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# Heavily Modified Waters in Europe: Case Study on the Hagmolen-Hegebeek

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# Heavily Modified Waters in Europe: Case Study on the Hagmolen-Hegebeek

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## Ten Geleide

Op 22 december 2000 is de Europese Kaderrichlijn Water (KRW) in werking getreden.
Nog niet op alle onderdelen is de KRW operationeel. De regionale waterbeheerders worden, soms door tussenkomst van het RIZA, het RIVM, de Unie van Waterschappen, of de STOWA, betrokken bij het nader vormgeven van diverse praktische bepalingen. (waaronder wijze van beoordelen, wijze van rapporteren, opstellen van referenties, de klassificatie van grondwater en het indelen van water in categorieën)
In het kader van de implementatie van de Kaderrichtlijn wordt onderzocht wat de gevolgen zijn van het indelen van watersystemen in de categorieën die genoemd zijn in de Kaderrichtlijn. Eén van die categorieën is de categorie 'heavily modified' (sterk veranderd). Deze categorie is naar verwachting belangrijk voor de stroomgebieden binnen Nederland.
In een overleg tussen vertegenwoordigers van de EU-lidstaten is afgesproken dat in een aantal studies in de EU-landen nagegaan zal worden wat de gelukkige en minder gelukkige kanten zijn van de toe te passen systematiek van indelen in categorieën en wat de gevolgen zijn van deze indeling, bijvoorbeeld voor het beheer of de rapportageverplichting. De STOWA is opdrachtgever geweest van een casus in de Hagmolenbeek (Waterschap Regge en Dinkel), waarbij de systematiek van het benoemen van een water als "heavily modified" geheel is doorlopen. Aandacht is onder meer besteed aan de oorzaken van de verandering, de aard van de verandering en de maatregelen die nodig zijn om het watersysteem weer in een natuurlijker toestand te brengen, alsmede aan de kosten die daarmee dan gemoeid zijn.
Het rapport is ingebracht in de werkgroep die de ervaringen van vergelijkbare casussen in meerdere Europese landen analyseert en evalueert.

Het rapport is opgesteld door dr. Carolin Lorenz van Witteveen+Bos.
Het onderzoek is begeleid door M. van Oirschot (RIZA), H.H. Tolkamp (Zuiveringschap Limburg), P. Eckstein (Unie van waterschappen), E.J.B. Uunk (Waterschap Regge en Dinkel) en B. van der Wal (STOWA).

Utrecht, januari 2002

De directeur van de STOWA,

Ir. J.M.J. Leenen

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# PART I

# 1 Preface [to be drafted by project managers] (1 page)

[insert the standard preface - drafted by the project managers - briefly explaining the European project on heavily modified water bodies as the context for the individual case study. This should explain the context to readers of the case study, who may not be familiar with the European project. ]

## 2 Summary Table (2 pages)

*[insert the summary table on the case study already provided; "Annex IV" of the minutes of the kick-off meeting of the European project on heavily modified water bodies.]*

# Annex IV: Information on Case Studies (one Table for each Case Study)

| | Item | Unit | Information |
|---|---|---|---|
| 1. | Country | text | Netherlands |
| 2. | Name of the case study (name of water body) | text | Hagmolenbeek - Hegebeek |
| 3. | Steering Committee member(s) responsible for the case study | text | Unie van Waterschappen / RIZA |
| 4. | Institution funding the case study | text | STOWA |
| 5. | Institution carrying out the case study | text | Witteveen+Bos |
| 6. | Start of the work on the case study | Date | 15 February 2001 |
| 7. | Description of pressures & impacts expected by | Date | June 2001 |
| 8. | Estimated date for final results | Date | December 2001 |
| 9. | Type of Water (river, lake, AWB, freshwater) | text | River |
| 10. | Catchment area | $km^2$ | 9256 (at present) + 1780 (additional catchment area after connection, see 19.) = 11036 ha = 110 $km^2$ (only Dutch part of catchment, excluding German part) |
| 11. | Length/Size | km/ $km^2$ | 26/110,36 = 0,24 km/$km^2$ (length of stream is 19 km at present, after connection total length will be ±26 km (see 19.) |
| 12. | Mean discharge/volume | $m^3/s$ or $m^3$ | Mean discharge = 0.579 m3/s, maximum discharge = 9.56 m3/s |
| 13. | Population in catchment | number | ± 5600 (villages Bentelo and Beckum) |
| 14. | Population density | Inh./$km^2$ | 5600 / 110,36 = 51 Inh/ $km^2$ |
| 15. | Modifications: Physical Pressures / Agricultural influences | text | Canalisation, drainage, installation of weirs, normalisation, disconnection with downstream part by the Twente canal, discontinue emissions from two sewers of the two villages Bentelo and Beckum |
| 16. | Impacts? | text | Unnatural discharges, impact on morphological processes (erosion, sedimentation, meandering), loss of natural stream flora and fauna, eutrophication due to agricultural emissions and stagnant parts in stream |
| 17. | Problems? | text | Stream does not comply to water quality and ecological standards |
| 18. | Environmental Pressures? | text | Agriculture, 2 rubbish dumps (in downstream part and in the German part) |
| 19. | What actions/alterations are planned? | text | Connection with downstream part (lying downstream of Twente canal), restoration of profile and installation of fish passages in mid/downstream part (upstream of Twente canal), adaptation of water distribution in the catchment |
| 20. | Additional Information | text | Transboundary stream: upstream part is located in Germany |
| 21. | What information / data is available? | text | Discharges, water quality, data on fish and macro-invertebrates and hydromorphology |
| 22. | What type of sub-group would you find helpful? | text | multifunctional |
| 23. | Additional Comments | text | Stream has not been assigned the policy function "nature" but an use-oriented function |

# 3 Introduction (2 pages)

*These Terms of Reference should guide the production of the case studies reports to be written in the framework of the European project on heavily modified water bodies. They are provided as a standard report format* ***which can simply be overwritten****. Please do not alter the formatting of paragraphs, headings etc. For tables and boxes within this case study, please make use of the following models:*

***Table 1 [model heading for a table]***

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

***Box 1 [model heading for a box or map]***

*You received two files of Terms of Reference for your case study. In general, you should only use file ‚HMWB TOR' consisting of Part I, II and III for producing your case study. Part I includes chapters 1-4 which give an introduction to the case study. In chapter 4, you should identify different water bodies within your case study area.*

*In Part II, the physical alterations, the ecological status, the identification and designation as heavily modified and the definition of maximum and good ecological potential (see chapters 5-9) should be described for the water bodies in the case study area. In general, it is expected that the different water bodies in your case study would be affected by similar pressures and physical alterations.*

*Part III is dedicated to highlight main findings during the identification and designation process and the lessons learned in the case study. Please try not to exceed a total of 50 pages (excluding maps and annexes). A number of pages is also indicated for each section next to the first level heading to guide the authors. They do not intend to be prescriptive.*

*In case your case study consists of water bodies affected by substantially different pressures and physical alterations, please try to group them (to a limited number of groups) by similar pressures and physical alterations (in chapter 4). If the impacts of these pressures are distinct it would be useful to report your Part II results separately. Use the separate file ‚HMWB extra Part II TOR' and complete it separately for each impact group. In total, please do not exceed a length of 80 pages (excluding maps and annexes), including all groups of water bodies.*

It should be noticed that the designation procedure for HMW waters is still in development. The content of this paper is based on the available information and present insights. Both the information and insights can change over time.

## 3.1 Choice of Case Study

*[Please give general explanations and reasoning for the choice of the case study.]*

For this case study, the catchment area of the Dutch stream Hagmolen-Hegebeek is chosen. A stream as water type is chosen for the following reasons:

- Streams are water systems, which are managed by organisations, which act on a regional, catchment scale, the so-called Water boards. Furthermore, in most streams the human caused, hydromorphological changes to the stream are spatially differentiated along the length axis and in the catchment. With regard to these two aspects, this case study differs from the other Dutch case study, the Haringvliet-Hollands Diep. The water authority, responsible for the Haringvliet-Hollands Diep is Rijkswaterstaat, which acts on a national scale. The predominant hydromorphological impact on the water system is the building of the Haringvliet dam;
- Streams are interesting water bodies for this case-study on the determination of heavily modified waters, because of their complex cause-effect chain. The cause - effect chains within stream ecosystems cover a large area, as the hydromorphology, water quality and ecology of streams is strongly influenced by the geology, hydrology and land use of the whole catchment area. The search for measures for improving the ecology of the stream should not only focus on the stream itself, but has to take into account the whole catchment area. Due to this complexity a stream is interesting as case for testing the HMW-procedure;

There has been chosen for the stream Hagmolen-Hegebeek for the following reasons:

- The stream is representative for the problems of many streams in areas on sandy soil lying above the sea level in the Netherlands. During centuries the hydrology of the catchment area has been completely adapted to agricultural use;
- There are different types of hydromorphological changes in the stream and the changes differ in space, so the stream is suitable to test the procedure for the designation of heavily modified waters;
- The Hagmolen-Hegebeek is a transboundary stream;
- The availability of data is, compared to other streams, relatively high, e.g. discharge, water quality, fish stock and macro-invertebrates.

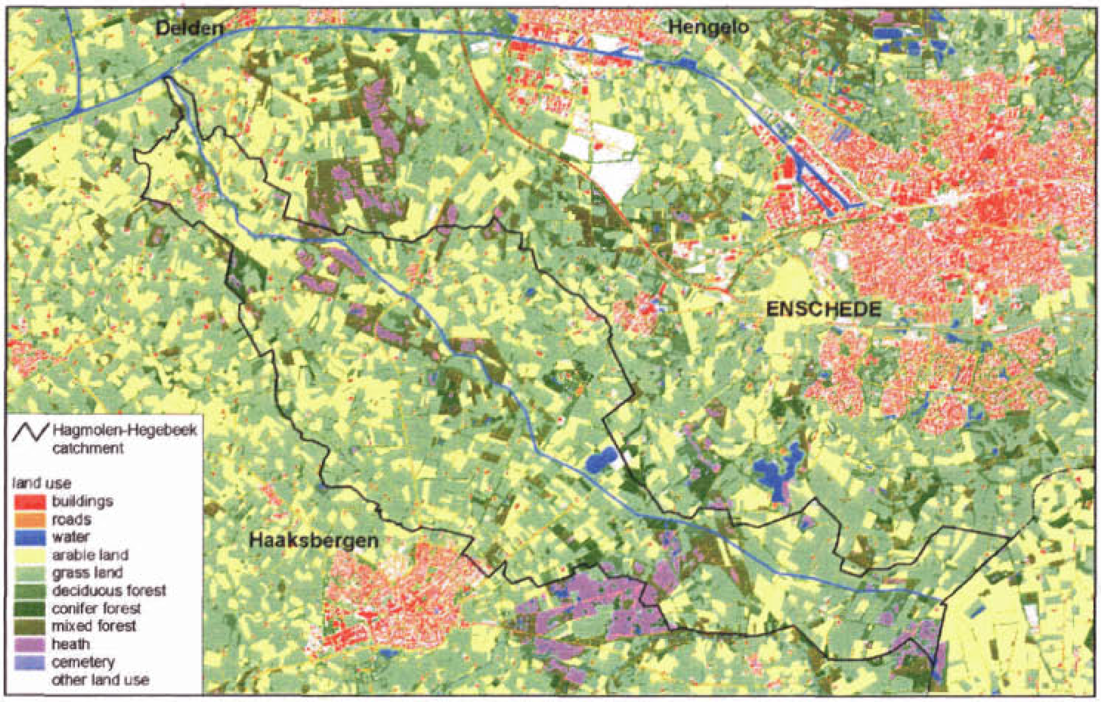
## 3.2 General Remarks

*[Explain the location and nature of the water bodies within the case study area (map). Explain the place of the case study in the sub-group structure adopted by the European project on heavily modified water bodies.]*

The Hagmolen-Hegebeek is situated to the west of the city Enschede in the eastern part of the Netherlands (see figure 3.1 for a map). The major land use in the catchment is agriculture. The stream has been changed by channelization, the building of weirs and drainage in the catchment to optimise the hydrological preconditions for the agricultural function.

The case study is placed in the subgroup multifunctional. The catchment area is adapted for different uses. The main use is agriculture. Other uses are recreation, habitation and nature.

Figure 3.1 Figure of the Hagmolen-Hegebeek stream, its catchment and the land use in the catchment.



# 4 Description of Case Study Area (3 pages)

## 4.1 Geology, Topography and Hydrology

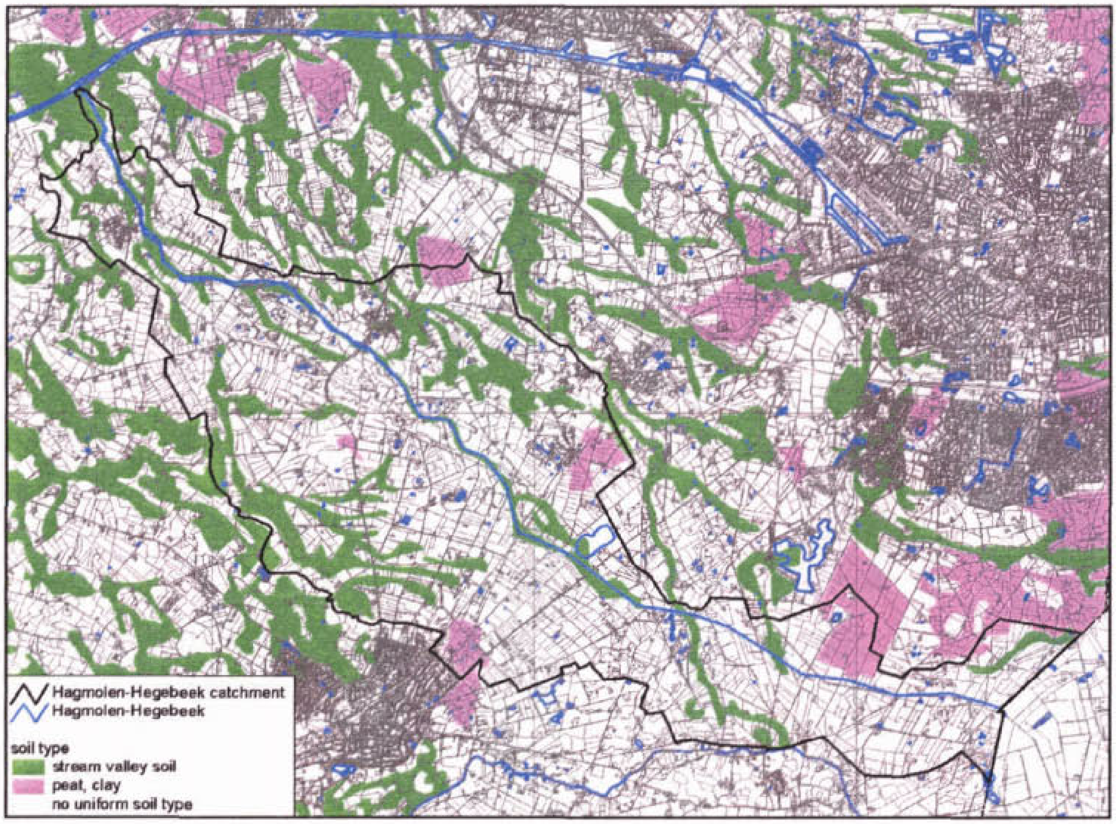
*[Please briefly consider the geology, topography and hydrology of the catchment. Include information from summary table and provide further detail and explanations on: type of water; surface of the catchment in km²; length [in km] or surface size [in km²] of the water; mean discharge in [m³ per second] or total water volume [in m³]; altitude; depth; salinity and tidal range; describe seasonal and other variations in flow and any other important aspects of flow dynamics. Maps showing the river network, coastal length should be provided.]*

The Hagmolen-Hegebeek is a stream and can be identified as water category 'river'. The length of the stream is ± 27 km and the catchment area is around 110 $km^2$. It is situated to the west of the city Enschede in the eastern part of the Netherlands. The altitude of the catchment ranges between +50 m NAP (Nieuw Amsterdams Peil) at the top of the lateral moraine at upstream part of the catchment and +12m NAP and the downstream part, where the stream flows into the Twente canal.

Northwestern oriented erosion valleys have been formed by the discharge of the Hagmolen-Hegebeek between the steep hills along the lateral moraine and the weakly undulating "dek" landscape. The lateral moraine consists mainly of tertiair sand, loam and clay and is hardly pervious for water. The above soil layer consists in the stream valley mainly of loamy "eerd" soils and in the midstream of the Hagmolenbeek of peat. The soil in the higher parts is mainly made of "podzol" soil and thick "eerd" soils (Grontmij, 1995). In figure 4.1 a map with the soil types in the catchment is presented.

The mean quantity of flow is 0,6 $m^3/s$ and the maximum quantity of flow is 10 $m^3/s$. The seasonal variation in the quantity of flow is extremely large. During June till September the discharge is 0 $m^3/s$ for on average 2-5 days. During winter the stream has high discharges. Formerly the catchment of the Hagmolen-Hegebeek was part of the catchment of the Regge. Due to the building of the Twente canal in 1936 for navigation purposes, the Hagmolenbeek flows into the canal and has been cut of from the catchment of the stream the Regge. The regulation of the hydrology has lead to a yearly maximum waterlevel of the Hagmolen-Hegebeek of 0,50 (or 0,80 cm) below groundlevel.

Figure 4.1 Map of the soil types in the Hagmolen-Hegebeek catchment.




## 4.2 Socio-Economic Geography and Human Activities in the Catchment

*[Please describe the case study area, including maps. Please consider the (socio-economic) geography of the catchment. Include information from summary table (chapter 2) and provide further detail and explanations on: population in the catchment [number] and population density [in persons per km²]; explain distribution of population and identify the most important centres of population; describe the most important economic activities and water uses in the catchment and their impacts on the water body and adjacent aquatic and terrestrial ecosystems (in quality, quantity and morphology).]*

The water authority responsible for the Hagmolen-Hegebeek is the Water board Regge & Dinkel. The population in the catchment measures 5600 inhabitants, the density is 51 inhabitants/km$^2$. The population is mainly concentrated in the villages Bentelo and Beckum. In each village a sewage spillway is connected to the Hagmolenbeek, emitting sewage water into the stream after stormwater events. The main economic activity in the catchment is agriculture. Approximately 85% of the surface in the catchment is used for agricultural purposes. Agriculture consists mainly of pastures for dairy cattle. Other land uses are habitation (± 5%) and nature (10%). Most of the physical changes of the Hagmolen-Hegebeek have been carried out to optimise the hydrology of the catchment for agricultural purposes. In figure 3.1 the land use in the catchment is presented. The physical changes have led to a canalised stream with a highly unnatural discharge. Furthermore, the water quality of the stream is eutrophic has been impacted by nutrient emissions. The standards for nutrients are exceeded (Grontmij, 1995).

