GROUNDWATER MANAGEMENT IN THE NETHERLANDS : BACKGROUND AND LEGISLATION

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Introduction

Until recently in history, groundwater in the Netherlands was never a problem. There was always plenty of good groundwater in the thick diluvial sediments, fed by precipitation and by rivers like the Rhine, Meuse, and Scheldt and their side-streams. The Dutch lowlands - the coastal zone at about sea-level - floated on groundwater, as they still do; and in the hills in the central, eastern, and southern parts of the country, there was no big shortage of groundwater either. The groundwater quality was quite good too. Only in some parts of the coastal area was the groundwater brackish or even salty, and at some places it still is.

Today, the groundwater situation is different. For economic agriculture, the drainage level was lowered to obtain a higher production; large areas were drained to build houses; and groundwater extractions for drinking water and industry increased. This is locally causing shortages of groundwater. Even groundwater quality is deteriorating, threatened as it is by industrial pollution, nitrates and phosphates (fertilisers, manuring), pesticides, and acid rain.

In the Netherlands, the groundwater level varies from 0.5 to 1.0 m below surface in the western parts of the land; in the higher areas from 1.0 to 20.0 m. By its hidden nature, the impact of groundwater extractions and pollutions upon groundwater quantity and quality is not easy to see, and only little by little have people become aware of the problems with groundwater. Now that groundwater monitoring networks have been established, they are revealing the effects that groundwater lowering is having upon nature and agriculture, and also the effects that polluted groundwater is having on surface water quality. Especially in a densely populated country like the Netherlands, people feel a strong need for regulation and legislation.

The authorities recognised the changing groundwater situation, studied it, and managed to relate it to other matters such as rain, surface water, drainage, and groundwater extractions. In 1984, this led to the Second National Policy Document on Water Management. In 1989, measures to combat the problem of man-made drought (damage to nature caused by lowering the groundwater level through drainage and groundwater extractions) were laid down in the Third National Policy Document on Water Management. Water management was adjusted to the new situation and so was the legislation: on 1 March 1984, a new Groundwater Act was passed. This act is mainly concerned with groundwater quantities; for groundwater quality, there is other legislation (e.g. the Soil Protection Act). Since 1987, there is also a Water Management Act that covers the management of surface water, surface water levels, water discharge and recharge, drainage, and the relationship between surface water and groundwater. The Groundwater Act covers groundwater management in relation to groundwater extractions by pumping. This paper will focus upon the Groundwater Act.

Groundwater in the Netherlands

When a hole is dug or drilled into the earth, the groundwater table is found at a certain depth. Beneath this level, all soil pores are filled with water and there is a positive water pressure; this is the saturated zone. Just above the groundwater level, pores can also be filled with water, but there is a negative water pressure. Closer to the surface is the unsaturated zone, which is important for all kinds of vegetation.
Beneath the groundwater table the water flows (very slowly, only a few metres or decimetres per year) according to Darcy's Law:

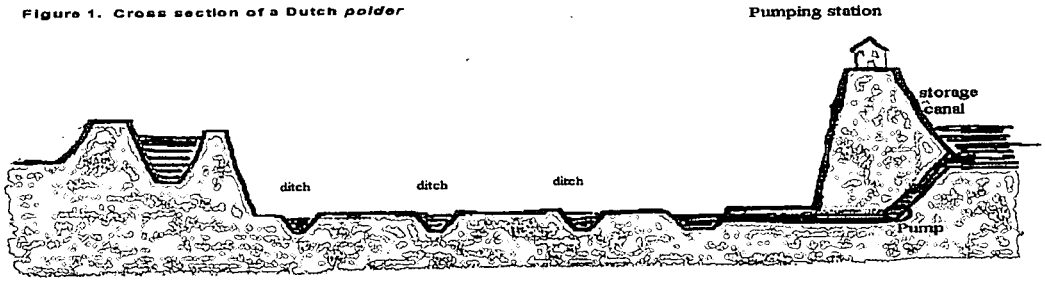
$$q = kD \cdot dh/dx$$

in which q = flow per unit length, kD = transmissivity, x = distance, and h = pressure head. In practice, it is not always as simple as that.

