	
Surface	1 sqm
Soil column depth	1.5 m
Outer diameter	1.65 m
Total height	1.85 m
Water flux resolution	0.01 mm/10 g
Silicon carbide porous cups rake (active surface)	5100 sqcm

Measurement of water balance parameters and weather data considering soil surface and soil water properties



Details of layout and construction of a Meteo-Lysimeter and it‘s service well

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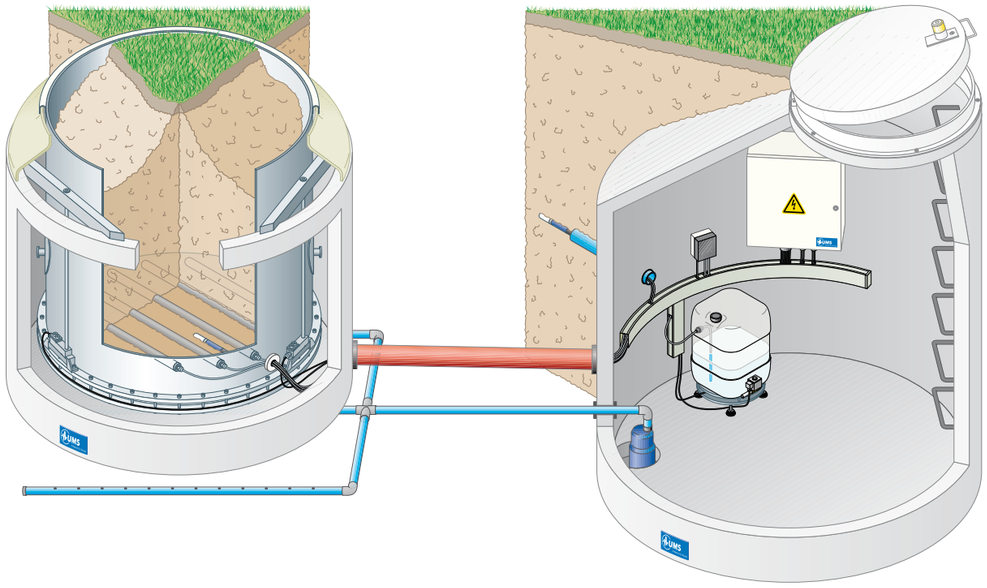
Field-identical measurement of precipitation as well as determination of true evapotranspiration and leachate rate



The Hydro-Lysimeter with service well

Installation of the Hydro-Lysimeter

Rime and dew can also be dominant, and are measurable with the Hydro-Lysimeter

The Hydro-Lysimeter supplies you with the most important water balance parameters with precision and reliability.

Substantial data for professional water management, long-term monitoring and assured projections
Is your task to calibrate and evaluate water balance models with real data? Then you need precise data about precipitation, precipitation intensity, evapotranspiration and leachate. The Hydro-Lysimeter offers them as continuously measured data. If you are a water supplier, a state or federal institution, involved in water management or a hydrographic service you receive substantial information for decision-making, monitoring or projections.

Advantages of the UMS system solution
The key benefits of the Hydro-Lysimeter are:
1. You receive highly resolved and precise data about precipitation and evapotranspiration on the site, measured directly on the soil surface. Mass change measured with an accuracy of 100 grams (0.1 mm precipitation) and a resolution of 10 grams (0.01 mm). Leachate measured with an accuracy of 10 grams and a resolution of 1 gram.
2. Measure fractions of precipitation from dew and rime. Depending on the location these can cumulate to up to 100 mm in a year's water balance.
3. Calibrate water balance models against true mesoclimatic conditions. Measure field-identical evapotranspiration, the real-time evapotranspiration on the surface under true climate and water conditions.
4. The amount and composition of leachate is gained under field-identical conditions for determination of the groundwater recharge rate in real time with high resolution.
5. Precipitation is measured directly on the soil surface considering real wind conditions, soil moisture and vegetation. Due to the relatively large surface of 1 square meter you get the best possible precipitation data.
6. UMS Lysimeters supply information about the true water conversion processes taking place on the surface down to a selectable soil depth.

Other advantages
- Field-identical water regime;
- Field-identical temperature regime in the Lysimeter;
- Connection to Ethernet, remote control by GSM or GPRS;
- An optional tool for snow measurement automatically offers additional information about the water equivalent of snow;
- Standard Lysimeter height is 1.5 meters. If required a height of up to 2 meters is available.
- The evapotranspiration determination is done by weight measurement, not by evapotranspiration models.

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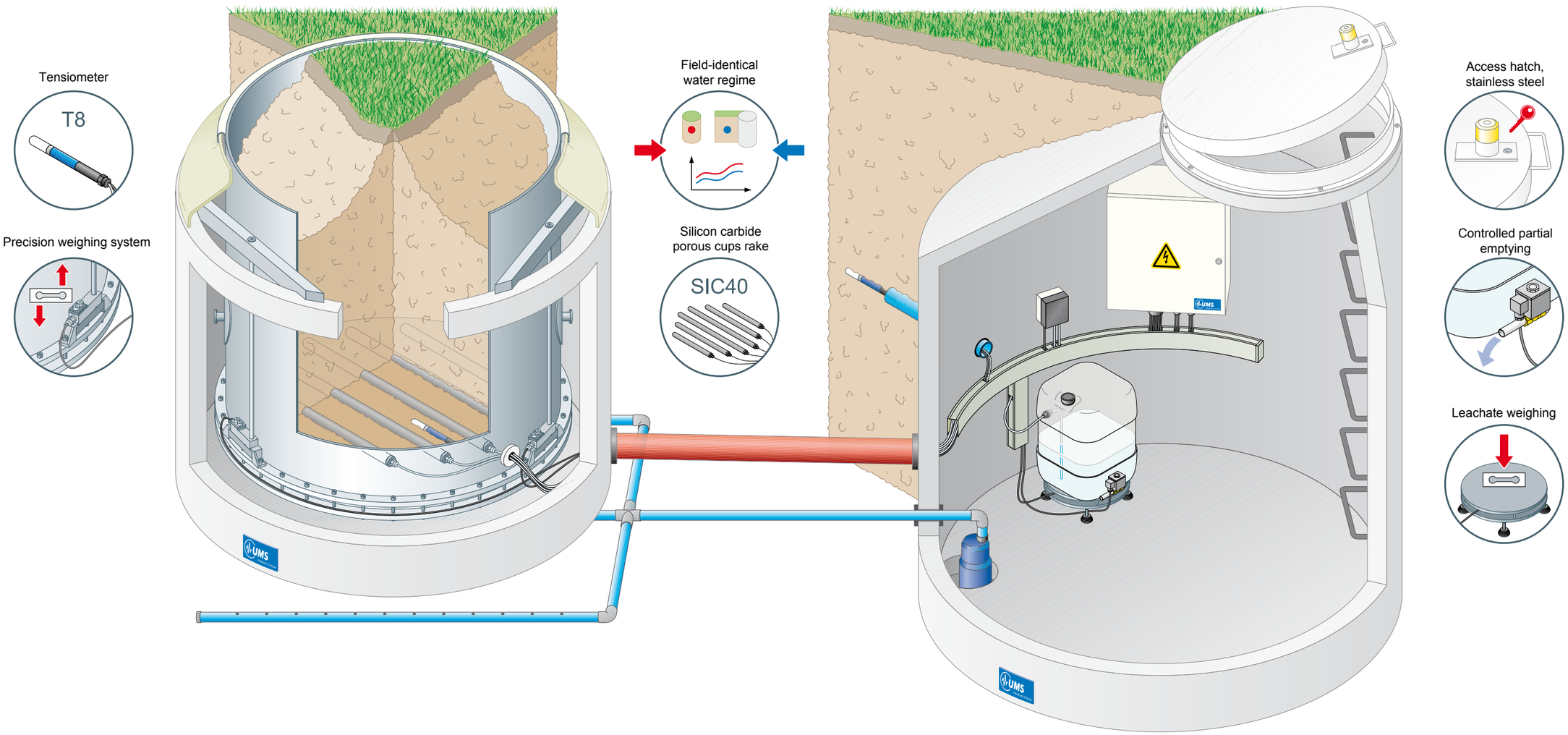
Field-identical measurement of precipitation as well as determination of true evapotranspiration and leachate rate