## 4.3 Identification of Water Bodies

*[Refer to HMWB paper 7 ver 2 and the WFD Annex II, 1.2 "Ecoregions and Surface Water Body Types" for detail; if possible provide information according to either system A or system B.*

*This section should identify the water bodies within the study area. The description of water bodies should define the extent of the impact of the physical modification (i.e. it should include the unaffected water body immediately upstream and downstream).*

*Depending upon the circumstances, the impacts of a pressure may affect one water body or a series of water bodies.*

*If necessary, please group the water bodies according to different pressures and physical alterations. Please identify each water body clearly and group the water bodies according to the types of pressures to which they are subject (see table 2).*

*The following*

*<u>Table</u> serves as an example for grouping water bodies and indicating which sections (Part II, Part IIa) they refer to. You could use it for grouping the water bodies of your case studies, if you think such a grouping is useful. Please note that the separation is optional and only useful where there are fundamentally different pressures and physical alterations that affect distinct water bodies in your case study area. It is to avoid having more than 2 (or max. 3) different groups (and accordingly Parts II).*

*A map should be provided showing the water bodies relative to the modified characteristics. This section should include discussion of:*

- *the main issues which were considered important in identifying the water bodies;*
- *any problems experienced in identifying the water body;*

*comments on the level of differentiation (minimum size of water body) which was considered appropriate. ]*

The Hagmolen-Hegebeek belongs either to the surface water category river (as a natural water) or heavily modified. It is not an artificial water.

In this section the stream has to be divided in waterbodies on the basis of:

- **Application of the typology system** as defined in Annex II. This will split rivers into units based upon system "A" or "B" which will define the type-specific hydromorphological and physicochemical conditions. According to system A, Annex II of the WFD, the Hagmolen-Hegebeek is situated in one ecoregion, the Central plains. The altitude typology is lowland (<200 m), the size typology based on the catchment area is medium (>100 to 1000 $km^2$) and the geology is both siliceous and organic. The application of the typology system does not lead to the identification of different waterbodies.
- **Definition of hydromorphological units** (e.g. major physical divisions - separate tributaries, main river stretches between large tributaries). The stream in this case-study is a typical lowland stream, which can be divided into 2 hydromorphological units; the Hegebeek is a typical upstream part of a stream and the Hagmolenbeek is a 'midstream' part (see Box 1). In former times the streams Hegebeek, Rutbeek and Buurserbeek were located in the same catchment and the Hagmolenbeek was located in another catchment. During periods of high precipitation the two catchments were

connected with each other due to the development of large marshy areas.

- **Type specific biological condition** (e.g. the degree to which the waterbody forms a consistent ecological type, in terms of ecosystem structure and function). We use the „nature target" (natuurdoeltypen) typology of streams of Verdonschot (2000) to describe the reference conditions of the case-study stream. According to this typology the Hagmolen-Hegebeek is a slowly flowing lowland stream (langzaam stromende beek). The typology makes a further distinction between upstream and midstream parts of streams; the ecological community of the Hegebeek should resemble the community of upstream part of slowly flowing streams and the ecological community of the Hagmolenbeek to the midstream part of slowly flowing streams (see box 1).
- **Effective management unit,** taking into account the pressures and resultant impacts. The catchment area and the stream of the Hagmolenbeek and the downstream part of the Hegebeek have been largely adapted to agricultural needs (drainage, canalisation, and weirs). The upstream part of the Hegebeek is almost natural; the stream meanders and the banks are natural. Next to the pressures, the policy determined by the regional government (the province Overijssel) differs between the Hegebeek (both upstream part no. 20-11-4 and downstream part no. 20-5-1) and the Hagmolenbeek (no. 20-5) (Waterhuishoudingsplan Overijssel 2000+). The Hegebeek is designated as 'quality water' and its catchment is a so-called "quality water area". In this category, the quality of the watersystem has to comply with a 'target situation'. This target is defined as the best possible state on a long term under certain human preconditions. To achieve this target situation, restoration measures with regard to hydrology, morphology and water quality have to be taken. The Hagmolenbeek is designated as 'perception water'. This means that the stream should "look nice" by implementing mainly morphological measures. For this category a less stringent level is defined for water quality and water quantity; the basic ecological level. The target for the ecological quality is the almost highest quality (see also section 6.1), which is comparable to the good ecological status of the Water Framework Directive. The Hagmolen catchment has a use-oriented function and agriculture is an important use in the catchment.

On the basis of the four abovementioned criteria, two waterbodies can be distinguished (see table 4.1):

- the upstream Hegebeek (stream no. 20-11-4)
- the downstream part of the Hegebeek (20-5-1) and the Hagmolenbeek (20-5).

Only one pressure group is distinguished, namely agriculture.

**Table 4.1 [Details on separate groups of water bodies]**

| Name of the group | Main pressures of the group | Main physical alterations of the group | Water bodies of the group | Section referring to the group | page numbers |
|---|---|---|---|---|---|
| **Group 1** | Agriculture | - Channelisation<br>- Disruption of river continuum<br>- Drainage of catchment | Upstream Hegebeek<br>Downstream Hegebeek & Hagmolenbeek | Part II (included in the HMWB TOR file) | |

## Box 1. Description of the natural reference of the Hagmolen-Hegebeek: the slowly flowing lowlandstream (Verdonschot, 2000).

Slowly flowing lowlandstreams are characterised by a relatively slow flow and small dynamics of discharge. They meander through the landscape. The temperature dynamics are small due to shading. The profile of the stream is asymmetric with sandbanks, steep banks, places with slowly flowing and stagnant water and places with accelerations with banks of gravel. There is plenty of organic material in the stream; treetrunks, branches, leaves, detritus.

**Upstream part of the slowly flowing stream (langzaam stromende bovenloop): reference for the Hegebeek**

These streams occur in the flat parts of the Pleistoceen sandy area. The streams are fed by sources, leading to a permanent flow of water and a relatively constant discharge. The upstream parts meander and are rich of different structures. The streams have a sandy soil with organic elements. On the banks grows alder, which shades the stream. Next to alder, herbs and mosses are growing. The catchment area is covered with deciduous forest. The environment is oligo-mesotrophic. The characteristic macro-invertebrate community consists of rheophilic, coldwater stenothermic and stream tolerant species. Most species live on hard substrate and some species live in the sediment and in the water. The species composition is diverse; the most important groups are worms (*Annelida*), Crustaceans (*Crustacea*), Flies (*Diptera*), Caddisflies (*Trichoptera*), Chironomides (*Chironomidae)*.

The fish community consists of rheophilic species. Characteristic species for the slowly flowing stream are Brook lamprey (Beekprik, *Lampetra planeri*), Dace (serpeling, *Leuciscus leuciscus*), Minow (Elrits, *Phoxinus phoxinus*), Brown trout (Beekforel, *Salmo trutta fario*), Schneider (Gestippelde alver, *Alburnoides bipunctuatus*), Grayling (Vlagzalm, *Thymallus thymallus*). Fish species, which occur also in these streams, but which are not especially characteristic for the upstream part of slowly flowing streams) are Stickleback (Driedoornige stekelbaars, *Gasterosteus aculeatus*), Stone loach (Bermpje, *Barbatula barbatulus*), Bullhead (Rivierdonderpad, *Cottus gobio*), Gudgeon (Riviergriondel, *Gobio gobio*).

**Midstream part of the slowly flowing stream (langzaam stromende bovenloop): reference for the Hagmolenbeek**

These streams occur in the flat parts of the Pleistoceen sandy area. The quantity of flow is relatively constant. The stream meanders and the profile has a large diversity of structures. On the banks grows alder, ash, which shades the stream. Furthermore, herbs, ferns and mosses are growing on the banks. The catchment contains deciduous forests with oack, alder, ash and beech. The streams have a sandy soil with organic elements, such as fallen trees or waterplants. The environment is oligo-mesotrophic. The macro-invertebrate community consists of both rheophilic and stagnant water species. The species live on hard substrate, in the sediment and in the water. The species composition is diverse; the most important groups are beetles (Kever, *Coleoptera*), Caddisflies (Kokerjuffer, *Trichoptera*), Chironomides (Vedermuggen, *Chironomidae*).

The fish community consists of rheophilic, euriotopic and limnophilic species. Characteristic species for the slowly flowing stream are Burbot (Kwabaal, *Lota lota*), Chub (Kopvoorn, *Leuciscus cephalus*), Lampern (Rivierprik, *Lampetra fluviatalis)* Brook lamprey (Beekprik, *Lampetra planeri*), Barbel (Barbeel, Barbus barbus), Nose carp (Sneep, *Chondrostoma nasus*), Dace (Serpeling, *Leuciscus leuciscus*), Minow (Elrits, *Phoxinus phoxinus*), Brown trout (Beekforel, *Salmo trutta fario*), Schneider (Gestippelde alver, *Alburnoides bipunctuatus*), Grayling (Vlagzalm, *Thymallus thymallus*), Ide (Winde, *Leuciscus idus*), Wheatherfish (Grote modderkruiper, *Misgurnus fossilis*), Moderlieschen (Vetje, *Leucaspius delineatus*). Fish species, which occur also in these streams, but which are not especially characteristic for the upstream part of slowly flowing streams) are Ten-spinedstickleback (Tiendoornige stekelbaars, *Pungitius pungitius*), Stone loach (Bermpje, *Barbatula barbatulus*), Bullhead (Rivierdonderpad, *Cottus gobio*), Gudgeon (Riviergriondel, *Gobio gobio*), Spined loach (Kleine modderkruiper, Cobitis taenia), Pike (Snoek, Esox lucius, Roach (Blankvoorn, *Rutilus rutilus*).

## 4.4 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

It is rather unclear how to identify water bodies on the basis of the guidelines of section 4.3. The identification of water bodies has to be based on 4 criteria: the application of the typology system, the definition of hydromorphological units, the type specific biological condition and the effective management unit. These criteria are rather different and can therefore lead to different divisions of water bodies.

Furthermore, the minimum length or size of a waterbody is unclear. The length of the waterbody upstream Hegebeek is only 1250 m. The total size of the Hagmolen-Hegebeek is 27 km. This small length raises the question if the water body is significant enough for distinction and description.

# PART II

# 5 Physical Alterations (5 pages)

## 5.1 Pressures and Uses

*[This chapter should provide detailed information on significant pressures on the water bodies, i.e. the economic and social forces that create pressure on the water bodies. See HMW paper 5 ver 3, nr. 3 for the terminology concerning pressures.]*

The main pressure on the Hagmolenbeek-Hegebeek is agriculture. Furthermore, the Hagmolenbeek has been disconnected of the Reggestream because of the construction of the Twente canal for navigation and flood protection purposes.

## 5.2 Physical Alterations

*[This section should refer to the physical alterations which result from the above pressures (See HMW paper 5 ver 3, nr. 4-9 for terminology on physical alterations). This should include reference to alterations to the water bed, banks and riparian zone. Photographs, maps, plans, graphs and tables should be produced as required. In particular, please discuss the types of physical alterations, which are considered to be relevant/appropriate. These may include:*

- *direct physical alterations upon river channel or bed such as river straightening;*
- *alterations resulting from pressures upon riparian zone such as flood defence ;*
- *indirect physical alterations such as drainage work on adjacent land;*

*Others...]*

The physical alterations in the Hagmolen-Hegebeek can be classified into three types:

1. the change in morphology
2. the change in catchment areas.
3. the change in hydrology of the catchment

To describe the physical alterations the list of single impacts of HMW paper 5 version 3 has been used. The direct physical alterations to the stream resulting from the agricultural pressure are:

1. Changes in the morphology of the stream:

- Channelization/straightening of the stream to achieve a faster discharge of precipitation;
- A change in river profile, namely broadening of the stream, to achieve a faster discharge of precipitation;
- Building of 20 weirs in the stream to reduce the periods of low discharges in summer. The weirs are not built for irrigation purposes, as mentioned in the HMW paper 5, but to retain the water in the stream.

2. The change in catchment areas by using weirs and 'dividing installations' (verdeelwerken) in order to achieve a more even discharge of streams. During periods of high and low discharges the discharges of a number of streams is divided into different catchments. This impact is not mentioned in the HMW paper 5. The following adaptations have been made:

- Disconnection of the downstream catchment area of the Hagmolenbeek from the catchment of the river Regge. The Hagmolenbeek discharges presently into the Twente-canal (see figure 5.1);

Figure 5.1 Discharge of Hagmolenbeek into the Twente canal.

- Enlargement of the German catchment area of the Hegebeek. In Germany, a part of the catchment area of the stream Bruninksbeek is connected to the Hegebeek
- Division of discharge between the Hagmolenbeek and the Rutbeek at low discharges. A discharge dividing installation has been built in the Hagmolenbeek 1 km downstream of the tributary Rutbeek. The maximum discharge to the Rutbeek is 0,24 $m^3/s$. At high discharges, most of the water is transported through the Hagmolenbeek;
- (Probable) disconnection of the stream Buurserbeek from the Hagmolenbeek. It is still uncertain if the streams Buurserbeek/Schipbeek discharged into the Hagmolenbeek in former times (Tauw, 2001). Possibly the Hagmolenbeek en Buurserbeek were interconnected during wet periods, when large parts of the catchments of the streams changed into marshy areas and water flowed from one catchment into other. It is still uncertain if both streams were connected formerly.
- Division of discharge between the streams Hegebeek and Usselerstroom due to a dividing installation. At high discharges in the Hegebeek water is transported into the Usselerstroom in order to realise a basic discharge of 0,315 $m^3/s$ in the Hegebeek.

An indirect physical alterations to the stream is:

<u>3. Change of the hydrology of the catchment:</u>

- Land drainage in the catchment area to achieve a faster discharge of precipitation and a more optimal waterlevels for agricultural purposes.

## 5.3 Changes in the Hydromorphological Characteristics of the Water Bodies and Assessment of Resulting Impacts

[Describe the hydromorphological changes, which result from the direct physical alterations. For example:

- change in flow regimes and the consequent impact upon downstream channel morphology (e.g. connected to interrupted sediment transport);
- lake water level regulation and the impact on lake basin morphology;
- artificial flow regime and the impact on riparian vegetation and bank morphology ;

Others...]

**Morphology**

The variation in river depth and width of the Hagmolenbeek and the downstream part of the Hegebeek has been reduced drastically due to the channelization and broadening of the stream (see table 5.1 and figure 5.2). The Hagmolenbeek has been straightened. The northern bank of the stream has a steep river profile, but the southern bank has a more gentle slope of 1:3 with vegetation growing on it at the traject from Meddelerweg till the discharge along the Wolfkaterweg (20-5-5).

The morphology of the upstream part of the Hegebeek is relatively natural; the stream meanders and the banks are natural. However due to erosion caused by periodic high discharges from the

German part of the catchment the stream has become situated very low in the stream valley (see figure 5.3).

The substrate of the streambed has changed; the amount of silt and small organic matter (dead algae) has decreased and the contribution of sand, gravel and large particles organic matter (leaves, wood) has decreased. Low stream velocities lead to sedimentation of silt and to a change of communities to a silt adapted population of species. Eutrophication effects occur in the downstream part of the Hagmolenbeek, increasing the amount of dead algae. The contribution of shredders (feeding on large organic material, like leafs) in the macro-invertebrate community is very low in the Hagmolenbeek.

Figure 5.2 Impression of the Hagmolenbeek.

Figure 5.3 Impression of the Hegebeek.

Table 5.1 The hydromorphology is described by the following parameters:

| | Hydrology | | River continuity (#Weirs) | Morphology longitudinal | Morphology lateral | | Structure and substrate streambed |
|---|---|---|---|---|---|---|---|
| | Quantity of flow | Dynamics of flow | | River depth and width variation | River depth and width variation | Structure of the riparian zone | |
| Hegebeek upstream 20-11-4 (2 km) | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is available: almost permanent 2 till 3 different „flow patterns" are present | Yes (0) | Present: natural meandering pattern | Present: natural meandering pattern | Natural vegetation: stream is almost completely shady | Silt, sand, gravel, organic matter and dead wood |
| Hegebeek downstream 20-5-1 (3 km) | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is absent: almost permanent only one „flow pattern" present | No (6) | Absent due to canalisation | Absent due to normalisation | Semi-natural vegetation at one side of the stream: Half of stream is shady | Silt, sand, organic matter |
| Hagmolen-beek 20-5 (22 km) | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is absent: almost permanent only one „flow pattern" present | No (14) | Absent due to canalisation | Absent due to normalisation | Semi-natural vegetation at one side of the stream: Half of stream is shady | Silt, sand, organic matter |

### Hydrology

The hydrology of the whole stream and catchment has drastically changed, due to human impact. The seasonal variation in the quantity of flow is extremely large. The large variation in the quantity of flow leads in turn to a large variation of the ecologically important parameters stream velocity and water depth. The mean discharge is 0,579 $m^3/s$ and the maximum discharge 9,56 $m^3/s$ (measured at the monitoring point, where the Hagmolenbeek discharges into the Twente canal). During June till September the water is stagnant for on average 2-5 days (stream velocity is 0 $m^3/s$). During winter the stream has high discharges, causing high stream velocities and water depths. The regulation of the hydrology in the catchment has lead to a yearly maximum waterlevel of the Hagmolen-Hegebeek of 0,50 below groundlevel. The upstream parts of the streams in the Hagmolen catchment are fed by seepage water.