The western and northern coastal areas: the lowlands

In the western parts of the Netherlands, along the coast, land is just above or just below sea level. Large areas are 4 to 5 m below sea level. The deepest polders (east of the city of Rotterdam) are 7 m below sea level. In this zone, there is a complicated system of managing the surface waters with pumps, sluices, and many canals. Especially in peaty areas, the land surface is just a few decimetres above the level of the surrounding canal waters. In that situation, the groundwater table is directly influenced by the level of that surface water. Drawing down the surface water level by pumping (in earlier days, with windmills) means increasing the drainage of the land and a lowering of the groundwater table; this is the way the Dutch have always kept their land dry. On the other hand, drawing down the groundwater level too far is dangerous: the soil, losing its water pressure, will subside, especially in peaty areas. In some polders, the land surface has sunk 2 to 4 m because of continued drainage and over-pumping throughout the centuries. For a cross section of a Dutch *polder*, see Figure 1.

Figure 1. Cross section of a Dutch *polder*



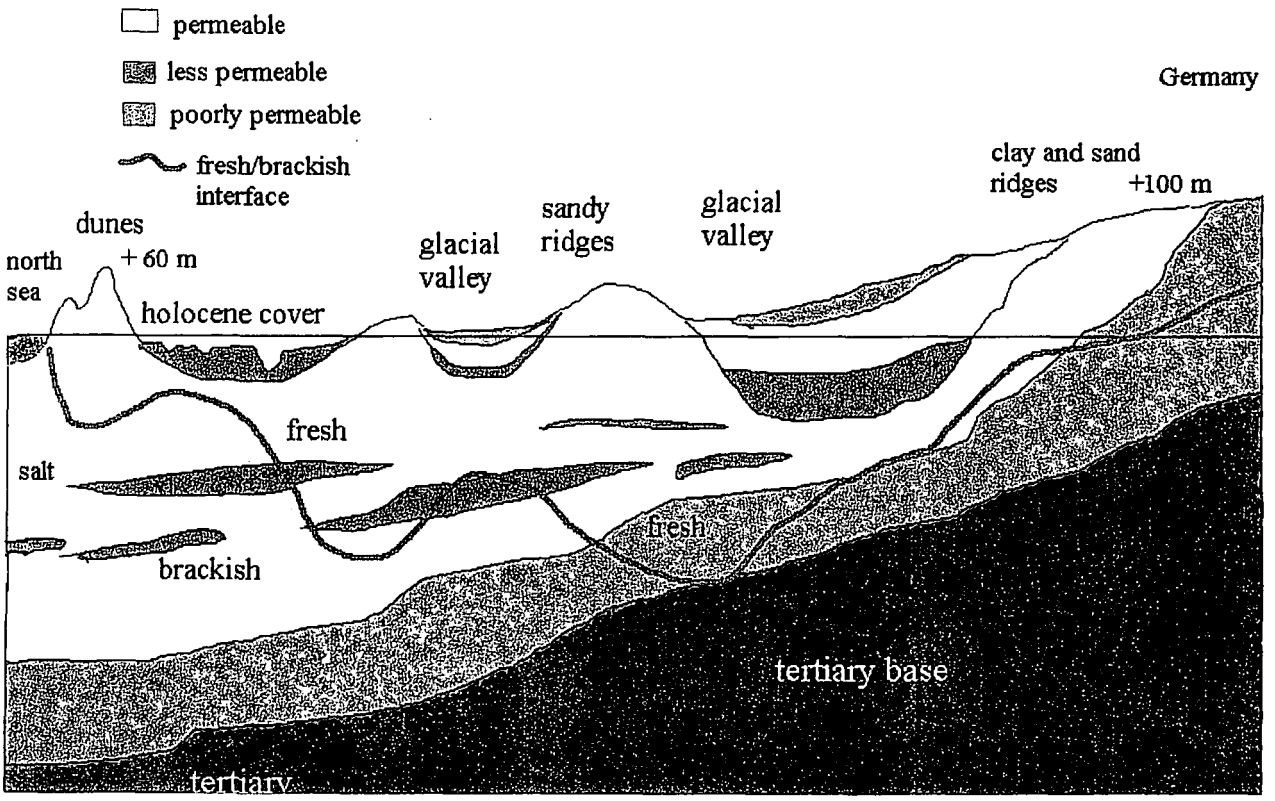
Scheme of a Dutch polder

The subsoil of these western and northern parts of the Netherlands consists of semi-permeable clay and peat layers of holocene age, ranging in thickness from 0 m inland to 25 m at the coast. Along the shoreline are dunes - sandy hills up to 40 m high - which protect the land from being flooded by the sea.

