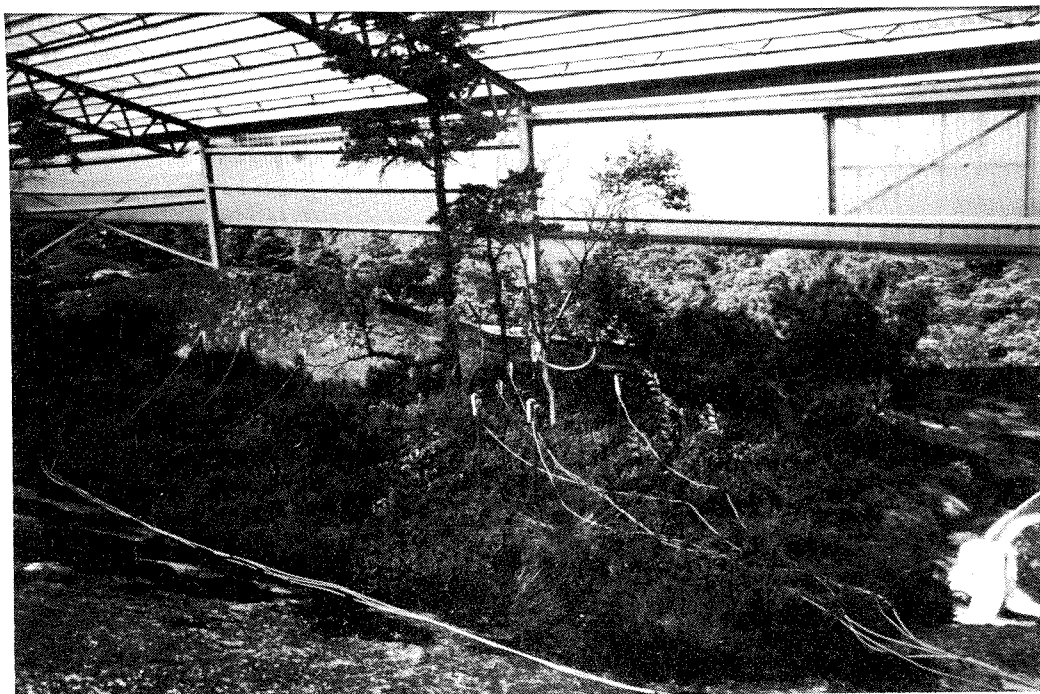


# Acid Rain Research

REPORT 14/1988

Water and Ion Movement through a Minicatchment  
at Risdalsheia, Norway (RAIN-project)



# NIVA - REPORT

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At Risdalsheia (Southernmost Norway) the relation between water flow paths and streamwater chemistry through a small headwater catchment was investigated. The importance of these pathways for the interaction between soil solution and runoff chemistry was investigated by a tracer experiment with LiBr. The experiment was designed using all available information about ion transport at EGIL-catchment in a simple model that predicted the breakthrough curve for a given tracer input. The unique facility of a roofed catchment allowed attainment and maintainance of a hydrological steady-state under highflow conditions during this tracer experiment. The chemical changes of the moving soil water due to soil/soil solution interaction mainly occurred during vertical (unsaturated) infiltration. Most ions reached their runoff concentration levels after these few cm of vertical infiltration. Only the ions  $SO_4$ ,  $NO_3$ , and H increased along the saturated lateral flow path. Subsurface, translatory flow and equilibrium reactions along vertical infiltration flow paths are the key processes that explain the behavior of stormflow chemistry at the EGIL-catchment.

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**Water and Ion Movement through a Minicatchment  
at Risdalsheia, Norway (RAIN-project)**

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**Abstract**

At Risdalsheia (Southernmost Norway) the relation between water flow paths through a small headwater catchment and streamwater chemistry was investigated. Runoff at the EGIL-catchment (398 m<sup>2</sup>) is acidified and stems from a thin, patchy, and poorly developed soil. The whole catchment is covered by a roof that extends 2-3 meters beyond its boundaries. This setup provides an unusual opportunity possibility to control catchment hydrology. The patterns of soil water movement during storm runoff were identified by automatically recording tensiometers. Even under flow conditions equivalent to 50 (mm.day<sup>-1</sup>) no signs of surface flow or components bypassing the soil were found. Flow occurred near the soil surface and was mixed with resident soil water.

The importance of these pathways for the interaction between soil solution and runoff chemistry was investigated by a tracer experiment with LiBr as the tracer solute. The tracer episode followed a 4-week dry period without runoff. The experiment was designed using all available information about ion transport at EGIL-catchment in a simple model that predicted the breakthrough-curve for a given tracer input. The model is valid for a simple flow region and constant flow

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conditions. The unique facility of a roofed catchment allowed attainment and maintainance of a hydrological steady state under highflow conditions during this tracer experiment.

The soil solution was monitored by lysimeters at various soil depths. Breakthrough of the tracer occurred two hours after application and peak concentrations of about 25% of the input level indicate intensive mixing with soil water during transport. Br was recovered in 11 of 13 lysimeters.

The chemical changes of the moving soil water due to soil/soil solution interaction mainly occurred during vertical (unsaturated) infiltration. Most ions reached their runoff concentration levels after these few cm of vertical infiltration. Only the ions  $\text{SO}_4$ ,  $\text{NO}_3$ , and H increased along the saturated lateral flow path.  $\text{SO}_4$  in runoff was in excess of the input concentration level as typical for rewetting episodes after extended dry periods. Due to the lateral and vertical chemical gradients in the soil solution this  $\text{SO}_4$  was partly derived from oxidation in stagnant pockets of the soil.

Subsurface, translatory flow and equilibrium reactions along vertical infiltration flow paths are the key processes that explain the behavior of stormflow chemistry at the EGIL-catchment. Due to the short residence time of soil water, dilution occurs on a time scale of few hours, and its effects can be observed within a single episode. With increasing catchment size dilution processes affect streamwater chemistry within a series of episodes (time scale: days) or among seasons (time scale: weeks-months). The vertical extent of the vadose zone and the total amount of soil water that is able to mix with event water should be used when comparing runoff chemistry among catchments.

## 1. Introduction

The generation of storm runoff in natural, highly responsive catchments is not well understood. The key processes can be investigated in terms of their physical and chemical aspects. The research in this field, however, has been little coordinated between these two aspects (*Kennedy et al.* 1986). Runoff research has traditionally been based on physical methods and has lead to the variable source area concept. Within the last decade, there has been an increasing number of isotope and chemical studies of runoff from small forested catchments. Results from this work changes the emphasis within the variable source area concept from saturated overland and rapid macropore

flow to subsurface, translatory flow as the dominating process in runoff generation (*Kennedy et al. 1986, Pearce et al. 1986*).

Acidification of surface waters by acid deposition is concentrated in areas such as southern Norway that represent examples of highly responsive catchments. Soil processes play a key role in the transfer of acidity to surface waters (*Reuss and Johnson, 1985*). Thus acid rain research is a field where a sound concept of the relation between rainfall, soil solution and runoff is necessary. The appropriate spatial and temporal scales, however, necessary to study the links between soil processes and streamwater chemistry is in most cases unknown.

At Birkenes, a typical small acidified catchment in Southernmost Norway,  $\text{SO}_4$  levels in runoff are highest following extended dry periods (*Christophersen et al, 1982, Sullivan et al, 1987*). Such peak  $\text{SO}_4$  levels are usually associated with low pH and elevated concentrations of labile inorganic aluminum (*Sullivan et al, 1987*). The mainly podzolic soils at Birkenes show typical pH-gradients with depth, and it was hypothesised by *Christophersen et al (1982)* that the released  $\text{SO}_4$  stems from shallow soil layers. Studies of the dilution of streamwater  $\text{O}^{18}$  by event water, however, revealed under all flow conditions a major contribution from pre-event water (*Christophersen, 1987*). Therefore the Birkenes model, a conceptual charge balance model of streamwater chemistry, fails to explain the combined behavior of pH, Al,  $\text{SO}_4$ , and  $\text{O}^{18}$  (*Christophersen, 1987*). The parameterization of hydrology in this model has no spatial resolution beyond the catchment scale. Thus it cannot be used to test different hypotheses about the interaction of the infiltrated rainfall within the catchment soils.

This report describes a tracer experiment conducted at Risdalsheia (RAIN-project), about 10 km from Birkenes. During this tracer episode the rewetting of the soil after an extended dry episode was studied in detail. The following sections describe the tracer experiment as well as the modelling work that was used to prepare and evaluate the tracer experiment.

## 2. The site

At the Risdalsheia site two roofs covering whole headwater catchments provide control over the amount of precipitation and the fluxes of major ions that are collected by the roof and recycled by a sprinkler system underneath. Under one of the roofs (KIM catchment,  $856 \text{ m}^2$ ) the

recycled precipitation is first ion-exchanged to simulate pre-acid rain conditions. The roofed EGIL-catchment ( $396\text{ m}^2$ ) receives ambient acid precipitation and serves as a control for this treatment (Wright et al, 1986).

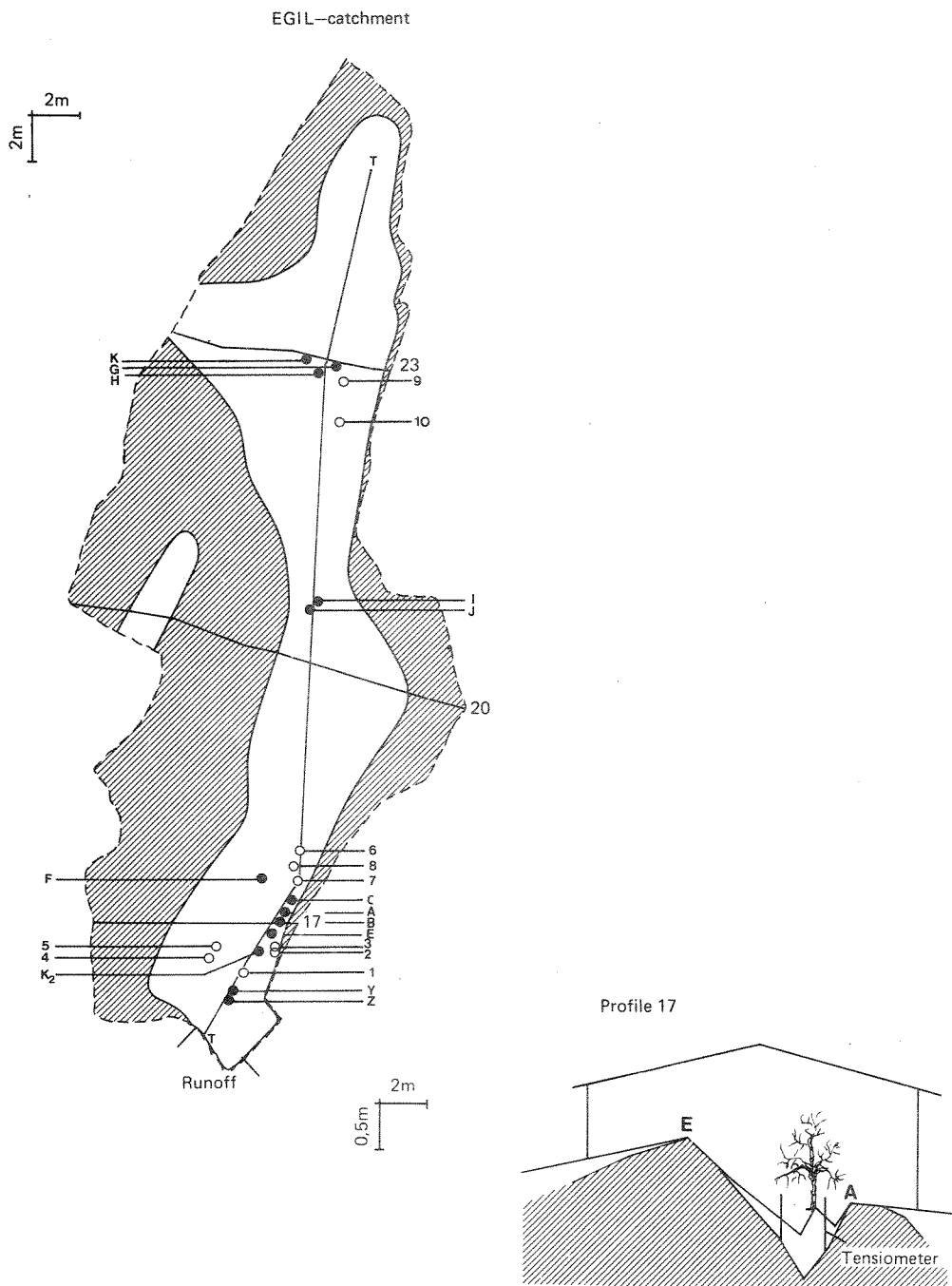


Figure 1: The EGIL-catchment (hatched areas represent bare rock).

The soils at Risdalsheia are typical of upland southern Norway, a region where water acidif-

cation is widespread. The granitic bedrock is only partly covered by thin and patchy soil. The soil is rich in humic material and has only a small reservoir of exchangeable base cations (*Lotse and Otabbong, 1985*).

### 3. Methods

#### 3.1. Bulk soil properties

The soil at all three catchments has been sampled yearly for analysis of bulk chemistry (*Lotse and Otabbong, 1985*). The sampling density is about one auger-sample per  $4 \text{ m}^2$  of soil. Total depth of soil is recorded as amount of soil that was recovered in the auger (*Lotse and Otabbong, 1985*) and as depth from the surface (this report). In 1985 14 undisturbed soil samples ( $250 \text{ cm}^3$ ) were taken from a soil pit about 10 meter outside the roof. From these samples the relation between soil water potential and water content (pF-curve) for drying conditions, the relation between hydraulic conductivity and water content ( $K_r$ -curve), and bulk density were determined. The methods are described by *Opara-nadi (1980)*.

#### 3.2 Input and output fluxes

The rainfall water is collected by the roof, stored in tanks with a capacity equivalent to 9 mm, and distributed underneath the roof by a sprinkler system. The maximum rainfall rate is  $2.2 \text{ mm.hr}^{-1}$  for the EGIL-roof. The total amount of precipitation is recorded weekly. During the tracer experiment in July 1986 the rainfall rate underneath the roof was recorded at 15-min intervals. The chemistry of the recycled rainfall water was sampled at 30 min intervals directly from the sprinkling system (appendix).

All runoff water from the catchment is collected into a 500 L tank. This tank is automatically emptied by a flushing valve, and the time is recorded by a data logger (appendix). The resolution of this system for EGIL catchment ( $398 \text{ m}^2$ ) is equivalent to 0.935 mm of runoff. The tank is equipped with an automatic sampler for water chemistry. During the tracer experiment water was collected directly at the outlet at 30-min intervals. A complete description of the installations at the three catchments at Risdalsheia is given by *Wright (1985)*.

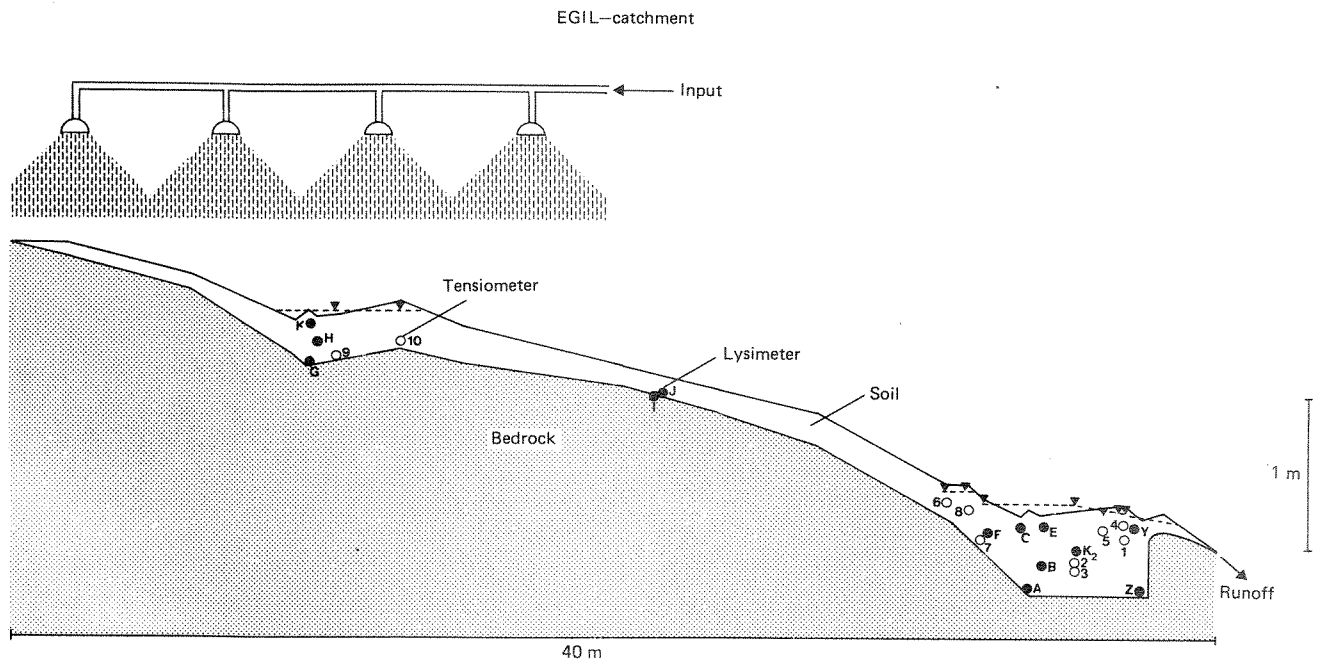


Figure 2: Cross section through the EGIL-catchment along the T-T line in figure 1.

### 3.3 Soil water

A system of 10 tensiometers and 16 lysimeters monitored the movement of water and ions through the soil at EGIL catchment. The tensiometers recorded from July to November 1985 and from June to July 1986 (*Hauhs, 1986a*)(1-10 in figures 1 and 2).

In November 1985 five suction lysimeters were installed in the lower part of the EGIL-catchment (*Hauhs, 1986b*). These lysimeters are of the same type as used by the ALBIOS-project (*Cronan, 1986*). They were installed at exactly predefined depths in relation to the groundwater table at highflow. During installation these lysimeters were pushed the last 3-5 cm down into the soil to ensure tight contact. Preliminary results from a natural rainfall event in November 1985 indicated that they were not able to sample moving soil water (*Hauhs, 1986b*).