Formerly the catchment of the Hagmolen-Hegebeek was part of the catchment of the Regge. Due to the building of the Twente canal the Hagmolenbeek has been disconnected from its former catchment and discharges into the canal. The hydrology can be characterised as follows:

- A low spatial variation of flow due to a low diversity in stream morphology (loss of meanders, vegetation, etc.)
- A highly variable and unnatural pattern of quantity of flow: the stream has high peak discharges in winter and spring and periods with low discharges and stagnant water in summer. This large variation in quantity of flow has been caused by:

  ⇒ The change of morphology: the straightening and broadening of the streambed leads to a fast discharge of the precipitation

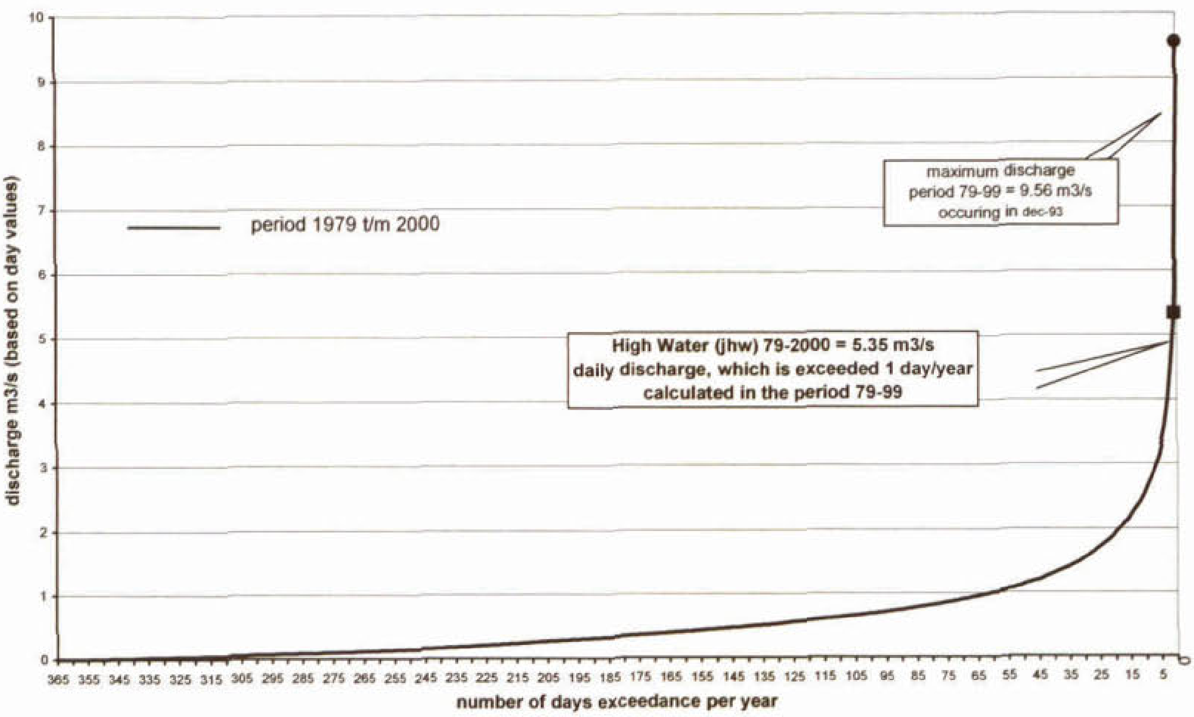
  ⇒ The building of weirs: instead of a complete drying up of the stream in summer, the weirs retain the water during low quantities of flow discharges causing stagnant water in the stream

  ⇒ Land drainage by ditches in the catchment area. The drainage leads to a lower groundwater table and a lower groundwater buffer capacity. Due to this lower groundwater buffer capacity, a dry period leads to low discharges in shorter time. The ditches transport precipitation from the catchment very fast to the stream, causing high discharges during wet periods.

  ⇒ The connection to the ground water bodies: The combination of a shallow impermeable clay layer in the soil in the higher parts of the catchment and the relatively high ground water levels in the lower parts of the catchment lead to a relatively low retention of precipitation in the soil and relatively high discharges in the streams after a period of rain.

The hydrology is described quantitatively by discharge data of the Hagmolenbeek at its discharge point at the Twente canal (see figure 5.4).

Figure 5.4. Average yearly discharge pattern for the period 1979-2000 measured at the monitoring point, where the Hagmolenbeek discharges into the Twente canal.




The requirements of the WFD with regard to hydrological and morphological parameters of rivers to be described are:

- River continuity
- Hydrological regime:
  - ⇒ Quantity and dynamics of waterflow
  - ⇒ Connection to ground water bodies
- Morphological conditions:
  - ⇒ River depth and width variation
  - ⇒ Structure and substrate of the river bed
  - ⇒ Structure of the riparian zone

## 5.4 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

Comparison of the hydrological and morphological parameters described in this section with the requirements in the WFD shows that most parameters have been described qualitatively and not quantitatively.

It can be concluded that a qualitative description of the physical alterations and the morphology is sufficient to determine the main problems (natural meandering stream with variation in habitat, stream velocity and substrate has been normalised and canalised into straight channel with weirs). With regard to hydrology more quantitative data are needed on:

- The number of days and the moment in the year of minimum and maximum stream velocities and water depth;
- The seasonal discharge pattern of the Hagmolenbeek prior to the physical alterations (historical reference).

These quantitative hydrological data would enable a better assessment of the impact of hydrology on the ecological condition of the stream and how human influence has changed the hydrology.

# 6 Ecological Status (7 pages)

[In this chapter, please describe the current ecological status of the water body, following the structure of WFD Annex V, 1.1 "Quality Elements for the Classification of Ecological Status". Refer to HMW paper 6 ver 2.]

## 6.1 Biological Quality Elements

*[Please describe briefly the current ecological condition of the water body (with more detail provided below). It will be important to discuss the following aspects:*

- *The range of biological measurements (phytoplankton, macrophytes, phtytobenthos, macroinvertebrates, fish fauna) used and the extent to which it is considered that they adequately reflect the pressures resulting from the physical modification upon the water body. Would additional measurements be needed in the future? Shortfalls in the information available should be highlighted here and proposals for additional measurements should be suggested.*

*The extent to which the impacts upon biology are a consequence of the physical alterations. Both upstream and downstream impacts should be described. Are other pressures (such as pollution) important? How can such pressures be separated?]*

The biological quality elements used to determine the ecological status of the Hagmolen-Hegebeek are macro-invertebrates and fish. Information on the presence and distribution of water- and riparian plants is lacking.

<u>Macro-invertebrates</u>

The ecological assessment method EBEOSWA (Ecologische BEOordeling van Stromende WAteren) is used to assess the ecological condition of the Hagmolen- and Hegebeek on the basis of macro-invertebrates. The method is based on a combination of multivariate analysis of macro-invertebrate data and expert judgement. The principal idea of the method is that the composition of the macro-invertebrate community is the result of a number of environmental factors, namely hydrology and organic load as the main factors and nutrient load, substrate and the macro-invertebrate community structure as side factors. For each of the influencing environmental factors an assessment is given on the basis of the diversity and abundance of the macro-invertebrates found in the stream under study. This assessment per environmental factor enables to determine the contribution of the different environmental factors to the ecological status of the stream and to prioritise measures for ecological rehabilitation. For example, when hydrology scores low and organic load high, measures to improve the ecology of the stream have to focus on hydrology. The overall assessment is calculated from the scores of the environmental factors.

The ecological assessment of the method is based on a classification in 5 classes:

1. Highest ecological quality: both sensible and general species are present. Sensible species will disappear with some human influence.
2. Almost highest ecological quality: part of the sensible species and all general species are present
3. Medium ecological quality: sensible species have disappeared, only general species are left.
4. Low ecological quality: general species have disappeared
5. Lowest ecological quality: only certain very tolerant species are left.

These 5 classes seem to correspond to the 5 classes of the Water Framework directive. Therefore we assume that a good ecological status as target for natural waters in the WFD corresponds to the almost highest ecological quality. The targets set by the provincial policy plans are as follows. The target for the Hegebeek as a „quality water" is the highest ecological quality. In the Hagmolenbeek the target is lower; the almost highest ecological quality, as the stream has been designated as 'perception water'.

In table 6.1 the scores of the EBEOSWA method are given for two measurement points in the Hagmolenbeek and one measurement point in the upstream part of the Hegebeek for the period 1990-1999. The scores differ per year, as they depend on the amount of precipitation that has fallen in a certain year. In wet years the ecological condition is better than in dry years (pers.comm. G.Schmidt).

In the period 1990-1998 the quality of the Hegebeek fluctuates between moderate and almost highest. For the factor structure the score sometimes low. In 1998 the ecological quality is the almost highest for hydrology and highest for trophy and community structure. With regard to substrate and saproby the Hegebeek has a moderate ecological quality in 1998. It can be concluded that the Hegebeek has a moderate tot good ecological status (based on macro-invertebrates) in the period 1990-1998.

The goal of the WFD, a good ecological status (corresponding to an almost highest ecological quality) has not been reached in the Hagmolenbeek. The hydrology is the most restrictive environmental factor for a good ecological quality in the Hagmolenbeek. The low ecological classes of the factors substrate and community structure are the result of the impacted hydrology. Low stream velocities lead to sedimentation of silt and to a change of communities to a silt adapted population of species. Eutrophication effects occur only in location 20.010 in the downstream part of the Hagmolenbeek. Furthermore, the contribution of shredders (feeding on large organic material, like leafs) in the macro-invertebrate community is very low in the Hagmolenbeek.

Tabel 6.1: Overview of the ecological quality according to EBEOSWA at 3 measurement points in the Hegebeek/Hagmolenbeek.

| Wg.nr. | Name | mpc | Coördinates | Date | Policy | Target | Assesment results EBEOSWA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Main factors | | Side factors | | |
| | | | | | | | Hydrology | Saprobic | Trofy | Substrate | Structure |
| 20-5 | Hagmolenbeek | 20.010 | 243,08/473,58 | 13.10.89 | Perception water | | | | | | |
| | | | | 02.10.90 | | | | | | | |
| | | | | 16.05.94 | | | | | | | |
| | | | | 04.11.96 | | | | | | | |
| | | | | 01.06.99 | | | | | | | |
| | | | Average | | | | | | | | |
| | | 20.017 | 252,40/65,50 | 25.04.94 | Perception water | | | | | | |
| | | | | 09.07.97 | | | | | | | |
| | | | Average | | | | | | | | |
| 20-11-4 | Hegebeek - bovenloop | 20.212 | 257,10/464,17 | | Quality water | | | | | | |
| | | | | 10.09.91 | | | | | | | |
| | | | | 19.10.93 | | | | | | | |
| | | | | 11.10.94 | | | | | | | |
| | | | | 11.10.95 | | | | | | | |
| | | | | 07.09.98 | | | | | | | |
| | | | Average | | | | | | | | |

Legend:

| Legenda: | Highest ecological quality | |
|---|---|---|
| | Almost highest ecological quality | |
| | Medium ecological quality | |
| | Low ecological quality | |
| | Lowest ecological quality | |

Fish

With regard to fish, data on the presence of cert

ain fish species are available (see table 6.2). Only the Gudgeon (*Gobio gobio*) and the Stone loach (*Barbatula barbatulus*) are typical rheophilic stream species. These are however general occurring species in streams, which are not characteristic for the type „slowly flowing streams" as the Hagmolenbeek and Hegebeek are (see paragraph 4.3 and Box 1). The real characteristic species for the slowly flowing streams, such as Brook lamprey (Beekprik, *Lampetra planeri*) and Dace (serpeling, *Leuciscus leuciscus),* are not present in the Hagmolen-Hegebeek (see also list of reference species in Box 1, chapter 4). The other fish species occurring in the Hagmolen-Hegebeek, such as Perch (*Perca fluviatilis*) and Carp (*Cyprinus carpio*), are indicator species for stagnant and slowly flowing waters. The conclusion on the basis of the presence of fish species is that the Hagmolen-Hegebeek is not suitable for the most sensible stream species, thus the ecological condition is not very good. However, some rheophilic species are present, so the condition is not bad as well. The ecological condition for fish can be classified as being moderate to good. This means that the good ecological status has not yet been reached. The causes for this situation can be numerous:

- Lack of suitable habitat conditions for spawning and growth, such as substrate, stream velocity, waterdepth, especially in the canalised and normalised Hagmolenbeek. The Hegebeek has a natural morphology, but its length of 1250m is limited.
- Unsuitable hydrological conditions in summer, namely low stream velocities and water depths. This is caused by a combination of low quantity of flow during summer periods and the large number of weirs, leading to stagnant water of limited depth.

- Lack of possibilities to reach the stream due to migration barriers in the Hagmolenbeek and the connected streams, such as the German part of the Hegebeek, the Regge (due to the Twente canal), the Rutbeek and the Usselerstroom. Reference species, such as the brook lamprey do occur in the Dinkel stream. Due to the large number of migration barriers in the streams, this species can not migrate from the Dinkel via the Vechter Regge to the Hagmolenbeek, even if the ecological condition would be suitable for these sensible species.
- Lack of suitable water quality, such as high oxygen levels. Water quality data of the Hegebeek (table 6.4) show that the oxygen levels in summer are too low for salmonids and other rheophilic fish, needing levels > 7 $mgO_2/l$.

More research is needed to determine the most limiting cause(s) for the present fish population in the Hagmolen-Hegebeek and to define the most suitable set of measures to reach the good ecological status (e.g. installation of fish barriers, improvement of water quality, improvement of habitat conditions).

Table 6.2: Overview of fish observations in the Hegebeek/Hagmolenbeek.

| Scientific name | Dutch name | Presence in Netherlands | characteristic for streams | Indicative for: | Hegebeek | | Hagmolenbeek | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 20-11-4 | 20-5-1 | 20-5-A | 20-5-B |
| Carassius carassius | kroeskarper | quite general | | stagnant and (slowly) flowing waters | | | + | |
| Cyprinus carpio | karper | very general | | stagnant and (slowly) flowing waters | | + | | |
| Gobio gobio | riviergrondel | quite general | + | (semi) natural streams and rivers | | + | + | |
| Rutilus rutilus | blankvoorn | very general | | stagnant and (slowly) flowing waters | + | + | + | |
| Barbatula barbatulus | bermpje | quite general | + | (semi) natural streams | + | + | + | |
| Esox lucius | snoek | very general | | stagnant and (slowly) flowing waters | | | + | |
| Gasterosteus aculeatus | 3-doornige stekelbaars | very general | | stagnant and (slowly) flowing waters | | | + | |
| Pungitius pungitius | 10-doornige stekelbaars | very general | | stagnant and (slowly) flowing waters | | + | + | |
| Perca fluviatilis | baars | very general | | stagnant and (slowly) flowing waters | | + | + | |

Notice: 20-5-A = Hagmolenbeek till Beckum, 20-5-B = Hagemolenbeek from Beckum till Twente canal.

Biodiversity

Beside their role as bio-indicators species and communities have a significance for the (inter)national nature management.

To determine the actual significance for nature management a recently developed nature assessment method for streams in Twente will be used (Schmidt, 1999). The assessment is based on the presence of ***aquatic species of particular significance***. These are species, which need particular interest from the water- and nature management because of their:

- rareness in the Netherlands
- naturalness, which means that they depend on a natural situation
- characteristicness for stream ecosystems. They represent an original or a desired ecosystem quality.

The aquatic species of particular significance are selected from the group's macrophytes, fish and macro-invertebrates (Trichoptera, Ephemeroptera, Odonata, Plecoptera and Coleoptera). The presence of these aquatic species of particular interest leads to the classification of stream(reach)es with a low, middle or high interest for nature management. This indicator is presented in this case-study next to the macro-invertebrate method EBEOSWA, because both methods differ in their way of assessment, leading to different scores in different situations (see information in box 2). Table 6.3 presents the results of the classification are given. The Hegebeek has a high aquatic significance based on macro-invertebrate and fish data. The two locations in the Hagmolenbeek have a low significance and are only based on macro-invertebrate data.

Table 6.3 Scores for the significance for nature management on the basis of aquatic species of particular significance.

| location | species | Ecological quality levels | | | Total score |
|---|---|---|---|---|---|
| | | Rareness | Characteristicness | Naturalness | |
| Hagmolenbeek location 1 | macrofauna | Moderate | Low | Low | LOW |
| Hagmolenbeek location 2 | macrofauna | Low | Low | Moderate | LOW |
| Hegebeek | macrofauna and fish | High | Low | High | HIGH |

**Box 2. Ecological assessment on the basis of macro-invertebrates**

This case-study presents two methods for the assessment of the ecological condition based on macro-invertebrates. Both methods differ in their way of assessment, leading to different scores in different situations:

- EBEOSWA is based on the abundance of species. Each species is indicative for a certain ecological condition. EBEOSWA makes a distinction between:

⇒ General species, which can live in a broad range of environments and are tolerant for human disturbance;

⇒ Specific species, which have very specific requirements with regard to the abiotic environment and are very sensible for human disturbance.

The calculation of the score of the ecological condition is based on the abundance of a species and its indication for a certain ecological condition (general versus specific).

- The presence of aquatic species of particular significance (rareness, naturalness, characteristicness for stream ecosystems). On the basis of the presence of these aquatic species of particular interest stream(reach)es are classified into the classes low, middle or high interest for nature management.

Due to the calculation method of EBEOSWA the score of the ecological condition can be relatively low in situations, where there are very specific species present, but the abundance of general species is high as well. These situations occur quite often, as general species tend to dominate, both in affected and natural, unpolluted areas. The high abundance of general species will decrease the score and overrule to a certain extent the presence of some very specific species. Because of this disadvantage we also present the results of the assessment method based on the presence of aquatic species of particular significance.

Conclusion ecological status

On the basis of the macro-invertebrate indicator, the biodiversity indicator and the presence of fish described above it is concluded that the upstream part of the Hegebeek has a good to moderate status.

The Hagmolenbeek and the downstream part of the Hegebeek have a low ecological quality on the basis of macro-invertebrates. The EBEOSWA score is moderate to low ecological quality. The presence of aquatic species method gives also a low score for macro-invertebrates.

With regard to fish the Hagmolen-Hegebeek has a moderate to good ecological status, because of the presence of both (general) rheophilic and stagnant water fishes in the stream.

## 6.2 Physico-Chemical Elements

*[Does the physical alteration have an impact upon the physico-chemical elements? Examples of such impacts are:*

- *low oxygen levels because of straightened and deepened channel*
- *low temperature because of discharge of the dam, etc.*

*Describe the scale of the change in physico-chemical elements in the context of other pressures (e.g. pollution).]*

The water quality of the Hagmolen and Hegebeek is affected mainly by:

- Organic pollution due to the discharge of sewage water
- Nutrient pollution caused by run-off and drainage water from agricultural land

The water quality characteristics of the Hegebeek and Hagmolenbeek for the year 2000 are presented in table 6.4 and 6.5. Table 6.6 describes the regional standards for the Hegebeek and Hagmolenbeek. The main conclusions are:

- The oxygen levels in 1999 are ± 5–6 mg/l $O_2$, which is not very high. In the year 2000 the oxygen levels are around or lower than 7 mg$O_2$/l in the summer period. The lower standard for basic water is met (5 mg/l $O_2$), the higher standard of quality water is not reached (7 mg/l$O_2$). The standards for salmonid fishes (> 7mg/l $O_2$ and cyprinid fishes (> 6 mg$O_2$/) are also not reached during summer periods. The saprobic indicator (based on the macro-invertebrate assessment method, see table 6.1) shows a decline in ecological quality in the Hagmolenbeek from the highest to the medium ecological quality in the period 1990-1999, indicating that organic pollution affects negatively the biological community.
- In the year 2000 the standards for nutrients are exceeded. The nitrite values exceed the standard for salmonid fish of 0,1 mg$NO_2$-N/l. In the Hegebeek the regional standards for running water are exceeded for phosphate, nitrate and ammonium (see table 6.6). In the Hagmolenbeek the trofy indicator based on the macro-invertebrate community (table 6.1) indicates a low ecological quality. The ammonium values do not exceed the standards in the Hagmolenbeek, but they are high enough to reduce the oxygen level in the water due to the nitrification process (e.g. ammonium is processed into nitrate by consuming oxygen).

The conclusion is that the physico-chemical elements oxygen and nutrients exceed the standards and that the combination of the hydromorphological changes (stagnant water in summer) and organic and nutrient emissions affects the biological community negatively. The water quality of the Hagmolen-Hegebeek is on the basis of the abovementioned information classified as moderate for oxygen due to organic pollution and low for nutrients due to eutrophication.