Below the holocene layers, there is a pleistocene system of permeable sand and gravel layers, also with some semi-permeable clay layers. The sandy layers act as aquifers and contain fresh groundwater. But, with increasing depth, brackish or even salt water is to be

found. At a depth of 200 to 250 m, there is an impermeable base, the bottom of the Dutch hydro-geological system. Figure 2 gives a cross section of the Netherlands.

Figure 2. West to east hydro-geological cross section of the Netherlands



In these coastal lowlands, there seems to be enough groundwater and surface water, although it is not possible to extract groundwater everywhere. It depends on water levels and groundwater quality (fresh, brackish, salt, polluted). Locally, there can be a groundwater deficit or, rather, a shortage of fresh water.

Some aspects of groundwater extraction in the lower coastal areas are:

- Groundwater in the top holocene layers is not very useful for drinking water. It is polluted by industry, fertilizers, and pesticides. The poor quality of the surrounding surface water can also badly influence the groundwater quality in the holocene clay and peat layers;
- Lowering the groundwater table in the weak peat layers by extractions makes the land surface subside; the layers compress, and can cause damage to buildings;
- Extracting too much groundwater carries the risk of brackish or even salt water rising from the deeper pleistocene;
- The pleistocene layers form a better reservoir for drinking water, but here too, there are limitations to extractions. Pumping or over-pumping from these layers can bring up brackish or saline water. Lowering the water pressure in the pleistocene aquifer can cause a lowering of the groundwater table in the holocene top layers, causing subsidence and damage to buildings.

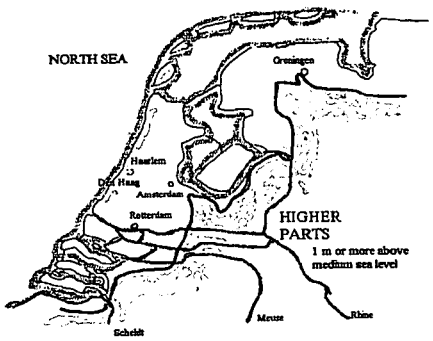
Better sites to extract groundwater are to be found in the higher parts of the Netherlands: the central, eastern, and southern areas.

The higher central, eastern, and southern parts of the Netherlands

It should be noted that "high" in the Netherlands only means "up to 300 m". The highest point is Mount Vaals, 321 m, in the south of the country, near the city of Maastricht on the Belgium/German border.

Most of the higher parts of the country range from 10 to 50 m above sea level (see Figure 3); some hills are 100 to 200 m high. The groundwater situation in these higher parts is more like that in most other European countries. There may be a rather thin layer of clay or peat at the surface, but down to the impermeable hydrogeological base, the whole system can be regarded as one big pleistocene package with some clay lenses. Those clay lenses are not always present. The Province of Drenthe, for instance, consists of pure sand. Also the sandy hills and ridges of the Veluwe area, in the Province of Gelderland, are only sand, created by the Scandinavian ice masses in the third glacial era. The highest hills here are about 110 m (Mount Imbosch). In the Veluwe, there are some local sands that look like small deserts, which, on a warm summer day, can have temperatures of up to 60°C (micro-climate).

Figure 3. Higher and lower parts of the Netherlands



Dividing the Netherlands in a "low" and a "high" part

Groundwater extractions in these higher parts directly influence the groundwater table and can damage the vegetation, as far as that vegetation depends directly on that groundwater. Most agriculture needs relatively wet conditions and so does much of nature. For agriculture, damage by lowering the groundwater table means decreased production; in the worst cases, crops wither and there is no drinking water for cattle. For nature that thrives in wet conditions (moors, brooklands, streamlets, etc.; very often protected wetland areas), it also means withering of vegetation and finally results in the disappearance of rare species.

So, although much more fresh water is stored in the higher parts of the country than in its lowlands, here too the amounts of groundwater that can be extracted are limited.

Some figures about groundwater and the use of groundwater

In an average year, there is a total inflow of water into the Netherlands of up to 110 500 million m^3; most of this is transported to the country by the River Rhine: 69 000 million m^3. Precipitation makes a significant contribution, with 30 100 million m^3; this is about 30% of the total amount of water, typical for a humid area. There are no large variations over the years, the average precipitation being about 760 mm/year. In the past six years summers have been relatively dry.