Hydro-Lysimeter

Service well



Details of layout and construction of a Hydro-Lysimeter and it‘s service well

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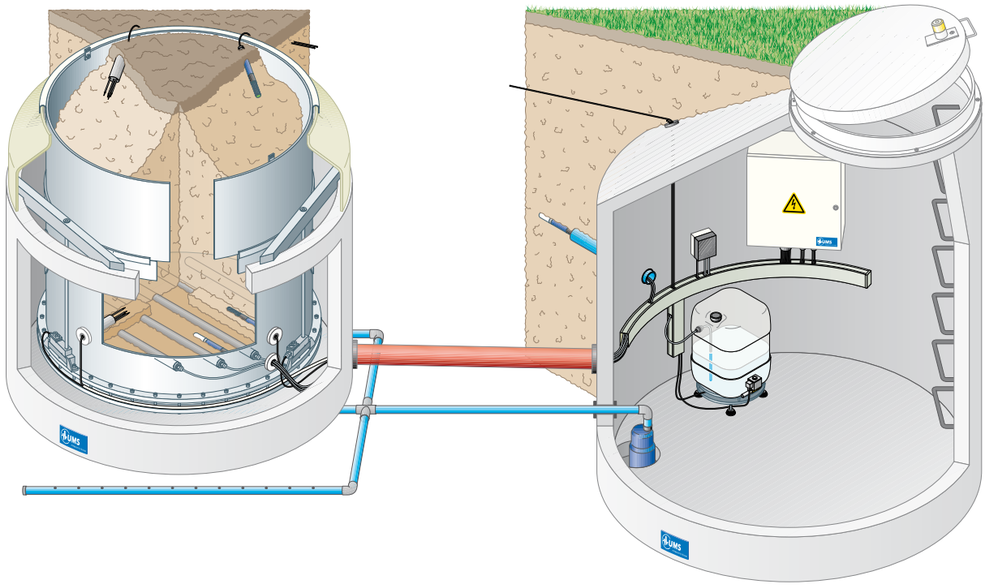
Cultivation based on substantial data for optimized yield and groundwater protection



The Agro-Lysimeter with service well

Lysimeter with installed sensors, field sensors in the background

Agro-Lysimeter after machined farming

The Agro-Lysimeter visualizes the availability of water and fertilizer, and measures precipitation, evapotranspiration and leachate.

Field-identical measurements for sustainable agriculture and long-term groundwater protection
Do you need to know where and when water and fertilizer are available for plant use? Or when fertilizers leach into the groundwater? These are just two fundamental questions required for sustainable agriculture. Questions that can be answered by the Agro-Lysimeter.

Advantages of the UMS system solution
1. Water balance and matric potential, offering information about water availability and water stress, are measured within a defined volume in the depths of the main root zone.
2. Water content and matric potential are also measured beneath the main root distribution zone – to give early warning of over fertilization and over irrigation.
3. The amount and composition of leachate is gained under field-identical conditions and stored in the cool service well.
4. You receive highly accurate and precise data of precipitation and evapotranspiration measured directly on the soil surface. Mass change measured with an accuracy of 100 grams (0.1 mm precipitation) and a resolution of 10 grams (0.01 mm). Leachate measured with an accuracy of 10 grams and a resolution of 1 gram.
5. Option: Pore water samplers in both zones collect soil water leachate samples. Analysis of the leachate information is used to determine the availability of fertilizers and the potential threat of groundwater contamination.

Other advantages
- Field-identical water regime;
- Field-identical temperature regime in the Lysimeter;
- Connection to Ethernet, remote control by GSM or GPRS;
- An optional device cuts snow automatically to enable weighing also during snow coverage.
- Standard Lysimeter height is 1.5 meters. If required a height of up to 2 meters is available.
- The evapotranspiration determination is done by weight measurement, not by evapotranspiration models.
- The upper ring section of the Lysimeter cylinder can be lifted off for tillage. Besides, the load cells are hung out and the Lysimeter is affixed. Then, conventional tillage operations with agricultural machinery is possible on the Lysimeter soil as well.

Content of supply:
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- Precision weighing system
- 2 pcs. T8 Tensiometers for regulation and supervision
- Weighable 60 l leachate tank with controlled partial emptying to 40 l
- 2 pcs. FD/TDR soil moisture probes
- 2 pcs. SIS matrix sensors
- Enclosure MBR-1 with data logger DT80, reverse flow peristaltic pump and power supply unit
- Lysimeter concrete well shaft
- Service well shaft (Ø 2.35 m; height 2.3 m)
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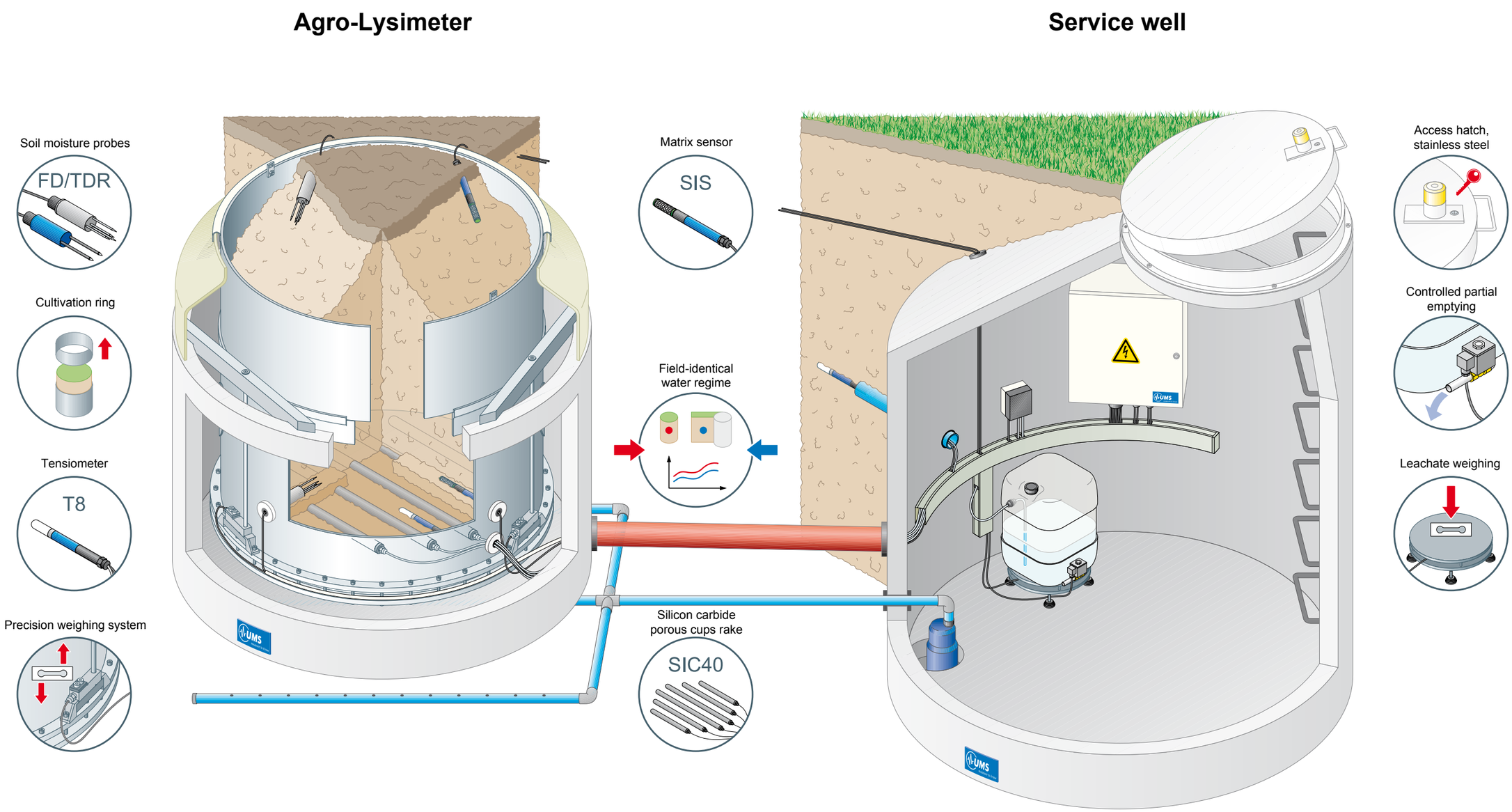
Cultivation based on substantial data for optimized yield and groundwater protection