In 1986 two of the five suction lysimeters were removed (No. 1 and 4; see appendix) and suction lysimeters of the ALBIOS type were installed in ten new positions (A-K in figures 1 and 2). In these new positions compaction of soil at the tip was avoided. Two zero-tension lysimeters (X and Y) were placed at a depth of 10 and 40 cm in the zone where the streamlines have to converge (*Hauhs, 1986b*)(see figures 1 and 2). This type of zero-tension lysimeter is described by *Parnell (1986)*. One additional suction lysimeter (K2) with a ceramic cup was installed in the lower part



of the catchment (figures 1 and 2). It is of the same type as used in ion-budget studies in West Germany (*Meiwes et al. 1985*).

#### 4. Theory

Ion transport through a spatially-defined soil unit can be described as a stochastic process (*Jury et al,1986*). This model is based on the definition of a probability density function for the travel time of a tracer solute moving at steady convective flow through a field soil. The method thus aims at the time aspect of solute transport. It provides residence times for comparison with the time scales of biological and chemical processes that might affect the movement of ions through soils (*Sklash and Farvolden,1979*).

The travel time distribution function can be derived from breakthrough curves of tracer solutes. With the exception of mass balance the model proposed by *Jury et al.* does not require any further mechanistic assumptions about processes within the flow region. The results, however, cannot be interpreted in mechanistic terms of solute transport.

A second class of models describing solute transport uses a mechanistic approach that has its most general form in the following equation (*Nielsen et al. 1986*):

$$\frac{\delta \rho s}{\delta t} + \frac{\delta \theta c}{\delta t} = \frac{\delta}{\delta z} \left( \theta D \frac{\delta c}{\delta z} - qc \right) + \sum_i \phi_i(c, s, \dots) \quad (1)$$

Where  $c$  and  $s$  are solute concentrations associated with the solution and solid phases of the soil,  $\rho$  is the bulk density,  $D$  is the dispersion coefficient,  $q$  is the soil water flux density, and  $\phi_i$  are rates of solute removal or supply not specifically included in  $s$ .

Together with appropriate boundary and initial conditions equation (1) describes one-dimensional transport during transient flow conditions. During transport of ions through porous media non-equilibrium between the moving solution and the solid phase can occur because of (1) diffusion-controlled or (2) chemically-controlled kinetic rate reactions (*Nielsen et al. 1986*). Due to the interpretation of such non equilibrium situations the transport can be conceptualized as a physical nonequilibrium between mobile and immobile phases or as controlled by a surface reaction rate

law. Such different concepts may still result into the same mathematical model of solute transport (NKEDI-KIZZA *et al.* 1984). Since surface reactions with Br are negligible I will use the physical model of mobile and immobile water to account for non-equilibrium flow conditions.

*Sposito et al.* (1986) showed that under conditions of one dimensional steady flow the mechanistic transport models of the type described above can be transformed into a travel time probability density function (pdf). The travel time distribution function is the Laplace transform of the following equation:

$$\begin{aligned}\tilde{g}_1(s) &= \exp\left\{\frac{1}{2}P - \frac{1}{2}\left(P^2 + 4BRPs\left(1 + \frac{(1-b)W/B}{(1-b)Rs + W}\right)\right)^{\frac{1}{2}}\right\} \\ \tilde{g}_1(s) &= \int_0^{\infty} \exp(-sT)g_1(T)dT\end{aligned}\quad (2)$$

where  $g_1(T)$  is the travel time pdf evaluated at the point  $X=1$ ;  $P$ ,  $W$ ,  $B$ ,  $R$  are dimensionless parameters of the convection/dispersion equation. In terms of a mobile/immobile flow model they have the following physical interpretation:

**Table 1:** *Physical interpretation of parameters appearing in the mobile/immobile phase model*

$$\begin{aligned}B &= \phi_m \frac{R_1}{R} \\ R &= 1 + \frac{\rho_b K_d}{\theta} \\ R_1 &= 1 + \frac{f\rho_b K_d}{\theta} \\ W &= \frac{\alpha L}{\theta_m v_m} \\ K &= K_d \\ P &= \frac{v_m L}{D} \\ X &= \frac{x}{L}\end{aligned}$$

where:  $\phi_m$ , mobile phase volume fraction  $=\theta_m/\theta$ ;  $\theta_m$ , volumetric content of mobile phase;  $\rho_b$ , dry bulk density;  $\theta$ , volumetric water content;  $f$ , mass fraction of solid phase sorbing from/in component 1;  $\alpha$ , mass transfer coefficient between components;  $v_m = q/\theta_m$ ;  $v = q/\theta$ ;  $K_p$ , sorption distribution coefficient;  $D$ , solute dispersion coefficient.

Equation (2) was used to design the tracer experiment at EGIL catchment. Some of the parameters from (2) could be calculated or estimated from the hydrologic results of the preceding

year (Hauhs, 1986a). Measurements of runoff and soil solution chemistry at EGIL catchment during a rainfall episode in November 1985 led to preliminary conclusions concerning ion transport (Hauhs, 1986b). Solute movement at EGIL was hypothesized to occur only in a small (mobile) fraction of the pore system with little mixing with resident soil water. This assumption was derived from the observation that during this episode the five suction lysimeters failed to sample a solution that was chemically similar to runoff water (Hauhs, 1986b).

#### 4.1 Design of the tracer experiment

The hypothesis about ion transport at EGIL-catchment was transferred with help of equation (2) into a travel time probability density function (pdf). The aim of the tracer experiment was to test this pdf. For the derivation of the pdf the three-dimensional flow problem that is shown in figures 1 and 2 was reduced to one-dimensional horizontal flow through a thin slab of soil.

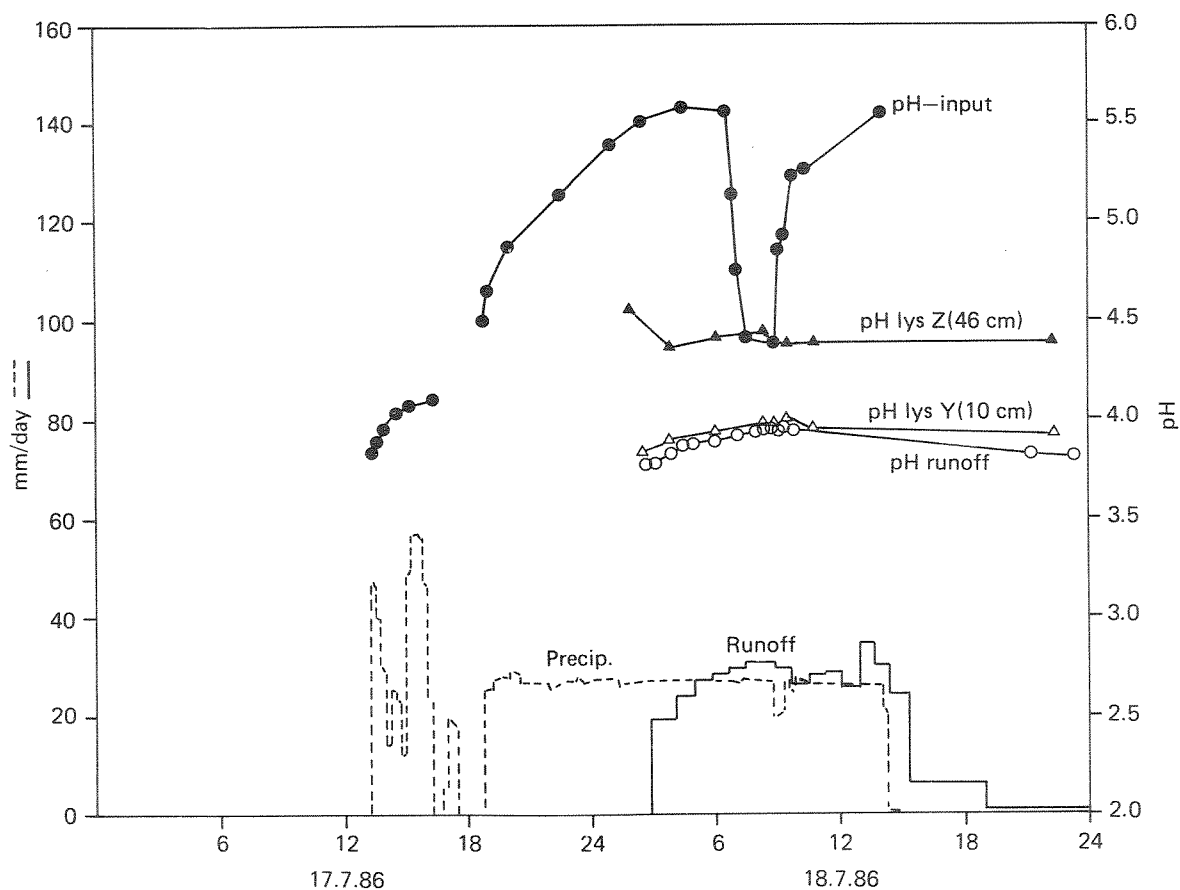


Figure 3: Rates of precipitation and runoff for the tracer episode, pH values in input, runoff, and the two zero-tension lysimeters Y and Z.

The tensiometer measurements in 1985 revealed that the range from the onset to maximum runoff ( $850 \text{ L.hr}^{-1}$ ) is caused by only a small rise in the position of the groundwater table (3-5 *cm*) (*Hauhs,1985b*). I will assume the extreme case that at steady state all flow is confined to such a small depth interval. The flow rate for the tracer event was  $425 \text{ L.hr}^{-1}$ . This situation can be approximated by a slab of soil of 30 *m* length (figure 2), 5 *m* width (figure 1), and 0.017 *m* depth. A length of 30 *m* implies that all tracer solute that in reality was spread between 20 and 40 *m* distance from the outlet is modelled by 30 *m* horizontal transport. With a porosity of 0.8 this slab of soil contains 2040 *L* of which about 50% can be expected to drain after watering has ceased ( $\approx 2.6\text{mm}$ ). This corresponds to the 4-6 *mm* of runoff that usually build the recession limb after maximum runoff events at EGIL-catchment (*Hauhs,1986a*). From these assumptions the mobile fraction of soil water ( $\phi_m$ ), the pore water velocity (*v*) and the amount of water that is equivalent to one pore volume can be calculated (table 2). The restriction of flow to the depth increase in the groundwater table gives an upper bound for the estimate of the mobile water fraction.

**Table 2:** *assumed parameters of equation (2) to describe steady state flow conditions*

$L=3000 \text{ cm}$ $q=1250 \text{ cm.hr}^{-1}$ $\phi=0.5$ $\Theta=0.8$ $T=4.8 \text{ hrs}$ $\rho=0.35 \text{ g.cm}^3$	$D=2000 \text{ cm}^2.\text{hr}^{-1}$ $K=1.5 \text{ cm}^3.\text{g}^{-1}$ $f=0.5$ $\alpha=0.15 \text{ hr}^{-1}$
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The time necessary to replace one pore volume of mobile water was estimated to be 2-3 hours. The parameters (*D,K,f, $\alpha$* ) that describe exchange of the moving solute with immobile water and sinks for the tracer solute during the soil passage were taken from the ranges given by *Nkedi-Kizza et al.* (1985). As this exchange was hypothesized to be of minor importance at EGIL-catchment the lowest numbers were used for the prediction. The model summarizes all information that was available prior to the tracer experiment. The pdf and the expected breakthrough curve (btc) calculated with the parameters in table 2 are included in figure 7. A tracer pulse of  $13.5 \text{ mg.L}^{-1}$  applied for two hours would thus have resulted in a peak concentration of about 50% of the input arriving 2.3 hours later at the outlet.

## 5. Results and discussion

### 5.1. The tracer-episode

The tracer experiment was preceded by a dry period from 19 June to 17 July during which only 6.3 mm of precipitation fell. The tensiometers indicate that this was the driest period at Risdalsheia since the start of treatment under the EGIL-roof in 1984. The episode began with natural precipitation on 17 July at 13:15. During the entire episode the sprinkler system supplied water only to the upper part of the catchment (figure 2). About 1000 L of the natural rainfall of pH 4.0 (figure 3) was stored in one of the cisterns, detached from the sprinkling system and mixed with 15 gr of Br added as LiBr. After the natural precipitation had ceased watering was continued with ion-exchanged water from a nearby lake. The application rate to the catchment was  $425 \text{ L.hr}^{-1}$  and lasted until 14:10 on 18 July. A small reduction in this rate occurred between 9:00 and 9:15 on 18 July due to filter clogging. The water budget for the episode is given in table 3. Table 4 contains the physical properties of the EGIL-catchment.

**Table 3:** *water budget for the tracer episode*

1. stored 19 June	$20.2 \text{ m}^3$	(mean value after end of runoff)
2. input 19 June - 17 July	$2.5 \text{ m}^3$	(calculated by diff. from 1 + 2 - 4)
3. evapotranspiration loss	$-7.2 \text{ m}^3$	
4. stored 17 July 13:00	$15.5 \text{ m}^3$	(from tensiom. meas.)
5. input episode	$10.6 \text{ m}^3$	(measured)
6. runoff episode	$-5.9 \text{ m}^3$	(measured)
7. stored at the end of the episode	$20.2 \text{ m}^3$	(from tensiom. meas.)

The timing of runoff compared to the development of soil suction along the catchment indicates that no bypass flow occurred (figure 4). All tensiometers rewetted in order of their distance

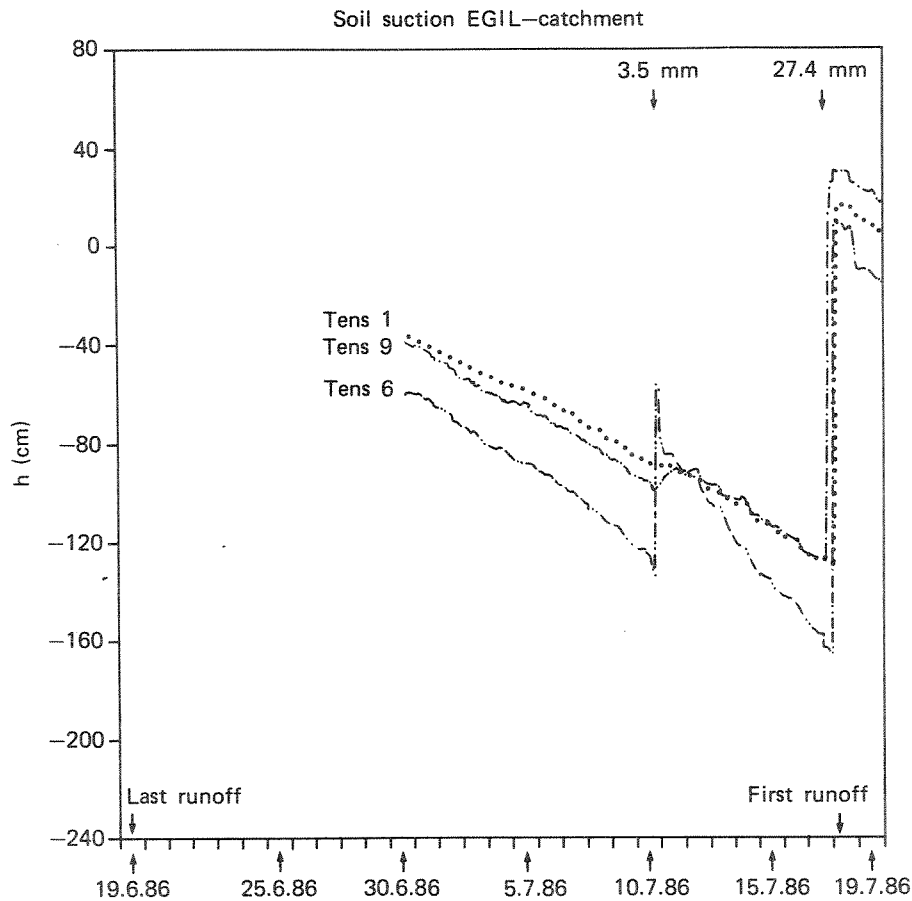


Figure 4a: Soil water potential prior and during the tracer episode.

from the point where infiltration started (figure 2). From the time lag in soil suction recovery at the individual tensiometer positions a schematic pattern of rewetting can be reconstructed (figures 5 and 6). Runoff started at 2:40 on 18 July and reached its steady-state value about 2.5 hours later (figure 3).

The surface of the soil in the middle and lower part of the catchment remained dry during the entire episode. In the same soil depressions within the lower part of the catchment, however, patches of free water appeared under steady state conditions (figure 6). This water had to reinfiltrate to become runoff.

The supply of ion-exchanged lakewater was stopped at 6:45 and for the following two hours a total of 850 L from the tracer-cistern water was applied at the same rate. This change in the applied water is marked by a sharp pH-drop from 5.4 to 4.4 (figure 3). From 8:45 the supply was switched back to the clean water and the pH-values increased again.

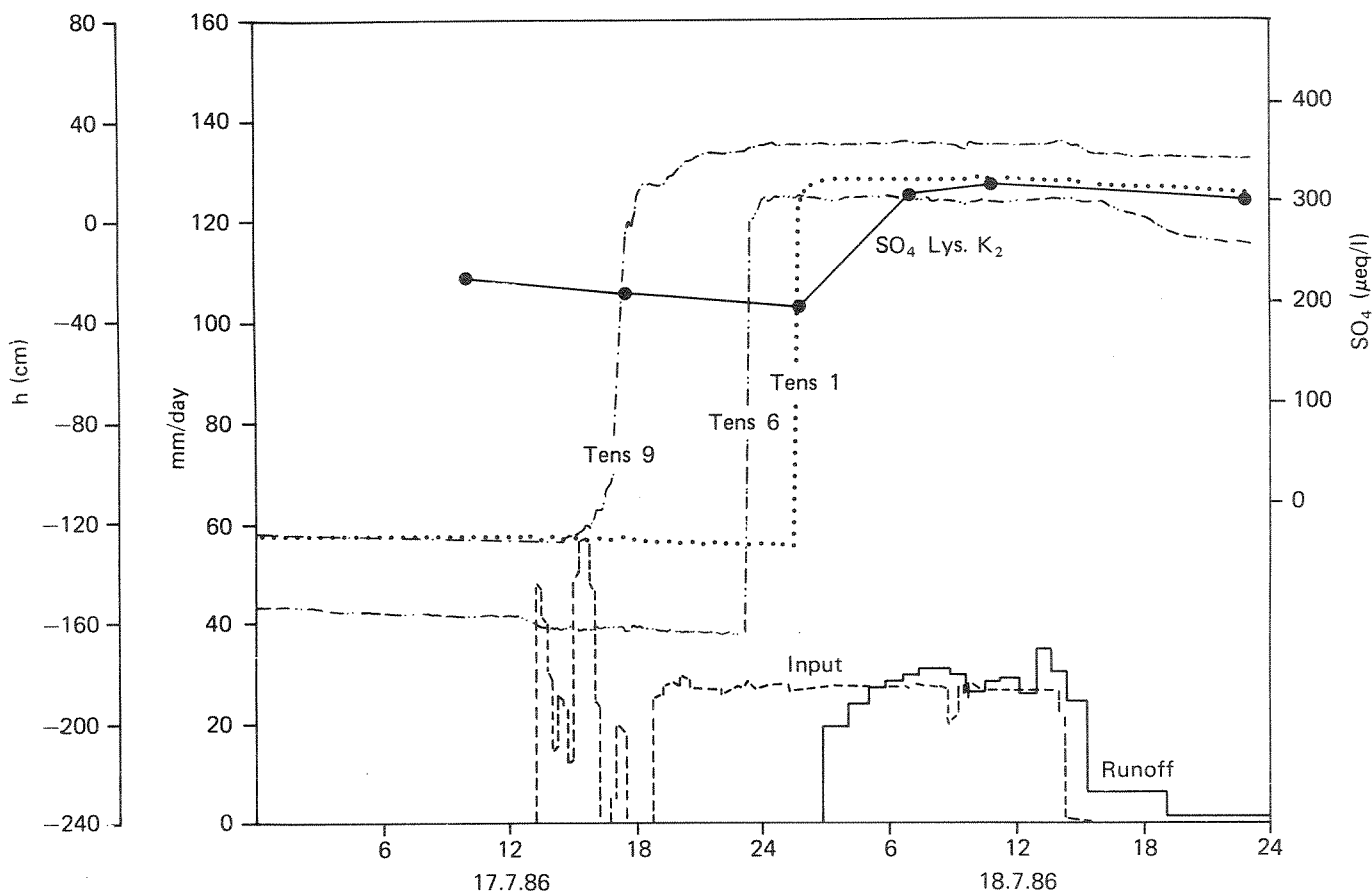


Figure 4b: Soil water potential during the tracer episode and  $\text{SO}_4$ -levels in suction lysimeter  $\text{K}_2$ .