Table 1. Water balance of the Netherlands in an average year [10^6 m^3]

In		Out	
Precipitation	30 100	Evapotranspiration	19 500
Rhine (at the border)	69 000	Different uses	5 000
Meuse (at the border)	8 400	River outflow	86 000
Other river inflows	3 000		
	--------- +		--------- +
	110 500		110 500

In this hydrological situation, groundwater is extracted as is shown in Table 2.

Table 2. Groundwater extractions in the Netherlands

Groundwater extraction in the year 1988 (in mln m^3)	
Public water supplies	800
Industrial extractions	375
Sprinkling (agriculture)	175
Other extractions	100 +
TOTAL	1450

Given the problems with man-made drought in the Dutch countryside, it is not likely that much more groundwater is going to be extracted than it is today. Some groundwater is used by agriculture for sprinkling. Much more water, however, is "used", or "lost by pumping out", so for drainage of agricultural land to obtain suitable economic conditions for optimal production.

Table 3 gives information about land use.

Table 3. Land use in the Netherlands in 1983 (Central Bureau of Statistics)

	Land area (sq km)	%
Cultivated land	24 042	70.9
Woodland	2 969	8.7
Nature areas (heath, dunes, etc.)	1 557	4.6
Built-up areas (incl. roads)	5 356	15.8
Total land area	33 924	100

Total number of inhabitants in the Netherlands: 15.5 million

Groundwater management, the Groundwater Act

Introduction

The groundwater level can be influenced by varying the level of the surrounding surface waters, by building weirs, and by installing drains. This is more or less covered by the Water Management Act, which places much authority in the hands of the Water Boards. Because of the sometimes direct relationship between surface water and groundwater, especially in the lowlands, groundwater management very often means surface water management.

A Water Board is a typically Dutch institution, historically the oldest institution in the Netherlands. Some of them were founded in the 12th century. A Water Board manages the water system or systems of a unit-area, consisting of one or more polders. The unit-area is a hydrological unit, often a catchment area or part of a catchment area. Each province has several Water Boards within its borders; they are responsible to that provincial authority. In some cases, a hydrological unit or catchment area extends beyond the provincial border; then, the Water Board has to deal with two provinces. Nowadays, for efficiency, there is a tendency towards larger Water Boards.

The groundwater level is also affected by groundwater extraction; this is subject to the Groundwater Act. In the following pages, we shall take a look at some details of the Groundwater Act.

Historical review

Even in olden times, people in the Netherlands had fresh-water wells, most of them very shallow and dug by hand. It was not always easy to find fresh water in the Dutch lowlands, especially before the dikes were built. We know of the well in Iglo Tadema's saga (AD 100). Iglo was a Frisian chieftain who owned a well in the neighbourhood of Stavoren, Friesland.

Unfortunately, his men took too much water from that well. A dreadful dragon appeared and the well turned salty. It is not known which groundwater law the men had broken.

Another example is the well of Saint Willibrord (AD 700) near Castricum, North Holland. Saint Willibrord knew something about groundwater and showed the people where they should dig. This well, which contributed much to his popularity, still exists.

Again, little is known about water legislation in those times. There are, of course, the Old Frisian Laws, written in the years 1100-1300. It could be useful to study that legislation to look for aspects of water and groundwater management.

In the years 1700-1800, special fresh-water transport was needed to supply a big city like Amsterdam with drinking water. So about AD 1800, special "water vessels" transported fresh water from the lakes of Central Holland and Utrecht to Amsterdam. Only small quantities of water could be transported in this way, so this was only a short-term solution. Amsterdam, but also other large cities, needed large-scale water supplies. When surface water of good quality was no longer available, the city was constantly in search of good groundwater. Of course, groundwater was available in the dunes, but people were also aware of the presence of good groundwater at other sites, especially sandy areas in the central, eastern, and southern parts of the country. In the beginning of this century, about 1910, Amsterdam studied the possibilities of extracting groundwater near Barneveld, in the central part of the Netherlands. For the linguists: Barneveld, in English, means "spring field", which indicates the presence of water.