Details of layout and construction of a Agro-Lysimeter and it's service well

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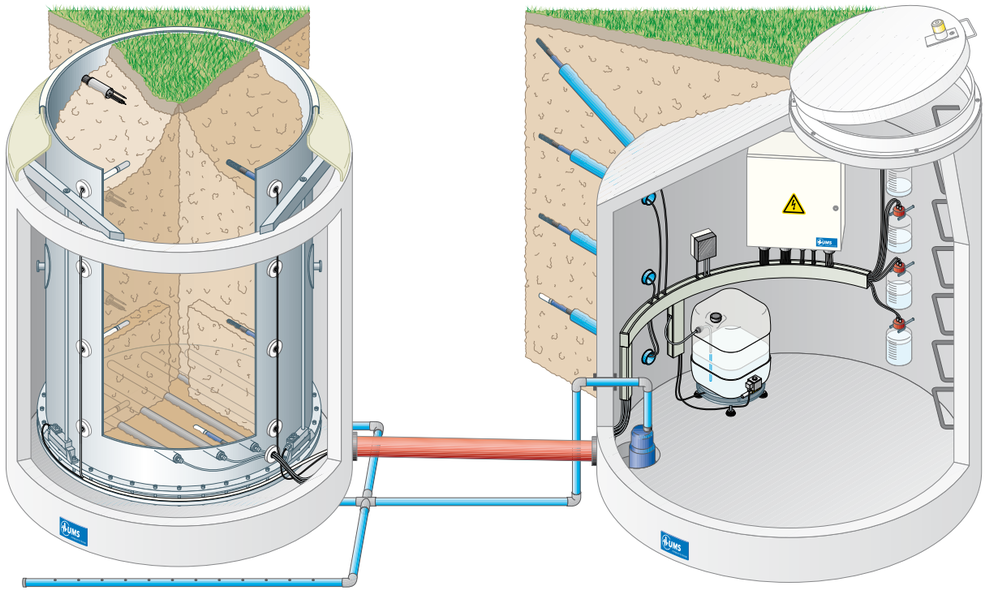
Laboratory precision – under rough field conditions



The Science-Lysimeter with service well

Lysimeter with installed sensors

Science-Lysimeter with climate chamber

The Science-Lysimeter is our modular precision measurement system for scientific studies and research in soils.

High-end measuring technology offers reliable data for research.
Soil conservation is a primary aim. The knowledge about the soil's function and usefulness as „buffering zone" and interface to atmosphere is fundamental and essential for future-oriented food production.
With the variety of variables and parameters research work becomes a complex scientific challenge.
The Science-Lysimeter has been designed as a modular and configurable system for investigation of soil specific properties, soil utility and conservation. The Science-Lysimeter can be configured to match the task and research aim.
These Lysimeters combine the advantages of laboratory and field investigations as they offer laboratory precision even under rough field conditions.

Advantages of the UMS system solution
1. The Lysimeter can be equipped with Tensiometers, TDR-/FD-probes or pore water samplers in different depths to receive depth specific information about water dynamics.
2. Identical probes are installed in the field as a reference.
3. Thus, mass balances and other results can be extrapolated from a defined Lysimeter volume and surface to a wider or increased area.
4. The instrumentation can be customized and specifically selected according to your research task.

Other advantages
- Field-identical water regime;
- Field-identical temperature regime in the Lysimeter;
- Connection to Ethernet, remote control by GSM or GPRS;
- An optional device cuts snow automatically to enable weighing also during snow coverage.
- Standard Lysimeter height is 2 meters.
- The evapotranspiration determination is done by weight measurement, not by evapotranspiration models.
- T8 Tensiometers for precise matric potential measurement;
- Silicon carbide suction cups for low sorption soil water sampling;
- Depth-graded, detailed information;
- Easy to maintain by functional lifting bolts and pluggable and addressed cabling and pluggable tubing.