Table 4: *physical properties of the EGIL-catchment*

area ( $\text{m}^2$ )	396
covered by soil (%)	49.2
mean soil depth (m)	0.14
soil volume ( $\text{m}^3$ )	27.8
bulk density ( $\text{g.cm}^3$ )	
depth 10-15 cm	0.35
depth 20-25 cm	0.95
soil mass (t)	13.3
max. water capacity ( $\text{m}^3$ )	21.2 ( $\hat{=}$ 54 mm)
yearly runoff (mm)	1092

The ceramic cup lysimeter ( $\text{K}_2$ ) collected soil solution under the dry conditions that preceded the episode, whereas none of the suction lysimeters of the ALBIOS type extracted any soil solution during that time. After the rewetting of the catchment soils during the episode all lysime-

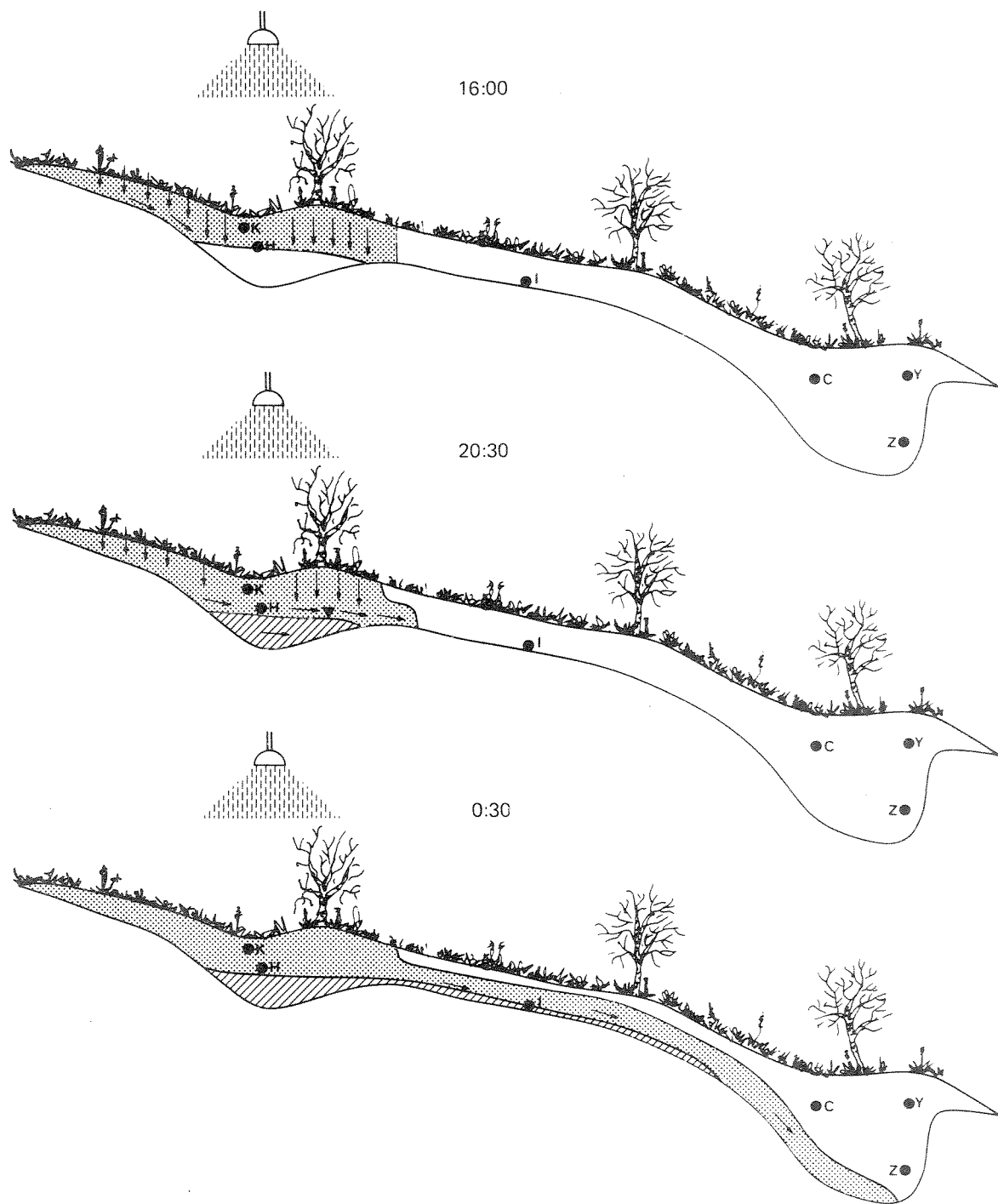


Figure 5: Schematic pattern of the rewetting (first 8 hrs.).

ters gave water. The first sampling of lysimeter water occurred at 2:00 (appendix) about 4 hours after the lysimeters in the upper half of the catchment (H,K,G,J) were rewetted (see figures 2 and



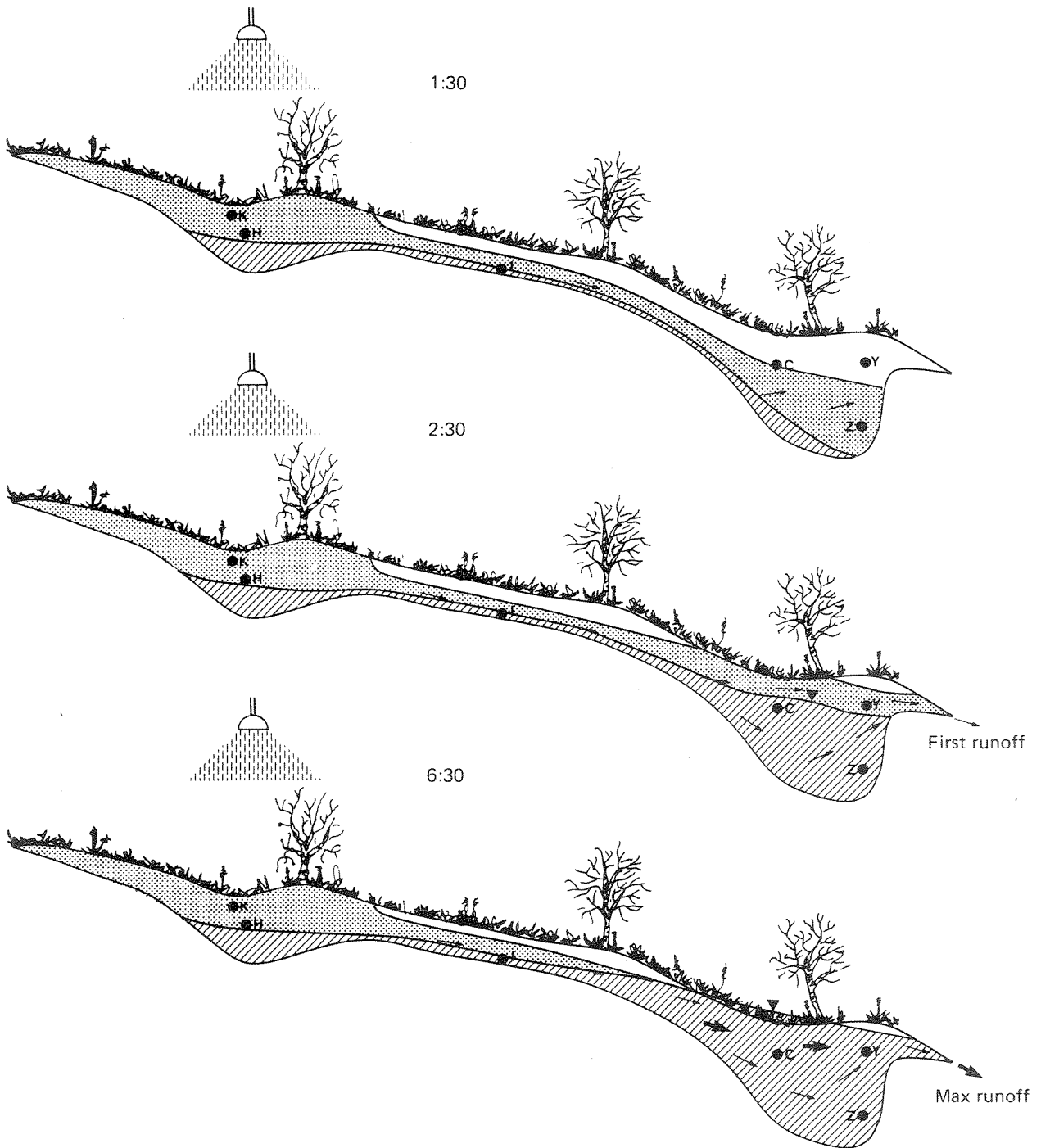


Figure 6: Schematic pattern of the rewetting (from 8 hrs. until steady state).

6). The next sampling was conducted at 6:00 when the lower parts of the catchment had been rewetted. The 9:30 sampling was intended to coincide with the breakthrough peak at the outlet.

The last sampling occurred between 21:00 and 22:00.

Due to a failure in the automatic sampler all runoff samples from the outflow tank were spoiled by mixing. Runoff chemistry data thus are available only from samples taken directly from the outlet. No data are available for the period between 9:15 and 21:00 on 18 July. Soil solution and runoff chemistry indicate that only minor changes ( $\pm 10\%$ ) occurred during the last five hours of the steady state condition (exception Br). The last runoff sample from 9:15 describes the missing data. The last two runoff samples were taken from the recession limb of the episode (appendix).

## 5.2 Results for the tracer ion

The tracer experiment with LiBr illustrates three characteristics of stormflow at EGIL-catchment:

1. All event water infiltrates the soil.
2. Lateral, saturated flow occurs at high porewater velocities ( $> 10m.hr^{-1}$ ).
3. Mobile water mixes intensively with resident soil water.

Throughout the episode the zero-tension lysimeter Y yielded a solution that was chemically identical with runoff water (appendix). This lysimeter was installed two meters above the point at which runoff emerges from the soil (figure 2). Thus it sits within the zone of streamline convergence indicated by tensiometer data (*Hauhs, 1986b*). The data from lysimeter Y were also used to describe the breakthrough curve (btc) of Br in runoff water (figure 7).

Figure 7 shows the shape of the input tracer pulse. The points in this figure give the measured Br-concentrations in runoff and lysimeter Y. Due to the estimated parameters in table 2 one pore volume is equivalent to 4.8 hours. Steady-state flow conditions prevailed until 14:15, about 8 hours after the start of tracer application. The last two Br-concentrations are plotted against cumulative runoff and have therefore been advanced in time (figure 7).

A comparison of the predicted and the measured Br response allows two conclusions despite the missing data:

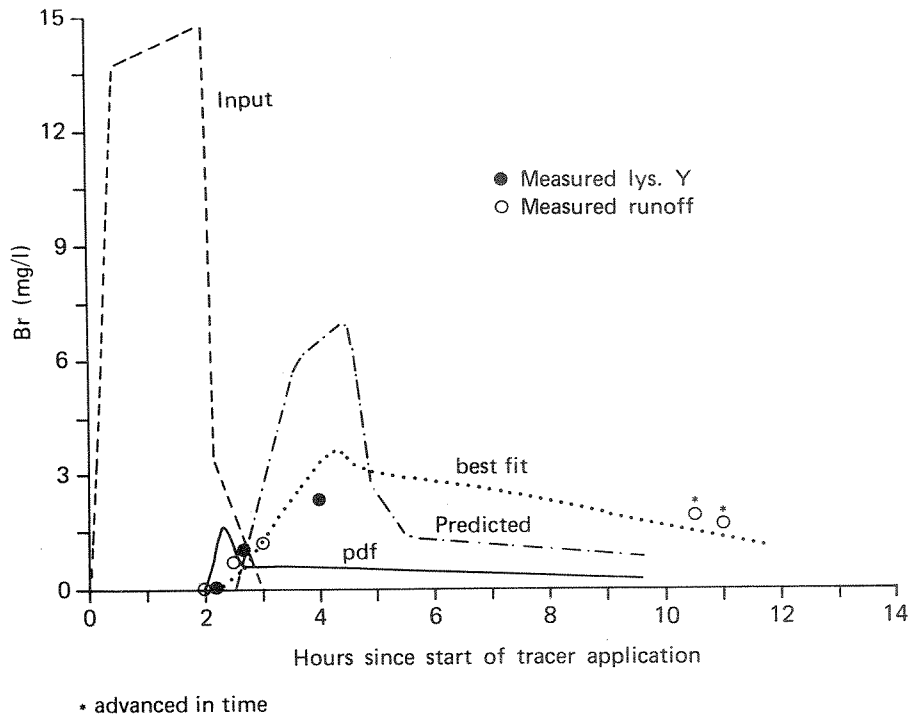


Figure 7: Breakthrough of the tracer (predicted, best fit, and measured). The solid line gives the travel time probability density function for the best fit (The Y-scale is dimensionless for this curve).

1. The delay in the start of the breakthrough curve was well predicted.
2. Mixing with the soil water was underestimated by the model. The peak concentration in runoff was rather 20-25% of the applied Br-input than the predicted 50% .

This deviation from the earlier results at the EGIL-catchment (*Hauhs, 1986b*) is confirmed by the results from the suction lysimeters. In 11 out of the 13 newly installed lysimeters Br was recovered. None of the three remaining lysimeters from November 1985 gave Br (LYS 2, 3, and 5; appendix). Compaction of soil probably occurred during installation of the latter. The reliability of suction lysimeters in such soils may largely depend on installation procedures. The results from lysimeter 2, 3, and 5 are therefore excluded from the discussion.

The model presented in section 3.1 was adapted to account for the deviations in figure 7 and the best estimate has been also included into figure 7. To this end the parameter D from table 2 was changed to value of  $40\,000\text{ cm}^2.\text{hr}^{-1}$ . With the one-dimensional model as used here the process of dispersion cannot be separated from the effect of an input that was spread at a 15-20 m distance (figure 2). In any case convection was the dominating process during this event. The

value of  $\alpha$  (table 2) that describes exchange with immobile water was increased to  $0.40 \text{ hr}^{-1}$ . This value accounts for the lower peak concentration in figure 7. It is within the range of values given by *Nkedi-Kizza et al.*(1985).

Despite the large number of variables for which independent estimates were available, the application of equation (2) remained empirical and required parameter fitting. This example, however, shows that the model was useful to anticipate important aspects of a field-scale tracer experiment. Since the recovered Br revealed a vertical flow field that was not restricted to the uppermost two cm of the groundwater the mobile water fraction is less than 0.5 the value used in the model (table 2). The geometry of the flow region was simplified but the results indicate that both the volume and velocity of the mobile water fraction were correctly predicted.

### 5.3 Results for non-conservative ions

#### 5.3.1 The relation between fluxes and storages

The relation between the storages inside the catchment and the yearly fluxes of individual ions (*Wright and Gjessing, 1986*) are given in table 5. The storages were calculated from the physical properties given in table 4 and the chemical inventory by *Lotse and Otabbong, 1985*.

The turnover times for exchangeable Na and Mg are small. This might be due to the relatively high input from seasalts. The turnover times of exchangeable K, Ca, H and total-S are of about the same size (10 years). The nearly balanced  $SO_4$ -fluxes at EGIL-catchment indicate an equilibrium with respect to deposition.

The corresponding fluxes at KIM-catchment, which receives "clean" rain, are included in table 5. Changes in soil storages at the KIM-roof are necessary to explain the delayed response in  $SO_4$ -output after two years of treatment.

#### 5.3.2. Results concerning ion transport

The reaction of single ion species during the rewetting event at EGIL-catchment can be described in three ways:

**Table 2: Storages, mean fluxes and turnover times (storage/output) at EGIL-catchment fluxes for KIM-catchment in brackets (corrected for differences in catchment size)**

	Stored (eq)	In (eq.yr <sup>-1</sup> )	Out (eq.yr <sup>-1</sup> )	Turn.(yrs.)
exchg. Na	26	39 (37)	36 (31)	0.7
exchg. K	31	3 (1)	3 (2)	10
exchg. Ca	62	5 (2)	6 (4)	10
exchg. Mg	34	9 (8)	9 (6)	4
exchg. H	370	38 (17)	40 (29)	9
exchg. Al	672	- (-)	7 (4)	100
SO <sub>4</sub> (ads.)	1.2			-
SO <sub>4</sub> (water sol.)	8.7			0.2
S (total)	483	44 (13)	45 (23)	11
NO <sub>3</sub>		27 (8)	13 (2)	-
NH <sub>4</sub>		25 (2)	6 (2)	-
N (total)	5300	52 (10)	19 (4)	280
Cl	not. meas.	43 (44)	43 (41)	-

- A) Concentration patterns over time in runoff and soil solution.
- B) Horizontal gradients in the soil solution during steady state conditions.
- C) Vertical gradients in the soil solution during steady state conditions.

#### A) Concentration patterns

Ion-exchanged water was used during most parts of the episode. That is why input concentrations are well below their output values. Table 6 gives the total amounts in input and output for the episode.