Despite the negative effect of water quality, the theory on stream ecology argues that the ecological status of the stream is influenced much more by hydrology and morphology than by water quality (Verdonschot et al., 1995). Because of the large human impact on the hydromorphology and the important role of hydrology in a stream ecosystem, the flow characteristics and habitat diversity are probably the limiting factors for ecological rehabilitation. However, the present oxygen levels in the Hagmolenbeek and Hegebeek can limit the occurrence of rheophilic fishes, such as salmonids. Improved flow characteristics will increase the oxygen level in the stream.

Table 6.4 Water quality data of the Hegebeek in 2000-2001.

| Date | Tot-N (mg/l) | $NH_3$-N (mg/l) | $NH_4$-N (mg/l) | $NO_3$-N (mg/l) | $NO_2$-N [mg/l] | $O_2$ (mg/l) | Tot-P (mg/l) | $PO_4$ (mg/l) | Water temperature |
|---|---|---|---|---|---|---|---|---|---|
| 03-02-00 | 17,42 | 0,0001 | 0,3 | 15 | 0,02 | 9,5 | 0,14 | 0,07 | 6,4 |
| 15-02-00 | 16,25 | 0,0003 | 1,1 | 13 | 0,05 | 9,5 | 0,32 | 0,09 | 6,9 |
| 20-03-00 | 13,72 | 0,0002 | 0,6 | 11 | 0,02 | 10,2 | 0,14 | 0,06 | 4,5 |
| 01-05-00 | 11,55 | 0,0005 | 0,5 | 9 | 0,15 | 7,3 | 0,18 | 0,03 | 11,8 |
| 23-05-00 | 11,83 | 0,0021 | 2,4 | 7,5 | 0,13 | 7,2 | 0,24 | 0,08 | 10,1 |
| 28-06-00 | 9,16 | 0,0003 | 0,6 | 7 | 0,06 | 4,3 | 0,05 | 0,04 | 11,2 |
| 30-08-00 | 11,17 | 0,0002 | 0,2 | 9 | 0,07 | 7 | 0,15 | 0,09 | 12,8 |
| 27-09-00 | 16,04 | 0,0009 | 0,2 | 14 | 0,14 | 6,3 | 0,09 | 0,09 | 14,1 |
| 20-10-00 | 14,86 | 0,0003 | 0,2 | 13 | 0,06 | 7,5 | 0,15 | 0,04 | 9 |
| 14-11-00 | 18,01 | 0,0003 | 0,2 | 16 | 0,11 | 7,7 | 0,11 | 0,05 | 8,2 |
| 07-12-00 | 16,6 | 0,0007 | 0,4 | 13 | 0,1 | 8,4 | 0,21 | 0,05 | 7,6 |
| 20-12-00 | 16,26 | 0,0004 | 0,4 | 14 | 0,06 | 11 | 0,07 | 0,06 | 3,2 |
| 18-01-01 | 16,24 | 0,0005 | 0,8 | 14 | 0,04 | 8,8 | 0,2 | 0,16 | -0,4 |
| 22-02-01 | 16,45 | 0,0003 | 0,6 | 14 | 0,05 | 9,3 | 0,12 | 0,07 | 4,3 |
| 20-03-01 | | 0 | 0,2 | ---- | ---- | 7,8 | 0,1 | 0,06 | 4,1 |
| 17-04-01 | 13,24 | 0,0002 | 0,2 | 11 | 0,04 | 9,9 | 0,09 | 0,04 | 6,7 |
| 28-05-01 | 11,47 | 0,0001 | 0,3 | 8 | 0,07 | 4,6 | 0,16 | 0,04 | 14,1 |

Table 6.5 Water quality data of the Hagmolenbeek in 2000-2001.

| datum | N-tot [mg/l] | $NH_3$-N [mg/l] | $NH_4$-N [mg/l] | $NO_3$-N [mg/l] | $NO_2$-N [mg/l] | $O_2$ [mg/l] | Tot-P [mg/l] | $PO_4$ [mg/l] | Water Temperature |
|---|---|---|---|---|---|---|---|---|---|
| 27-01-00 | 12,08 | 0,0012 | 0,7 | 9,5 | 0,18 | 12,7 | 0,11 | 0,04 | 1,9 |
| 08-02-00 | 12,59 | 0,0017 | 0,8 | 10 | 0,09 | 11 | 0,05 | 0,04 | 6,8 |
| 25-02-00 | 11,56 | 0,0005 | 0,8 | 7 | 0,06 | 10,9 | 0,82 | 0,22 | 4,7 |
| 13-03-00 | 12,48 | 0,0007 | 0,6 | 9,5 | 0,08 | 10,6 | 0,08 | 0,05 | 7,7 |
| 25-04-00 | 8,52 | 0,0013 | 0,3 | 6 | 0,12 | 8,9 | 0,11 | 0,08 | 12,8 |
| 19-05-00 | 6,12 | 0,0034 | 0,4 | 3,5 | 0,12 | 7 | 0,09 | 0,06 | 16 |
| 05-06-00 | 6,6 | 0,0011 | 0,1 | 4,6 | 0,1 | 6,2 | 0,08 | 0,04 | 19 |
| 06-07-00 | 7,52 | 0,0013 | 0,1 | 1,2 | <0.02 | 4,7 | 0,3 | 0,01 | 19 |
| 13-09-00 | 8,82 | 0,0005 | 0,1 | 6,5 | 0,12 | 6,6 | 0,09 | 0,04 | 17,7 |
| 06-10-00 | 10,47 | 0,0025 | 0,3 | 7,5 | 0,17 | 7,8 | 0,16 | 0,08 | 12,6 |
| 30-10-00 | 11,42 | 0,002 | 0,3 | 8,5 | 0,12 | 9,5 | 0,12 | 0,07 | 10 |
| 22-11-00 | 11,6 | 0,002 | 0,8 | 8,5 | 0,1 | 9,5 | 0,21 | 0,12 | 6,1 |
| 14-12-00 | 13,52 | 0,004 | 1,1 | 10 | 0,22 | 9,9 | 0,13 | 0,07 | 8 |
| 12-01-01 | 12,46 | 0,0016 | 0,9 | 9,5 | 0,06 | 12,3 | 0,18 | 0,04 | 1,6 |
| 07-02-01 | 12,26 | 0,0006 | 0,9 | 9,5 | 0,06 | 10,4 | 0,19 | 0,08 | 6,6 |
| 06-03-01 | 11,35 | 0,0009 | 0,6 | 9 | 0,05 | 12,5 | 0,09 | 0,06 | 2 |
| 05-04-01 | 10,18 | 0,0009 | 0,5 | 8 | 0,08 | 10,1 | 0,13 | 0,05 | 8,3 |
| 07-05-01 | 9,09 | 0,0036 | 0,3 | 6,5 | 0,09 | 8,9 | 0,05 | 0,02 | 11,7 |
| 11-06-01 | 4,66 | 0 | <0.1 | 3,3 | 0,06 | 9,8 | <0.03 | 0,01 | 16,3 |
| 13-07-01 | 1,74 | 0,0016 | 0,2 | 0,4 | 0,04 | 5,1 | 0,03 | 0,03 | 18 |

Table 6.6 Regional water quality standards for the Hegebeek and Hagmolenbeek.

| Stream | Standard | $NH_4$-N (mg/l) | $NO_3$-N (mg/l) | $O_2$ (mg/l) | Tot-P (mg/l) |
|---|---|---|---|---|---|
| | | 90‰ at T>10°C | 90‰/year | 10‰/year | Mean summer value |
| Hegebeek | Quality water | 0,2 | 1 | 7 | 0,05 |
| Hagmolenbeek | Basic water | 0,8 | 10 | 5 | 0,15 |

## 6.3 Definition of Current Ecological Status

*[How have the physico-chemical and biological quality elements been brought together in order to define ecological status?*

*Has this been done using an existing classification or using expert judgement?*

*Is it considered a good approximation to the definition of good ecological status as defined by the directive - what are the weakness in the current definition?]*

The ecological status of the Hagmolen-Hegebeek will be based only on the biological quality elements, described in section 6.1. The reasons for this decision are that:

- Hydromorphology is more than water quality the steering factor for the ecological status of the Hagmolenbeek (Verdonschot et al., 1995)
- The ecological assessment method includes indicators (based on the macro-invertebrate community present) for water quality problems, such as organic pollution and eutrophication.

In case, the hydromorphology has been improved to a large extent, water quality can become the limiting factor, for example to reach the highest ecological quality. Present oxygen levels in the Hagmolen and Hegebeek can limit the occurrence of rheophilic fishes, such as salmonids.

On the basis of the macro-invertebrate indicator, the biodiversity indicator and the presence of fish described in section 6.2 it is concluded that the upstream part of the Hegebeek has a good to moderate status.

The Hagmolenbeek and the downstream part of the Hegebeek have a low ecological quality on the basis of macro-invertebrates. The EBEOSWA score is moderate to low ecological quality. The method based on the presence of aquatic species of particular significance gives also a low score.

With regard to fish the Hagmolen-Hegebeek has a moderate to good ecological status, because of the presence of general rheophilic and stagnant water fishes in the stream. More research is needed to determine the most limiting cause(s) for the present fish population in the Hagmolen-Hegebeek (e.g. habitat, hydrology, water quality, migration) and to define the most suitable set of measures to reach the good ecological status (e.g. installation of fish barriers, improvement of water quality, improvement of habitat conditions).

## 6.4 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

With regard to the biological and physico-chemical parameters the following conclusions can be made.

Parameters

Not all the required parameters were available; there are no data on algae and macrophytes. With regard to fish only information on the presence of species is available, but no data on the composition, abundance and age structure of fish. Macro-invertebrate data on composition and abundance are available.

According to our stream ecologists it makes no sense to monitor and assess phytoplankton in streams, as required by the WFD, because in general phytoplankton does not grow in streams. Phytobenthos, growing on substrates (stones, plants), is a required parameter of the WFD as well. It is however only meaningful to monitor phytobenthos for ecological assessment in case nutrients are the limiting factor for the ecological quality of running waters. Presently, in many streams morphology and hydrology are still limiting for ecology, therefore monitoring and assessment of periphyton will provide no additional information.

Assessment method based on 5 classes

For most parameters there are no results available of an assessment method based on five classes. Only for macro-invertebrates results of suitable ecological assessment methods are available. For the other parameters expert-judgement has been used to assess the ecological status.

With regard to fish data on the presence of certain species were present. In combination with expert-judgement and a reference condition the ecological condition has been assessed. The water quality data have been assessed on the basis of expert judgement and the regional standards and general oxygen standards for fish. The EBEOSWA method for macro-invertebrates has 5 classes and the classes seem to correspond with the 5 classes of the WFD. Moreover, the method indicates which hydromorphological or water quality parameter is the limiting factor for the ecological condition. However, the EBEOSWA method tends to show low scores in cases where very specific species are present, but general species are still dominating. Therefore, we decided to include the indicator method "presence of aquatic species of particular significance" (rareness, naturalness, characteristicness for stream ecosystems) in our assessment of the ecological status.

Furthermore, the EBEOSWA method is based on data of a large number of streams in the Netherlands. As many Dutch streams have been impacted by human activities (the Netherlands has one of the highest population densities of Europe), the ecological quality results of EBEOSWA will possibly yield a somewhat more positive picture of the ecological level than assessment methods from other countries would. The intercalibration exercise should make the differences between countries more clear

An additional discussion point is the instability of the ecological status. The scores differ per year, as they depend on the amount of precipitation that has fallen in a certain year. In wet years the ecological condition is better than in dry years. To overcome this problem the average result over a period of ten years has been used.

# 7 Identification and Designation of Water Bodies as Heavily Modified (6 pages)

*[Refer to HMW paper 7 ver 2].*

## 7.1 Provisional identification of HMWB

On the basis of the physical alterations described in chapter 5 and the current ecological status described in chapter 6, the downstream part of the Hegebeek and the Hagmolenbeek are provisionally identified as Heavily Modified Waters. The upstream part of the Hegebeek is provisionally identified as natural.

## 7.2 Necessary Hydromorphological Changes to Achieve Good Ecological Status

*[Here, the changes to the hydromorphological characteristics that would be (theoretically) necessary for achieving good ecological status should be assessed. Based on this, the effects these changes would have on the specified "Uses" shall be estimated and evaluated. [Article 4.3 (a).* [1]

*How have the required measures to achieve good ecological status been defined?*

*How has the impact of these measures on water uses been described?*

*How have "significant adverse effects" been defined (tools could range from simple descriptions of the consequences to economic analysis)?* [2]

*How have impacts upon the wider environment been assessed? This should include upstream/downstream effects, wider implications of mitigation measures - waste disposal or energy use.]*

### 7.2.1 Required hydromorphological changes to achieve the Good Ecological Status

The required hydromorphological changes relate to the restoration of the three types of physical alterations (described in section 5.2) in the Hagmolen-Hegebeek, namely:

- change in morphology;
- change in catchment areas and
- change in hydrology of the catchment.

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[1] Article 4.3 (a) WFD. "*Member States may designate a body of surface water as artificial or heavily modified when: (a) the changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant adverse effects on* [Uses]: *i) the wider environment, ii) navigation, including port facilities, or recreation, iii) activities for the purposes of which water is stored, such as drinking water supply, power generation, irrigation, iv) water regulation, flood protection, land drainage; or v) other equally important sustainable human development activities.*"

[2] Different methods for decision-making are:

- rule of thumb
- expert assessment (incl. qualitative and quantitative data)
- direct consideration of "main" or dominant uses,

involving political decision, public involvement and consensus among water users.

The question is which hydromorphological change will lead to the good ecological status. To answer this question the ecological effect of the different changes has to be predicted: what is the effect of restoring only the morphology of the stream, what is the ecological improvement in case the hydrology is restored as well? To what extent has the hydrology to be restored? What is the natural, undisturbed discharge pattern of the stream? These are difficult questions and only a calibrated ecological model could predict quantitatively the effect of measures taken in the stream or catchment on the ecological condition over the whole length of the stream. Such a model is not available (yet). Therefore, a combination of expert-judgement, data analysis and literature has been used to determine the hydro-morphological measures needed to achieve a good ecological status. We choose the approach of comparing the Hagmolen and Hegebeek with comparable reference streams (respectively the Ruenbergerbeek and the Hagmolenbeek) in order to detect the major factors for a certain ecological condition in a stream. A detailed description of the comparison is given in appendix A. The conclusions of the comparison are the following.

**Upstream part of the Hegebeek**

The Hegebeek has a moderate to good ecological quality. The Hegebeek has a natural morphology and no weirs. The hydrology of the Hegebeek has been changed by human impact; the German catchment has been enlarged and the hydrology of the German catchment has been adapted to agricultural needs (e.g. drainage). Due to the periodic high discharges from the German part of the catchment, the stream has become situated very low in the stream valley due to erosion. Although the Dutch part of the Hegebeek itself has no weirs, the parts upstream and downstream of the Hegebeek have numerous barriers limiting the migration of fishes into the Hegebeek. Furthermore, the water quality is not suitable for sensible rheophilic species due to low oxygen values. Hydromorphological changes needed to achieve the good ecological status are:

- Restoration of the hydrology in the upstream German catchment of the Hegebeek leading to a more natural quantity and dynamics of flow. This should lead to higher stream velocities and quantities of flow in summer.
- Improvement of the possibilities for migration for fish and macro-invertebrates.

**Downstream part of the Hegebeek and Hagmolenbeek**

This part of the stream has a low ecological quality. Comparison with the reference stream showed that restoration of the natural morphology and improvement of the water quality will probably lead to an ecological status between good and moderate, depending on the amount of precipitation in a year (ecological status is higher in wet years). To achieve a stable good ecological status the quantity and variation of flow has probably to be restored as well.

**Discussion**

The approach of comparing the Hagmolen- and Hegebeek with comparable reference streams in order to detect the major factors for a certain ecological condition in a stream is debatable. Two streams can be comparable to a certain extent, but they are never completely the same with regard to hydrology, morphology and ecology. This means that the derivation of the required hydromorphological changes to achieve the Good Ecological Status on the basis of a comparison with a reference stream remains uncertain. It would be preferable to use a well-calibrated ecological model. This model should be based on a large number of data of different streams for the prediction of the required hydromorphological changes. As this model is not available (yet), we use the method of comparison with a reference stream.

### 7.2.2 Required measures to reach the good ecological status

Three types of measures can be distinguished to improve the hydrology and morphology in the Hagmolenbeek. The measures restore the three types of physical alterations (described in section 5.2), namely change in morphology, change in catchment areas and change in hydrology of the catchment. The three types of measures are:

1. Restoration of the morphology of the stream (beekherstel)

2. Restoration of the former catchment area by removal of dividing works and reconnection and disconnection of catchments (stroomgebiedsbenadering)

3. Restoration of the hydrology in the catchment by decreasing the level of drainage in the catchment and increasing the groundwater level (systeembenadering)

Ad 1. Restoration of the morphology of the stream (beekherstel) implies:

- Restoration of the former meandering pattern of the stream.
- Changing the profile of the stream from the present broad profile with steep banks to a profile with the main channel for the basic discharge (zomer bed) and a wider channel including the riparian zone and floodplains for high discharges (winterbed).
- Allowing natural stream vegetation to grow on the banks.
- Restoration of side-channels and marsh areas in the stream valley.
- Removal of weirs.

Ad 2. Restoration of the former catchment area can be done by:

1) Reconnecting former subcatchments, such as the Regge and perhaps also the Buurserbeek. It is still uncertain if the streams Buurserbeek/Schipbeek discharged into the Hagmolenbeek in former times (Tauw, 2001). It is possible that the Hagmolenbeek en Buurserbeek were interconnected during wet periods, when large parts of the catchments of the streams changed into marshy areas and water flowed from one catchment into other. This is however uncertain, because the border between both catchments is relatively high. Reconnection of former subcatchment of the Buurserbeek will probably increase the basic level of the quantity of flow, the high quantity of flow during wet periods and reduce the period of low to zero quantities of flow during dry periods in the Hagmolenbeek. This measure has also been presented in the „Regge visie" as an ecological restoration measure. Reconnection of the downstream part of the

Hagmolenbeek to the Regge stream via connection under the Twente canal will have no effect on the hydrological characteristics of the Hagmolenbeek. However, the measure can have a positive effect, because the possibilities for fauna to migrate from the Hagmolenbeek to the Regge will probably increase and the original catchment will be restored

2) Removing the discharge works. This will lead to a more uneven quantity of flow in the Hagmolenbeek. The difference between high and low discharges will rise: the high discharges will even be higher and low discharges lower than at present. The effect of this measure on the ecological condition is uncertain. The flow pattern will become even more extreme and unnatural. The risk of a dry stream or stagnant water increases. A possible positive effect could be that morphological processes, such as erosion and sedimentation, intensify at higher discharges, leading to higher habitat diversity. The positive effect holds only in case the stream morphology has been restored. What the ultimate ecological effect is of removing the dividing works remain uncertain. Therefore, this measure will not be discussed further in this case-study project.

