Quality of Groundwater, Proceedings of an International Symposium, Noordwijkerhout, The Netherlands, 23—27 March 1981, W. van Duijvenbooden, P. Glasbergen and H. van Lelyveld (Eds.), *Studies in Environmental Science*, Volume 17

MULTI-PURPOSE SOLUTION FOR THE PROTECTION AGAINST POLLUTION OF A GROUNDWATERABSTRACTION FOR WATERSUPPLY

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INTRODUCTION

The Municipal Waterworks of Amsterdam (G.W.) founded a groundwater pumping station in the year 1888 north of the town of Hilversum, 25 km south-east of Amsterdam. In 1901 another water supply company, the "Midden Nederland" Water Works (W.M.N.), started in the same area.

Already in 1875 the municipality of Hilversum made infiltration works for sewage water east of the town, in an area with small lakes with a distance of about 1500 m south-east of the pumping stations. Together with the natural flow to the north-west, the recharged sewage water flows to the pumping stations and can give troubles in the future.

During the last century new residential and industrial areas were build to the north of the old town of Hilversum. Today the border of the town is close to the pumping stations. The groundwater below the town is polluted by sewage water from the leaky sewerage and probably by direct infiltration of sewage. The water level in the sandy subsoil is about 5 to 10 m below land surface.

Already from 1934 investigations were made to find a solution for the problem of pollution. In 1977 in the attracted groundwater of G.W. a little amount of trichloro-ethene (TCE) was discovered. This gave a start to a new tackle of the problem. The results of this evolution are presented here.

SITUATION OF THE PUMPING STATIONS

The pumping station GW has a capacity of 2 million m3 per year (65 l/sec). It means only 2% of the total capacity of the Amsterdam Water Works, but it has a special significance, because

the other sources are mainly from surface water.

The pumpingstation W.M.N. with a capacity of 8 million m3 per year (250 l/sec) supplies the town of Hilversum and some areas around. The founding of this pumpingstation gave a big change to the pattern of groundwater flow. It caused that today the catchment area of the GW pumpingstation is situated to the south-west and is covered largely by the town of Hilversum. The catchment area of the W.M.N. is north and east of this pumpingstation. The influence of the pumping brings about that the infiltrated sewage water moves from the lakes to this pumpingstation.

GEOHYDROLOGICAL CONDITIONS

The geological situation of the area is a rather complicated system. Originally, during the Riss Glaciation here arose an icepushed ridge, consisting of generally medium coarse sands and some claylenses of little importance. The base is found at a depth of 160 m below O.D., where the clay-layers of the Icenian formations start.

Geo-hydrological calculations by mathematical models and observations of the differences in groundwater quality lead to a division in two layers. The first aquifer contains freatic water. In this aquifer the pumpingstations abstract the groundwater. The transmissivity is 1750 m2/d with a thickness of the water-bearing layer of 35 m.
So the average permeability is 50 m/d. The separation between the aquifers is caused by the mentioned clay-lenses, it has a low resistance of 10 days.

The second, deep, aquifer with a thickness of 105 m has a transmissivity of 3150 m2/d and an average permeability of 30 m/d.
The groundwater head in both aquifers has no significant difference.

The natural groundwater quality in both aquifers is not quite the same. In the relation to this paper the content of oxygen can be mentioned. The first aquifer has a content of about 6 mg O_2/l and the second one is anaeroob. In both aquifers the chloride content is low (12 mg/l) and also the nitrate (0,1 mg/l).

From old maps with contourlines of the groundwaterhead is concluded that the natural flow of the groundwater amounts to an average of 1.5 m3/d.m', proportional to the transmissivities spread over the two layers. The direction of the natural flow is west-north-west.

THE POLLUTION OF THE GROUNDWATER

The influences of pollution, which have to be daaled with in the pumpingstations, can be divided in three major types. The first originates from the lakes in the south-east, both others are caused by the town to the south- and south-west.

From the lakes a recharge took place of about 1.5 million m3 per year sewage water. In this report will be used characteristic high values of chloride (about 100 mg/l) and ammonium (35 mg/l). The first parameter is a good tracer of the sewage water, the second has consequences for the purification system of the drinking water production.

In the present situation the sewage water is largely attracted by the W.M.N.-pumpingstation. This can be measured by the increasing chloride content of the drinking water, now 40 mg/l. The high levels of ammonium are found today only half way between the lakes and the W.M.N.-wells. The reason might be that the sewage is mixed with aerobic natural groundwater, which oxidises the ammonium. Also other influences may work. In a part of the area between the lakes and the pumpingstations the observed quality of the groundwater approximates the sewage quality: the water is nearly anaerobic and the ammonium content keeps high. The sewage water is also present until a big depth in the second aquifer.