SO<sub>4</sub> is the dominate ion in both soil solution and runoff. Figure 8 gives the measured concentrations in input, output and the two zero-tension lysimeters X and Y (see figure 2 for positions). Runoff levels of SO<sub>4</sub> seem to converge towards a value of about 130  $\mu\text{eq.l}^{-1}$  which is close to the yearly mean concentration in runoff (119  $\mu\text{eq.l}^{-1}$ ) (Wright, 1985). Table 7 shows the

**Table 6: Total input and output during the tracer event at EGIL-catchment**

	Input	Output
$H_2O(mm)$	28.5	15.0
$SO_4 (meq.m^2)$	0.90	2.49
$NO_3 ( " )$	0.48	1.52
$Cl ( " )$	0.21	0.73
$Br ( " )$	0.45	0.19
$H ( " )$	0.71	1.82

chemical composition of runoff water from EGIL-catchment during the episode. As most curves have a shape similar to that of sulfate shows in figure 8 they can be characterized by their initial value in the first runoff water at 2:40 on 18 July, at the breakthrough of the tracer (9:15 on 18 July) and in the recession limb (21:15 on 18 July).

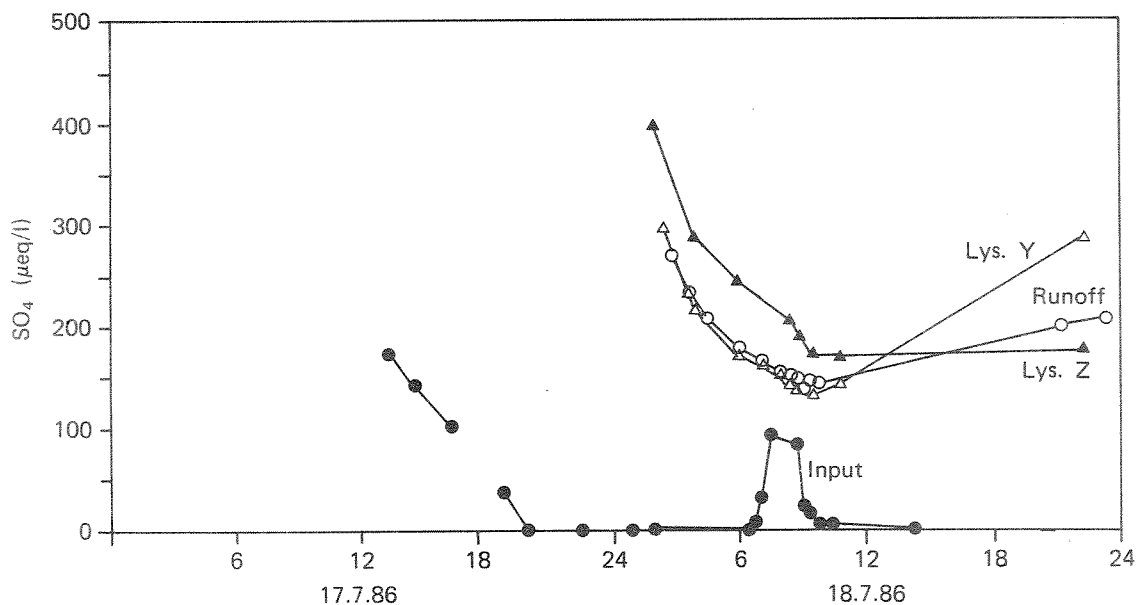


Figure 8:  $SO_4$  in input, runoff, and the two zero-tension lysimeters Y and Z.

Most of the elements of table 7 show a dilution during the event to 36-67 % of their initial concentrations. These elements ( $H, Na, Ca, Mg, Al_{org} \ddagger, SO_4, NO_3, Cl$ ) recover in the recession limb of the episode to 55-89% of their initial values in the first runoff water. Thus pH is highest during the

$\ddagger$  Nonlabile monomeric (organic) aluminum

**Table 7: Runoff chemistry during the episode**

	2:40 (%)	9:15 (%)	21:15 (%)
pH	3.78	3.95	3.83
H <sup>*</sup>	166 (100)	112 (67)	148 (89)
Na	145 (100)	88 (61)	107 (74)
K	11 (100)	5 (45)	5 (45) <sup>†</sup>
NH <sub>4</sub>	64 (100)	36 (56)	22 (34) <sup>†</sup>
Ca	35 (100)	20 (57)	29 (83)
Mg	58 (100)	31 (53)	44 (76)
Al <sub>org</sub> ( $\mu\text{gr.l}^{-1}$ )	224 (100)	208 (93)	197 (88) <sup>†</sup>
Al <sup>3+</sup>	76 (100)	27 (36)	48 (63)
SO <sub>4</sub>	270 (100)	143 (53)	200 (74)
NO <sub>3</sub>	176 (100)	80 (45)	96 (55)
Cl	77 (100)	40 (52)	47 (61)
TOC ( $\text{mg.l}^{-1}$ )	13.6 (100)	13.0 (96)	10.9 (74) <sup>†</sup>

\*( $\mu\text{eq.l}^{-1}$ ) otherwise noted

† elements that deviate from the general shape (no increase in the recession limb)

peak flow at the hydrologic steady state. This behavior is completely different from larger catchments such as Birkenes (*Christophersen et al. 1982*). The four species NH<sub>4</sub>, K, Al<sup>3+</sup>\* and TOC showed a different concentration pattern as dilution continued throughout the episode. From the pattern in which the rewetting occurred (figures 5 and 6) and the small changes in groundwater level after the watering was stopped, it can be concluded that highflow corresponds with the shallowest flowpaths through the soil. Both the raising and the falling limbs of the hydrograph represents water that had larger travel times and had passed through deeper layers in the soil.

### B) Horizontal gradients

The levels of most ions in runoff and soil solution seemed to approach constant values towards the end of the steady-state conditions. For most of the suction lysimeters the chemical composition of

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\* Monomeric labile (inorganic) aluminum calculated by difference from reactive and nonlabile monomeric aluminum

the sampled soil water changed only slightly between 10:00 and 21:15 (exception Br and lysimeters without Br). The last samples taken from the suction lysimeters at 21:15 are representative for the steady-state conditions during the episode. Of the instantaneous samples (runoff, zero-tension lysimeters) the samples from 9:15 represent the steady state conditions.

From the lysimeter results the main water flow path was identified along the lysimeter sequence K and H (vertical infiltration), I, C, Y (horizontal flow) and finally runoff. The concentrations that correspond to the hydrologic steady state for these sampling points are shown in figure 9. In contrast to the horizontal pathway the infiltration process is characterized by relatively low porewater velocities. This is concluded from the observation that no ponding occurred in the infiltration area and transport was unsaturated in the first few cm of soil.  $\text{SO}_4$  (78%) and H (46%) do not reach their final values along the infiltration pathway. Thus the internal sources for Cl and  $\text{SO}_4$  were spatially different for this episode.

The four species that showed a different concentration pattern over time in runoff (table 7) do not increase along the horizontal flowpath from lysimeter H to runoff. This indicates that the easiest mobilization of these elements occur in the uppermost cm of soil at the EGIL-catchment.  $\text{NH}_4$  and K might have been enriched by decomposition of organic matter during the preceding dry period. The decrease in the concentration of  $\text{NH}_4$  and K along horizontal transport may be due to the artificial flow conditions without further infiltration of water beyond lysimeter I (table 8).

**Table 8:** *Concentrations corresponding to the hydrological steady state conditions*

$(\mu\text{eq.l}^{-1})$	K	H	I	C	Y	Runoff
$\text{NH}_4$	-	64	77	46	45	36
K	-	13	6	6	5	5
$\text{Al}_{\text{org}}$	196	286	211	275	188	208
$\text{TOC } (\text{mg.l}^{-1})$	-	-	12.3	-	12.3	13.0



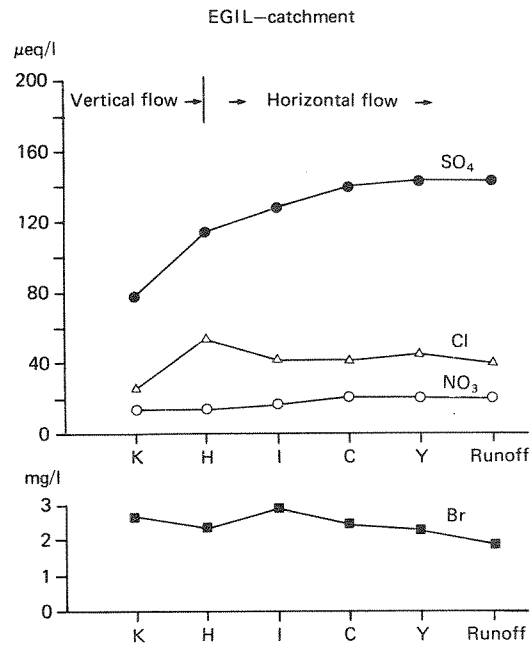


Figure 9: Lateral gradients along the major flow path (SO<sub>4</sub>, NO<sub>3</sub>, Cl, and Br).

### C) Vertical gradients

The lysimeters revealed various degrees of Cl-dilution during the event. The extent of dilution is calculated by the ratio of the Cl-concentration in the first and last sample. A comparison of this dilution process with the maximum Br concentrations at the individual lysimeters is shown in figure 10. In figure 10 the lysimeters in the upper 20 cm of soil are grouped above the deeper ones (exception: lysimeter E). Despite the steady state flow conditions under which the tracer was applied, the Br reached a depth of 45 cm (lysimeter A). There is, however, a considerable spatial heterogeneity since adjacent lysimeters (A,B and K<sub>2</sub>) show large differences in amounts of recovered Br. Both Br and Cl can be treated as conservative ions, and the vertical gradients reveal the flow gradients across the soil profile.

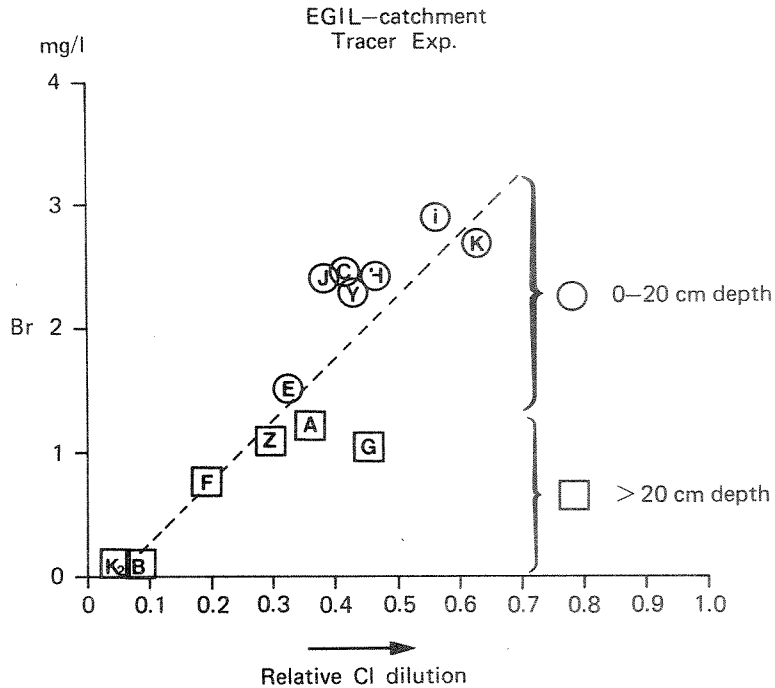


Figure 10: Recovered Br versus Cl-dilution.

The existence of a relatively deep water flow paths at steady state indicates that return flow areas with water emerging from layers deeper than 20 cm must exist in the lower part of the catchment. The shallow lysimeter E (figure 2) samples water that is typical of deep layers and may thus represent a return flow area. The same change in composition also should occur in the recession limb when the contribution of water with longer contact times and probably deeper pathways increases.

The chemical composition of water from the shallow lysimeters is similar to the runoff water during the hydrologic steady state conditions. These sampling points represent the soil layer with the largest fraction of flow and thus intensive mixing. The differences among deep lysimeters are much larger (table 9). The two candidates for return flow water (Lysimeter E, recession limb) are related to deep layer chemistry. An exception to this pattern is the pH. H<sup>+</sup>-concentrations usually increase according with depth in the soil profile (*Lotse and Otabbong, 1984*). This is also the case for soil solution. However, return flow water is the most acid water in the system.

**Table 9: Concentrations from lysimeters beyond and above 20 cm, lysimeter E and runoff (9:15 and 21:10)**

	> 20 cm			Run.	< 20 cm			Lys E	Run.
	m <sup>+</sup>	min-max	(n)	9:45	m <sup>+</sup>	min-max	(n)		21:10
pH	4.47	4.23-4.77	(6)	3.95	4.10	3.96-4.28	(6)	3.90	3.83
Na <sup>†</sup>	112	102-127	(3)	88	85	83-90	(4)	194	107
K	6	1-6	(3)	7	7	5-13	(4)	9	5
NH <sub>4</sub>	31	1-54	(3)	36	55	46-64	(4)	26	22
Ca	23	17-49	(3)	20	21	18-25	(5)	83	29
Mg	42	33-47	(3)	31	29	22-33	(5)	188	44
Al <sup>*<sub>org</sub></sup>	134	128-237	(3)	208	211	188-283	(5)	168	197
Al <sup>3+</sup>	71	45-214	(3)	27	12	9-33	(5)	234	48
SO <sub>4</sub>	171	129-306	(6)	143	139	88-145	(6)	679	200
NO <sub>3</sub>	124	4-192	(6)	80	72	44-84	(6)	140	96
Cl	67	43-78	(6)	40	42	30-48	(6)	66	47
Br	0.4	0.0-1.2	(6)	1.2	2.5	2.3-2.9	(6)	0.7	1.9

†  $\mu\text{eq.L}^{-1}$  otherwise noted \* ( $\mu\text{gr.l}^{-1}$ ) + median

## 6. Discussion

### 6.1 The sources of sulfate

The lysimeter K<sub>2</sub> was the only one that sampled water during the dry period that preceded the tracer episode. The results of the tracer experiment show that this lysimeter was installed within a stagnant zone (table 11). It is located in the trapped groundwater of the EGIL-catchment (*Hauhs, 1986b*). Between 19 June and 17 July the groundwater disappeared from this zone, and this part of the soil experienced at a matrix potential of -100 cm, the driest conditions in the last two years.

Under the preceding wet conditions soil solution showed exceptionally high pH and low SO<sub>4</sub>-levels (figure 11). This was most probably caused by sulfate reduction. The soil around lysimeter K<sub>2</sub> was unsaturated from 26 June to 18 July. The exchange of soil air seems to be also limited as indicated by the measurements of soil CO<sub>2</sub> (*Wright and Gjessing, 1986*). These measurements

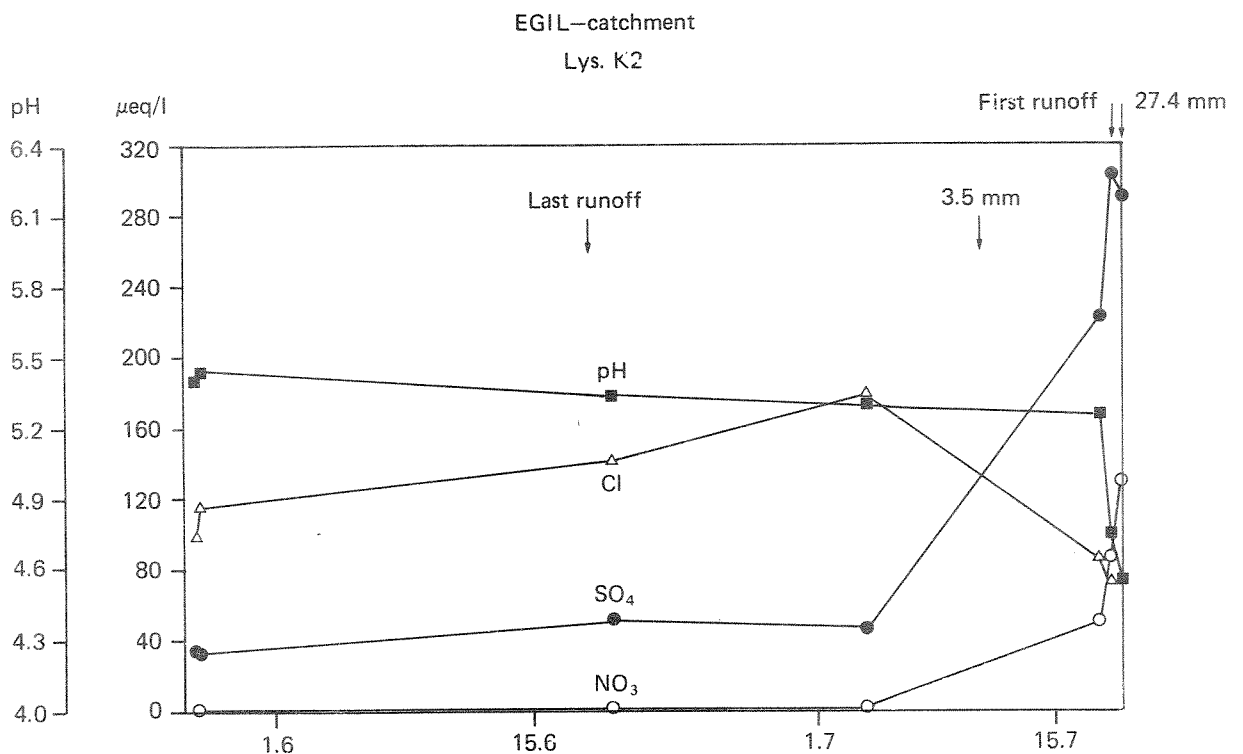


Figure 11: Soil solution chemistry at lysimeter K<sub>2</sub>.

are conducted at the EGIL-catchment close to lysimeter K<sub>2</sub>. In late July in 1985 this zone became unsaturated and the CO<sub>2</sub>-levels increased to about 50 times atmospheric levels.

On 10 July a small rainfall event produced a wetting front that reached the deepest parts of the catchment (figure 4) but did not cause saturation in any part of the soil. This infiltration water apparently initiated the oxidization process (figure 11). The first increase in SO<sub>4</sub> paralleled a decrease in Cl and the pH remained unchanged. The pH values dropped first with the final rewetting on 17-18 July.

## 6.2 A hypothesis explaining the soil water interaction during the tracer episode

The observations of the preceding sections can be summarized by the following hypothesis:

Most elements reach their final concentrations during vertical infiltration at relatively low porewater velocities. Along the horizontal pathway with porewater velocities larger than 10  $m.hr^{-1}$  cations (except H) undergo only minor changes (decreasing NH<sub>4</sub> and K, increasing Ca and Mg,

see appendix). Because of the small fractions of soil that are in contact with mobile water, the dominating process is dilution.