Around 1900, people were already using techniques of making groundwater wells, installing filters and pumps, and extracting the groundwater. But there still wasn't any groundwater legislation; there was no Groundwater Act as there is now. Those who wanted to extract groundwater merely had to apply for a license under the *Hinderwet* (the Nuisance Act). Nuisance was most characteristic for cases of groundwater extractions: if the extraction was considered a nuisance, no license was granted and no groundwater could be extracted.

In those days, of course, little was known about the consequences of groundwater extraction. Nobody knew much about the effects of lowering the watertable, which could be land subsidence, damage to buildings, or the withering of vegetation. A special "Commission of Experts" was therefore installed to study the possible consequences of groundwater extraction in Barneveld. As a result, the Barneveld plan was rejected and, for its groundwater exploitation, Amsterdam had to go to the dunes south of Haarlem. From that time onwards, Commissions of Experts were occasionally installed to investigate the consequences of groundwater abstractions.

In 1934, this led to a permanent Commission of Experts, known as the COWABO: the Commission extracting Water from the soil (Dutch: *bodem*). This COWABO Commission only dealt with groundwater extractions for industrial purposes and for the drainage of building sites. The COWABO could advise the National Government, the provinces, and the municipalities.

In 1954, the Groundwater Act Drinking Water Companies was passed by the Dutch Parliament. A special Commission of Experts on groundwater extractions was installed to advise the Minister of Public Health. This commission was called COGROWA (Comission Groundwater Act Drinking Water Companies).

From that time onwards, "nuisance" was no longer the most important item, but rather "tolerance" and "damage". Typical of this Groundwater Act was that, because of public

interest and public health, licenses for groundwater extractions could be granted (if the expected damage was not too severe) and that people were to tolerate these extractions and their consequences; but those who suffered damage could get paid or compensated for the damage done. Today, this act has been replaced by the Groundwater Act.

The new Groundwater Act has been in force since 1984. It covers all groundwater extractions - and infiltrations - for all purposes: drinking water, industry, sprinkling for agriculture, and draining building sites. Here, too, there is a system of tolerating groundwater extractions, granting licenses, and paying/compensation for damage involved. A Commission of Experts (the Technical Commission Groundwater Management) was again in operation, but, in the early 90's, the Commission was dismissed. The technical advice on groundwater extractions is now given by provincial experts who have built up the necessary know-how.

Headlines of the Groundwater Act 1984

There is no ownership of groundwater in the Netherlands. Even the land owner does not possess the groundwater under his territory; that is to say, according to the Civil Law, he only owns the water at the moment it has been brought to the surface. To extract groundwater on your own land, you need a license (or permit). The conditions are laid down in the Groundwater Act (1984). This Groundwater Act deals with groundwater extractions by means of an installation: a pump or a pumping station. Influencing the groundwater table by draining with ditches and canals is not subject to the Groundwater Act, but to the Water Management Act (1987).

The implementation of the various regulations of the Groundwater Act is in the hands of the provinces. In this way, the provincial authority is the groundwater manager.

An important instrument in managing groundwater is granting (or refusing) licenses for groundwater extractions. Another instrument is the registration of extractions.

But what is the groundwater managers's philosophy about the granting of licenses? In what cases will a license be granted? How much groundwater can we use? For what purposes?

In the Netherlands, a densely populated area with intensive groundwater use, possibilities are not unlimited. Up till 1980, it was assumed there should be about 1850 million m^3 groundwater ready for use. This "exploitable amount of groundwater", divided over the twelve Dutch provinces, formed the basis of groundwater management.

Today, with about 1500 million m^3 being used nation-wide, groundwater extractions will not increase much. Locally, where the groundwater table has dropped too far - with damage to nature and to agriculture - no more groundwater can be extracted. At other places, where surface water is plentiful, some more groundwater can possibly be extracted. For every region there is a "most suitable groundwater situation", a situation where the groundwater table corresponds best with local functions like agriculture, housing, and nature. In Dutch groundwater management practice, this "most suitable groundwater situation" is going to be defined, and will serve as the basis for the licensing policy. Of course, much research and a lot of discussions are going on about what is the "most suitable groundwater situation".

Another aspect is the kind of groundwater use. For what purposes? In the Netherlands, the limited groundwater resources are mostly reserved for special "high-class" purposes, purposes that absolutely need high- quality water: for drinking water, preparing food, drinks,

etc. In some cases, a license can be refused, or water of a lower classification can be used (e.g. cleaning water for industries, cooling water, sprinkling, etc.).