Ad 3. Restoration of the hydrology in the catchment (systeembenadering). This measure implies the restoration of the hydrology of the catchment and stream. The objective is a more natural discharge pattern, which means a reduction of high discharges, a higher basic discharge and a longer period of basic discharge. This discharge pattern can be realised by a rise of the groundwater level in the catchment and a decrease of the drainage capacity in order to retain the water in the catchment for a longer time.

A modelling exercise has been carried out to determine the effect of the first two measures on the hydrology and morphology of the Hagmolenbeek. The modelling results predict the relative effect of the restoration of the natural morphology and restoration of former catchments compared with the present situation. This means that no absolute, but only relative conclusions can be made on the basis of the modelling. The effect of the third measure (restoration of the hydrology in the catchment) has been determined by the use of literature and expert judgement. A more detailed description of the modelling and expert-judgement is presented in appendix B. A summary of the effect of the measures on the hydrology and morphology is described in table 7.1.

Table 7.1 A summary of the effect of the restoration measures on the hydrological, morphological and ecological characteristics of the Hagmolenbeek.

| Measure | Description of measure | Effect on morphology | Effect on hydrology | Effect on ecology |
|---|---|---|---|---|
| **Morphology restoration** | • the restoration of the former meandering pattern of the stream.<br>• changing the profile of the stream from the present broad profile with steep banks to a profile, in which the basic discharge is transported through the main channel (zomerbed). At high discharges, the additional water is transported through the riparian zone and floodplains (winterbed).<br>• allowing natural stream vegetation to grow on the banks.<br>• the restoration of side-channels and marsh areas in the stream valley.<br>• removal of weirs | Natural morphology is restored:<br>• the stream meanders and side channels occur<br>• natural vegetation grows on the banks and marshes occur in the stream valley<br>• the habitat diversity increases | • The stream velocity increases strongly<br>• The diversity of stream velocity increases due to the higher morphological diversity<br>• The period of a stream velocity > 5 cm/s increases<br>• Due to the removal of weirs the stream will stand clear of water during dry periods instead of stagnant water in the present situation. Probably some pools will still be filled with water.<br>• The maximum water depth decreases<br>• The minimum water depth becomes zero (stream stands clear of water) instead of a certain minimum water depth as in the present situation (being determined by the height of the weirs) | Positive effect:<br>• The increased diversity of morphology and stream velocities has a positive effect on the species diversity<br>• The increase in stream velocity and the increase in the period of flowing water will stimulate rheophilic species<br><br>Negative effect:<br>• The risk of a stream standing clear of water during dry periods increases<br>• The resulting vegetation may reflect higher trophic levels than desired (as a result of higher nutrient concentrations in the surface water) |
| **Reconnection Buurserbeek** | It is still uncertain if the Buurserbeek had been connected to the Hagmolenbeek in former times. The reconnection has been modelled by increasing the quantity of flow with 10% at the connection of the Rutbeek with the Hagmolenbeek | Morphological processes, such as erosion and sedimentation, will intensify at higher quantities of flow leading to a higher habitat diversity and a lower level of the stream bottom. This holds only in case the stream morphology has been restored. | • The stream velocity increases to a limited extent<br>• The period of a stream velocity > 5 cm/s does not differ from the present situation<br>• Due to the presence of weirs the stream will have stagnant water during dry periods<br>• The maximum water depth increases due to a higher quantity of flow<br>• The minimum water depth is determined by the height of the weirs<br>• The risk of a dry stream will probably decrease. This will depend on the quantity of flow of the reconnected stream during dry periods. | Positive effect:<br>• It is expected that the limited increase in stream velocity will stimulate rheophilic species<br>• The risk of a stream standing clear of water during dry periods will probably decrease<br><br>Negative effect:<br>• The risk of extreme high quantities of flow increases. These high quantities of flow can lead to the flushing out of species |
| **Restoration of morphology and reconnection of the Buurserbeek** | Combination of the two measures described above | Restoration of the natural morphology as described above and increase of morphological processes due to higher quantities of flow | • The stream velocity increases the most strongly compared to the other measures and the present situation<br>• The diversity of stream velocity increases due to the higher morphological diversity<br>• The period of a stream velocity > 5 cm/s increases to the largest extent compared to the other measures and the present | Positive effect:<br>• The increased diversity of morphology and stream velocities has a positive effect on the species diversity<br>• The increase in stream velocity and the increase of the period of flowing water will stimulate rheophilic species<br>• The risk of a stream standing clear of water |

| | | | | |
|---|---|---|---|---|
| | | | situation<br>• Due to the removal of weirs the stream will stand clear of water during dry periods instead of stagnant water in the present situation<br>• The maximum water depth decreases compared to the present situation and the measure reconnection of the Buurserbeek, but increases compared to the measure restoration of morphology<br>• The minimum water depth becomes zero (stream stands clear of water) | during dry periods will probably decrease<br><br>Negative effect:<br>• The resulting vegetation may reflect higher trophic levels than desired (as a result of higher nutrient concentrations in the surface water) |
| **Reconnection to Regge** | Reconnection of the downstream part of the Hagmolenbeek to the Regge stream via connection under the Twente canal. The measure restores the original catchment. The catchment approach is important in the Water Framework Directive. | - | • This measure will hardly affect the hydrological characteristics of the Hagmolenbeek, because the reconnection takes place in the downstream part of the Hagmolenbeek | • The possibilities for fauna to migrate from the Hagmolenbeek to the Regge will probably increase, as fish migrates through these connections. The possibilities for migration increase with lower stream velocities and enough light in the connection.<br>• The improvement of the ecological situation after reconnection of former subcatchments depends also on the hydrological characteristics after reconnection and on the morphology of the stream and the naturalness of the banks. The downstream catchment of the Hagmolenbeek (northern of the Twente canal) has the same characteristics as the upstream catchment; its hydrology is adapted to the agricultural requirements (weirs, steep profile, drainage). |
| **Restoration of hydrology in the catchment** | Restoration of the hydrology of the catchment and stream. The objective is a more natural discharge pattern, which means a reduction of high discharges, a higher basic discharge and a longer period of basic discharge. This discharge pattern can be realised by a rise of the groundwater level in the catchment and a decrease of the drainage capacity in order to retain the water in the catchment for a longer time. | - | • On the basis of expert-judgement and literature it is determined that for a restoration of the original quantity and pattern of flow a decrease of the drainage capacity of 70-80% and a rise of the groundwater level in the catchment with 20-50 cm is needed. The groundwater levels III, VI and VII will change to the levels I, II and III respectively.<br>• Decrease of extreme ranges of quantities of flow in the stream: during dry periods the quantity of flow will increase and during wet periods the quantity of flow will increase due to the larger retention of precipitation in the catchment | • Restoration of the original quantity and pattern of flow in the stream<br>• The risk of a stream standing clear of water will decrease<br>• The risk of flushing out of organisms due to high quantities of flow in the stream will decrease<br>• Water quality will improve as the rainfall-runoff process proceeds more through the soil resulting in retention of pollutants |

### 7.2.3 Impact on water uses and significant adverse effects

Restoration of the natural morphology impacts only agricultural activities directly bordering the stream, as the abovementioned changes to the stream morphology need space and agriculture will be impossible in a broader border along the stream. The loss of agricultural land in the catchment due to this measure will be 5%. This land is the most fertile in the catchment due to regular flooding of the land by the stream. But the flooding can also have a negative effect on the yields depending on the moment and duration of flooding. The 5% land needed for morphology restoration will have to be bought by the Waterboard from the farmers. This implies costs for buying the land and remeandering the stream. The agriculture in the rest of the catchment area will not be significantly impacted by this measure. It is concluded that a loss of 5% of the land is not a significant impact.

The reconnection of a catchment area can lead to an increased risk of floods as a result of the increased quantity of flow. The modelling exercise showed that water level after reconnection increases with a range of 1-20 cm compared to the present situation. This leads to a small increase of the risk of floods (see table 7.2 and appendix B, section 7B1.2.4.). It is difficult to determine the significance of this effect, as it depends on the frequency, the point of time and the location of flooding.

Table 7.2 Estimation of risk of floods based on prediction of waterlevels after the implementation of the different restoration measures in m + NAP for typical discharges at four locations sensitive for flooding. **Bold figures:** waterlevel exceeds ground level.

| Measure | Discharge ↓/ Distance from Twentecanal (m)→ | 5893 | 7557 | 9308 | 11693 |
|---|---|---|---|---|---|
| Present | Design discharge | 18,45 | 20,60 | 22,75 | 25,65 |
| | 2* Design discharge | **18,80** | 20,75 | 23,00 | 25,90 |
| Morphology restoration | Design discharge | 18,55 | 20,50 | 22,60 | 25,55 |
| | 2* Design discharge | **19,00** | **20,80** | 22,90 | 25,80 |
| Reconnection of catchment | Design discharge+10%* | 18,49 | 20,60 | 22,76 | 25,66 |
| | 2* Design discharg+10%*e | **18,90** | **20,80** | 23,03 | 25,93 |
| Reconnection of catchment and morphology restoration | Design discharge+10%* | 18,55 | 20,50 | 22,65 | 25,57 |
| | 2* Design discharge+10%* | **19,03** | **20,84** | 22,92 | 25,86 |
| Height of groundlevel: | | 18,67 | 20,78 | 23,08 | 25,93 |

* It is estimated that the reconnection of catchment leads to an increase of the discharge with 10%.

The restoration of hydrology has a significant effect on other uses in the catchment, namely agriculture. A higher groundwater level will decrease the yields at locations, where the present groundwater level is optimal for the cultivated crops. At locations, where groundwater levels are presently too low, a rise in groundwater level will increase the yields. The change in yield has been estimated by using so-called HELP tables (see appendix C, section 7B.1.5.3.). These tables predict the yield reduction as a result of drought and flooding. The yield reduction at higher groundwater levels is ± 30%, which is a doubling of the present yield reduction number. The costs of the 15% extra yield reduction due to rising groundwater levels are 1,8 million €/year. This can be qualified as a significant effect. The Hagmolen catchment has a use-oriented function, which aims at developing an economic sound agriculture. The rise of groundwater levels conflicts with the development of agriculture in the catchment. Other streams and corresponding catchments, e.g. Hegebeek, have a nature function: ecological restoration measures in the catchment can be implemented more easily in these catchments.

### 7.2.4 Impacts on the wider environment

The impacts on the wider environment describe the negative effects on related watebodies:

- The restoration of former catchments leads to reconnection and disconnection of streams. This re- or disconnection of streams to the Hagmolenbeek can improve the hydrological boundary condition for ecology. It can also lead to running dry of streams in adjacent watersheds in dry periods or extreme high discharges in the Hagmolenbeek during wet periods depending on the present discharge pattern and the hydrological effect of the dis-/re-connection.

## 7.3 Assessment of Other Environmental Options

*[This section should consist of two parts and the first part defines the scope of the second:*

- *The first part should refer to the identification and definition of the beneficial objectives served by the modified characteristics of the water body [see Art. 4.3 (b))]* [3]
- *The second part should consider other alternatives to the existing "water use" [again see Art. 4.3 (b)]. There are three aspects to the test of Art 4.3 (b). Alternatives to the existing "water use" must:*
- *be technically feasible;*
- *not be disproportionately costly;*
- *reasonably achieve significantly better environmental option.*

*How have these issues been addressed?*

*How wide has the assessment of options been?]*

### 7.3.1 Identification and definition of the beneficial objectives served by the modified characteristics of the water body

The normalisation and canalisation of the stream and the drainage in the catchment have been carried out to optimise the hydrology of the catchment for agricultural purposes. Furthermore, due to the normalisation and canalisation of the stream agriculture on the land directly next to the stream became possible. Thus, the area of land suitable for agriculture has increased.

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[3] Article 4.3 (b) WFD. "*Member States may designate [...] as heavily modified, when: (b) the beneficial objectives served by the [...] modified characteristics of the water body can not, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.*"

The change of catchment areas by disconnection and reconnection of tributaries and the installation of dividing works has been carried out to reduce the risk of floods.

The disconnection of the Hagmolenbeek from the Regge has been caused by the building of the Twentecanal for navigation and watermanagement purposes. The disconnection decreases the risk of floods in the Regge catchment.

### 7.3.2 Alternatives to the existing "water use"

*Restoration of the natural morphology*

Restoration of the natural morphology impacts only agricultural activities directly bordering the stream, as the restoration of the stream morphology needs space and agriculture will be impossible in a broad border along the stream (±15 m). The agriculture in the rest of the catchment area will not be significant negatively impacted by this measure. An alternative for the farmer to the existing water use is to sell the land to the water board and to buy alternative land in the catchment area.

<u>(Technical) feasibility</u>

The area along the stream, where morphology restoration is performed, has to be bought from farmers or private owners on a voluntary basis. The voluntary basis leads actually to delays and incomplete restoration, as some owners are not willing to sell their ground for various reasons.

Furthermore, acceptance of the measures by the local people is important. As part of a restoration of the Hagmolenbeek during the 90's a line of trees had been planted along the stream. These trees have been removed, as the locals didn't like them. Due to acceptance problems the actual restoration of the stream was less ambitious than planned before.

<u>Costs</u>

The total costs of stream restoration consist of the following:

⇒ The costs of buying the area needed. The average price for land in Twente is € 36.300,- /ha.

⇒ The costs for building the new profile and the meandering pattern of € 2,26,- /m$^3$

The total costs for the restoration of the Hagmolenbeek amount to € 1.543.350,--.

These costs are the gross costs for the Waterboard of the restoration measure itself. Probably the waterboard can make use of existing subsidies for stream restoration. The yield of the sale of the land (€ 1.407.172,--) by the farmer can be regarded as compensation costs, which the farmer can use to buy alternative land. It is assumed that maintenance costs of the stream and banks will remain the same. Most probably the maintenance costs will decrease in the long run, as a natural stream needs less maintenance.

<u>Environmental effects in a wider context</u>

Environmental effects on a wider context refer to negative effects of the alternatives on the air, soil, water and biodiversity. There are no environmental effects in a wider context.

*Restoration of the former catchment*

The increased risk of floods due to the restoration of the former catchments can be reduced by the creation of so-called retention areas. These areas are mainly located in the lowland plains and are flooded temporarily during wet periods to reduce the risk of floods downstream. The creation of retention areas is a new policy in Dutch water management. The general goal is to designate approximately 3% of the area in a catchment as retention areas.

In the Hagmolenbeek catchment, these low level retention areas will be situated in the stream valley soils (beekdalgronden). In figure 4.1 a map of the soil composition of the Hegebeek-Hagmolenbeek catchment is shown, in which the stream valley grounds are represented. The retention areas have not yet been designated officially.

Technical feasibility

Restoration of former catchments is an important management goal of the Waterboard Regge & Dinkel. A study has been performed to the possible traject of the reconnection of the Hagmolenbeek to the Regge. A number of different alternative trajects have been defined and described. It can be concluded that this measure is technically feasible.

The creation of retention areas is a Dutch policy to decrease the increased risks of flooding. The general objective is to designate approximately 3% of the area in each catchment of the Netherlands as retention area. Thus, this alternative to the existing water use is technically feasible as well.

Costs

The costs of this measure consist of:

- Costs of the re/dis-connection works themselves. The costs are estimated to be:

  - € 1.815.705,-- for the reconnection of the downstream part of the Hagmolenbeek to the Regge stream via connection under the Twente canal. The costs consist of the construction of a connection under the Twente canal (a so-called "onderleider").

  - € 9.5324,--: for the reconnection of the Buurserbeek to the Hagmolenbeek. The costs consist of the costs of €68.089,-- for purchase of ± 2 ha of land and the costs of € 27.236,-- for the excavation of ±10.000 $m^3$ soil. The reconnection of the Buurserbeek is only relevant in case the Hagmolenbeek en Buurserbeek have actually been interconnected in former times. This is still uncertain.

- Costs of the alternatives to existing water use, in this case the costs of the creation of so-called retention areas to reduce the risk of floods. In another catchment of the Waterboard Regge & Dinkel, the Dinkel, retention areas have been selected and the farmers owning this land are compensated for the use of their land as retention area. These compensation costs are used to calculate the costs of the creation of retention areas in the Hagmolenbeek catchment. The retention areas are mostly low-lying areas, such as the stream valley land (see figure 4.1 for the location of stream valley soil). The average compensation costs for inundation are € 250,--/ha year. The total costs are 3% x 9256 ha (present catchment size) x € 550,--/ha·year= € 69.450,--/year

Environmental effects in a wider context

There are no environmental effects in a wider context.

*Restoration of the hydrology in the catchment*

The restoration of hydrology has a significant effect on agriculture in the catchment, as a higher groundwater level will generally decrease the yields. Locally the yield can increase at higher groundwater levels, because the area is too dry in the present situation. The farmers could be compensated financially for the yield reduction by subsidies or by higher prices for their products. The alternative to change to crops that need high groundwater levels (such as rice) is not an option (yet). There are no examples available of areas in Netherlands, where the groundwater level has been increased and the negative effect to farmers have been reduced by changing to an alternative crop. Both financial compensation of farmers and the change to other crops depends largely on the future global, European and national agricultural policy.

Technical feasibility

The restoration of the hydrology of the catchment is difficult to implement, because the present major function assigned by the regional government (province) to the Hagmolen catchment is development of agriculture. This political decision complicates the implementation of hydrological restoration measures, which will affect agriculture negatively, in an "agricultural development area".

Costs

The damage costs of the yield reduction have been calculated by using HELP tables. The total costs for the Hagmolen catchment amount to € 1.815.700,--/year.

Environmental effects in a wider context

There are no environmental effects in a wider context.

The different costs and feasibility of the restoration measures and the alternatives to present water use are summarised in table 7.3. With regard to the costs, different types are distinguished:

- The costs of the restoration measure itself, e.g. the costs for digging a meandering stream;
- Compensation costs of the alternative. The costs aim to compensate the negative impact on uses, e.g. the costs for the creation of retention areas for the increased risk of floods. In some cases the costs of the restoration measure are simultaneously compensation costs, e.g. for morphology restoration the land has to be bought from the farmer by the Waterboard. For the Waterboard these are costs of the measure, whereas for the farmers these earnings can be regarded as compensation costs, which he can use to buy alternative land.
- Damage costs, which represent the financial losses of the users due to the negative impact of the restoration measure, e.g. the loss of income due to lower agricultural yields. The alternative option for this negative impact is to compensate the users for their financial losses. Therefore, these costs are comparable with compensation costs.

If the HMW working paper (HMW8version 6 appraisals paper) on appraisal techniques has been understood well, the costs of the restoration measure itself are not part of the disproportionate costs appraisal to determine if a water is HMW or natural. However, the costs of these measures can be high, therefore we have included these costs in the summary table (see also discussion point in section 7.4).