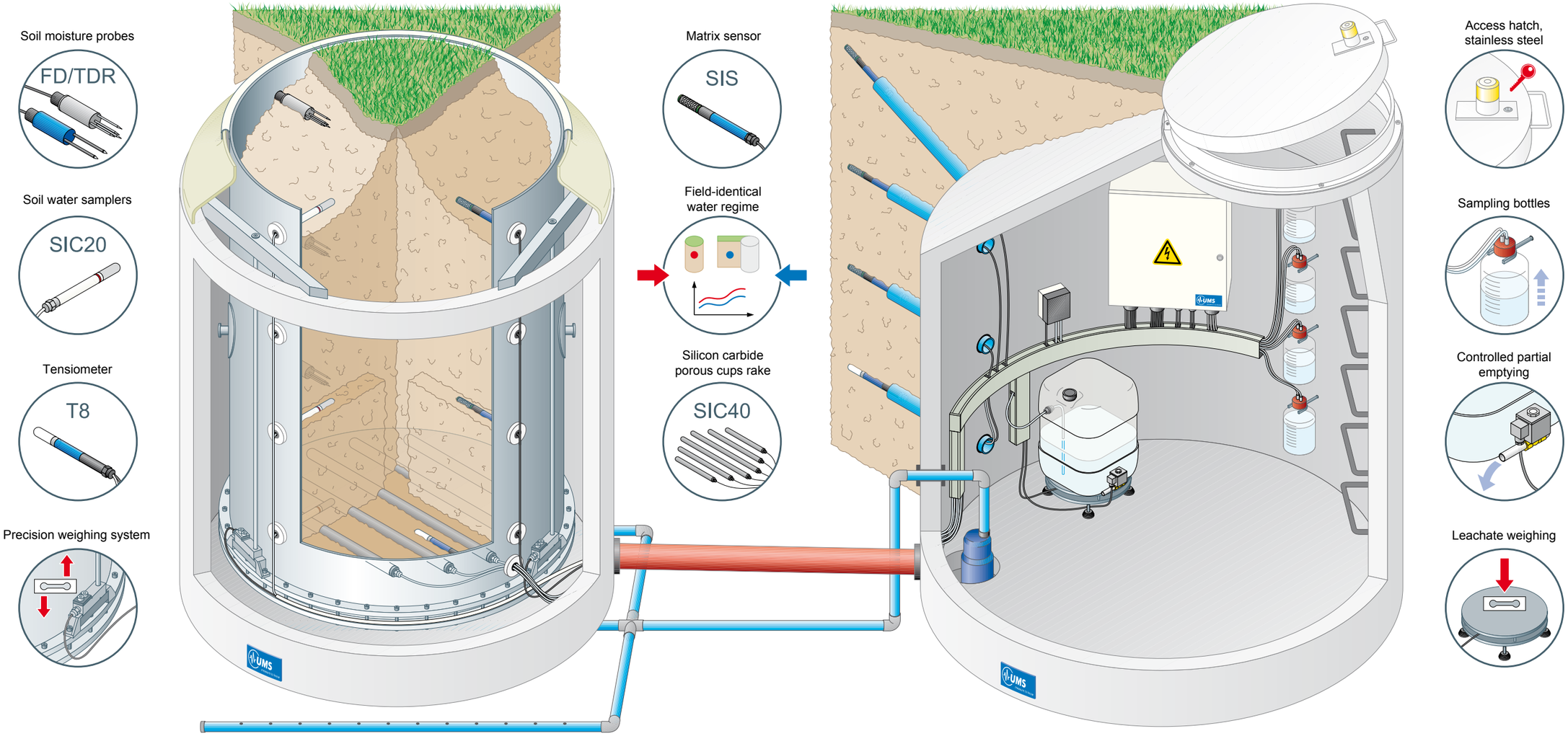
Content of supply:
- UMS Lysimeter cylinder with silicon carbide porous cups rake
- Precision weighing system
- 2 pcs. T8 Tensiometers for regulation and supervision
- Weighable 60 l leachate tank with controlled partial emptying to 40 l
- 8 pcs. FD-soil moisture probes
- 6 pcs. SIS matrix sensors
- 8 pcs. SIC20 soil water samplers
- 8 pcs. SF1000 sampling bottles
- 1 pc. VS-pro vacuum controller
- Enclosure MBR-1 with data logger DT80, reverse flow peristaltic pump and power supply unit
- Lysimeter concrete well shaft
- Service well shaft (Ø 2.35 m; height 2.3 m)
- Float switch pump with drainage system

Technical Information	
Surface	1 sqm
Soil column depth	2 m
Outer diameter	1.65 m
Total height	2.35 m
Water flux resolution	0.01 mm/10 g
Silicon carbide porous cups rake (active surface)	5100 sqcm

Laboratory precision – under rough field conditions

Science-Lysimeter

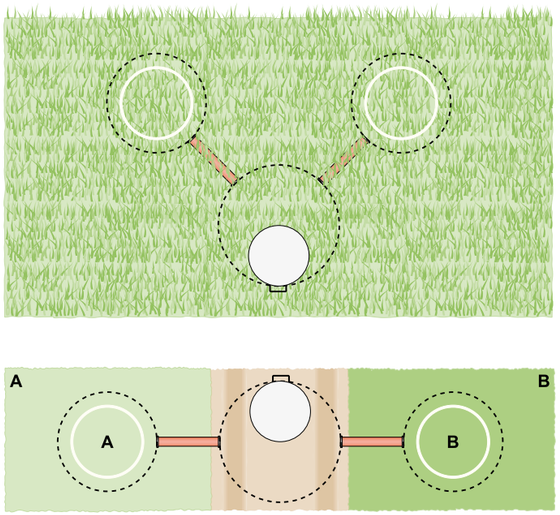
Service well



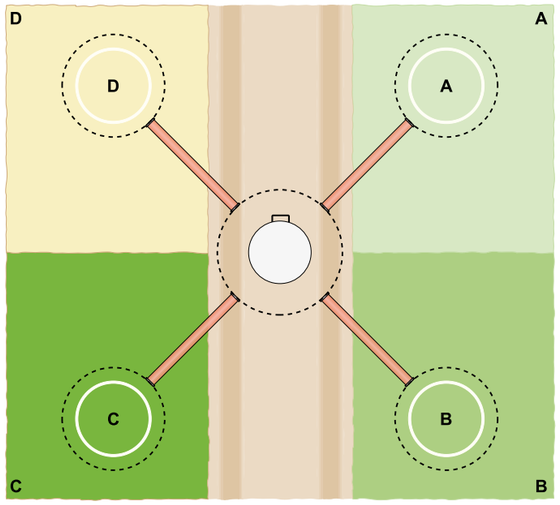
Details of layout and construction of a Science-Lysimeter and it‘s service well

UMS GmbH ● Gmunder Str. 37 ● 81379 Muenchen ● Germany ● Tel. +49 (0) 89/ 12 66 52-0 ● Fax +49 (0) 89/12 66 52 20 ● www.ums-muc.de

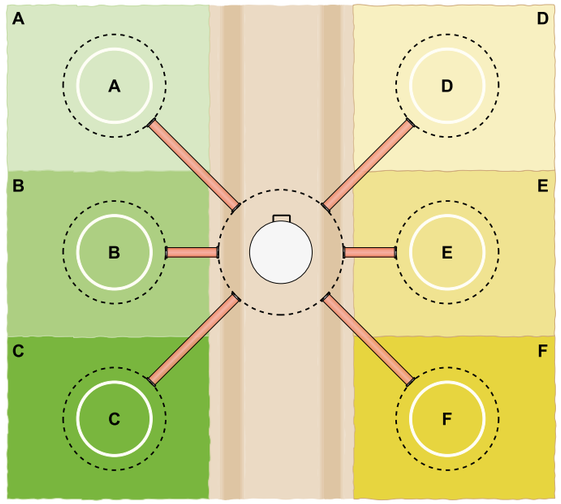
Increased monitoring capacity for comparison of various cultivation treatments



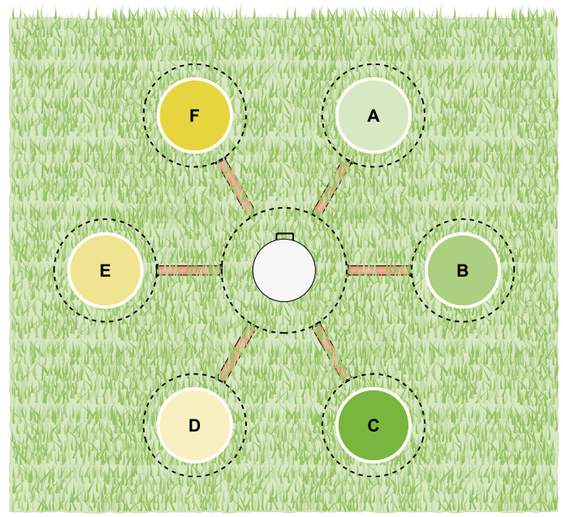
At the top: 90 Degree layout
At the bottom: Duplex field layout (Wagna)



Tetragon layout



Hexagon linear layout (HBLA-Raumberg)



Hexagon circular layout (TERENO)

Stations with several Lysimeters increase your measuring capacity. Or compare the effects of various treatments of fertilization or irrigation under identical climatic conditions.