Since some years the recharge by sewage could be stopped because a system for purification and a pipeline for disposal of the effluent was build. But the recharge went on up till now, because Nature Conservation did not like the lakes to dry up because of the special avifauna. There is no other source available.

The pollution from the town shows two different characters. From the south-west the groundwater is marked by high contents of nitrate. Values of 100 mg/l are observed. In the existing purifications of the G.W. station nitrate cannot be removed and the content in the drinking water increased until 25 mg/l. This is the maximal desired value in future, the highest allowed value will be 50 mg/l. This part of the catchment area is covered by residential districts.

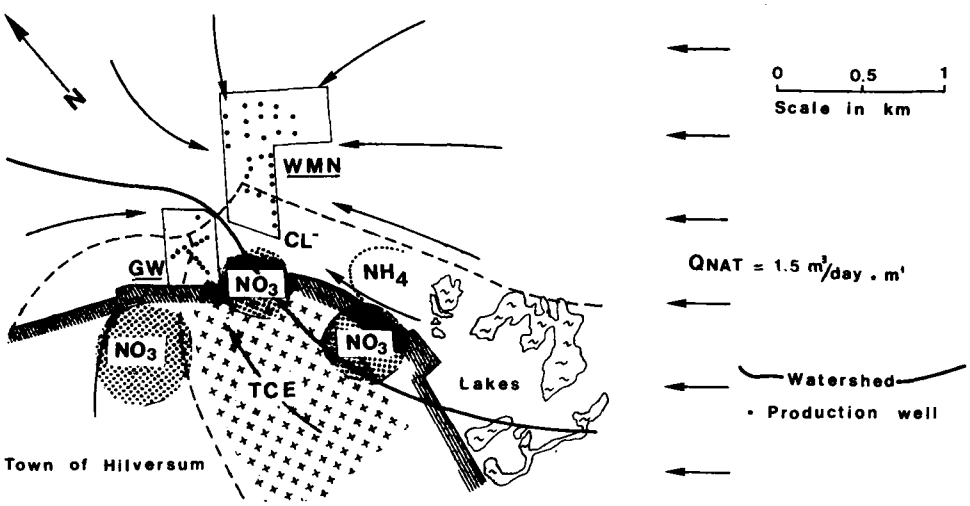
South of the pumpingstations there is a district with many industrial activities. The pollution is heavier. The groundwater in the first aquifer is here often anaerobic and nitrate-reduction follows. Only at the outskirts high nitrate-contents are observed. Recently a more serious pollution was found in this area: the trichloro-ethene (TCE). Samples from observation wells showed values up to 2000 microgram per litre. The G.W. station established about

70 µg/l, the W.M.N. station was not affected. The standard for drinking water is fixed on less than 1 µg/l, but preferably not measurable . The removal of TCE can be done very well by filtration through granular activated carbon (G.A.C.). The investment and the operation of this purification is expensive.

THE PROBLEM AND THE ANSWER

Primary the question for the Water Works of Amsterdam was how to get rid of the TCE. The removal of TCE from the raw water can be carried out by stripping and activated carbon filtration. The rather big changes of the TCE-content in the raw water makes the removal by GAC-filtration up till below the mentioned standard not certain for reasons of desorption and is also more expensive. Research on the stripping showed that a rather simple installation could be developed which permanently gives an effluent with a TCE-content less than 10 µg/l. This value is accepted for water that is drained of to surface water.

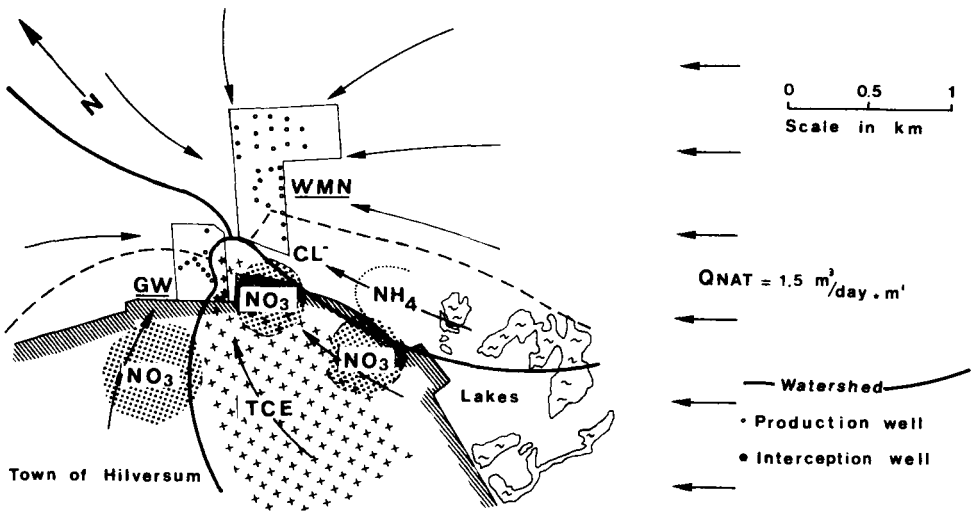
Secondly the increase of nitrate content must be avoided and, if possible, the content should decrease. A third condition for the solution is that the production-wells of W.M.N. do not get any negative consequences. And finally, the recharge with sewage water should be stopped.