Table 7.3 Summary of costs and feasibility of measures and alternatives to present water use.

| Measure | Type of costs | Total costs | Technical Feasibility | Societal feasibility |
|---|---|---|---|---|
| **Morphology restoration** | Costs of measure<br><br>Compensation costs for buying alternative agricultural land | - Buying of land: €1.407.172,-- *<br>– Creation of natural morphology: €147.500,--<br><br>- Selling of land: F1.407.172,--* | Measure is technically feasible | Acquisition of ground on a voluntary basis |
| **Reconnection catchment** | Costs of measure<br><br>Compensation costs for the alternative creation of retention area | - Building of reconnection Regge: €1.815.705,--<br>- Buying land and building of reconnection Buurserbeek: €95.325,--<br><br>- Creation of 3% retention area in catchment: €69.450,-- /year | Measure is technically feasible | Policy of Waterboard |
| **Restoration hydrology** | Damage costs of yield reduction<br><br>(in case the farmers are compensated for these costs are comparable to compensation costs) | Yield reduction due to higher ground water levels €1.815.700,--/year | Increase of groundwater level and decrease of drainage is technical feasible<br>- Change to alternative crops as alternative to existing water use is not feasible | The designation of HMW waters conflicts with the Dutch policy of spatial planning: presently the catchment has agricultural function |

*The land for morphology restoration has to be bought by the Waterboard from the farmer. For the Waterboard these are costs of the measure, whereas for the farmers these earnings can be regarded as compensation costs, which he can use to buy alternative land.

*Costs of present maintenance*

An indication of the total costs of the present maintenance of the Hagmolen-Hegebeek is given in table 7.4. The costs amount to almost €90.785,-- per year. However, a large part of these activities will have to be made also in case the measure morphology restoration has been carried out, but the frequency will be lower:

- The frequency of mowing will probably decrease to once per year (depends of the profile after restoration)
- The maintenance of the plantation decreases to once in the 5 years
- The number of weirs will decrease and all remaining weirs will have a fish passage. The exact number is not yet known and has to be determined by hydrological modelling (For the

cost calculation the number of weirs has been decreased by 50%, the total number of fish passages remains the same).

- The restoration of profile is not necessary anymore, as morphological processes will determine the profile.

The total maintenance costs after morphology restoration are estimated to be €31.775,--/year, which is a decrease of 65% of the maintenance costs before morphology restoration.

Table 7.4 Indication of the cost in euro of the present maintenance of the Hagmolen-Hegebeek.

| Activity | Frequency/year | costs in € | unit length/surface/# | | total costs in €/year |
|---|---|---|---|---|---|
| **Mowing** | | | | | |
| mowing/raking combination | 2,5 | 0,45 | m | 27000 | 30.640 |
| mowing soil | 1,5 | 0,15 | m | 27000 | 5.883 |
| **Construction works** | | | | | |
| cleaning fish passages | 8,0 | 34 | per passage | 12 | 3.268 |
| mowing bridges, weirs, culvert | 1,0 | 11 | per work | 67 | 760 |
| **Plantation** | | | | | |
| mowing plantation | 1,0 | 0,14 | $m^2$ | 27000 | 3.677 |
| trimming plantation | 0,3 | 1,14 | $m^2$ | 27000 | 7.660 |
| **Restoration stream channel** | | | | | |
| Restoration of paths | 1,0 | 0,23 | m | 27000 | 6.128 |
| Restoration of collapsed banks | | 908 | | | 908 |
| Restoration of profile | 0,1 | 12,5 | m | 27000 | 33.704 |
| **Total costs of maintenance** | | | | | **€92.628,–** |

## 7.4 Designation of Heavily Modified Water Bodies

*[Describe how the designation process has been applied (include maps of designated water bodies). See HMW paper 3 ver 3, paper 7 ver 2.*

*What issues have determined the scope of the designation - compare different approaches (see HMW paper 7 ver 2). It is recommended that both designation options described in paper 7 ver 2 fig.7 & 8 are applied. This involves*

*1) the case where only the morphology of the water body is altered and it affects the ecological status or*

*2) the case where the hydromorphology is altered and it affects the ecological status.*

*The preferred options should then be identified.]*

In this section (parts of) the Hagmolen-Hegebeek have to be designated as HMW on the basis of the technical feasibility and costs of alternatives, which reduce the negative effects on other uses. The designation should be carried out on the basis of two different approaches:

1) Designation as HMW on the basis of physical alteration: the physically altered part of the river is designated as HMW and the affected parts up- and downstream are natural with less stringent objectives. The physical alterations to the Hagmolen-Hegebeek are:
   - River channel straightening
   - Changing the profile into a broad channel with steep banks
   - Installation of weirs
   - Drainage in the catchment.

2) Designation of HMW on the basis of changes to the hydromorphological characteristics: not only the physically altered part, but also the affected up- and downstream part of the river are designated HMW.

The information needed for the designation has been collected in the foregoing sections 6 and 7.1 and 7.2.

In section 6.1 it was concluded that the upstream part of the Hegebeek has reached a moderate to good ecological status on the basis of assessment by macro-invertebrates. With regard to fish it was concluded that the Hagmolen and Hegebeek are not suitable for sensible stream species and that stagnophilic species are dominating. More research is needed in order to find the real cause(s) for the present fish population in the Hagmolen-Hegebeek and to determine suitable restoration measures. The Hegebeek has a natural morphology and no weirs. The hydrology of the Hegebeek has been changed by human impact; the German catchment has been enlarged.

According to the first designation approach based on physical alteration the upstream part of the Hegebeek could be designated as natural. However, the ecological condition has a moderate to good ecological status. As the hydrology and water quality of the Hegebeek depends completely on restoration measures taken in the German part of the catchment, a less stringent objective could be assigned in case the ecological quality would deteriorate to a moderate ecological status. It is however still uncertain if the status natural with a less stringent objective can be designated for such cases. In box 3 more information is given on the present transboundary management of the Hegebeek.

According to the second designation approach on the basis of changes to the hydromorphological characteristics, the Hegebeek could be designated HMW. The migration barriers and the low ecological quality in the Hagmolenbeek and in the German part of the Hegebeek are probably the reason that the ecological status fluctuates between the good and moderate ecological status.

The downstream part of the Hegebeek and Hagmolenbeek has a moderate respectively low ecological quality. Information on the effectiveness, costs and feasibility of restoration measures, which has been collected in section 7.1 and 7.2 is summarised in table 7.1 and 7.3 will be used for the HMW designation process. The downstream part of the Hegebeek and the Hagmolenbeek are designated HMW, because the restoration of the hydrology of the catchment is needed to attain the good ecological status. The comparison of the Hagmolenbeek with the reference stream Ruenbergerbeek showed that the restoration of the morphology would lead to a good to moderate ecological quality. Additional hydrological measures, such as the reconnection of former catchments and the restoration of the hydrology of the catchment are needed for a longterm achievement of GES.

The costs of the restoration of the hydrology of the catchment is high (€1.800.000,--/year). Moreover, the societal feasibility is too low to attain the good ecological status in 2015. The restoration of the hydrology of the catchment is difficult to implement, because the present major function assigned by the regional government (the province Overijssel) to the Hagmolen catchment is development of agriculture. The consequence of this political decision is that it will be difficult to implement hydrological restoration measures, which will affect agriculture negatively, in an "agricultural development area".

The restoration measures morphology restoration and reconnection of the catchments have no disproportionate costs and are technically feasible. However, for the realisation of morphology restoration the Waterboard depends on the farmers or private owners, which sell their ground to the Waterboard on a voluntary basis. The voluntary basis leads actually to delays and incomplete restoration, as some owners are not willing to sell their ground for various reasons.

Application of the two different designation approaches makes no difference to the designation of the Hagmolenbeek as HMW, because the whole Hagmolenbeek has been physically altered and its hydromorphological characteristics have been changed.

**Box 3. Transboundary measures in the German catchment**

The Netherlands and Germany have regular consultations about the transboundary Hegebeek at different management levels. The Dutch waterboard Regge & Dinkel has a number of wishes with regard to:

- Restoration of former catchments: the catchment of the Hegebeek has been enlarged ( 1/3 of the area has been reconnected). Due to this enlargement the stream has been engraved into the valley. The Dutch waterboard aims the restoration of former catchments.
- Improvement of the retention of precipitation water leading to higher discharges in summer and lower discharges in winter.
- Decrease of diffuse emissions from agriculture causing an improvement of water quality in the Hegebeek.

Germany has not yet made any decisions with regard to the abovementioned measures in the Hegebeek catchment. As the German part of the Hegebeek has been largely adapted to agricultural needs and has a relative low ecological condition, the German water managers have not put high priority on restoration measures in the catchment. The expectations are that the hydrology and water quality will not improve drastically in the short term. Except from these regular, transboundary consultations no other instruments for transboundary river management exist.

A complicating circumstance is the different organisation of water management in the Netherlands and Germany. In Germany the responsibilities are distributed over a number of partners:

- The Ünterwasserbehörde for the management of waters
- The Oberwasserbehörde for the policy of waters
- The municipality for the purification of waste water
- The Kreis, being a co-ordinating organisation (a sort of province)

This large number of Dutch and German partners complicates the making of agreements with regard to transboundary measures.

## 7.5 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

This section discusses the process of establishing chapter 7: what were the problems and how have these problems been solved. The following discussion points could be raised:

- The procedure of designating water bodies as HMW starts from the assumption that it is possible to derive the exact cause-effect relationship between a measure taken and the resulting ecological condition. However, these relationships are for most ecosystems very difficult to make and are accompanied by a high degree of uncertainty. In the case Hagmolenbeek we tried to predict the hydromorphological measures needed to achieve the Good Ecological Status by comparing the Hagmolenbeek with the hydromorphology, water quality and ecology of a reference stream, the Ruenbergerbeek. However, this approach is debatable, as two streams can be comparable to a certain extent, but they are never completely the same. This means that the derivation of the required hydromorphological changes to achieve GES remains uncertain. This lack of knowledge and uncertainty raises questions with regard to the juridical and financial consequences of not achieving the values of the biological parameters belonging to the GES or GEP after 15 years. Isn't it more practicable to describe the objectives of the WFD also in hydrological, morphological and water quality terms in addition to the biological terms ?

- Due to a lack of a combined groundwater-surface water model a quantitative and reliable prediction of the effect of a certain measure taken at a certain place and time (reconnection of former catchment areas, rising ground water level, reduction of drainage) on the discharge in the stream is impossible. Moreover, modelling results are based on assumptions as well, leading to a certain degree of uncertainty. Next to modelling, we used an alternative approach, based on expert-judgement and analysis of comparable studies. It should be borne in mind that this procedure has to be applied to all streams and rivers in the Netherlands and that almost all these waters have been impacted by changes of morphology in the stream and hydrology in the catchment. For some of these waters suitable models exists, but for a large number of waters these models are not available (yet). At the same time a large number of ecological restoration plans of streams are carried out at present. An integrated research programme on the ecological (and economic) efficiency of different measures (including monitoring data of present projects) could increase the knowledge on stream rehabilitation and stimulate the development of calibrated models.
- In the *HMW 8 version 6 appraisals paper Consideration of the possible appraisal techniques involved in the designation process for HMW* the use of a consultative forum or group of experts is proposed to decide whether adverse effects are significant or costs are disproportionate. This approach will probably not work in a lot of cases, as the consideration of significance and costs is subjective and political. If you have a consultative forum with stakeholders and interest groups, such as farmers and environmental ngo's, the farmers will probably think that the adverse effects and the costs of the restoration measures in the Hagmolenbeek are significant and disproportionate and the ngo will find the opposite. With regard to the group of experts the question is what type of experts? Scientists, consultants, policy-making officials? Are they independent enough with regard to the different interests at stake? We think that the discussion with stakeholders has been carried out already through the process of democratic decision-making and has taken shape in policyplans with regard to spatial planning and the designation of nature- or use-oriented functions of water. The fact that the Hegebeek has a nature function and the Hagmolen a use-oriented function is the product of democratic decision-making and discussion with stakeholders.
- According to the EU HMW paper 7 version 2, the designation of Heavily modified water bodies (section 7.4) should be based on two different approaches, namely the physical alteration or the hydromorphological alteration of the water body. However, in section 7.3 the costs and feasibility of the different alternatives have been determined. It would be more logical to use this information to designate a waterbody as HMW or natural. Moreover, the Water Framework Directive states that a water can be designated HMW in case the costs of alternatives are disproportionate or not technically feasible. We recommend to base the designation of HMW on the collected information on alternatives and not on the physical or the hydromorphological alteration of the waterbody.

- In the HMW designation procedure the costs have to be determined for alternatives for uses, which are negatively impacted by the hydromorphological changes needed to reach a good ecological status. If these costs are disproportionate, the water becomes HMW. The costs of the restoration measures themselves are not considered, although these costs can be high and can even be higher than the costs of the alternatives for the negative impact on uses. The fact that the costs of measures are not included in the disproportionate costs can lead to the following situation. A water has been designed natural or HMW with a certain GEP on the basis of the costs of alternatives, but later in the River Basin Management Plan route the costs of the restoration measures are considered too high and the water will be designated natural or HMW with a less stringent objective. This forest of different objectives makes the application of the WFD very complex. Therefore, it is proposed to replace the less stringent objective by the possibility to have a longer time period to achieve the GEP or GES. This means that the objectives remain the same, but restoration measures which are too expensive can be carried out at a later period.
- It is difficult to determine the (technical) feasibility of certain measures and alternatives. Catchments and streams, which have been adapted to agricultural needs during centuries, can not be restored to their natural condition in 15 years. Furthermore, the implementation of most of the measures depends at the moment on voluntary co-operation and acceptability by the local public and the farmers. How this co-operation and acceptability will develop in the coming years is uncertain. Expropriation of land is presently only possible in the Netherlands to reduce the risk of floods, but not to improve the ecological quality of waters. Next to these local aspects, the global, European and national agricultural market and politics determine the possibility for the farmers to compensate yield reduction as a result of environmental measures (e.g. higher ground water levels, using less pesticides and nutrients) in higher prices (e.g. more expensive products from biological farming) or by obtaining subsidies (e.g. stimulation of biological farming). At present, the agricultural sector is in a difficult economic position and probably a lot of space will become available, because farmers can not survive financially. This space will be used by the remaining farmers (who have to extensify) and for other functions (nature development, housing). On the other hand, the difficult economic position will probably reduce the willingness of the farmers to cooperate in ecological restoration projects, as the nature lobby is not considered to be a partner.
- The designation of HMW waters conflicts with the Dutch policy of spatial planning. The Hagmolenbeek has the function of perception water with relatively low ecological goals. The catchment of the Hagmolenbeek has agriculture as major function. This means that the function nature and ecology has a lower priority than the function agriculture. This way of spatial planning policy and function designation conflicts with the Water framework, in which each water should reach a good ecological status. Only if it is technically infeasible or if the costs are too high lower ecological goals can be set. To solve this problem spatial planning aspects should be incorporated in the framework directive. The spatial planning policy relates to the low feasibility with regard to stream morphology restoration. The space needed for restoration has to be bought on a voluntary basis, leading to delays and incomplete restoration. If the spatial planning policy would designate nature as most important function in the catchment, the Waterboard would have more instruments to obtain the area along the stream.

- This case-study gives some insight in the administrative burden with regard to the man-hours needed for designation of all waters in a catchment as natural, artificial or heavily modified and reporting the results to the European Union. The administrative burden for the Waterboard Regge & Dinkel is estimated to be:
  - 1,3 man-year for the first designation;
  - 0,26 man-year for the revision of the HMW designation after 6 years;
  - Increase of biological monitoring with regard to macrophytes and macro-invertebrates (from once in 4 to 8 years to once in 3 years) and starting the monitoring of phytoplankton and fish (from incidental monitoring to once in 3 years) in almost all waters.

The estimated time needed for the first designation, namely 1,3 man-year, is probably the minimum time needed, as a relatively large amount of data and information on the Hagmolen-Hegebeek have been available for this case. Furthermore, this case-study has been carried out by persons, which are relatively good informed about the Water Framework Directive and the HMW designation procedure. Bearing this in mind, it is expected that on average the Dutch Waterboards will need a time investment of 2 man-years to perform the first designation on their waters. This large administrative burden means a large investment of the personal and financial means of the Water boards. Clear guidances on how to perform the designation and what information is to be collected are therefore needed.

# 8 Definition of Maximum Ecological Potential (6 pages)

*[Please discuss, to the extent possible at this stage, the maximum ecological potential (MEP) of the water body that is achievable (see WFD Annex II, 1.3 "Establishment of Type-Specific Reference Conditions for Surface Water Body Types", with reference to WFD Annex V, Table 1.2.5 "Definitions for Maximum, Good and Moderate Ecological Potential for Heavily Modified or Artificial Water Bodies" giving the normative definitions of ecological potential). Identify any areas requiring further clarification.]*

## 8.1 Determining Maximum Ecological Potential

The Maximum Ecological Potential (MEP) will be determined in the following way:

1. Determination of hydromorphology of MEP on the basis of:

   – The altered hydromorphological conditions which are a consequence of the physical impact of the use. These hydromorphological conditions are determined by the consideration of the disproportionate costs and technical feasibility of measures in the designation procedure

   – All mitigation measures that have to be taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds.

2. Determination of the water quality of MEP. The water quality should correspond to the High Ecological Status and Good Ecological Status of a stream, being designated as natural water, but the impact of the altered hydromorphological conditions on the water quality has to be taken into account in the determination of the water quality. For example, a low stream velocity, due to an altered hydrology, will decrease the oxygen content. For the Hagmolenbeek it is decided to use the regional standards for water quality to determine the MEP and GEP. These regional standards are partly based on national standards and partly on regionally developed standards. For the MEP the standard of negligible risk (VR: verwaarloosbaar risico) and for the GEP the standard of the maximum acceptable risk (MTR: maximaal toelaatbaar risico) will be applied. The standards are described in table 8.1.

Table 8.1 Application of regional standards for water quality as MEP and GEP. For the MEP the standard of negligible risk and for the GEP the standard of the maximum acceptable risk applies.

| variable | Needed adaptation to measurements | unity | Standard for MEP | Standard for GEP |
|---|---|---|---|---|
| $NH_4$-N | 90‰ at T>10°C | MgN/l | 0,4 | 0,8 |
| $O_2$ | 10‰ per year | Mg/l | 7 | 5 |
| $NO_3$-N | 90‰ per year | MgN/l | 5 | 10 |
| Tot P | Average summer concentration | MgP/l | 0,05 | 0,15 |
| $SO_4$ | 90‰ per year | Mg/l | 40 | 100 |

3. Search for a comparable water body and description of its hydromorphology, water quality and biology.
4. Prediction of the biology of MEP on the basis of expert-judgement of the measures and water quality of the MEP and the characteristics of the comparable water body.

Part of the method for deriving a MEP is the search for a comparable water body. In most cases it will be impossible or very difficult to find a water body that meets all criteria. In case such a water body can be found, it remains risky to base the MEP of your HMW water on the characteristics of the comparable water body, as two streams can be comparable to a certain extent, but they are never completely the same. It would be preferable to base the maximal ecological potential on a reconstruction of some theoretical status using a combination of different methods (e.g. ecological prediction models, historical data or spatial reference waters).