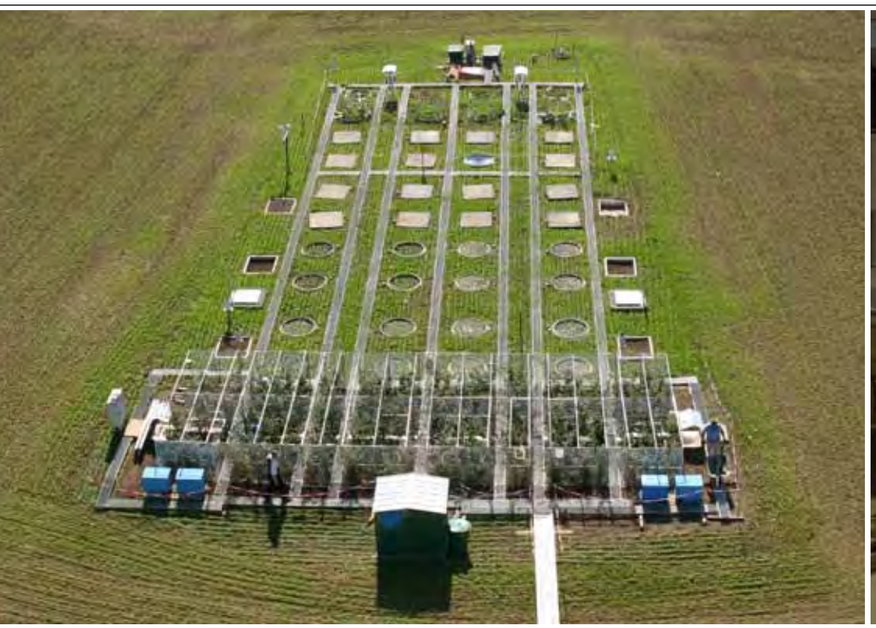
Two or more UMS Lysimeters for comparative studies
To determine various treatments at one site, two or more Lysimeters are connected to one logger and one service well. Depending on your requests and local conditions Lysimeters can be installed in sets of two.
They can compare diverse cultivation methods and crop rotations, as well as conventional and organic farming. For comparison studies on the same soil but with different treatments (fertilization, irrigation or CO_2 treatment) up to 6 Lysimeters can be connected to one logger and service well.

Advantages of a tetragon layout
The service well is installed in the corner of four fields. The length of the connection pipes is flexible, so the Lysimeters can be placed far inside the field to minimize any influences from beyond the boundary ridge.
If the Lysimeters should be cultivated with machines use Agro-Lysimeters with removable rings (see Agro-Lysimeter).

Advantages of a linear layout
To compare various crop rotations or variations from **A to F** in a linear alignment a parcelling of the Lysimeter surrounding is recommended as this is easier to cultivate.
Linearly aligned Lysimeters are also recommended if autonomous robots or automatic systems for irrigation and tracer application or gas treatment hoods are used.

Advantages of a hexagon layout
For projects aiming at a comparison of soils under changed climatic conditions the Lysimeters can be arranged as a ring. Then, the soils are brought in from different locations and are exposed and surveyed under changed climatic conditions.
Because of the the geometric similarity of the hexagon layout the Lysimeters are exposed to equal conditions which is especially advantageous for comparative studies. Then, Lysimeters **A to F** are filled with different mesocosmos from various locations, or represent the variability of one ecosystem.

Research platform for interdisciplinary projects with 48 Lysimeters



Site from the bird's eye view

View of the service cellar

View of the station from the field

The aim of this station is the exploration of complex eco systematic processes and to reveal physical, chemical and biological processes in the soil.

Research platform for different tasks
This station is the common platform for scientists of the Helmholtz-Research-Center as well as for interdisciplinary research cooperation.
Remarkable features are the modular design and the possibility to observe the station more or less from one control room.

A representative "copy" of the field
The Lysimeters are placed in the center of a one hectar large field, thus island effects are minimized. The soil soil columns were taken from different locations and each has a volume of 2 cubic meters. These soils or mesocosmos are used for comparative studies. Meteorological data is measured parallel and is available for users together with the soil and water data.
The Lysimeter station closes the gap between field and greenhouse experiments or exposition chambers and offers advantages of determining processes in naturally embedded soils.

Measurement of nearly all soil relevant data
The soil columns are equipped with sensors in five depths, for example tensiometers, TDR probes, temperature probes and pore water samplers. For monitoring root growth empty tubes for inserting a camera can be installed. By using soil gas samplers chemical and microbial processes are detectable.
A further main aspect is the soil's balance of substance. For measuring substance migration 16 of the 48 Lysimeters were placed in a monitored area where tracer experiments with radioisotopes or conservative tracers can be executed without endangering the surroundings.

For climate research projects 16 Lysimeters were equipped with a soil surface heating device. Thus, the soil temperature of these Lysimeters can be raised with a selectable temperature in comparison to a reference Lysimeter.

Flexible adaptation for new types of task
The station was particularly designed that all service or maintenance work as well as the mounting or replacement of Lysimeters can be executed without disturbing the surrounding field. To achieve this, a service cellar was built.
New Lysimeters are lowered offside the field and brought to their position via a subterraneous corridor. Then they are equipped with the required instrumentation and lifted so the cylinder rim is at the same level as the field surface.

From first conceptual thoughts to final servicing – all from one source
UMS has been involved in the setup of the station since the conceptual design started in 1991. UMS has supplied and installed the measuring equipment, data loggers, networking, pore water samplers and vacuum systems and performed the initial operation.
Now, for more than 15 years UMS has supported the Research Center by taking care of on-site service, maintenance and repairs.

Reference Univ. Doz. Dr. Eckart Priesack, Helmholtz-ResearchCenter Munich, Institute of Soil ecology:

„We'd like to express our thanks for many years of good cooperation with the company UMS in the development, set-up and operation of the Lysimeter station. Especially the excellent competence of UMS in soil physics, the prompt support and reliable on-site service contributed to the success of the experiments with our soil-plant-systems in Lysimeters."

Machine operated cultivation with no disturbance of the precision measurement

Lysimeter for machine operated cultivation

Agro-Lysimeter with removable cylinder section

Field with Agro-Lysimeter after sowing

This Lysimeter station allows comparative investigations of conventional and organic farming with a focus on ground water protection, nitrogen dynamics and water household under customary treatment.

Precision Lysimeter for machine operated and customary farming
The aim of the design was to develop a high precision weighable Lysimeter which still can be cultivated with standard machinery. The solution was that the upper part of the Lysimeter cylinder is a removable ring, and that the load cells can be fixed to be safe against overload. After farming the field the precisely fitting ring is reattached and weighing is restarted.