ABSTRACTION BY PRODUCTION WELLS ONLY

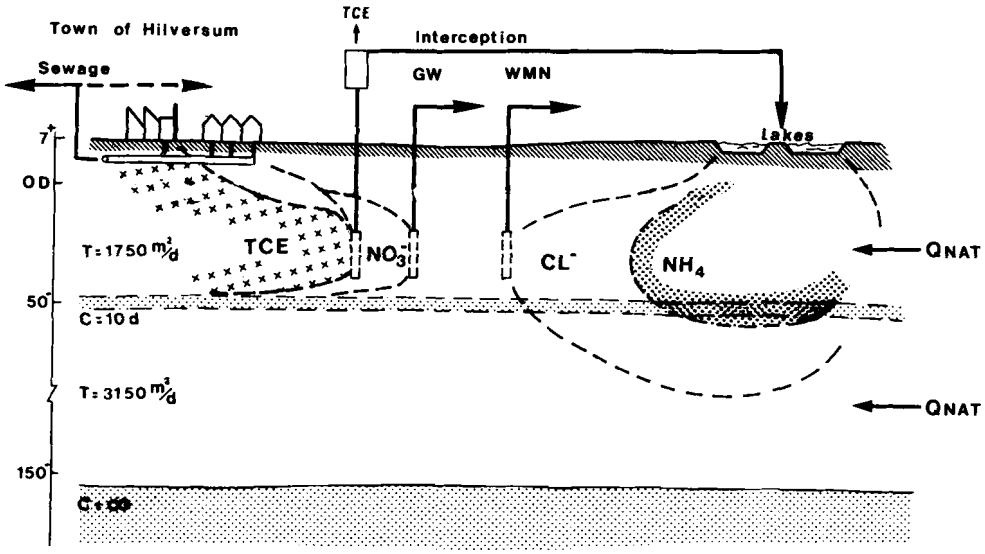
On this base a system of interception-wells was developed. The wells create a third catchment area that covers the total TCE-contamination, so the production wells of both GW and W.M.N. are safe guarded against TCE. Also some areas with a high content of nitrate are taken with, so partly the nitrate shall not go to the production-wells of GW and W.M.N. The front of ammonium is only very little accelerated on its way from the lakes to W.M.N. Its is expected that it will do no harm to the quality of the drinking water production.

To lose the interception-water use is made of the partly reconstructed rainwater sewer. The rainwater and interception-water can be pumped directly to the lakes for recharge. After the stripping to values, lower than 10 µg/l, the TCE-content is decreased more in the pipeline, by the pumping and by the exposure to the air during the time on the lake. Experiments did not result in any TCE on the lakes. During full operation of the system a content of less than 1 µg/l is expected.



ABSTRACTION BY PRODUCTION- AND INTERCEPTION- WELLS

The total interception system was worked out by many calculations in a geo-hydrological computer model. This model was developed by mr C. van den Akker and is described in the paper: "Streamlines and traveltimes of groundwater in a two-layered aquifer system".



SCHEME OF INTERCEPTION

Different arrangements and capacities of interception-wells were tried out until the optimal was found, both in the hydrological and in the economical way. Also the replacement of the production-wells of GW was considered and in particular a removal to the second aquifer, partly or totally. Apart from the financial consequences there appeared two unwanted effects. The first was that the contamination of TCE, now localised in the first aquifer,was widely dispersed in the second aquifer. Secondly, the present protection of the wells of W.M.N. against the pollution of TCE and nitrate by the system of GW would disappear.

The project is expected to be performed in 1981 by a cooperation between the two watersupply companies GW and W.M.N., the municipality of Hilversum, the nature conservation foundation and the sewage treatment board.

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