## 8.2 Measures for Achieving MEP

*[Description of measures that would theoretically have to be undertaken in order to allow comparison with the closest comparable water body.*

*How has the appropriate level of mitigation been defined?]*

These measures for achieving MEP consist of:

1. Inclusion of hydromorphological measures needed to achieve GES that are technically feasibly and do not lead to disproportionate costs, namely:
   - Stream restoration (meandering, smaller and natural profile, natural banks, side channels, marshes)
   - Restoration of catchment by reconnection of the Hagmolenbeek to the Regge under the Twente canal
2. Exclusion of the hydromorphological measures, which have led to the designation as HMW (the measures were not technically and societally feasible or implied disproportionate high costs), namely:
   - Restoration of the hydrology of the catchment
3. All mitigation measures that have to be taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds.
4. Measures to achieve the water quality objectives described in section 8.1.

An overview of all possible (hydromorphological and mitigation) measures for streams is presented in table 8.2. However, some mitigation measures are not applicable to the Hagmolenbeek or may be more or less feasible. Therefore, the measures have been classified according to their feasibility in the following categories:

0. Not applicable in Hagmolenbeek case
1. Hydromorphological measure, which is not feasible due to significant negative impact on uses and technical unfeasibility/disproportionate costs of alternatives: basis for designation as HMW
2. Hydromorphological measure, which is feasible: no significant negative impact on uses and technical feasible and no disproportionate costs of alternatives
3. Moderate feasible mitigation measure due to impact or costs: will probably be excluded in River basin plan on the basis of a cost-effectiveness study
4. Feasible mitigation measure: no impact on uses and low costs

With regard to the water quality measures listed in table 8.2 the distinction is made between reduction measures, which are part of the national policy and are obligatory and additional reduction measures. Additional reduction measures for manure, households and pesticide are not very feasible, because of the use-oriented function of the Hagmolenbeek catchment and will probably be excluded in the River basin plan.

Table 8.2 Overview of mitigation measures in the Hagmolenbeek.

0: measure not applicable in Hagmolenbeekcase
1: hydromorphological measure, which is not feasible due to significant negative impact on uses and technical infeasibility/disproportionate costs of alternatives: basis for designation as HMW
2: feasible hydromorphological measure: no significant negative impact on uses and technical feasible and no disproportionate costs of alternatives
3: moderate feasible mitigation measure due to impact or costs: will probably be excluded in River basin plan
4: feasible mitigation measure: no impact on uses and low costs

| | | | Hydrology | | | Morfology | | | | Water quality | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aspect** | **Measure** | **feasibility of measure** | ground-water | surface hydrol. | surface hydraul. | length profile | width profile | substrate mozaïek | migration/ continuum | oxygen/ saproby | nutrients | micro-pollutant |
| Hydrology | reducing/stopping sprinkling | 1 | +++ | ++ | | | | | | | | |
| | reduction drainage | 1 | +++ | ++ | | | | | | | | |
| | development of inundation zone/creation of retention areas | 2: part of morphology restoration | | ++ | + | | | | | | | |
| | partial removal of weirs | 2: part of morphology restoration | | | ++ | | | | ++ | | | |
| | construction of fish passages | 2: part of morphology restoration | | | + | | | | ++ | | | |
| | development of side channels | 0: too low discharges | | | | | | | | | | |
| | stimulation of infiltration | 0: too few built area | | | | | | | | | | |
| | create forest | 1 | +++ | ++ | | | | | | | | |
| | restore former catchment area | 2: reconnection of Regge | | ++ | ++ | | | | ++ | | | |
| | create hydrological buffer | 1 | | ++ | + | | | | | | | |
| Morphology | passive development of meanders | 2: part of morphology restoration | | + | ++ | +++ | ++ | ++ | | | | |
| | reconstruction of meanders | 2: part of morphology restoration | | | ++ | +++ | +++ | ++ | | | | |
| | removal of artificial embankment | 2: part of morphology restoration | | | ++ | | +++ | ++ | | | | |
| | adaptation of channel maintaining the capacity | 2: part of morphology restoration | | | ++ | | ++ | +++ | | + | | |
| | adaptation of channel reducing the capacity | 1 | + | + | +++ | | +++ | +++ | | + | | |
| | application of holes and sandbanks | 2: part of morphology restoration | | | + | ++ | ++ | +++ | | | | |
| | application of disturbing objects | 2: part of morphology restoration | | | ++ | + | ++ | + | | + | | |
| | application of structure adapted to target species | 2: part of morphology restoration | | | | | | ++ | | | | |
| | creation of steep and overhanging banks | 2: part of morphology restoration | | | | | +++ | +++ | | | | |
| | application of pools | 2: part of morphology restoration | | + | | | | ++ | | | | |
| | restoration of old meanders | 2: part of morphology restoration | | | ++ | +++ | +++ | ++ | | | | |
| | planting wooded bank | 2: part of morphology restoration | | | + | | ++ | +++ | | + | | |
| Water quality | reduction of manure emissions due to national policy | 4 | | | | | | | | ++ | +++ | + |
| | reduction of manure emissions due to additional measures | 3 | | | | | | | | ++ | +++ | + |
| | reduction of household emissions due to national policy | 4 | | | | | | | | +++ | ++ | ++ |
| | reduction of household emissions due to additional measures | 3 | | | | | | | | +++ | ++ | ++ |
| | reduction of pesticide emissions due to national policy | 4 | | | | | | | | | | +++ |
| | reduction of pesticide emissions due to additional measures | 3 | | | | | | | | | | +++ |
| | reduction of other diffuse pollution due to national policy | 4 | | | | | | | | ++ | ++ | ++ |
| | reduction of diffuse pollution from 2 stormwater-overflows | 4 | | | | | | | | ++ | ++ | ++ |
| | creation of bufferzone | 3 | | | | | | | | ++ | ++ | + |
| | improving sewage work | 0 | | | | | | | | +++ | ++ | ++ |
| | separation of water flows | 0 | | | | | | | | +++ | +++ | +++ |
| | removal of topsoil | 1 | | | | | | | | | ++ | ++ |
| | creation of helofyte filter | 0 | | | | | | | | +++ | +++ | + |
| Maintenance | ecological maintenance of stream channell | 4 | | ++ | +++ | | ++ | +++ | | + | + | |
| | ecological maintenance of banks | 4 | | | | | + | ++ | | + | + | |
| Other | re-introduction of species | 4 | | | | | | | | | | |
| | regulation of recreation | 0 | | | | | | | | | | |

## 8.3 Comparison with Comparable Water Body

*[Describe how a comparable water body was identified - what selection strategy was defined based upon typological (physico-chemical and hydromorphological) parameters. Was biological data used as part of the selection process? Was the ecological condition of the water body comparable to the HMWB?]*

The step to be taken in this section is the selection of another comparable waterbody as a reference for the MEP. The selection criteria are:

- Comparability of waterbodies with regard to the general characteristics, therefore the comparable water body should also be the same water type as the Hagmolenbeek; the middle part of a slowly flowing lowlandstream.
- A hydromorphology corresponding with the MEP. This means that the included measures of section 8.2 have either been carried out already or exist by nature and that the excluded measures of section 8.2 have not been carried out. For example, if stream morphology restoration is feasible, but the restoration of the hydrology in the catchment is not feasible, then the reference stream has to have a natural morphology, but an unnatural hydrology due to drainage in the catchment.
- Availability of data on hydromorphology, water quality and biology in order to describe the MEP quantitatively.

For the selection of a comparable reference water body an inventory study is used, which has been carried out by the Water board and includes all streams in its management area (Schmidt, G., 1999. De selectie van stromende waterparels in Twente. Waterschap Regge & Dinkel). In this inventory the streams are described on the basis of macro-invertebrate and fish data and abiotic characteristics (hydrology, morphology, water quality, maintenance).

On the basis of the three criteria mentioned above the Ruenbergerbeek is suitable as comparable reference stream, because:

- It is the middle part of a slowly flowing lowlandstream
- The morphology is natural, which is comparable to the morphology of the Hagmolenbeek after stream restoration has been carried out
- The hydrology is comparable to the Hagmolenbeek:
  - ⇒ Both streams are fed by rain
  - ⇒ The land use in the catchment is comparable
  - ⇒ The catchment has been drained to optimise agriculture
- The substrate of both streams is different; the Hagmolenbeek is sandy, whereas the Ruenbergerbeek has a loamy soil with gravel banks. This difference in substrate will probably cause a quicker drying up of the Hagmolenbeek, as water infiltrates more easily in sand soil than in loamy soil. Moreover, the difference in substrate can lead to differences with regard to the presence of certain critical species, living only on sandy or loamy substrate.

- The water quality of the Ruenbergerbeek with regard to oxygen and nutrient levels is better than the present water quality of the normalised and canalised Hagmolenbeek. The future stream restoration in the Hagmolenbeek will probably increase the oxygen levels. As the land use of both streams is comparable, we assume that the oxygen levels of the Hagmolenbeek after stream restoration will be comparable to the levels in the Ruenbergerbeek. Despite the fact that the Ruenbergerbeek has a better water quality, the concentrations of various substances still exceed the standards of both the GEP and MEP (see table 8.1). This means that the Ruenbergerbeek is not a suitable comparable waterbody for the MEP with regard to water quality. It should be noticed, that all streams in the management area of the Waterboard have not yet achieved the water quality objectives of the MEP, which is the standard of negligible risk. The reason for this is the agricultural practice. As a result phosphate, nitrate and metals leach into the ground- and surface water leading to high concentrations. Herbicides (not shown in this study) are also (occasionally) present in rural streams in concentrations far above the standards.

The Ruenbergerbeek has been compared with the Hagmolenbeek in section 7.2.1. in order to derive measures for achieving the Good Ecological Status. The hydromorphology, water quality and biology of the Ruenbergerbeek are described below.

<u>Hydromorphology</u>

The hydromorphology of the Ruenbergerbeek is described in table 8.3. The main difference with the Hagmolenbeek is the morphology. The lateral and longitudinal morphology is more natural due to the presence of curves and an irregular profile. The riparian vegetation is not completely natural, but consists of grasses and moss. The hydrology is comparable to the Hagmolenbeek, as the catchment characteristics are comparable. However, due to more infiltration the Hagmolenbeek will probably desiccate quicker than the Ruenbergerbeek.

Table 8.3 Description of the hydromorphology of the Ruenbergerbeek (Schmidt, 1997).

| | Hydrology | | River continuity | Morphology longitudinal | Morphology lateral | | Structure and substrate streambed |
|---|---|---|---|---|---|---|---|
| | Quantity of flow | Dynamics of flow | (#Weirs) | River depth and width variation | River depth and width variation | Structure of the riparian zone | |
| Ruenberger-beek- upstream 41.205 | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is available<br><br>flow velocity in summer: average = 5 cm/s, maximum = 25 cm/s (measured 18/06/92) | Yes (0) | Present: natural pattern with curves | Present: irregular profile<br><br>Stream bed width = 300 cm<br><br>Channel width=260 cm<br><br>Channel depth =20 cm | riparian vegetation consisting of grasses and moss<br><br>surroundings consisting of grassland with trees<br><br>40% shadow | Silt and organic matter |
| Ruenberger-beek- Downstream 41.204 | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is available<br><br>flow velocity in summer: average = 5 cm/s, maximum = 20 cm/s (measured 16/06/92)<br><br>flow velocity in autumn: average = 15 cm/s, maximum = 74 cm/s (measured 23/10/92) | Yes (0) | Present: natural pattern with curves | Present: irregular profile<br><br>Stream bed width = 220 cm<br><br>Channel width=180 cm<br><br>Channel depth =10-20 cm | riparian vegetation consisting of grasses and moss<br><br>surroundings consisting of grassland with trees<br><br>>60% shadow | (dumped) stones and gravel, organic matter and dead wood |

Water quality

In table 8.4 the water quality values over the year 2000 of the Ruenbergerbeek are presented. Comparison with the water quality values of the Hagmolenbeek (table 6.5) show that most water quality variables are comparable, except from ammonium and oxygen values. With regard to $NH_4$ and $O_2$, the water quality of the Ruenbergerbeek is better. In table 8.5 the test water quality values are compared with the regional standards, which have been defined as the MEP and GEP values (see table 8.1). The water quality values of 2000 do not exceed the GEP value for 2015. This means that at present the ecological objectives for 2015 are met. However, total phosphate, sulphate and nitrate exceed the MEP value.

With regard to water quality objectives of the MEP it can be concluded that achievement of these high objectives is almost unreachable before 2015 due to an inheritage of the past. A large number of soils in the area are saturated with nutrients. Reactions of nutrients and calcium in the subsoil liberate metals from the soil, which subsequently leach into ground- and surface waters. Leaching of these substances into the ground- and surface water will lead to high concentrations in the streams and rivers, despite the fact that emission reduction measures have been taken in the catchment.

Table 8.4 Average water quality values per month over the year 2000 of the Ruenbergerbeek in mg/l.

| Date | Kj-N | total N | $NH_4$-N | $NO_2$-N | $NO_3$-N | $O_2$ | Total P | $SO_4$ | $PO_4$ |
|---|---|---|---|---|---|---|---|---|---|
| 26-01-00 | 2,7 | 11,24 | 0,2 | 0,04 | 8,5 | 12,60 | 0,07 | | 0,07 |
| 10-02-00 | 1,7 | 11,24 | 0,2 | 0,04 | 9,5 | 10,80 | 0,05 | | 0,05 |
| 06-03-00 | 1,7 | 9,73 | 0,1 | 0,03 | 8,0 | 11,20 | 0,06 | | 0,04 |
| 07-04-00 | 2,4 | 8,95 | 0,1 | 0,05 | 6,5 | 10,20 | 0,15 | 56 | 0,04 |
| 08-05-00 | 1,6 | 7,08 | 0,1 | 0,08 | 5,4 | 7,20 | 0,06 | | 0,03 |
| 15-06-00 | 1,5 | 5,97 | 0,1 | 0,07 | 4,4 | 6,80 | 0,08 | 62 | 0,08 |
| 31-07-00 | 2,0 | 8,08 | 0,1 | 0,08 | 6,0 | 7,50 | 0,19 | | 0,06 |
| 05-09-00 | 1,3 | 8,34 | <0.1 | 0,04 | 7,0 | 7,90 | 0,08 | 55 | 0,06 |
| 04-10-00 | 1,5 | 9,55 | 0,2 | 0,05 | 8,0 | 8,10 | 0,08 | | 0,04 |
| 26-10-00 | 1,3 | 6,54 | <0.1 | 0,04 | 5,2 | 7,80 | 0,07 | 59 | 0,03 |
| 17-11-00 | 1,1 | 10,17 | <0.1 | 0,07 | 9,0 | 8,90 | 0,08 | | 0,07 |
| 12-12-00 | 1,6 | 11,69 | <0.1 | 0,09 | 10,0 | 8,50 | 0,14 | 60 | 0,08 |

Table 8.5 Test water quality values allowing comparison with the regional standards, which have been defined as the MEP and GEP values for water quality. The **bold** value exceeds the GEP value and the *italic* value exceeds the MEP value. The values have been adapted according to the needed adaptations to measurements described in table 8.1

| Date | $NH_4$-N | Total P | $NO_3$-N | $O_2$ | $SO_4$ |
|---|---|---|---|---|---|
| 01-01-1990 | 0,40 | **0,16** | **10,7** | 8,1 | - |
| 01-01-1992 | *0,50* | **0,37** | **22,0** | 8,0 | *69* |
| 01-01-1995 | 0,30 | *0,09* | *6,1* | 8,5 | *65* |
| 01-01-1998 | 0,40 | *0,13* | **12,0** | 7,8 | *71* |
| 01-01-2000 | 0,20 | *0,11* | *9,5* | 7,2 | *62* |

Macro-invertebrates

The ecological quality of the Ruenbergerbeek over the last ten years based on the macro-invertebrate assessment method EBEOSWA is presented in figure 8.1. The almost highest ecological quality (green) corresponds with the good ecological status (GES) according to the WFD. The policy goal of the water board is to reach the highest ecological quality, relating to the status of quality water.

For some factors and years the quality is higher or equal to the GES and for some factors and years the factors score lower. The scores differ depending on the climate of the year: in wet years the scores are higher than in dry years. The hydrological conditions are the limiting factor for the ecological quality of the Ruenbergerbeek. The scores for trophy, substrate and structure are related to the hydrology.

In the Ruenbergerbeek a relatively large number of (very) rare macro-invertebrate species have been observed (figure 8.2 and table 8.6). Many of these species are typical stream organisms, and are indicative for unpolluted and oxygen-rich and fastly flowing water. It is assumed that in former times these species had a wider spread in the catchment of the Dinkel, but that they have been pushed back due to the canalisation of the streams and the desiccation of the catchment.

Based on the EBEOSWA method and the presence of rare species the ecological quality of the Ruenbergerbeek based on macro-invertebrates is considered to be a moderate to good ecological status.

Figure 8.1 Overview of the ecological quality according to EBEOSWA at one measurement point in the Ruenbergerbeek over the period 1990-2000 (based on 8 measurements).

| Wg.nr. | Name | mpc | Coördinates | Date | Policy | Target | Assesment results EBEOSWA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Main factors | | Side factors | | |
| | | | | | | | *Hydrology* | *Saprobic* | *Trofy* | *Substrate* | *Structure* |
| 41 | Ruenbergerbeek | 41.001 | 268,86/473,40 | 06.11.90 | Quality water | | | | | | |
| | | | | 08.11.93 | | | | | | | |
| | | | | 30.10.95 | | | | | | | |
| | | | | 03.09.96 | | | | | | | |
| | | | | 16.09.97 | | | | | | | |
| | | | | 01.09.98 | | | | | | | |
| | | | | 09.09.99 | | | | | | | |
| | | | | 23.10.00 | | | | | | | |
| | | | | | | Average | | | | | |

| Legenda: | | |
|---|---|---|
| | Highest ecological quality | |
| | Almost highest ecological quality | |
| | medium ecological quality | |
| | Low ecological quality | |
| | Lowest ecological quality | |

Figure 8.2 Observation of rare species in the Ruenbergerbeek over the period 1990-2000 (based on 8 observations).