Field-identical water regime by controlled matric potential
The soil columns were cut down to the hydraulic water shed and fitted with the matric potential transmission. At this site, this method was realized for the first time in the current version.
Both matric potential in the field as well as inside the Lysimeter column are measured simultaneously and compared. If the Lysimeter soil has more moisture than the soil in the field, water is withdrawn from the soil above the Lysimeter's bottom plate through the suction cups rake. In reverse, water is injected in case the Lysimeter soil is too dry. Thus, a field-identical water regime inside the Lysimeter is established.

Video surveillance to avoid erroneous measurements
The station is under video surveillance and can be remote controlled either by the operator or UMS. This minimizes the danger of data loss, and with the daily or event-triggered monitoring the progression of data can be followed.
With the review of the video recording weight changes caused by animals can be detected. Then the changes are not counted as precipitation.

System for model calibration of physical and chemical processes
The meteorological station measures all parameters which are required for modelling the water balance in comparison with the Lysimeter readings.
The meteorological station measures wind speed in a height of 2 meters and 4 meters, air humidity, air temperature, barometric pressure, surface identical precipitation (with precipitation gauge and sampler), solar radiation and net solar radiation over the Lysimeter.
The real evapotranspiration (ET) is determined from the Lysimeter mass changes, precipitation and leachate amounts on different time scales. The grass reference evapotranspiration (ET_0) is calculated from the meteorological data.

UMS meteorological sensors and precipitation are measured separately and versus the climatic data from the ZAMG (Central Institute for Meteorology and Geodynamics, Austria). As a result redundant data sets are available for evapotranspiration modelling from the climatic data and the evapotranspiration measurement of the Lysimeter. Thus, this UMS Lysimeter system offers the possibility for model calibration of physical and chemical processes.

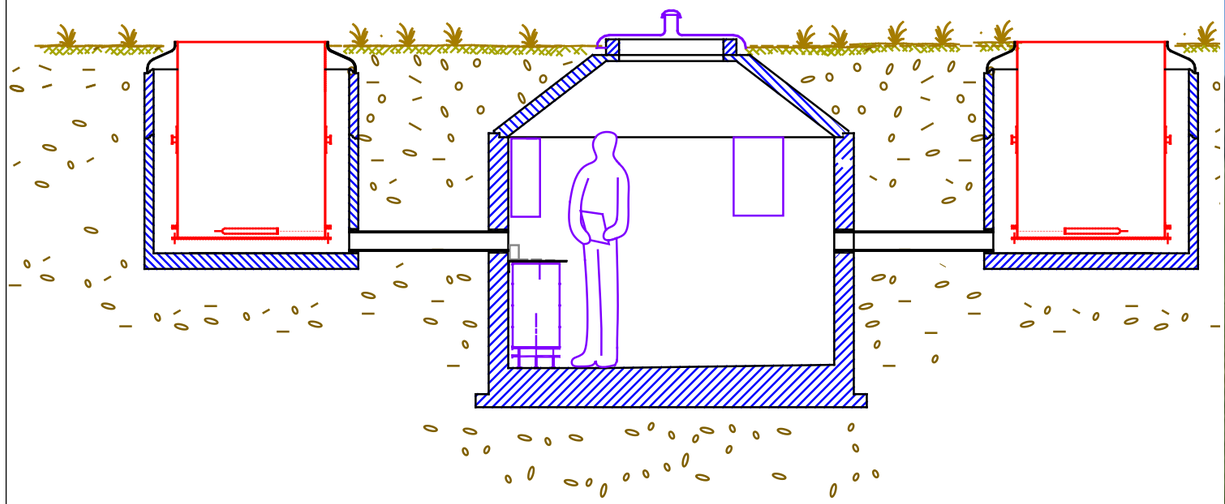
Further highlights of the station
Data from about 120 hydrologic and climate sensors are collected online by remote control, visualized, verified and stored in a high-performing database. In this case the data are evaluated and interpreted by algorithms developed by the institute. In addition, soil water solution is extracted from various depths for analysis of nitrate and ammonium transfer and conversion.

From first conceptual thoughts to final servicing – all from one source
UMS has been involved in the setup of the station since the conceptual design started in 1991. Following, UMS has supplied and installed the measuring equipment, data loggers, networking, pore water samplers and vacuum systems and performed the initial operation. Now, for more than 15 years UMS has been the partner of the Joanneum Research taking care of on-site service, maintenance and repairs.

Reference Univ. Doz. Dr. Johann Fank, Joanneum Research Wagna, Institute for WasserRessourcen-Management, President of the Lysimeter Research Group:
„Over the complete period of time from the conceptual design until the erection and launch of this complex Lysimeter site, including all concomitant soil hydrological measurements, the Joanneum Research Center has been accompanied by UMS as a competent and especially reliable partner. The cooperation in research, development and realization of innovative measurement technology for the protection of ground water supplies has been exemplary at any time.
Especially for inventive tasks UMS can be explicitly recommended as a partner in research and development.
It is our intention to realize further developments and new concepts insistently in cooperation with UMS."

UMS Lysimeter systems for the TERENO network

UMS-Lysimeter sites for the TERENO project in Germany



Cross section of the construction

18 lysimeters sites in Fendt/Bayern

UMS stations are part of research observatories spread across Germany and have the target to measure environmentally relevant effects of climate change in the agrosphere.

Network for environmental monitoring
TERENO (Terrestrial Environmental Observatories) is a research platform of the Helmholtz Association of German Research Centers, coordinated by the Research Center Jülich. The platform can and should be shared by universities and other non-university research institutes.
The observatories supply data which can be of importance for questions in the field of climate or environmental research, for example effects of climate change on ecosystems, analysis of interactions and reactions in the complex of soil-vegetation-atmosphere or the scale-comprehensive alignment of measurements and models.

Measure already today the effects of climate change in the agrosphere
The Karlsruhe Institute of Technology IMK-IFU, as partner of the Helmholtz-Initiative „TERENO“ installed a network of climate-feedback-stations in the Ammer catchment area in Southern Bavaria. The target is the long-term (>10 years) monitoring of effects on solute transport, soil fertility, water availability and water quality caused by global change factors (climate change, changes in land use).

Experiments are realized in a network of miniature Lysimeters with soil columns from different grassland locations and declining altitudes. The target is to determine and quantify biosphere-hydrosphere-atmosphere interchanges.
The soil columns are taken from a higher altitude to the measuring site at a lower altitude to achieve a natural temperature/precipitation gradient to simulate the anticipated climate change. Additionally, extreme events like heavy rain or intense drought can be experimentally simulated.
In connection with climatic and meteorological stations the following investigations should be accomplished:
- Energy, water and nutrition balances
- Emission of greenhouse gases (CO_2, N_2O, CH_4)
- Solute eluviations into the groundwater (e. g. NO_3, DOC, DON)
- Biodiversity (vegetation, soil biota)