The existence of flow pathways through deeper soil layers leads to return flow areas in the lower part of the catchment that are characterized by a different chemistry. The return flow water mirrors the vertical gradients in soil solution chemistry. The exceptional pattern of pH can be explained by the sulfate release mechanism.

22 % of the final sulfate is picked up along the horizontal pathway. It probably stems from oxidation of previously reduced sulfur released at the contact zone with stagnant pockets in the soil. Since the pore water velocity prohibits ion exchange the released sulfur is accompanied only by H. Thus the normal pH-gradients in this soil will be reversed during rewetting. Such soils will show maximum sulfate levels in runoff when the first rewetting after an extended dry period occurs. This hypothesis is in agreement with observations from the nearby Birkenes catchment (*Christophersen and Wright 1980; Sullivan et al.1986*).

### 6.3 Comparison of treatment versus control catchments

This section gives a comparison with the adjacent KIM-catchment where 11 days after the tracer event at the EGIL-catchment a natural major storm event with a total of 37 mm caused complete rewetting. The KIM-catchment received ion-exchanged water during this storm (as also for the last two years). The quality of the water that induced rewetting was therefore the same at both catchments. I will inspect the response at the KIM-catchment for possible treatment effects resulting from the two years of enclosure.

Figure 12 shows the precipitation rate underneath the EGIL-catchment. It exceeds for several hours the maximum watering capacity of the sprinkler system. The runoff from the EGIL-catchment is representative for situations when the catchment is wet (*Hauhs,1986a*). The geometry of this catchment prevents runoff before all catchment soil is rewetted. In KIM-catchment three outlets drain different parts of the catchment. One of these subcatchments mainly consists of bedrock with only shallow soil patches. That is why runoff from KIM-catchment already starts before the rewetting is completed. Later during the storm event the KIM-catchment was also completely rewetted (figure 12) and in the recession limb runoff rates exceeded those from EGIL. This is due to the slightly thicker soils at the KIM-catchment (*Lotse and Otabbong,1985*).

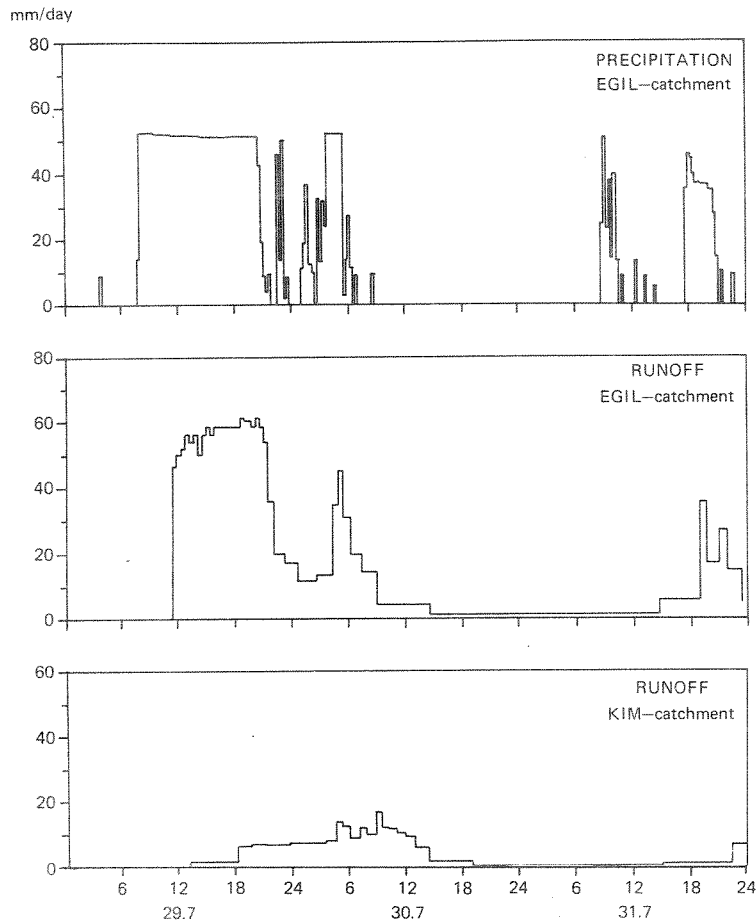


Figure 12: Rates of precipitation (upper) and runoff (lower) for the natural rewetting episode at the KIM-catchment. During this episode the EGIL-catchment had already been rewetted because of the tracer episode (runoff from EGIL is given by the graph in the middle).

To compare the chemical response from the corresponding rewetting events at both catchments the concentrations in runoff are plotted against cumulative runoff (figure 13 and 14). The last symbols in the plot from the EGIL-catchment indicate concentration levels in the recession limb. At the KIM-catchment no lysimeters had been installed. I will therefore use the results from the EGIL-catchment to identify the different types of soil solution that combine into runoff water.

EGIL-catchment: No runoff before total rewetting. Deeper layers already contribute to runoff from the first outflow (figure 13). Maximum concentrations in the first water with following dilution. In the recession limb again deeper soil water is dominant with low  $\text{NH}_4$ , and high  $\text{SO}_4$ , H, and  $\text{Al}^{3+}$ -levels.

KIM-catchment: Runoff from subcatchments starts before the rewetting of the bulk soil. The first runoff from the KIM-catchment thus corresponds with the soil solution chemistry in the

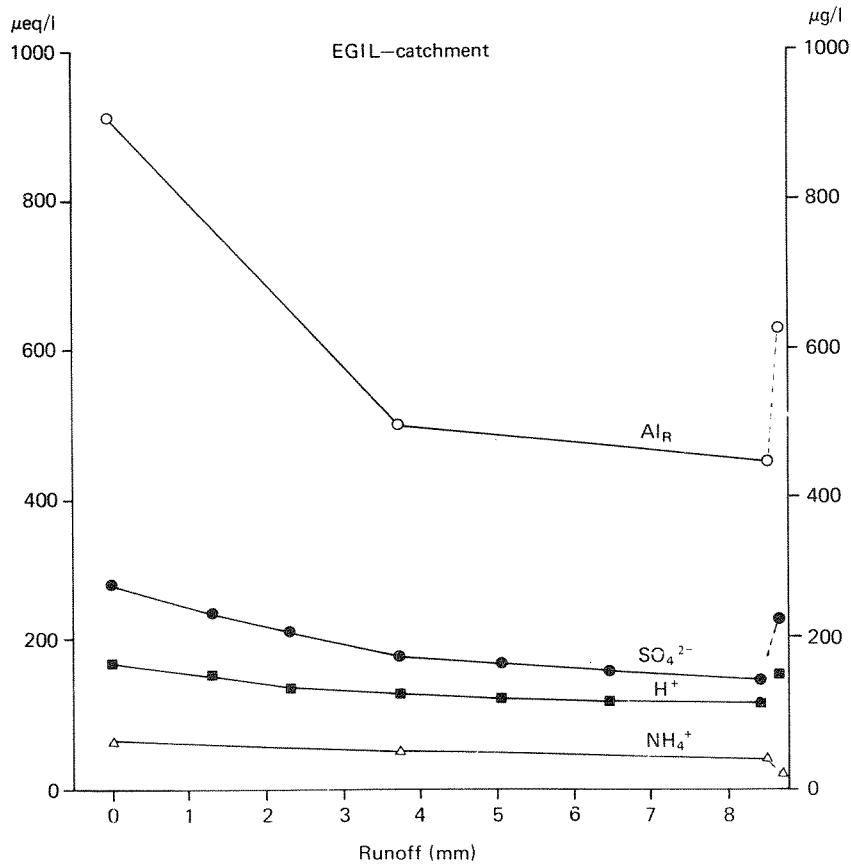


Figure 13: Runoff chemistry at the EGIL-catchment during the rewetting (tracer episode: 17-18 July).

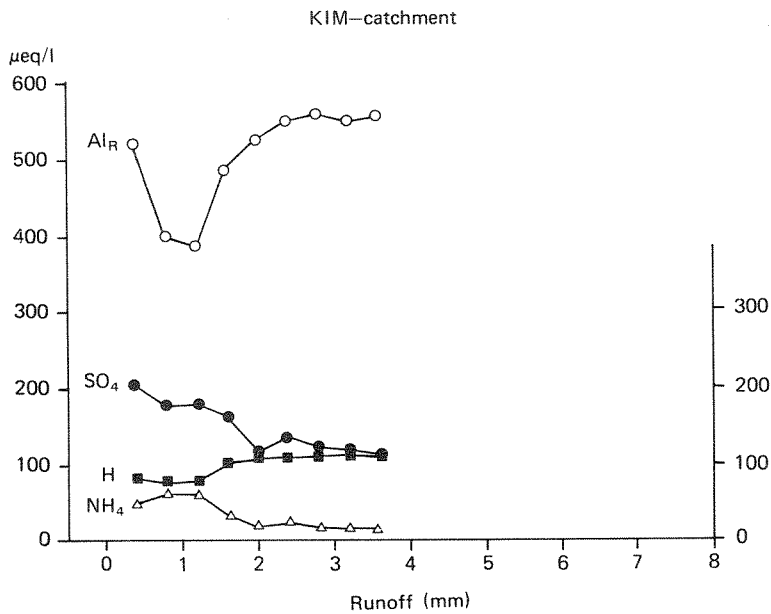


Figure 14: Runoff chemistry at the KIM-catchment during the rewetting (natural storm: 29-30 July).

shallow lysimeters at the EGIL-catchment (e.g. high NH<sub>4</sub>). After 3 mm of runoff the deeper

layers gradually become rewetted and start to contribute to runoff water. All ions that were typical of water from deep layers at the EGIL-catchment start to increase whereas  $\text{NH}_4$  is further diluted. However,  $\text{SO}_4$  rather follows the pattern of  $\text{NH}_4$  rather than that of  $\text{H}$  or  $\text{Al}^{3+}$ . Sulfate obviously behaves at the KIM-catchment as an ion that is released primarily from shallower soil layers compared to EGIL-catchment.

The mechanism that is suspected to cause the release of the additional sulfate at EGIL is oxidation in the relatively small stagnant soil pockets. One can conclude that the difference in sulfate response is caused by a decrease in amount of easily-soluble sulfur at KIM. To confirm this future soil inventories at both catchments should concentrate on stagnant parts of the deeper soil. A further decline in sulfate levels in runoff from KIM is a consequence of this conclusion.

## 7. Conclusions

This tracer experiment gives information on both hydrological and chemical aspects of storm-flow generation at the extremely responsive EGIL-catchment. All runoff water was derived from subsurface translatory flow without any sign of overland or macropore flow. The following two processes were identified as most important for streamwater chemistry:

- Dilution
- Varying flow paths in the soil

Vertical seepage across the unsaturated (or vadose) zone occurs at relative low porewater velocities and reactions with the soil matrix such as cation exchange or adsorption/desorption can control seepage water chemistry. When this vertical transport turns into saturated, lateral flow the water quality beyond that point remains largely unchanged. An exception to this are soils where saturated flow comes in contact with stagnant soil pockets. After extended dry periods the rewetting events that conduct the first water back to the stagnant parts of the soil may be enriched in  $\text{SO}_4^-$ ,  $\text{NO}_3^-$ , and  $\text{H}^+$  also during lateral flow. This process reverses for a short time the vertical pH-gradients in the soil solution.

In the case that two different processes (desorption and oxidation) control streamwater  $\text{SO}_4$  the  $\text{Al}^{3+}$ -levels in runoff will no longer seem to be in equilibrium with one mineral phase. This is



because the oxidation occurs under saturated flow conditions. Such a hypothesis is able to explain the behavior of the Birkenes catchment. Watersheds with deeper permeable soil layers show a much more regular pH-pAl relation (*Hooper and Shoemaker, 1985*).

In soils where the vadose zone extends to depths  $> 1$  meter changes in the height of the zone of saturated flow occur along minor gradients in soil chemistry. The runoff chemistry under such conditions is independent of flow. Since the volume of the soil matrix that is in contact with vadose water is relatively large, runoff chemistry can be affected by dilution only at time scales larger than months (weeks). This is exemplified by the Lange Bramke catchment in the Harz mountains (*Herrmann et al. 1984; Hauhs, 1986a*). In shallow soils lateral, saturated flow occurs in the vicinity soil surface and cuts across substantial gradients in the soil chemistry. As a consequence the time-variation in runoff chemistry increases towards responsive catchments. The soil volume that is accessible for reactions with seepage water is highly variable and may be restricted to a few cm-dm. Therefore dilution may affect the runoff concentration of single ions between storm episodes (e.g. Birkenes). In the extreme case of the EGIL-catchment the time scale of dilution is of the same order as single stormflow episodes.

Models that aim at the description of the soil/soil-solution relations during stormflow depend on a realistic representation of the dynamic extent of the unsaturated zone. Within this zone the currently used equilibrium concept is apparently sufficient.

## 8. Acknowledgments

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## appendix

### Runoff data:

C1: date (year/month/day)

C2: time (hour:min)

C3: rate (mm.day<sup>-1</sup>)

860528	20.47	0.
860528	20.48	35.96
860528	21.25	35.96
860528	21.26	44.95
860528	21.55	44.95
860528	21.56	49.73
860528	22.22	49.73
860528	22.23	39.62
860528	22.56	39.62
860528	22.57	21.35
860529	00.00	21.35
860529	00.01	8.42
860529	02.40	8.42
860529	02.41	2.99
860529	09.00	2.99
860529	09.01	0.00
860529	23.59	0.00
860605	00.00	.1206
860612	18.08	.1206
860612	18.09	3.2138
860612	19.07	23.2138
860612	19.08	14.1726
860612	20.43	14.1726
860612	20.44	5.1785
860613	01.04	5.1785
860613	01.05	.5399
860614	18.39	.5399
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860718	10.30	26.4000
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860718	12.52	29.9200
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860729	18.56	61.1997
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860731	19.37	16.6222
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860731	21.50	14.3234
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860801	04.04	6.6325
860801	07.27	6.6325
860801	07.28	14.7956
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860801	18.26	3.1755
860801	18.27	.5169
860803	13.52	.5169
860803	13.53	1.3600
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860804	13.27	58.5390
860804	13.50	58.5390
860804	13.51	49.8665
860804	14.18	49.8665
860804	14.19	24.0428
860804	15.15	24.0428
860804	15.16	7.9669
860804	18.05	7.9669
860804	18.06	2.5646
860805	02.51	2.5646
860805	02.52	.0000
860805	23.00	.0000

Precipitation data:

C1: Date (year/month/day)

C2: time (hour:min)

C3: rate (mm.day<sup>-1</sup>)

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860710	14.30	13.63
860710	14.31	47.66
860710	14.45	47.66
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860710	15.01	17.59
860710	15.15	17.59
860710	15.16	.00
860710	15.30	.00
860710	15.31	.00
860710	15.45	.00
860710	15.46	11.65
860710	16.00	11.65
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860710	16.15	47.29
860710	16.16	17.24
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860710	16.45	9.71
860710	16.46	9.54
860710	17.00	9.54
860710	17.01	10.36
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860710	18.31	37.98
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860728	07.31	.00
860728	07.45	.00
860729	03.31	.00
860729	03.45	.00
860729	03.46	8.93
860729	04.00	8.93
860729	04.01	.00
860729	04.15	.00
860729	07.31	.00
860729	07.45	.00
860729	07.46	14.10
860729	08.00	14.10
860729	08.01	52.34
860729	08.15	52.34
860729	08.16	52.25
860729	08.30	52.25
860729	08.31	52.22
860729	08.45	52.22

860729	08.46	52.39
860729	09.00	52.39
860729	09.01	52.48
860729	09.15	52.48
860729	09.16	52.50
860729	09.30	52.50
860729	09.31	52.06
860729	09.45	52.06
860729	09.46	52.01
860729	10.00	52.01
860729	10.01	51.99
860729	10.15	51.99
860729	10.16	51.97
860729	10.30	51.97
860729	10.31	51.94
860729	10.45	51.94
860729	10.46	51.92
860729	11.00	51.92
860729	11.01	51.85
860729	11.15	51.85
860729	11.16	51.69
860729	11.30	51.69
860729	11.31	51.71
860729	11.45	51.71
860729	11.46	51.71
860729	12.00	51.71
860729	12.01	51.73
860729	12.15	51.73
860729	12.16	51.71
860729	12.30	51.71
860729	12.31	51.69
860729	12.45	51.69
860729	12.46	51.50
860729	13.00	51.50
860729	13.01	51.43
860729	13.15	51.43
860729	13.16	51.48
860729	13.30	51.48
860729	13.31	51.59
860729	13.45	51.59
860729	13.46	51.64
860729	14.00	51.64
860729	14.01	51.59
860729	14.15	51.59
860729	14.16	51.62
860729	14.30	51.62
860729	14.31	51.29
860729	14.45	51.29
860729	14.46	51.38

860729	15.00	51.38
860729	15.01	51.31
860729	15.15	51.31
860729	15.16	51.33
860729	15.30	51.33
860729	15.31	51.26
860729	15.45	51.26
860729	15.46	51.22
860729	16.00	51.22
860729	16.01	51.08
860729	16.15	51.08
860729	16.16	51.22
860729	16.30	51.22
860729	16.31	51.12
860729	16.45	51.12
860729	16.46	51.26
860729	17.00	51.26
860729	17.01	51.33
860729	17.15	51.33
860729	17.16	51.26
860729	17.30	51.26
860729	17.31	51.31
860729	17.45	51.31
860729	17.46	51.45
860729	18.00	51.45
860729	18.01	51.50
860729	18.15	51.50
860729	18.16	51.45
860729	18.30	51.45
860729	18.31	51.50
860729	18.45	51.50
860729	18.46	51.48
860729	19.00	51.48
860729	19.01	51.43
860729	19.15	51.43
860729	19.16	51.43
860729	19.30	51.43
860729	19.31	51.64
860729	19.45	51.64
860729	19.46	51.57
860729	20.00	51.57
860729	20.01	51.57
860729	20.15	51.57
860729	20.16	51.55
860729	20.30	51.55
860729	20.31	42.59
860729	20.45	42.59
860729	20.46	19.65
860729	21.00	19.65