Licenses are granted for ever: there is no limit in time. In the Dutch groundwater management system, the license is not transferable to other persons, neither can it be sold.

Summarising, the important keywords are "personal licenses", the "most suitable groundwater situation", and "high-class purposes" for groundwater use.

In the Netherlands, so densely populated, the influence of a groundwater extraction, especially a large one, is nearly always noticeable. There may even be damage to agriculture, to housing, or to nature. Nevertheless, a broad public interest (e.g. drinking water) can be the reason for granting the license and starting the extraction. In such a case, people have to tolerate the extraction, but they can be awarded compensation. So other keywords are_tolerance (you have to tolerate an extraction once a license has been granted) and compensation for damage.

But most important is a good groundwater policy, laid down in provincial water-policy documents that include sections on groundwater.

Provincial water management policy: groundwater section

By virtue of the Groundwater Act, the groundwater managers (i.e. the provinces) have to draw up groundwater plans, which should include:

- A description of the planning area;
- The aims and purposes of the groundwater policy;
- Measures to be taken, latest date of gaining the object, deadlines;
- An estimate of the costs of research needed for good groundwater management.

The groundwater section plans should be accompanied by the following information:

- Research details on relevant aspects;
- Investigation of all interested parties concerned;
- Relationship with surface water;
- Relationship with other plans and policies of the authorities involved.

Finally, there should also be some technical information:

- A description of the hydrogeological situation, particularly the "desirable groundwater situation, regarding all interests of nature and groundwater users involved";
- Registration of all groundwater extractions and infiltrations (their quantities);
- The influence of existing extractions and infiltrations;
- The future need for groundwater; the way it will be used;
- How to provide the future demands for groundwater? Are there any alternatives (like using surface water)?
- List of all research done and any other authorities involved.

Licenses for groundwater extraction

The Groundwater Act, in one way, is very special: once a license has been granted by the province, every citizen has to tolerate a groundwater extraction (or infiltration) whether he likes it or not. Very often there is a major interest of public water recreation or public health. This can be a reason for granting a license, even though there may be objections to it in the region.

The affected party can react in two ways:
- By asking the province for financial compensation for damage;
- By going to the High State Council to get the license cancelled before it comes into force.

Once the license has been granted and damage has been suffered (by farmers, for instance: decreased production, withering of crops, no drinking water left for cattle; also damage to buildings in housing areas), the affected party cannot lodge an appeal against that license. But, in such cases, he can claim compensation for the damage and can ask for an investigation into the damage. A Damage Commission of Experts will then study the damage and will propose the financial compensation to be paid to the affected party by the license-holder. The Damage Commission is a group of independent experts, paid by the provinces.

Before the provincial authority grants a license, it needs a technical report on all aspects of the planned groundwater extraction. This report is made by hydrological engineers of the provincial office, and is open to public inspection.

Very important in the license-granting procedure is the advice of the Provincial Water Management Commission, in which all parties concerned are represented.

Only the larger groundwater extractions are subject to the licensing procedure. It is not efficient to adopt this time-consuming procedure for lots of smaller extractions. For the relatively small groundwater extractions, special conditions are laid down in the Groundwater Act, and these extractions, of course, have to be registered; this can be regarded as a system of "common license". The smallest groundwater extractions only need to be registered; no special conditions apply.

Procedure of granting a license to extract groundwater, Dutch Groundwater Act

The steps that need to be taken before a license to extract groundwater is granted are the following:

To the province:

1 A written application is submitted to the provincial authority;
2 The province confirms the receipt of the application;
3 The province studies the application; makes a technical study of geo-hydrological, agricultural, and environmental aspects, and compiles this information in a technical report.

From province to municipality:

4 The date of hearing is agreed upon;
5 The application is posted at the town hall, visible to all citizens;
6 The hearing is organised by the Provincial Water Management Commission;
7 The municipality's judgement is pronounced;
8 The application + the municipality's judgement is sent back to the provincial authority.

Back at the province:

9 The application is discussed by the provincial water commission (managing commission: representatives of public organisations and all other parties concerned);
10 Back to the provincial authority, which decides whether to grant license;
11 The provincial decision is posted in the town hall, visible to the public;
12 Period of giving notice of appeal (by people who will be affected by the extraction);
13 License is granted and comes into force.