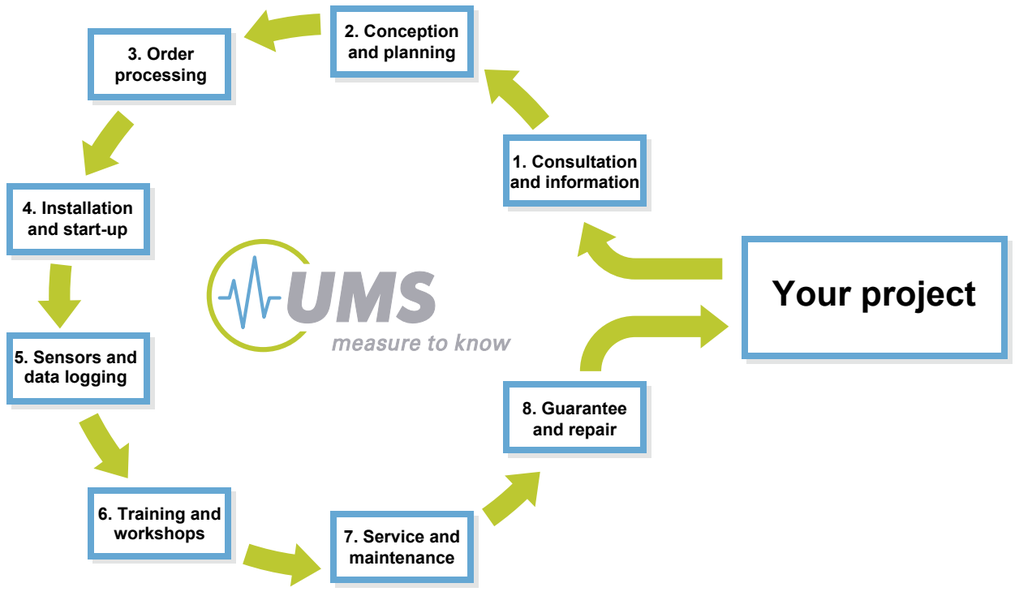
Reference
Dr. Ralf Kiese, KIT, Research Center Karlsruhe, IMK-IFU, Garmisch-Partenkirchen

Germanwide long-term monitoring on miniature ecosystems in Lysimeters: Soil–water resources–vegetation–climate–atmosphere
After 3 years of preparation UMS was charged with the installation of all in all 126 Lysimeters, each with approximately 3000 kilograms of soil material and from locations all over Germany.
The stations will be newly erected in 2010 with installation of 12 sites at four observatories, which are the Karlsruhe Institute of Technology (formerly Research Center Karlsruhe), the Research Center Jülich, the Helmholtz-Research-Center and the German Research Center for Geosciences in Potsdam.
All Lysimeters and stations have an identical design, which allows the direct comparison of the individual soils exposed to diverse climatic conditions.

From first conceptual thoughts to final servicing – all from one source
UMS supplies the equipment to all TERENO-SoilCan partners and is responsible for the installation and maintenance of this monitoring network.

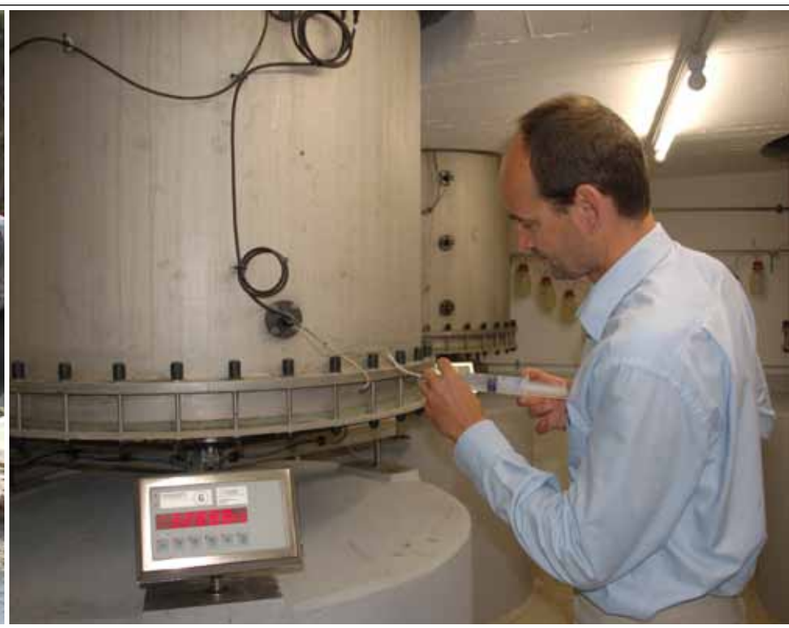
Reference Dr. Thomas Pütz, Agrosphäre (ICG-4), Research Center Jülich:
„UMS has been selected as supplier for the Lysimeter systems inside the project „TERENO-SoilCan“. UMS fulfilled the technical and the quality requirements completely.
Based on the competence in soil science and engineering and the excellent cooperation and long term relationship with UMS, we are looking forward to receiving professional setup and service for our new Lysimeter network.“

Complete solutions by one supplier – to avoid typical problems of coordination



The process chain for project planning, management and service

At the construction site



Refilling of a tensiometer with filling syringe

For the set-up of complete measuring solutions we offer the entire conception and planning, site management, installation, initial start-up, training and maintenance.

1. Consultation and information
When you get in contact with us we familiarize with your requirements and work out a raw concept for finding solutions. On this basis the decision is made to go on to the planning phase.

2. Conception and planning – detailed description of the facility
Within the planning phase a task description according to your individual targets is developed, and a specification list for the measuring equipment, installation, maintenance, data handling and interpretation is defined.
With this information a nonbinding quotation free of charge is worked out for you. In case of a call for tenders you will receive detailed descriptions of products and competences as well as the unique selling propositions.

3. Order processing – with distinct task sharing
Each order is processed by one manager in charge who is responsible for a correct and quickest possible delivery – a part of our approved quality assurance system.

4. Installation and start-up – because this is more than summarizing all component parts
This especially applies for the synchronisation of sensors, data loggers and sampling instruments that need to work reliably for many years, being easy to handle and requiring only low maintenance.
At UMS several graduated engineers are at your disposition to support, install and maintain your measuring systems.

5. Sensors and data logging – simply reliable
Our sensors, data loggers and soil sampling systems are optimally fitted. Our aim is that they operate reliably in the field for many years and require simple and minor support. Sensors are equipped with 1000-times proven connectors which are hermitically sealed, have gold plated pins, and guarantee maximum reliability and longevity. If necessary sensors can be easily connected to testing devices, and recalibration or replacement is uncomplicated.

6. Training and workshops – to work optimally from the very beginning
It is our aim that you get the appropriate instrumentation for your tasks, that you can work optimally with your equipment, and that you are content with it.
Therefore, we offer individual training and workshops for your new UMS system. You will be instructed on how to professionally handle the equipment, how to maintain it, and, if needed, how to calibrate these systems.
The training will be accomplished using examples with plausibility checks and interpretation of the data gained.

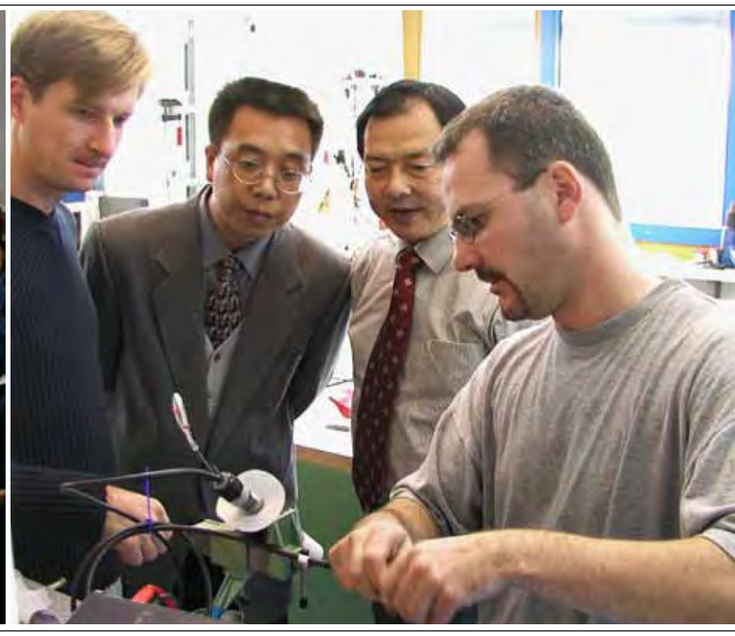
7. Service and maintenance – quick, reliable and available for years
We garantuee a long-standing support of your projects by our technicians and engineers. Repairs will be effected soonest possible in order to keep the loss of data low.
Our calibration service guarantees exact measuring results, a need for long-term projects.