860729	21.01	9.19
860729	21.15	9.19
860729	21.16	3.93
860729	21.30	3.93
860729	21.31	9.57
860729	21.45	9.57
860729	21.46	.00
860729	22.00	.00
860729	22.16	.00
860729	22.30	.00
860729	22.31	46.00
860729	22.45	46.00
860729	22.46	13.56
860729	23.00	13.56
860729	23.01	50.10
860729	23.15	50.10
860729	23.16	1.89
860729	23.30	1.89
860729	23.31	8.35
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860729	23.46	.00
860729	24.00	.00
860730	00.46	.00
860730	01.00	.00
860730	01.01	11.04
860730	01.15	11.04
860730	01.16	18.57
860730	01.30	18.57
860730	01.31	36.72
860730	01.45	36.72
860730	01.46	11.58
860730	02.00	11.58
860730	02.01	12.77
860730	02.15	12.77
860730	02.16	9.87
860730	02.30	9.87
860730	02.31	.00
860730	02.45	.00
860730	02.46	32.53
860730	03.00	32.53
860730	03.01	13.14
860730	03.15	13.14
860730	03.16	31.99
860730	03.30	31.99
860730	03.31	23.93
860730	03.45	23.93
860730	03.46	51.64
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860730	04.45	52.06
860730	04.46	52.08
860730	05.00	52.08
860730	05.01	52.13
860730	05.15	52.13
860730	05.16	52.06
860730	05.30	52.06
860730	05.31	2.78
860730	05.45	2.78
860730	05.46	13.85
860730	06.00	13.85
860730	06.01	27.32
860730	06.15	27.32
860730	06.16	11.09
860730	06.30	11.09
860730	06.31	.40
860730	06.45	.40
860730	06.46	9.45
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860730	07.46	.00
860730	08.00	.00
860730	08.16	.00
860730	08.30	.00
860730	08.31	9.21
860730	08.45	9.21
860730	08.46	.00
860730	09.00	.00
860731	08.31	.00
860731	08.45	.00
860731	08.46	25.23
860731	09.00	25.23
860731	09.01	51.66
860731	09.15	51.66
860731	09.16	23.76
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860731	09.31	38.21
860731	09.45	38.21
860731	09.46	14.48
860731	10.00	14.48

860731	10.01	40.16
860731	10.15	40.16
860731	10.16	14.08
860731	10.30	14.08
860731	10.31	.19
860731	10.45	.19
860731	10.46	9.45
860731	11.00	9.45
860731	11.01	.00
860731	11.15	.00
860731	12.01	.00
860731	12.15	.00
860731	12.16	13.80
860731	12.30	13.80
860731	12.31	.00
860731	12.45	.00
860731	13.01	.00
860731	13.15	.00
860731	13.16	9.10
860731	13.30	9.10
860731	13.31	.00
860731	13.45	.00
860731	13.46	.00
860731	14.00	.00
860731	14.01	1.29
860731	14.15	1.29
860731	14.16	6.06
860731	14.30	6.06
860731	14.31	.73
860731	14.45	.73
860731	14.46	.87
860731	15.00	.87
860731	15.01	.00
860731	15.15	.00
860731	17.16	.00
860731	17.30	.00
860731	17.31	36.02
860731	17.45	36.02
860731	17.46	46.26
860731	18.00	46.26
860731	18.01	45.23
860731	18.15	45.23
860731	18.16	40.13
860731	18.30	40.13
860731	18.31	36.74
860731	18.45	36.74
860731	18.46	37.68
860731	19.00	37.68
860731	19.01	37.05

860731	19.15	37.05
860731	19.16	36.98
860731	19.30	36.98
860731	19.31	37.09
860731	19.45	37.09
860731	19.46	36.62
860731	20.00	36.62
860731	20.01	35.74
860731	20.15	35.74
860731	20.16	35.15
860731	20.30	35.15
860731	20.31	27.71
860731	20.45	27.71
860731	20.46	15.06
860731	21.00	15.06
860731	21.01	1.19
860731	21.15	1.19
860731	21.16	10.92
860731	21.30	10.92
860731	21.31	.26
860731	21.45	.26
860731	21.46	.26
860731	22.00	.26
860731	22.01	.26
860731	22.15	.26
860731	22.16	.26
860731	22.30	.26
860731	22.31	9.78
860731	22.45	9.78
860731	22.46	.44
860731	23.00	.44
860731	23.01	.37
860731	23.15	.37
860731	23.16	.35
860731	23.30	.35
860731	23.31	.33
860731	23.45	.33
860731	23.46	.26
860731	24.00	.26
860801	00.01	.00
860801	00.15	.00
860801	03.16	.00
860801	03.30	.00
860801	03.31	3.32
860801	03.45	3.32
860801	03.46	20.79
860801	04.00	20.79
860801	04.01	.00
860801	04.15	.00

860801	04.16	.33
860801	04.30	.33
860801	04.31	9.40
860801	04.45	9.40
860801	04.46	35.27
860801	05.00	35.27
860801	05.01	42.40
860801	05.15	42.40
860801	05.16	42.40
860801	05.30	42.40
860801	05.31	36.58
860801	05.45	36.58
860801	05.46	15.25
860801	06.00	15.25
860801	06.01	10.97
860801	06.15	10.97
860801	06.16	1.43
860801	06.30	1.43
860801	06.31	.00
860801	06.45	.00
860801	06.46	.00
860801	07.00	.00
860801	07.01	15.48
860801	07.15	15.48
860801	07.16	51.15
860801	07.30	51.15
860801	07.31	17.40
860801	07.45	17.40
860801	07.46	16.39
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860801	08.15	12.93
860801	08.16	.00
860801	08.30	.00
860801	09.01	.00
860801	09.15	.00
860801	09.16	5.73
860801	09.30	5.73
860801	09.31	6.31
860801	09.45	6.31
860801	09.46	.00
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860801	10.30	.00
860801	10.31	14.17
860801	10.45	14.17
860801	10.46	.00
860801	11.00	.00
860801	11.46	.00



860801	12.00	.00
860801	12.01	10.38
860801	12.15	10.38
860801	12.16	.00
860801	12.30	.00
860801	15.46	.00
860801	16.00	.00
860801	16.01	12.25
860801	16.15	12.25
860801	16.16	19.79
860801	16.30	19.79
860801	16.31	5.92
860801	16.45	5.92
860801	16.46	6.15
860801	17.00	6.15
860801	17.01	.00
860801	17.15	.00
860801	18.01	.00
860801	18.15	.00
860801	18.16	11.44
860801	18.30	11.44
860801	18.31	.00
860801	18.45	.00
860803	23.46	.00
860803	24.00	.00
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860804	00.15	13.54
860804	00.16	.00
860804	00.30	.00
860804	00.31	.00
860804	00.45	.00
860804	00.46	11.53
860804	01.00	11.53
860804	01.01	.00
860804	01.15	.00
860804	01.16	2.10
860804	01.30	2.10
860804	01.31	50.03
860804	01.45	50.03
860804	01.46	24.30
860804	02.00	24.30
860804	02.01	33.12
860804	02.15	33.12
860804	02.16	35.10
860804	02.30	35.10
860804	02.31	27.95
860804	02.45	27.95
860804	02.46	20.88
860804	03.00	20.88

860804	03.01	49.67
860804	03.15	49.67
860804	03.16	51.38
860804	03.30	51.38
860804	03.31	50.63
860804	03.45	50.63
860804	03.46	47.27
860804	04.00	47.27
860804	04.01	16.28
860804	04.15	16.28
860804	04.16	7.46
860804	04.30	7.46
860804	04.31	11.46
860804	04.45	11.46
860804	04.46	.00
860804	05.00	.00
860804	10.46	.00
860804	11.00	.00
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860804	11.15	25.54
860804	11.16	50.91
860804	11.30	50.91
860804	11.31	50.89
860804	11.45	50.89
860804	11.46	50.87
860804	12.00	50.87
860804	12.01	50.91
860804	12.15	50.91
860804	12.16	42.87
860804	12.30	42.87
860804	12.31	28.25
860804	12.45	28.25
860804	12.46	50.54
860804	13.00	50.54
860804	13.01	46.73
860804	13.15	46.73
860804	13.16	46.61
860804	13.30	46.61
860804	13.31	26.68
860804	13.45	26.68
860804	13.46	34.64
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860804	14.15	12.21
860804	14.16	.00
860804	14.30	.00
860804	15.46	.00
860804	16.00	.00
860804	16.01	10.36

860804	16.15	10.36
860804	16.16	.00
860804	16.30	.00
860804	20.31	.00
860804	20.45	.00
860804	20.46	3.20
860804	21.00	3.20
860804	21.01	8.75
860804	21.15	8.75
860804	21.16	.00
860804	21.30	.00
860804	23.01	.00
860804	23.15	.00
860804	23.16	11.60
860804	23.30	11.60
860804	23.31	.00
860804	23.45	.00
860805	07.31	.00
860805	07.45	.00
860805	07.46	10.73
860805	08.00	10.73
860805	08.01	.89
860805	08.15	.89
860805	08.16	.00
860805	08.30	.00
860807	02.16	.00
860807	02.30	.00
860807	02.31	12.02
860807	02.45	12.02
860807	02.46	13.42
860807	03.00	13.42
860807	03.01	13.73
860807	03.15	13.73
860807	03.16	.94
860807	03.30	.94
860807	03.31	11.97
860807	03.45	11.97
860807	03.46	.00
860807	04.00	.00
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860807	05.16	11.23
860807	05.30	11.23
860807	05.31	.00
860807	05.45	.00
860807	08.31	.00
860807	08.45	.00

860807	08.46	11.48
860807	09.00	11.48
860807	09.01	.00
860807	09.15	.00
860807	12.31	.00
860807	12.45	.00
860807	12.46	11.53
860807	13.00	11.53
860807	13.01	.00
860807	13.15	.00
860807	15.31	.00
860807	15.45	.00
860807	15.46	13.33
860807	16.00	13.33
860807	16.01	23.88
860807	16.15	23.88
860807	16.16	10.55
860807	16.30	10.55
860807	16.31	6.24
860807	16.45	6.24
860807	16.46	.00
860807	17.00	.00
860807	17.46	.00
860807	18.00	.00
860807	18.01	2.06
860807	18.15	2.06
860807	18.16	17.24
860807	18.30	17.24
860807	18.31	.00
860807	18.45	.00
860807	18.46	11.93
860807	19.00	11.93
860807	19.01	39.15
860807	19.15	39.15
860807	19.16	28.72
860807	19.30	28.72
860807	19.31	34.15
860807	19.45	34.15
860807	19.46	.00
860807	20.00	.00
860807	20.01	4.89
860807	20.15	4.89
860807	20.16	49.84
860807	20.30	49.84
860807	20.31	50.49
860807	20.45	50.49
860807	20.46	49.23
860807	21.00	49.23
860807	21.01	48.74

860807	21.15	48.74
860807	21.16	49.77
860807	21.30	49.77
860807	21.31	50.77
860807	21.45	50.77
860807	21.46	49.51
860807	22.00	49.51
860807	22.01	48.86
860807	22.15	48.86
860807	22.16	49.88
860807	22.30	49.88
860807	22.31	50.68
860807	22.45	50.68
860807	22.46	49.60
860807	23.00	49.60
860807	23.01	34.31
860807	23.15	34.31
860807	23.16	27.92
860807	23.30	27.92
860807	23.31	21.56
860807	23.45	21.56
860807	23.46	16.32
860807	24.00	16.32
860808	00.01	.44
860808	00.15	.44
860808	00.16	11.62
860808	00.30	11.62
860808	00.31	.00
860808	00.45	.00
860808	03.16	.00
860808	03.30	.00
860808	03.31	13.40
860808	03.45	13.40
860808	03.46	.00
860808	04.00	.00
860808	04.01	.00
860808	04.15	.00
860808	04.16	13.92
860808	04.30	13.92
860808	04.31	.00
860808	04.45	.00
860808	05.46	.00
860808	06.00	.00
860808	06.01	20.39
860808	06.15	20.39
860808	06.16	2.20
860808	06.30	2.20
860808	06.31	3.25
860808	06.45	3.25

860808	06.46	8.51
860808	07.00	8.51
860808	07.01	.00
860808	07.15	.00
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860808	08.45	49.63
860808	08.46	17.89
860808	09.00	17.89
860808	09.01	16.96
860808	09.15	16.96
860808	09.16	13.92
860808	09.30	13.92
860808	09.31	.00
860808	09.45	.00
860808	09.46	11.37
860808	10.00	11.37
860808	10.01	10.52
860808	10.15	10.52
860808	10.16	38.61
860808	10.30	38.61
860808	10.31	17.42
860808	10.45	17.42
860808	10.46	28.58
860808	11.00	28.58
860808	11.01	10.59
860808	11.15	10.59
860808	11.16	11.60
860808	11.30	11.60
860808	11.31	27.50
860808	11.45	27.50
860808	11.46	26.31
860808	12.00	26.31
860808	12.01	4.65
860808	12.15	4.65
860808	12.16	11.39
860808	12.30	11.39
860808	12.31	.00
860808	12.45	.00

Results of the chemical analysis:

time: hr:min

mg.L<sup>-1</sup>: Na, K, Ca, Mg, SO<sub>4</sub>, Br, Cl, NO<sub>3</sub> - N, TOC

μgr.L<sup>-1</sup>: NH<sub>4</sub> - N, Al<sub>o</sub>, Al<sub>r</sub>

Type	Time	pH	Na	K	NH4-N	Ca	Mg	AlO	Alr	SO4	Br	Cl	NO3-N	TOC
RUNOF	02:40	3.8	3.3	.4	900.	.7	.7	224.	910.	13.0	-	2.7	2.5	13.6
RUNOF	03:30	3.8	-	-	-	-	-	-	-	11.2	-	2.3	2.1	-
RUNOF	04:25	3.9	-	-	-	-	-	-	-	9.9	-	2.1	1.7	-
RUNOF	05:55	3.9	2.4	.2	700.	.5	.4	223.	500.	8.4	-	1.8	1.5	12.8
RUNOF	07:00	3.9	-	-	-	-	-	-	-	7.9	.1	1.6	1.4	-
RUNOF	07:55	3.9	-	-	-	-	-	-	-	7.4	.1	1.5	1.3	-
RUNOF	08:22	3.9	-	-	-	-	-	-	-	7.3	.1	1.5	1.3	-
RUNOF	08:42	4.0	-	-	-	-	-	-	-	7.1	-	1.5	1.2	-
RUNOF	09:00	3.9	-	-	-	-	-	-	-	6.7	.1	1.4	1.1	-
RUNOF	09:17	4.0	-	-	-	-	-	-	-	7.0	.7	1.5	1.2	-
RUNOF	09:45	3.9	2.0	.2	495.	.4	.4	208.	450.	6.9	1.2	1.4	1.1	13.0
RUNOF	21:10	3.8	2.5	.2	300.	.6	.5	197.	630.	9.6	1.9	1.7	1.4	10.9
RUNOF	23:15	3.8	-	-	-	-	-	-	-	9.9	1.7	1.8	1.3	-
INPUT	13:20	3.8	.2	.1	150.	.3	.1	10.	75.	8.3	-	.9	1.7	-
INPUT	14:30	4.0	-	-	-	-	-	-	-	11.2	-	.6	1.0	-
INPUT	16:15	4.1	-	-	-	-	-	-	-	4.9	-	.5	.8	-
INPUT	18:45	4.5	-	-	-	-	-	-	-	1.8	-	.3	.3	-
INPUT	20:00	4.9	-	-	-	-	-	-	-	.7	-	.1	.1	-
INPUT	22:30	5.1	-	-	-	-	-	-	-	.3	-	.1	.0	-
INPUT	00:55	5.4	-	-	-	-	-	-	-	.0	-	.1	.1	-
INPUT	02:25	5.5	-	-	-	-	-	-	-	.0	-	.0	.0	-
INPUT	04:25	5.6	-	-	-	-	-	-	-	.1	-	.2	.1	-
INPUT	06:30	5.6	-	-	-	-	-	-	-	.0	-	.0	.0	-
INPUT	06:48	5.1	-	-	-	-	-	-	-	.4	1.7	.1	.0	-
INPUT	07:00	4.8	-	-	-	-	-	-	-	1.5	5.8	.4	.2	-
INPUT	07:30	4.4	-	-	-	-	-	-	-	4.4	13.7	2.0	.5	-
INPUT	08:44	4.4	-	-	-	-	-	-	-	4.0	15.0	1.0	.5	-
INPUT	09:00	4.9	-	-	-	-	-	-	-	1.1	4.2	.4	.1	-
INPUT	09:17	4.9	-	-	-	-	-	-	-	.7	3.0	.2	.1	-
INPUT	09:45	5.2	-	-	-	-	-	-	-	.3	1.4	.1	.0	-
INPUT	10:20	5.3	-	-	-	-	-	-	-	.3	1.3	.1	.0	-
INPUT	10:20	5.6	-	-	-	-	-	-	-	.0	<.1	.0	.0	-
LYS Z	01:50	4.6	-	-	-	-	-	-	-	19.0	-	2.4	1.3	-
LYS Z	03:50	4.4	3.7	.3	700.	.7	.8	185.	1260.	13.8	-	2.5	2.1	8.2
LYS Z	06:08	4.4	-	-	-	-	-	-	-	11.7	-	2.3	1.9	-
LYS Z	08:18	4.4	-	-	-	-	-	-	-	9.8	<.1	2.0	1.6	-
LYS Z	08:48	4.4	-	-	-	-	-	-	-	9.1	<.1	1.8	1.5	-
LYS Z	09:25	4.4	-	-	-	-	-	-	-	8.2	<.1	1.6	1.3	-
LYS Z	10:45	4.4	2.3	.2	750.	.4	.5	237.	880.	8.1	<.1	1.5	1.3	9.3
LYS Z	22:15	4.4	2.4	.2	700.	.5	.5	195.	790.	8.5	1.1	1.7	1.3	8.0
LYS Y	02:25	3.8	3.4	.3	950.	.8	.8	276.	850.	14.3	-	2.4	2.2	15.3
LYS Y	03:45	3.9	-	-	-	-	-	-	-	10.3	-	2.2	1.8	-
LYS Y	06:00	3.9	-	-	-	-	-	-	-	8.2	-	1.7	1.5	-
LYS Y	08:17	4.0	-	-	-	-	-	-	-	6.9	<.1	1.5	1.3	-
LYS Y	08:48	4.0	-	-	-	-	-	-	-	6.6	<.1	1.3	1.1	-
LYS Y	09:25	4.0	-	-	-	-	-	-	-	6.2	1.0	1.3	1.1	-
LYS Y	10:45	4.0	1.9	.2	700.	.5	.4	188.	302.	6.9	2.3	1.5	1.2	12.3