The procedure from Stage 1 (application submitted to province) to Stage 10 (decision made by province) may not take longer than 12 months. Stage 5 (application posted in town hall) to Stage 8 (application + comments and objections sent back to province) may take a maximum of 2 months, according to Article 19 of the Groundwater Act. The discussion by the provincial water commission (Stage 9) may take a maximum of 2 months.

Every year, about 15 to 20 licenses for larger groundwater extractions (more than 1 million m^3/year) are granted in the Netherlands. About 5 to 10 appeals are sent to the High State Council. There are, of course, numerous smaller extractions for many purposes; information about them is available from the provincial authorities.

Fees, levying

Every license-holder has to pay a levy to the province by virtue of the Groundwater Act. Article 48 of the act states the purposes for which the province can use this money:

- Research on groundwater problems, study of the provincial groundwater situation, and maintenance of the groundwater monitoring network (there are thousands of measuring points in the Netherlands);
- Compensation for damage:
  * If damage is caused by research activities ordered by the province (e.g. the effects of lowering the groundwater table by drilling tests);
  * If it is not quite clear which of the many groundwater extractions causes the damage.

  To avoid long waiting times because of very long and complicated investigations by the Damage Commission, the province can pay compensation.

The provinces decide which levy has to be paid; this differs from province to province. Most provinces have a levy of about 1 or 2 Dutch cents per m^3 extracted groundwater. This only has to be paid for the larger groundwater extractions, which have to be licensed. No levy is needed for the smaller extractions, but they do have to be registered.

Last year, the Dutch Parliament discussed an addition to Article 48 of the Groundwater Act, which will make it possible to use the levies to combat the problem of man-made drought. This will provide funds to pay for measures to restore damaged nature as far as this damage is related to groundwater extractions (20% of the drought problem is related to groundwater extractions; 60% is caused by drainage for agriculture). With this addition, levies will probably rise to perhaps 4 or 5 Dutch cents per m^3 extracted groundwater. This addition came into force on 1st January 1997.

Apart from the Groundwater Act, there is an Environmental Tax Act. The aim of this act is to make people aware of the environment and to prevent them from an endless use of groundwater, from polluting surface water, and so on. For these activities, people have to pay taxes to the National Government via the Ministry of Finance.

Using groundwater will cost the license holder:
- 34 Dutch cents per m^3 groundwater extraction for drinking water purposes;
- 17 Dutch cents per m^3 groundwater extraction for industrial purposes.

The yield of this tax flows directly to the state's finances and will not necessarily be used to solve groundwater problems.

The Groundwater Act; some articles concerning licenses for groundwater extractions

Finally, some of the articles in the Groundwater Act are presented as these are informative about the management system introduced by the Act.

Article 14
1 It is prohibited to extract groundwater or to infiltrate water, unless the provincial authority has granted a license for it;
2 Conditions can be added to that license to protect interests involved in groundwater management;
3 Stated in the license is how much groundwater should be extracted and the purpose of the extraction.

Article 16
1 A written application for a license to extract groundwater has to be submitted to the provincial authority;
2 The province declares by provincial regulation what information applicant should add to his application.

Article 18
The provincial authority sends a copy of the application and all other relevant information, including technical remarks, to:
a Municipalities, water boards, and drinking water companies in whose region the planned groundwater extraction will take place, and also to the farmers' representatives;
b The provincial water management commission.

Article 19
1 The burgomasters of the municipalities mentioned in Article 18 post the application for public scrutiny in the town hall, <u>one month</u> before the hearing mentioned in Article 19. The burgomasters announce this posting for the public in the official Dutch State Newspaper and also in regional newspapers;

2 During the period of posting for the public, anyone can raise objections against the planned groundwater extractions;
3 Within one month after the end of the period of posting for the public, the burgomasters send all objections to the provincial authorities.

Article 20
1 A hearing is to be organized in all municipalities involved; every person has the right to explain his objections;
2 A representative of the provincial authority leads the hearing; technical experts are present at the hearing;
3 A record is made of the hearing.

Conclusions

The Dutch groundwater policy and legislation have developed over a long period of experience. Now it is a complicated system of granting licenses based on the region's best suitable groundwater system, high-class purposes for groundwater use, tolerance, and compensation. It is very specific for the Dutch geographical system: a densely populated area with deep sediments and a humid climate.

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