8. Guarantee and repair, our responsibility for failures
A lifetime warranty is granted to our ceramic cups of T4 and T8 Tensiometers. In case a cup breaks you will receive a replacement free of charge. Any repair will be handled quickest possible.
In case of urgency a substitute unit will be provided temporarily in order to keep the dropout of your system short. Therefore, we keep many standard spare parts on stock.

„It is our aim to give you best possible support in your tasks.“

Our team

Workshop about „Pore water sampling“ at UMS in Munich



Trainings at customer site or at UMS: filling and checking of T4 Tensiometers

This is the guiding principle for our complete range of activities – from the first contact to order processing and our after-sales service.

Our team gladly supports you
At UMS our professional employees are at your disposition for any questions at any time. On the photo you see in the back from left to right:
Georg von Unold (Dipl.-Ing., managing director),
Martin Naleppa (Dipl.-Ing., export sales manager),
Renate Kerscher (Dipl. comm., public relations),
Tommy Keller (Dipl.-Ing., system engineer),
Marius Kischel (precision engineering, assembly),
Andreas Steins (Dipl.-Ing., development),
Stefan Engelhardt (Dipl. Geogr., Lysimeter technics)
In front left to right:
Axel Rescher (Dipl.-Ing., system engineering, maintenance),
Jessica Oschmann (export processing),
Thomas Pertassek (Dipl.-Ing., BaPS, software, sales),
Jola Nazar (Production),
Sonja Gassner (Dipl.-Ing., financial/personnel accounting),
Andreas Schürr (apprenticeship),
Udo Weiß (master technician, precision mechanics, workshop manager)
Not shown on the picture:
Rita Baur (Dipl.-Ing., production management INFIELD, HYPROP, BAPS, TS1),
Petra von Unold (Dr. Dipl.-Chem., UMS Soil-Lab services),
Carlis Sypereck (metalworker),
Wolfgang Sedlmeier (master technician, electronics, irrigation systems)
Ika Popovic (kitchen and cleaning lady).

UMS in short
Establishment of U&P GmbH in 1987
Development of tensiometers and monitoring systems
Establishment of UMS GmbH in February 1991
Associates: Dr. Petra von Unold und Georg von Unold
Managing director: Georg von Unold

Basic data 2009
- 18 employees
- Realized measuring systems: more than 500
- 100% self-financed

Premises
Gmunder Strasse 37, D-81379 Munich, Germany
1000 sqm at the MGH, Munich Commercial and Technology Center with sufficient space for testing and test set-ups, including outdoor test area.

UMS Soil-Lab services
Soil physics laboratory for determination of pF/WC and K/Psi curves by customer order.

UMS quality standard
UMS is certified by the DIN EN ISO 9001:2008 quality standard since 1996.

UMS is a member in the following societies:
- German standardization committee (DIN) NAW I 2/UA5/AK4 for the standardization of pore water sampling and sampling methods
- ATV-DVWK
- Network of Competence for Water
- Lysimeter Research Group
- DBG - German Soil Scientific Society
- ÖGB - Austrian Soil Scientific Society

Global partnerships
As a confidential partner UMS cooperates with the following companies and represents their products in the German and/or Austrian market:
- Decagon Devices
- Delta-T Devices
- Eijkelkamp Agrisearch Equipment
- Sentek Sensor Technologies
- Soilmoisture Equipment Corp.

UMS workshops – platform for interchange of experience
On our workshops actual lectures, presentation of new solutions, debates and discussions of various themes take place. They serve as a neutral platform for the interchange of experiences with colleagues and will help to optimize implemented methods and techniques. Mostly these workshops also provide hands-on sessions on sensors, loggers and other equipment in the afternoons.

UMS product catalogue – our entire portfolio
Beside the brochure on hand there is also a UMS-product catalogue available. You can download a pdf-file version either via internet or send a request by email to sales@ums-muc.de.

UMS in the internet – detailed information
Do not hesitate to visit our website www.ums-muc.de for further literature, manuals of our products and up-date information.

UMS newsletter – always up-to-date
Our newsletter can be subscribed via our homepage. It will be issued about 3 times a year and will supply you with the latest information on our products and systems.

Your UMS business partners

Georg von Unold
Consulting focus: measuring systems, contracting and warranty

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Fax + 49 (0) 89-12 66 52-20
gvu@ums-muc.de

Georg von Unold has been involved with Lysimeter design and installation since 1986. Since then he has successfully installed hundreds of Lysimeters.
Mr. von Unold's focus has been to design and manufacture Lysimeters that work with the accuracy of a laboratory design in the environment conditions of the field.
The combination of his education in mechanical engineering and 20 years of experience in soil scientific instrumentation has allowed him to work with scientists to make the best Lysimeters possible for their research requirements.

Stefan Engelhardt
Consulting focus: Lysimeter systems

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Stefan Engelhardt joined UMS in April 2009. He came from the University of Göttingen where he studied geography, chemistry and soil science.
Mr. Engelhardt has experience in working as an environmental consultant and researcher. He has extensive experience in studying the hydrologic cycle and enjoys the planning and implementation of research projects.
In 2009 he was responsible for the installation of Lysimeter systems in Germany, Austria, Italy and China.

Tommy Keller
Consulting focus: monitoring systems

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Tommy Keller has studied physical engineering at the University of applied science of Ravensburg/Weingarten.
From 1988 he worked for the Helmholtz-Research-Center, Munich (Institute of biochemical plant pathology).
From 1996 to 2003 Mr. Keller was associate and managing director of UP GmbH. After 3 years working as a sales engineer at SEBA-Hydrometrie he has been system engineer at UMS since 2006.
Mr. Keller is also responsible for products of our business partners Decagon und Delta-T and for monitoring systems.

Andreas Steins
Consulting focus: measurement and system engineering, data logger

Tel. + 49 (0) 89-12 66 52-18
Fax + 49 (0) 89-12 66 52-20
as@ums-muc.de

Andreas Steins is a graduated engineer for, focused on electronical engineering. Already a few years after finishing his thesis on wireless sensor networks in 1998, he took over the department of development.
Mr. Steins is your contact person for electronic system development, control and data technology.

Markus Berkmueller
Consulting focus: after sales services
Tel. + 49 (0) 89-12 66 52-23
Fax + 49 (0) 89-12 66 52-20
mb@ums-muc.de

Markus Berkmueller studied electronic engineering at the University of applied sciences in Munich. He worked for ten years in the field of electronic sensing, simulation and data analysis. Mr. Berkmueller is your consultant engineer for sensors & data logging related to Lysimeter solutions and monitoring systems.

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