LYS Y	22:15	3.9	2.8	.1	800.	.7	.7	188.	690.	13.8	1.6	1.8	1.3	9.6
LYS C	06:20	4.0	-	-	-	-	-	-	-	11.5	-	2.4	2.2	-
LYS C	10:25	4.1	-	-	-	-	-	-	-	7.4	<.1	1.5	1.3	-
LYS C	22:15	4.1	-	-	-	-	-	235.	-	6.7	2.5	1.5	1.2	12.3
LYS E	01:20	-	-	-	-	-	-	-	-	27.8	-	3.4	2.4	12.9
LYS E	06:35	3.9	-	-	-	-	-	-	-	28.0	-	2.8	2.5	-
LYS E	10:30	3.9	-	-	-	-	-	-	-	28.8	<.1	2.3	2.2	-
LYS E	22:45	3.9	4.5	.3	360.	1.7	2.3	168.	2280.	32.6	1.5	2.3	2.0	-
LYS H	02:10	4.4	-	-	-	-	-	-	-	9.5	-	3.0	1.9	-
LYS H	06:05	4.2	-	-	-	-	-	-	-	8.3	-	2.4	1.1	-
LYS H	09:40	4.3	-	-	-	-	-	-	-	6.1	<.1	1.8	.8	-
LYS H	23:05	4.3	-	-	-	-	-	285.	-	5.4	2.4	1.7	.7	-
LYS K	02:10	4.3	4.5	.3	360.	1.7	2.3	-	-	10.0	-	2.8	1.5	-
LYS K	06:05	4.3	-	-	-	-	-	-	-	5.6	-	1.3	1.3	-
LYS K	09:35	-	-	-	-	-	-	-	-	3.7	.7	.9	.8	-
LYS K	23:00	4.3	-	-	-	0.4	0.3	196.	279.	4.2	2.7	1.1	.6	-
LYSK2	4. JUL	5.3	-	-	-	-	-	-	-	2.2	<.1	6.2	.0	-
LYSK2	10:00	5.4	-	-	-	-	-	-	-	10.6	-	3.3	.7	-
LYSK2	17:45	5.3	-	-	-	-	-	-	-	9.6	-	2.9	1.1	-
LYSK2	01:40	5.1	-	-	-	-	-	-	-	9.1	-	2.6	1.2	-
LYSK2	06:55	4.7	-	-	-	-	-	-	-	14.5	-	2.5	1.7	-
LYSK2	10:40	-	-	-	-	-	-	-	-	14.8	<.1	2.5	1.9	-
LYSK2	22:40	4.5	-	-	-	-	-	-	-	13.9	<.1	2.6	1.8	-
LYS 3	22:35	4.0	-	-	-	-	-	-	-	12.6	<.1	2.8	1.1	-
LYS 4	22:20	4.0	-	-	-	-	-	-	-	32.5	<.1	3.5	.7	-
LYS A	06:25	4.2	3.8	.1	35.	1.4	1.1	-	3150.	29.6	-	3.4	3.2	-
LYS A	10:25	4.2	-	-	-	-	-	-	-	25.7	-	3.4	3.2	-
LYS A	22:45	4.2	2.6	.1	10.	1.0	.6	134.	2060.	14.7	1.2	2.2	1.7	-
LYS B	06:20	4.3	-	-	-	-	-	-	-	28.8	-	2.8	2.6	-
LYS B	10:30	4.3	-	-	-	-	-	-	-	-	-	-	-	-
LYS B	22:45	4.3	-	-	-	-	-	-	-	26.8	-	2.6	2.5	-
LYS F	06:20	4.6	-	-	-	-	-	-	-	8.3	-	2.5	2.7	-
LYS F	10:20	4.6	-	-	-	-	-	-	-	7.2	-	2.3	2.4	-
LYS F	22:45	4.6	-	-	-	-	-	-	-	5.2	.8	2.1	2.2	-
LYS G	02:20	4.8	3.8	.3	950.	.3	.4	100.	530.	10.1	-	5.0	1.1	-
LYS G	06:05	4.8	-	-	-	-	-	-	-	9.6	-	4.0	1.1	-
LYS G	09:40	-	-	-	-	-	-	-	-	8.9	-	3.5	1.0	-
LYS G	23:05	4.8	2.9	.2	425.	.3	.4	128.	530.	7.1	1.0	2.7	.6	-
LYS I	01:10	4.0	-	-	-	-	-	-	-	14.0	-	3.3	3.1	-
LYS I	10.05	4.1	-	-	850.	.3	-	220.	300.	-	-	-	-	-
LYS I	22:55	4.1	-	-	850.	.4	-	211.	315.	6.2	2.9	1.4	1.0	-
LYS J	22:10	-	-	-	-	-	-	-	-	10.9	-	2.5	2.4	-
LYS J	01:10	3.9	-	-	-	-	-	-	-	10.8	-	2.2	2.4	-
LYS J	06:10	4.0	-	-	-	-	-	-	-	11.6	-	2.0	1.6	-
LYS J	10:25	4.0	-	-	-	-	-	-	-	8.1	-	1.5	1.1	-
LYS J	22:55	4.1	-	-	-	-	-	-	-	6.9	2.5	1.5	1.1	-
LYS 5	22:30	4.0	-	-	-	-	-	-	-	7.4	-	1.8	.3	-
ROLF	14:27	3.8	2.7	.7	700.	.7	.8	171.	450.	17.0	-	4.0	.99	17.5
ROLF	14:59	3.8	2.7	.7	700.	.7	.8	179.	425.	13.0	-	4.6	.99	19.7



ROLF	16:05	3.8	2.8	.1	650.	.7	.8	188.	450.	19.0	-	3.9	-	16.9
ROLF	18:41	3.8	2.8	.5	650.	.7	.8	187.	485.	16.0	-	4.0	.94	15.6
ROLF	19:49	3.8	2.8	.5	600.	.7	.8	191.	465.	15.0	-	4.2	.95	15.6
KIM	13:12	4.1	3.1	.4	650.	.8	.5	251.	520.	9.8	-	5.5	.59	14.2
KIM	18:15	4.1	2.5	.5	850.	.7	.5	196.	400.	8.5	-	4.0	.80	12.6
KIM	19:43	4.1	2.4	.5	850.	.7	.5	187.	385.	8.6	-	3.9	.90	12.6
KIM	21:01	4.0	2.6	.4	460.	.6	.5	228.	485.	7.8	-	4.7	.96	13.9
KIM	22:21	4.0	2.6	.3	255.	.4	.4	278.	525.	5.6	-	5.5	.93	15.4
KIM	23:41	4.0	2.7	.3	305.	.4	.4	296.	530.	6.6	-	5.3	.98	15.8
KIM	02:17	4.0	2.7	.2	240.	.4	.4	306.	560.	5.9	-	5.8	.99	14.5
KIM	03:35	3.9	2.7	.2	245.	.4	.4	314.	550.	5.4	-	5.9	.99	15.5
KIM	04:43	3.9	2.7	.2	235.	.4	.4	315.	560.	5.4	-	6.2	.97	14.8
KIM	06:09	4.0	2.7	.2	215.	.4	.4	318.	560.	5.9	-	6.3	.96	17.0

Tensiometer data

C1: date (year/month/day)

C2: time (hr:min)

C3-C12 tens 1-10 (hpa)

860630	15:38	-35.6	-28.4	-10.4	-48.5	-38.5	-59.2	-30.9	-55.3	-39.2	-48.6
860630	16:12	-37.2	-29.0	-11.5	-49.8	-39.5	-60.3	-28.0	-55.0	-39.2	-48.9
860630	16:42	-36.7	-28.8	-10.4	-48.5	-39.0	-59.2	-28.0	-55.0	-39.5	-48.4
860630	17:12	-36.4	-28.7	-10.7	-49.3	-39.0	-59.2	-28.5	-54.7	-39.2	-48.1
860630	18:12	-37.4	-29.2	-11.2	-49.8	-39.3	-59.7	-30.9	-55.0	-39.7	-48.4
860630	19:12	-37.7	-29.6	-11.2	-50.3	-39.8	-59.7	-32.2	-55.3	-40.0	-49.4
860630	20:12	-38.0	-29.9	-12.0	-50.3	-40.1	-59.7	-33.3	-55.5	-40.0	-49.2
860630	21:12	-37.4	-29.9	-12.3	-50.9	-40.1	-59.5	-34.9	-56.1	-40.3	-49.7
860630	22:42	-38.0	-30.3	-11.8	-50.3	-40.9	-60.0	-35.7	-56.1	-41.1	-49.7
860701	00:12	-38.2	-30.3	-12.3	-50.3	-40.1	-60.3	-36.5	-56.3	-40.3	-50.2
860701	01:42	-38.8	-30.2	-12.0	-50.6	-40.6	-60.3	-37.0	-56.8	-40.8	-50.8
860701	03:12	-39.6	-30.8	-13.1	-51.7	-41.4	-60.8	-37.0	-56.8	-41.6	-51.3
860701	04:42	-39.0	-30.5	-12.3	-51.4	-40.9	-60.8	-37.8	-57.1	-41.3	-50.8
860701	06:12	-39.6	-30.8	-12.8	-51.7	-40.9	-60.5	-37.0	-56.8	-41.1	-51.0
860701	07:42	-39.0	-31.2	-12.0	-51.4	-41.7	-61.3	-36.5	-57.7	-41.8	-51.0
860701	09:12	-39.3	-31.5	-12.8	-52.2	-41.4	-61.9	-37.8	-57.4	-42.1	-52.3
860701	10:42	-40.1	-31.8	-13.9	-52.7	-42.2	-62.7	-38.8	-58.2	-42.7	-52.6
860701	12:12	-40.6	-32.3	-13.9	-53.0	-42.2	-61.9	-38.6	-58.2	-42.9	-52.9
860701	13:42	-40.4	-32.6	-14.2	-53.0	-42.7	-62.7	-38.1	-58.7	-43.4	-53.7
860701	15:12	-41.2	-33.3	-15.0	-53.5	-43.0	-62.9	-39.1	-59.2	-43.4	-53.9
860701	16:42	-41.7	-33.6	-15.2	-54.6	-44.0	-63.7	-39.9	-60.3	-45.1	-54.7
860701	18:12	-42.5	-34.3	-15.8	-55.1	-44.3	-65.1	-40.4	-60.0	-45.3	-55.5
860701	19:42	-42.5	-34.7	-16.3	-55.1	-44.8	-64.5	-42.0	-60.8	-45.6	-56.1
860701	21:12	-43.0	-34.9	-16.5	-55.7	-44.8	-65.6	-41.5	-60.8	-46.7	-56.3
860701	22:42	-43.6	-35.2	-16.8	-55.9	-44.8	-65.1	-41.2	-61.1	-46.9	-57.1
860702	00:12	-43.3	-35.2	-17.1	-56.2	-45.1	-65.6	-41.5	-61.9	-46.9	-56.1
860702	01:42	-43.3	-35.3	-16.5	-56.2	-45.6	-66.1	-41.8	-61.6	-46.7	-57.1

860702	03:42	-43.6	-35.4	-17.1	-56.2	-46.2	-67.5	-42.3	-61.9	-47.7	-57.1
860702	05:42	-44.3	-35.7	-17.1	-56.7	-45.9	-67.2	-42.6	-62.4	-48.0	-58.4
860702	07:42	-43.8	-35.8	-17.6	-56.7	-46.4	-67.2	-42.8	-62.7	-47.7	-59.3
860702	09:42	-44.6	-36.4	-18.4	-56.5	-46.7	-68.3	-43.4	-63.0	-49.3	-58.7
860702	11:42	-45.7	-37.6	-18.7	-58.1	-46.9	-68.3	-43.6	-64.0	-49.6	-59.8
860702	13:42	-46.7	-38.1	-19.7	-59.1	-48.3	-70.7	-44.4	-63.8	-50.1	-61.9
860702	15:42	-46.5	-38.8	-19.5	-59.9	-49.1	-70.9	-46.0	-65.9	-50.7	-61.9
860702	17:42	-47.5	-39.6	-20.8	-60.4	-49.6	-71.2	-47.3	-65.9	-52.3	-62.7
860702	19:42	-48.3	-40.1	-21.1	-61.3	-50.4	-72.3	-47.3	-66.7	-53.3	-64.0
860702	21:42	-48.6	-40.6	-21.9	-61.5	-50.7	-73.3	-47.6	-67.0	-53.6	-63.8
860702	23:42	-49.1	-40.6	-21.6	-62.3	-51.7	-73.3	-47.9	-66.4	-54.1	-65.6
860703	01:42	-49.4	-41.2	-22.7	-62.0	-51.4	-74.1	-44.2	-68.0	-54.4	-64.6
860703	03:42	-49.7	-41.3	-22.7	-62.8	-51.4	-74.1	-49.7	-68.3	-54.1	-64.6
860703	05:42	-49.9	-41.2	-22.1	-56.2	-51.7	-75.2	-48.9	-68.0	-54.7	-65.1
860703	07:42	-50.5	-41.4	-22.4	-62.8	-52.8	-75.7	-50.3	-68.6	-56.0	-66.2
860703	09:42	-49.9	-42.0	-23.5	-62.8	-51.7	-75.2	-50.5	-68.6	-55.4	-66.7
860703	11:42	-51.3	-43.0	-23.7	-64.2	-53.6	-76.3	-50.3	-69.4	-56.8	-67.8
860703	13:42	-51.8	-43.7	-24.8	-65.0	-53.6	-77.6	-51.3	-70.2	-57.1	-68.3
860703	15:42	-52.1	-44.4	-25.8	-66.3	-54.3	-77.9	-52.4	-71.5	-56.8	-69.1
860703	17:42	-52.6	-45.3	-25.6	-66.6	-53.8	-78.7	-53.2	-71.0	-59.2	-69.1
860703	19:42	-53.1	-45.6	-26.9	-66.6	-55.4	-80.0	-54.0	-72.0	-59.2	-71.2
860703	21:42	-53.4	-45.4	-26.4	-66.8	-55.7	-81.1	-54.5	-72.0	-59.4	-71.2
860703	23:42	-53.4	-45.7	-26.9	-67.1	-55.9	-80.8	-54.5	-72.8	-59.7	-71.5
860704	00:42	-53.9	-45.7	-27.4	-66.6	-55.9	-81.3	-54.5	-72.6	-60.5	-72.3
860704	01:42	-52.8	-45.9	-26.4	-67.6	-55.9	-81.6	-53.7	-73.4	-59.4	-72.8
860704	03:42	-54.7	-45.8	-26.6	-67.9	-55.9	-81.6	-55.6	-72.8	-60.5	-72.8
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860718	07:56	15.9	25.5	43.7	8.6	20.8	8.3	23.9	12.6	29.9	19.4
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860718 09:16	15.7	24.8	44.3	9.7	22.4	6.9	24.4	12.1	29.1	19.4
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860718 10:33	16.2	24.4	42.9	8.9	21.3	7.2	24.4	11.6	29.6	19.9
860718 11:03	15.4	24.5	43.4	8.6	20.5	6.7	24.9	12.6	29.3	19.4
860718 11:33	15.9	24.4	43.4	8.6	21.1	6.4	24.9	12.1	29.6	19.7
860718 12:33	15.9	24.5	43.2	8.1	21.1	7.2	25.2	12.1	29.3	20.2
860718 13:33	15.4	24.7	43.2	8.4	21.1	7.5	25.2	12.9	29.1	18.6
860718 14:23	15.7	24.6	43.2	8.4	21.1	7.8	24.9	12.4	30.4	19.7
860718 14:43	15.1	23.7	43.2	7.6	20.8	7.5	23.6	12.9	28.5	18.6
860718 15:03	14.6	23.0	42.4	7.3	20.0	6.9	22.8	10.5	28.8	19.4
860718 15:33	14.1	22.3	40.8	7.0	19.2	6.7	21.5	9.7	25.9	17.0
860718 16:03	13.5	22.0	40.5	6.2	18.7	6.7	20.1	9.2	25.6	15.9
860718 17:03	12.5	21.5	40.0	6.2	17.6	2.7	18.5	7.3	25.1	16.7
860718 18:03	12.2	21.5	39.7	4.4	17.1	.3	18.8	4.9	24.5	15.7
860718 19:03	12.5	21.3	40.0	2.0	14.4	-4.3	17.7	1.7	25.1	14.9
860718 20:03	12.0	20.8	39.5	.4	12.9	-7.4	16.2	-.4	24.8	15.1
860718 21:03	11.4	20.4	39.2	-.9	11.3	-8.5	15.6	-2.0	24.3	15.1
860718 23:10	10.1	20.5	38.4	-2.0	9.1	-10.1	14.8	-2.5	24.3	14.4
860719 00:10	9.8	20.5	38.1	-3.3	9.1	-9.9	15.1	-3.3	23.2	13.3
860719 01:10	9.8	20.8	39.5	-2.5	8.6	-9.6	14.8	-4.9	22.7	11.7
860719 02:40	9.6	20.2	37.9	-3.6	8.6	-10.1	14.8	-3.9	23.2	12.2
860719 04:10	9.6	20.2	37.3	-3.8	8.6	-9.9	14.8	-4.4	22.4	11.2
860719 06:10	9.6	20.3	38.1	-3.3	8.9	-9.9	14.3	-4.7	22.7	11.2
860719 08:10	8.5	19.6	37.9	-3.1	8.9	-9.9	14.8	-4.1	21.9	9.6
860719 10:10	8.2	18.6	37.3	-5.2	8.1	-11.5	14.6	-6.3	22.4	8.0
860719 12:10	7.2	17.6	35.8	-5.4	6.5	-11.7	12.4	-6.8	20.5	7.2
860719 14:10	7.4	17.0	34.2	-6.5	5.7	-12.5	12.2	-6.5	22.4	8.0
860719 16:10	6.1	15.8	33.9	-6.8	4.9	-13.3	10.8	-8.1	17.3	5.3
860719 18:10	5.1	14.7	32.8	-7.3	3.9	-14.4	9.2	-9.5	18.1	6.1
860719 20:10	4.3	13.9	32.3	-8.6	2.8	-15.2	8.7	-9.7	17.6	4.8
860719 22:10	3.7	13.8	32.0	-8.4	3.3	-15.2	8.5	-10.3	17.3	4.5
860720 00:10	4.3	14.1	32.0	-8.1	3.3	-16.0	8.2	-10.8	17.1	3.7
860720 02:10	4.3	13.8	32.8	-7.8	3.6	-16.3	8.7	-10.3	16.5	4.5
860720 04:10	4.5	13.9	33.1	-8.1	3.6	-16.0	8.7	-10.5	15.7	3.7
860720 06:10	4.3	13.6	32.3	-8.1	3.3	-15.7	8.7	-10.8	14.7	3.2
860720 08:10	3.7	13.8	32.3	-7.6	3.6	-15.7	9.2	-10.5	15.2	3.7
860720 10:10	4.3	13.4	31.8	-8.1	3.3	-16.0	8.7	-10.8	14.4	2.7
860720 12:10	3.7	13.1	31.8	-8.1	3.1	-18.1	7.9	-11.6	13.6	2.7
860720 13:10	3.7	13.3	31.5	-7.8	3.1	-20.0	7.6	-11.6	14.9	4.0
860720 14:10	4.0	13.3	31.8	-8.1	3.1	-20.3	7.9	-11.3	17.6	8.5
860720 15:10	3.5	13.1	31.8	-7.8	2.8	-21.0	7.9	-11.3	20.0	10.6
860720 16:10	3.7	13.0	31.5	-7.6	3.1	-21.6	7.9	-11.6	21.9	13.3
860720 17:10	3.7	12.9	31.2	-8.1	2.8	-22.1	8.2	-11.1	24.5	17.0
860720 18:10	3.2	13.0	30.7	-9.2	2.3	-22.4	7.1	-11.6	25.6	17.5
860720 18:40	3.7	13.2	31.5	-8.1	2.8	-22.9	7.6	-11.3	26.7	18.3
860720 19:10	4.3	13.9	32.6	-7.6	3.1	-20.5	9.8	-10.3	27.2	16.5

860720	19:40	5.1	15.7	34.4	-6.8	4.1	-9.9	15.9	-5.2	26.9	16.7
860720	20:10	9.3	21.4	39.7	-4.9	6.5	5.9	20.7	8.4	27.2	18.1
860720	20:40	12.8	21.9	40.5	1.2	16.3	6.7	21.2	8.9	26.1	17.3
860720	21:10	13.8	22.3	41.3	8.4	19.2	5.9	20.9	8.1	25.9	16.7
860720	21:40	13.8	22.3	40.8	7.8	18.7	5.1	20.4	7.6	25.3	16.2
860720	22:10	13.5	21.8	40.5	6.5	17.6	4.6	19.6	6.8	25.1	16.2
860720	22:40	13.3	22.0	40.5	6.5	17.6	4.0	19.6	6.5	25.1	16.5
860720	23:10	13.3	21.8	40.3	5.2	17.1	2.4	19.1	5.4	24.8	15.9
860720	23:40	13.3	22.1	40.3	3.3	16.0	.3	19.3	4.4	24.8	15.1
860721	00:10	13.0	21.6	40.0	3.1	15.8	-2.4	18.3	2.5	24.8	15.4
860721	01:10	12.2	21.6	40.5	2.3	13.4	-7.7	16.4	.6	25.3	16.2
860721	02:10	12.2	21.2	39.2	.7	12.3	-8.8	16.7	-.7	24.5	15.4
860721	03:10	12.2	21.0	38.1	.1	11.8	-10.1	17.0	-1.5	23.7	14.9
860721	04:10	11.4	21.1	39.5	-.9	11.3	-10.1	16.4	-2.3	24.8	15.9
860721	06:10	10.6	20.5	38.9	-.9	10.5	-11.7	15.6	-3.6	22.9	13.8
860721	08:10	10.4	20.5	38.7	-2.3	9.9	-10.6	16.2	-3.3	24.3	13.8
860721	10:10	9.0	20.2	38.1	-3.1	8.9	-12.0	15.9	-4.1	22.7	13.3
860721	12:10	8.2	19.0	36.8	-3.8	7.8	-12.0	14.8	-4.7	23.7	12.8
860721	14:10	7.4	17.8	36.0	-4.9	6.8	-12.8	14.0	-5.7	23.7	11.4
860721	16:10	6.9	17.0	35.2	-5.2	6.0	-12.0	12.7	-6.5	22.1	10.4
860721	18:10	6.6	16.1	34.2	-6.8	5.4	-13.6	11.9	-7.6	22.7	10.4
860721	20:10	5.1	15.9	34.4	-7.3	4.9	-13.0	11.9	-8.7	21.9	9.6
860721	22:10	5.6	15.6	34.4	-7.0	4.6	-13.3	11.4	-7.3	20.3	8.5
860722	00:10	5.6	16.0	34.7	-6.0	5.7	-14.4	12.2	-7.3	20.8	7.7
860722	02:10	6.1	16.2	34.7	-6.3	5.7	-13.3	12.7	-7.1	21.1	7.7
860722	04:10	6.9	16.6	35.5	-5.7	6.0	-13.6	13.0	-7.1	19.5	7.2
860722	06:10	7.2	17.0	35.8	-5.4	6.2	-13.3	13.0	-6.5	19.5	6.4
860722	08:10	7.4	17.2	36.0	-4.9	7.0	-12.5	13.5	-7.1	18.4	6.9
860722	10:10	5.6	15.5	34.2	-7.0	4.9	-13.9	11.1	-8.4	17.3	5.3
860722	12:10	4.8	14.3	32.8	-8.1	3.6	-15.2	9.8	-9.7	14.7	4.3
860722	14:10	3.7	13.6	32.0	-8.1	2.5	-21.0	9.2	-10.8	22.7	14.9
860722	14:40	3.5	13.6	31.5	-8.1	3.1	-19.5	9.0	-10.5	22.4	14.9
860722	15:10	3.7	13.2	31.8	-8.6	2.5	-18.7	8.7	-10.8	24.8	17.0
860722	15:40	3.5	12.9	31.2	-9.2	2.8	-18.4	7.6	-11.6	26.4	17.0
860722	16:10	2.7	12.5	30.4	-10.2	2.5	-17.0	8.5	-12.1	24.0	15.4
860722	16:40	2.7	12.6	31.0	-10.0	1.7	-18.4	9.8	-11.6	26.7	17.5
860722	17:10	3.2	12.6	31.5	-9.4	2.3	-17.6	9.0	-11.1	25.1	16.7
860722	17:40	3.2	13.6	32.0	-9.7	2.0	-15.7	11.6	-8.9	25.3	16.7
860722	18:10	3.2	14.6	33.1	-9.2	2.5	-14.1	13.0	-7.3	24.8	15.9
860722	18:40	4.0	16.1	35.2	-7.6	3.9	-12.0	14.8	-6.5	23.7	15.1
860722	19:10	5.3	16.8	35.0	-7.3	4.4	-11.7	15.4	-5.5	24.5	15.4
860722	19:40	5.9	18.0	36.6	-6.5	4.9	-11.2	16.4	-4.7	24.3	14.9
860722	20:10	6.6	18.9	36.8	-6.0	6.5	-10.4	15.9	-4.9	24.8	14.9
860722	20:40	8.0	20.2	37.6	-4.6	6.5	-10.1	16.4	-4.4	24.5	14.9
860722	21:10	8.8	20.5	38.7	-4.6	7.8	-10.1	16.4	-3.6	24.3	15.7
860722	21:40	9.8	20.7	39.2	-3.3	8.6	-10.1	16.4	-4.1	24.0	14.9
860722	22:40	10.9	20.5	38.9	-2.0	8.9	-10.1	16.7	-4.1	24.0	14.4
860722	23:40	10.6	20.6	38.4	-2.0	9.9	-9.6	17.2	-3.1	24.0	13.8
860723	00:40	10.9	20.6	38.9	-1.7	9.9	-9.6	17.0	-3.1	24.3	14.4

860723	01:40	11.4	20.8	39.2	-.4	10.5	-10.4	15.9	-3.6	24.0	13.3
860723	02:40	11.4	20.7	38.9	-.9	10.7	-10.6	16.4	-3.6	23.7	13.3
860723	03:40	11.4	20.8	38.9	-.9	10.2	-10.4	15.9	-4.1	23.5	12.5
860723	04:40	10.6	20.8	39.2	-1.7	10.2	-10.1	15.4	-4.7	22.4	11.2
860723	05:40	11.4	20.3	38.4	-1.2	10.7	-10.4	16.4	-4.4	22.7	11.2
860723	06:40	11.7	20.2	38.1	-1.7	10.2	-10.9	16.2	-4.1	23.5	12.2
860723	07:40	10.6	20.4	38.4	-2.0	9.9	-11.2	15.9	-4.4	22.1	10.6
860723	08:40	11.4	20.8	39.2	-.4	9.9	-10.9	15.1	-4.9	21.3	10.1
860723	09:40	10.4	20.0	37.9	-2.5	8.6	-11.2	16.2	-4.7	21.9	10.6
860723	11:40	8.8	18.9	37.3	-3.3	7.8	-11.7	14.8	-5.5	24.0	10.9
860723	13:40	7.4	17.5	36.0	-4.6	6.2	-12.8	13.2	-6.5	20.8	7.4
860723	15:40	5.3	15.7	33.1	-6.0	4.6	-14.6	11.9	-9.7	20.8	6.6
860723	17:40	4.8	13.8	32.0	-8.1	2.8	-15.7	10.0	-10.5	18.7	6.9
860723	19:40	3.7	12.8	30.7	-8.9	2.3	-17.0	9.0	-10.8	17.9	5.6
860723	21:40	3.5	12.6	31.2	-9.2	2.8	-16.0	8.7	-11.9	17.3	4.8
860723	23:40	3.2	13.4	31.5	-8.4	2.5	-16.0	9.2	-10.5	17.3	5.3
860724	01:40	3.5	14.0	32.8	-7.6	3.1	-16.5	9.8	-9.7	17.3	5.3
860724	03:40	4.0	14.0	32.0	-8.1	3.3	-15.2	10.6	-10.0	16.5	5.1
860724	05:40	4.5	14.5	32.8	-7.6	3.9	-15.2	10.3	-9.7	16.3	5.1
860724	07:40	5.1	14.5	32.8	-7.0	4.1	-16.3	9.5	-10.5	15.7	4.3
860724	09:40	3.7	12.9	31.5	-8.9	2.5	-16.3	8.5	-11.6	14.9	3.2
860724	11:40	2.7	11.6	30.4	-10.2	.7	-17.0	7.1	-12.9	14.1	2.7
860724	13:40	1.6	10.9	29.4	-10.5	.4	-18.4	6.3	-13.2	11.7	1.6
860724	15:40	.8	9.9	27.8	-12.4	-.6	-18.9	5.3	-14.3	13.9	1.9
860724	17:40	-.5	8.8	28.0	-13.1	-.9	-20.3	4.5	-14.8	11.7	1.3
860724	19:40	-1.1	8.5	26.7	-13.7	-2.0	-19.7	4.2	-15.6	10.7	-.8
860724	21:40	-1.1	8.3	26.2	-14.0	-2.2	-20.5	3.4	-16.4	10.1	-1.1
860724	23:40	-.8	8.1	27.0	-13.7	-2.0	-20.3	2.9	-15.9	9.6	-1.1
860725	01:40	-1.3	8.5	26.7	-14.0	-1.7	-21.0	3.4	-16.4	9.1	-.5
860725	03:40	-.5	8.4	26.5	-13.4	-2.2	-21.0	3.4	-16.7	9.3	-1.1
860725	05:40	-1.1	8.4	27.0	-12.9	-2.2	-20.8	3.7	-16.4	8.8	-1.1
860725	07:40	-1.3	8.2	26.7	-13.4	-2.5	-21.3	3.4	-16.4	8.0	-1.9
860725	09:40	-1.9	7.5	25.7	-14.0	-3.0	-21.6	2.9	-17.2	6.9	-2.4
860725	11:40	-2.7	6.6	24.9	-15.3	-3.8	-22.1	1.5	-18.3	6.7	-3.7
860725	13:40	-3.7	5.8	23.3	-15.8	-4.9	-23.2	.5	-18.5	6.1	-3.4
860725	15:40	-5.0	4.9	22.2	-16.9	-6.5	-23.5	-.9	-18.8	5.3	-4.0
860725	17:40	-5.3	3.6	22.5	-18.2	-6.7	-24.3	-.9	-20.1	4.0	-6.1
860725	19:40	-6.1	3.3	21.7	-18.5	-7.8	-24.8	-1.7	-20.9	2.9	-6.9
860725	21:40	-6.6	3.0	20.9	-19.3	-7.5	-25.8	-2.4	-21.7	2.7	-7.4
860725	23:40	-6.4	3.0	20.9	-18.7	-7.5	-25.0	-2.2	-21.7	2.1	-6.9
860726	01:40	-6.1	3.2	21.2	-19.5	-10.2	-26.1	-2.7	-21.2	2.1	-6.4
860726	03:40	-5.6	2.9	21.7	-18.7	-7.5	-25.3	-2.2	-21.4	1.9	-6.9
860726	05:40	-6.1	2.9	20.9	-18.5	-7.3	-26.1	-2.2	-22.0	1.9	-8.0
860726	07:40	-5.8	2.7	21.2	-17.9	-8.0	-25.6	-2.7	-21.7	1.6	-7.2
860726	09:40	-6.1	2.7	21.7	-19.5	-7.3	-27.2	-1.9	-22.5	.3	-8.0
860726	11:40	-7.2	2.0	20.1	-19.5	-8.3	-26.7	-2.7	-23.0	1.1	-8.2
860726	13:40	-8.2	1.3	19.6	-20.6	-8.8	-28.0	-3.5	-23.3	-1.1	-9.8
860726	15:40	-8.2	.4	18.2	-21.1	-10.2	-28.0	-4.6	-24.4	-1.3	-10.6
860726	17:40	-10.1	-.3	18.2	-21.7	-10.2	-28.3	-5.4	-24.6	-2.1	-11.7

860726	19:40	-10.1	-1.0	17.2	-22.5	-11.2	-29.3	-5.9	-25.4	-1.9	-11.7
860726	21:40	-10.1	-1.0	17.2	-22.7	-11.8	-29.3	-6.2	-25.7	-2.7	-12.2
860726	23:40	-10.1	-1.4	17.2	-22.7	-12.0	-30.1	-6.2	-26.0	-2.7	-12.2
860727	01:40	-10.4	-1.3	16.9	-23.0	-11.8	-30.1	-6.4	-26.0	-3.2	-12.0
860727	03:40	-10.4	-1.2	17.2	-23.0	-11.5	-30.4	-6.7	-26.0	-3.2	-12.2
860727	05:40	-9.3	-1.3	17.2	-21.9	-11.5	-33.3	-6.2	-25.4	-3.5	-12.5
860727	06:10	-10.1	-1.0	16.9	-22.5	-11.8	-33.8	-6.2	-25.7	-2.9	-12.5
860727	06:40	-10.1	-1.2	17.2	-22.7	-11.8	-34.4	-7.0	-26.0	-1.9	-11.7
860727	07:10	-10.4	-1.0	17.4	-22.5	-11.5	-35.2	-6.7	-26.0	-.8	-9.0
860727	07:40	-10.1	-1.1	17.4	-22.5	-11.8	-34.7	-6.4	-27.0	2.9	-4.5
860727	08:10	-10.6	-.9	17.4	-22.7	-11.5	-35.4	-6.4	-26.0	5.1	-1.1
860727	08:40	-10.1	-.9	17.2	-22.2	-11.5	-35.4	-6.4	-26.2	6.7	1.9
860727	09:10	-10.1	-.9	17.4	-22.2	-11.5	-35.4	-6.4	-26.0	8.8	4.3
860727	09:40	-9.0	-.4	18.8	-21.9	-12.3	-37.1	-5.1	-24.9	12.8	7.2
860727	10:10	-9.6	-.8	17.4	-22.7	-11.0	-34.1	-5.9	-25.7	13.3	9.8
860727	10:40	-9.0	-.5	17.7	-22.5	-11.8	-34.4	-6.7	-26.0	15.7	12.2
860727	11:10	-9.8	-.5	18.0	-21.7	-10.4	-34.4	-7.0	-26.5	15.5	12.0
860727	12:10	-9.8	-.8	17.2	-21.9	-11.0	-33.8	-6.4	-26.2	17.6	12.2
860727	13:10	-9.8	-.7	17.2	-21.7	-11.2	-33.1	-6.2	-26.0	17.6	11.4
860727	14:10	-10.4	-1.1	17.2	-23.0	-11.0	-32.5	-6.2	-25.7	17.9	10.4
860727	15:10	-10.9	-1.3	17.4	-21.7	-11.0	-32.8	-7.2	-26.0	18.1	10.9
860727	16:10	-10.6	-1.1	17.4	-22.7	-11.8	-32.3	-6.4	-26.2	17.1	9.3
860727	17:10	-9.8	-1.5	16.6	-21.9	-12.3	-31.7	-6.7	-26.8	17.3	8.8
860727	19:10	-10.6	-1.4	16.9	-23.3	-11.8	-32.5	-7.2	-26.8	16.0	7.2
860727	21:10	-10.6	-1.4	16.4	-23.0	-11.8	-32.8	-7.2	-26.8	15.7	5.8
860727	23:10	-10.6	-1.5	16.4	-23.0	-11.8	-33.1	-7.0	-26.5	14.7	5.6
860728	00:10	-10.4	-1.5	16.4	-23.3	-12.3	-34.1	-6.7	-26.5	14.9	5.1
860728	02:10	-10.6	-1.5	16.9	-23.0	-11.5	-33.3	-7.5	-26.8	13.9	4.3
860728	04:10	-10.6	-1.3	16.9	-22.7	-11.5	-33.1	-7.2	-26.8	13.9	4.3
860728	06:10	-10.6	-1.4	16.6	-23.0	-11.8	-33.1	-7.2	-27.0	13.3	3.2
860728	08:10	-10.1	-1.2	17.2	-22.7	-11.8	-33.8	-7.2	-26.8	12.5	3.4
860728	10:10	-10.9	-1.8	15.8	-23.0	-12.5	-33.3	-7.8	-27.8	12.3	2.4
860728	12:10	-11.1	-3.1	16.1	-24.8	-13.3	-33.1	-8.8	-27.8	12.3	1.9
860728	14:10	-12.5	-3.6	14.5	-24.8	-13.6	-33.6	-8.8	-28.1	9.9	.5
860728	16:10	-13.3	-4.3	14.0	-26.4	-14.7	-33.8	-9.9	-28.9	8.3	.0
860728	18:10	-13.0	-4.5	14.5	-25.9	-14.4	-34.4	-10.4	-30.0	6.9	-2.4
860728	20:10	-13.5	-4.9	13.2	-27.2	-14.9	-34.7	-10.4	-29.4	7.2	-2.1
860728	22:10	-14.6	-4.6	12.7	-26.2	-16.0	-34.4	-10.1	-30.5	7.7	-2.1
860729	00:10	-13.8	-4.7	12.9	-26.4	-15.5	-35.2	-10.4	-30.0	7.2	-2.4
860729	02:10	-13.8	-4.9	13.7	-26.4	-15.5	-36.8	-10.7	-29.4	6.4	-2.7
860729	04:10	-13.3	-4.7	13.5	-25.9	-14.9	-37.1	-10.4	-29.4	7.5	-1.9
860729	06:10	-13.5	-4.5	13.7	-25.9	-14.4	-38.1	-9.9	-29.2	6.4	-2.7
860729	07:40	-12.7	-4.9	12.1	-26.7	-16.8	-41.6	-8.6	-30.0	7.7	-.8

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