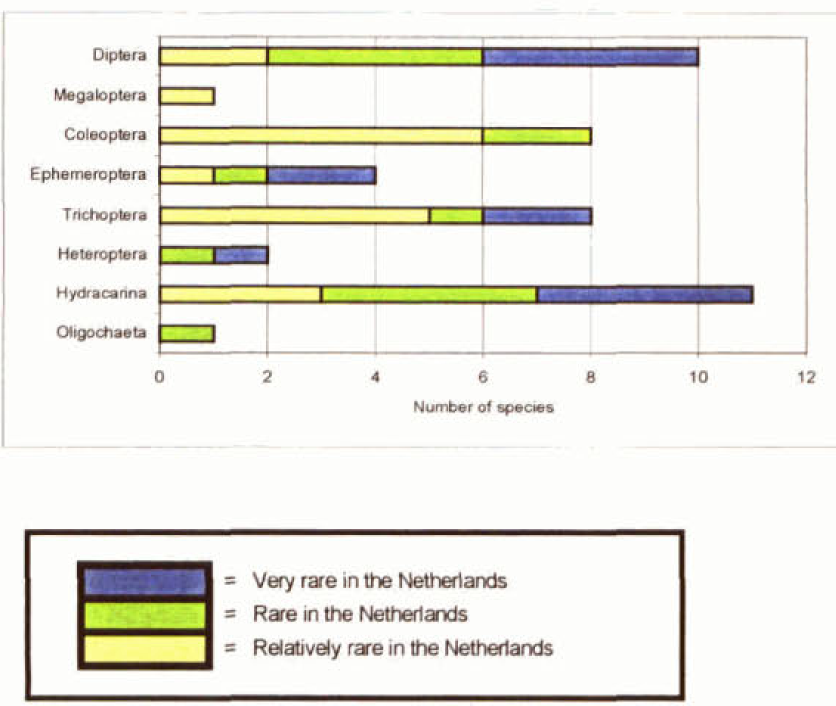


Table 8.6 Overview of rare running water species in the Netherlands.

| Order | Taxonname | Presence in NL | Order | Taxonname | Presence in NL |
|---|---|---|---|---|---|
| Diptera | *Prodiamese rufovittata* | very rare | Ephemeroptera | *Baetis tracheatus* | very rare |
| | *Thienemanniella clavicornis agg.* | very rare | | *Paraleptophlebia submarginata* | very rare |
| | *Polypedilum cultellatum* | very rare | | *Habrophlebia fusca* | rare |
| | *Stictochironomus maculipennis* | very rare | Heteroptera | *Velia saulii* | very rare |
| | *Corynoneura coronota* | rare | | *Gerris najas* | rare |
| | *Micropsectra gr. nutescens* | rare | Hydracarina | *Lebertia rivulorum* | very rare |
| | *Chironomus bernensis* | rare | | *Hygrobates longiporus* | very rare |
| Coleoptera | *Orectochilus villosus* | rare | | *Piona discrepans* | very rare |
| | *Helophorus gr. flavipes* | rare | | *Arrenurus zachariae* | very rare |
| Trichoptera | *Brachycentrus subnubilus* | very rare | | *Lebertia fimbriata* | rare |
| | *Limnephilus fuscicornis* | very rare | | *Sperchon clupeifer* | rare |
| | *Potamophylax cingulatus* | rare | | *Sperchon compactilus* | rare |
| Oligochaete | *Dero obtusa* | rare | | | |

Fish

The Ruenbergerbeek has a high ecological quality with regard to fish. The fish species present in the Ruenbergerbeek are described in table 8.7. Almost all species are typical stream species of the trout-salmon zone of a river. Dace and Bullhead are migrating species, which are specific for slowly flowing lowlandstreams. Next to these two specific species more general stream species occur in the Ruenbergerbeek.

Table 8.7 Fish species present in the Ruenbergerbeek, measured in 1996. In the last column the number of individuals measured in the Ruenbergerbeek are listed.

| species | Latin name | type | Zonation in river | Number |
|---|---|---|---|---|
| Stickleback | Gasterosteus aculeatus | Pioneer stream species | Trout-salmon | 3 |
| Stone loach | Barbatula barbatulus | General stream species | Trout-salmon | 8 |
| Gudgeon | Gobio gobio | General stream species | Trout-salmon | 4 |
| Dace | Leuciscus leuciscus | Specific stream species | Trout-salmon | 4 |
| Bullhead | Cottus gobio | Specific stream species | Trout-salmon | 36 |
| Roach | Rutilus rutilus | Roach type | Barbel-Bream | 8 |
| Rudd | Scardinius erythrophthalmus | Rudd type | Bream | 2 |

## 8.4 Description of MEP for Hagmolenbeek

The hydromorphology of the MEP will be the hydromorphology of the stream after morphology restoration, reconnection of former catchments and the ecological maintenance of the banks and channel (see table 8.9). The measures to be taken have been described in paragraph 8.2.

The water quality characteristics of the MEP are based on the regional standard of negligible risk (VR: verwaarloosbaar risico), which is described in table 8.1.

Table 8.9 The hydromorphology of the MEP of the Hagmolenbeek.

| | Hydrology | | River continuity | Morphology longitudinal | Morphology lateral | | Structure and substrate streambed |
|---|---|---|---|---|---|---|---|
| | Quantity of flow | Dynamics of flow | (#Weirs) | River depth and width variation | River depth and width variation | Structure of the riparian zone | |
| Hagmolen-beek | From incidentally/ periodically stagnant water to dry for short periods | Variation in flow is available | Increases: 20 weirs will be either removed or replaced by weirs with fish passages | Present: natural meandering pattern | Present: natural meandering pattern | Natural vegetation: stream is almost completely shady | Silt, sand, gravel, organic matter and dead wood |

The description of the biological parameters will be estimated on the basis of the hydromorphological and water quality characteristics of the MEP and the biological characteristics of the comparable water body, the Ruenbergerbeek.

The ecological quality of the Ruenbergerbeek based on macro-invertebrates is considered to be a moderate to good ecological status. This conclusion is based on the results of the EBEOSWA method, which fluctuate between moderate to very good. Furthermore, a relatively large number of (very) rare macro-invertebrate species have been observed, which are indicative for unpolluted and oxygen-rich and fastly flowing water.

However, the present water quality parameters of the Ruenbergerbeek exceed the values of the MEP with regard to nutrients. This means that the water quality belonging to the MEP of the Hagmolenbeek is better than the present water quality of the Ruenbergerbeek. On the basis of that it is concluded that the ecological quality with regard to macro-invertebrates of the MEP of the Hagmolenbeek will improve slightly due to a better water quality and is considered to be good.

The Ruenbergerbeek has a high ecological quality with regard to fish due to the presence of typical migrating stream species of the trout-salmon zone of a river. On the basis of this, it could be concluded that the MEP value of the Hagmolenbeek with regard to fish is good. However, next to the characteristics of the stream itself, it is important that the relatively rare fish can reach the Hagmolenbeek. Therefore, the ecological quality of MEP of good for fish is only achievable under the precondition that the connectivity and the ecological quality of the connected streams is suitable for migrating fish.

## 8.5 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

Part of the method for deriving a MEP is the search for a comparable water body. In most cases, it will be very difficult to find a water body that meets all criteria (comparability of waterbodies with regard to the general characteristics, hydromorphology corresponding with the MEP on the basis of the designation and availability of data on hydromorphology, water quality and biology in order to describe the MEP quantitatively). In case such a water body can be found (e.g. Ruenbergerbeek), it remains risky to base the MEP of your HMW water on the characteristics of the comparable water body, as two streams can be comparable to a certain extent, but they are never completely the same with regard to hydrology, morphology and ecology. It is concluded, that it is a better option to derive the maximal ecological potential from a reconstruction of a theoretical status. For this reconstruction a combination of different methods, such as the use of ecological prediction models, historical data or spatial reference waters could be used.

# 9 Definition of Good Ecological Potential (6 pages)

## 9.1 Determination of Good Ecological Potential

*[Describe the ecological potential to be achieved in the medium and long term. Refer to paper 3 ver 3, nr.3.*

*How has slight deviation from the MEP been defined?*

*Has the definition of good ecological potential been influenced by the practicability of the mitigation measures?]*

Practicality of measures

The measures needed to achieve the GEP may be a selection of the measures for the MEP taking into account the practicality of measures. In table 8.2 the feasibility of the mitigation measures has been described (class 3: not feasible mitigation measure, class 4: feasible mitigation measure).

Stream restoration has been classified as a feasible hydromorphological measure, however it depends on how much area can be bought along the stream on a voluntary basis. This remains an uncertain factor for the future.

Definition of GEP

In this section the Good Ecological Potential is determined. The definition of the GEP is that it deviates slightly from the MEP. According to the EU papers the interpretation of "slight deviation" can be influenced by the practicality of measures.

With regard to hydromorphology the difference between GEP and MEP is based on the extent of realisation of morphology restoration. As the realisation depends on how much area can be bought on a voluntary basis, certain sections of the stream can not be restored. Which part will be restored and which part not is still uncertain.

The water quality values of the GEP are based on the regional standard of the maximum acceptable risk and are described in table 8.1.

For the biological parameters macro-invertebrates and fish the choice has been made to define the "slight deviation" from the MEP for HMW waters the same as the slight deviation of the good ecological status from the reference condition for natural waters. This means that based on an ecological assessment of 5 classes, such as the EBEOSWA method, the GEP is one class lower than the MEP. With regard to fish no assessment method in 5 classes is available, therefore the GEP will be based on expert-judgement. Based on the ecological quality of the comparable water body Ruenbergerbeek, the GEP is defined as follows:

- Macro-invertebrates: GEP is one class lower than MEP (having the good ecological status), thus the Good Ecological Potential has the moderate ecological status.
- Fish: The ecological quality of the MEP is high due to the presence of specific stream species with relatively large numbers. We assume that for the GEP the general stream species dominate and that specific stream species are present but with a low abundance. The ecological quality is good to moderate.

## 9.2 Identification of Measures for Protecting and Enhancing the Ecological Quality

*[In this chapter, please describe the options for measures designed to protect and if necessary enhance the ecological quality of the water body. WFD Article 11 requires the establishment of a programme of measures, distinguishing between basic and supplementary measures.]*

The following measures will be taken to achieve the GEP in 2015:

Morphology restoration consisting of:
- development of inundation zone/creation of retention areas
- partial removal of weirs
- construction of fish passages
- passive development of meanders
- reconstruction of meanders
- removal of artificial embankment of channel
- adaptation of channel maintaining the capacity
- application of holes and sandbanks
- application of disturbing objects
- application of structure adapted to target species
- creation of steep and overhanging banks
- application of pools

Hydrological restoration measure, consisting of:
- restoration of the former catchment area

Water quality measures:
- reduction of manure emissions due to national policy
- reduction of household emissions due to national policy
- reduction of pesticide emissions due to national policy
- reduction of other diffuse pollution due to national policy
- reduction of diffuse pollution from two stormwater overflows

Other measures:
- ecological maintenance of stream channel
- ecological maintenance of banks
- re-introduction of species

In the sections 9.2.1 and 9.2.2 below the abovementioned measures have to be distinguished as basic and supplementary measures. This distinction has not been made, because the difference between the two types of measures is unclear. Comparison of the definition of both type of measures in the Water Framework Directive in article 11, part 3 and 4, revealed no clear difference, as:

- they both aim to achieve the ecological objectives described in article 4
- the definition of the basic measure (article 11, part 3) focuses on the objective of a measure and the definition of the supplementary measure (article 11, part 4) describes the instruments to be used in a non-exclusive list of supplementary measures in Annex VI,

part B. As all possible types of instruments (legislative, economic etc.) are listed, all possible measures will fall under one of the instruments.

As the abovementioned measures all aim to reach the environmental objectives of article 4 and fall under one of the instruments listed in Annex VI, part B, it is not possible to make a distinction between both measures. We would recommend providing clearer definitions and criteria for both type of measures.

### 9.2.1 Basic Measures

*[See Art. 11.3, which also refers to Art.10 and part A of Annex VI.*

*How has the link between the good ecological potential and any possible measures been determined?]*

### 9.2.2 Supplementary Measures

[See Art. 11.4 and part B of Annex VI.

*Can supplementary measures contribute to delivering environmental improvement?]*

## 9.3 Discussion and Conclusions

*[Discuss lessons learned, any problems encountered and how they were overcome.]*

The Good Ecological Potential has been determined in a pragmatic way, as the instructions in the HMW paper 12 ver 3.2 Maximum and Good Ecological Potential for Heavily Modified Waterbodies to determine the GEP are relatively vague (page 13:"It is intended that member states within the HMW working group follow their own approach, including statistical or ecological approaches or a combination of the two"). The GEP has been defined on the basis of:

- The practicality of measures for the hydromorphology
- The value of present regional standards for water quality
- Application of the same definition of "slight deviation" between GEP and MEP for HMW waters as for the slight deviation between good ecological status and reference condition for natural waters. This means that the GEP is one class lower than the MEP based on an ecological assessment of 5 classes (having more or less the classes: very good, good, moderate, bad, very bad).

It is however uncertain, if this combination of hydromorphological, water quality and biological parameter values would match "in the real world". To relate the different parameters with each other a well-calibrated ecological model for running waters is needed that predicts the biological values of a stream based on a certain hydromorphology and water quality. This model is not available (yet).

# PART III

# 10 Conclusions, Options and Recommendations (5 pages)

## 10.1 Conclusions

*[Highlight the "lessons learned" concerning the treatment of heavily modified water bodies in the Water Framework Directive. Discuss applicability of results in other river basins in the same ecoregion (of your country).]*

This case study has applied the designation procedure for HMW waters to the Dutch stream Hagmolen-Hegebeek. We consider the stream Hagmolen-Hegebeek representative for the problems of many streams located in areas on sandy soil lying above the sea level (mainly southern and eastern part of the Netherlands). In these areas the hydromorphology of the stream and the hydrology of the catchment has beencompletely adapted to agricultural use in a process that took centuries. Furthermore, subcatchments have been disconnected and reconnected to reduce the risk of floods. As a result different types of hydromorphological changes have been carried out in the stream on different locations, so we consider these type of streams interesting to test the procedure for the designation of heavily modified waters.

However, one hydromorphological impact, which occurs in a considerable number Dutch streams is the change of the hydrology of the catchment due to drinking water extraction. This impact does not occur in the catchment of the Hagmolen-Hegebeek, therefore this case-study is not representative for streams, which are heavily influenced by this impact.

With regard to the availability of data, most hydrological and morphological parameters have been described qualitatively and not quantitatively. It can be concluded that a qualitative description of the physical alterations and the morphology is sufficient to determine the main problems (a natural meandering stream with variation in habitat, stream velocity and substrate has been normalised and canalised into a straight channel with weirs). With regard to hydrology more quantitative data are needed on:

- the number of days and the moment in the year of minimum and maximum stream velocities and water depth;
- the seasonal discharge pattern of the Hagmolenbeek prior to the physical alterations (historical reference).

These quantitative hydrological data would enable a better assessment of the impact of hydrology on the ecological condition of the stream and how human influence has changed the hydrology.

With regard to the biological and physico-chemical parameters it is concluded that not all the required parameters are available. There are no data on plankton and macrophytes. With regard to fish, information on the presence of species is available, but there are no data on the composition, abundance and age structure of the fishes. Information on the composition and abundance of macro-invertebrates is available.

## 10.2 Options and Recommendations

*[Recommendations should be of general nature and pertain to the objectives of the European project on heavily modified water bodies. In particular, items for consideration in the harmonised and consistent implementation of the Water Framework Directive should be discussed. Highlight any clarifications of* Annexes or guidelines that may be needed or helpful.]

In this section the discussion points and recommendations are summarised, which have been presented in the previous text.

*Identification of waterbodies*

It is rather unclear how to identify water bodies on the basis of the guidelines of section 4.3. The identification of water bodies has to be based on 4 criteria: the application of the typology system, the definition of hydromorphological units, the type specific biological condition and the effective management unit. These criteria are different and can therefore lead to different divisions of water bodies.

Furthermore, the minimum length or size of a waterbody and catchment is unclear. The length of the waterbody upstream Hegebeek is only 1250 m. The total size of the Hagmolen-Hegebeek is 27 km. This small length raises the question, if the water body is significant enough for distinction and description.

*Ecological assessment method to determine ecological status*

This case-study presents two methods for the assessment of the ecological condition based on macro-invertebrates. Both methods differ in their way of assessment, leading to different scores in different situations.

Due to the calculation method of EBEOSWA the score of the ecological condition can be relatively low in situations, where there are very specific species present, but the abundance of general species is high as well. These situations occur quite often, as general species tend to dominate, both in affected and in natural, unpolluted areas. The high abundance of general species will decrease the score and overrule to a certain extent the presence of some very specific species.

Because of this way of assessment, we also presented the results of an assessment method based on the presence of aquatic species of particular significance.

In addition, the EBEOSWA method is based on data of a large number of streams in the Netherlands. As many Dutch streams have been impacted by human activities (the Netherlands has one of the highest population densities of Europe), the ecological quality results of EBEOSWA will probably yield a somewhat more positive picture of the ecological level than assessment methods from other countries would do. The intercalibration exercise should make the differences between countries more clear.

A third discussion point is the instability of the ecological status. The scores differ per year, as they depend on the amount of precipitation that has fallen in a certain year. In wet years the ecological condition is better than in dry years. To overcome this problem the average result over a period of ten years has been used.

*Monitoring of phytoplankton and phytobenthos in running waters*

According to our stream ecologists it makes no sense to monitor and assess phytoplankton in streams, as required by the WFD, because phytoplankton does not grow in streams. Phytobenthos, growing on substrates (stones, plants), is a required parameter of the WFD as well. It is however only meaningful to monitor phytobenthos for ecological assessment in case nutrients are the limiting factor for the ecological quality of running waters. Presently, in many streams morphology and hydrology are still limiting for ecology, therefore monitoring and assessment of periphyton will provide no additional information.

*Prediction of hydromorphological measures needed to achieve the Good Ecological Status is uncertain*

The procedure of designating water bodies as HMW starts from the assumption that it is possible to derive the exact cause-effect relationship between a measure taken and the resulting ecological condition. However, for most ecosystems these relationships are very difficult to make and are accompanied by a high degree of uncertainty. In the case Hagmolenbeek we tried to predict the hydromorphological measures needed to achieve the Good Ecological Status by comparing the Hagmolenbeek with the hydromorphology, water quality and ecology of a reference stream, the Ruenbergerbeek. However, this approach is debatable, as two streams can be comparable to a certain extent, but they are never completely the same. This means that the derivation of the required hydromorphological changes to achieve GES remains uncertain. This lack of knowledge and uncertainty raises questions with regard to the juridicial and financial consequences of not achieving the values of the biological parameters belonging to the GES or GEP after 15 years. Isn't it more practicable to describe the objectives of the WFD also in hydrological, morphological and water quality terms in addition to the biological terms?

*Prediction of hydrological effect of measures taken in the catchment is uncertain*

Due to a lack of a combined groundwater-surface water model a quantitative and reliable prediction of the effect of a certain measure taken at a certain place and time (reconnection of former catchment areas, rising ground water level, reduction of drainage) on the discharge in the stream is impossible. Moreover, modelling results are based on assumptions as well, leading to a certain degree of uncertainty. Next to modelling, we used an alternative approach, based on expert-judgement and analysis of comparable studies. It should be borne in mind that this procedure has to be applied to all streams and rivers in the Netherlands and that almost all these waters have been impacted by changes of morphology in the stream and hydrology in the catchment. For some of these waters suitable models exist, but for a large number of waters these models are not available (yet). At the same time a large number of ecological restoration plans of streams are carried out at present. An integrated research programme on the ecological (and economic) efficiency of different measures (including monitoring data of present projects) could increase the knowledge on stream rehabilitation and stimulate the development of calibrated models.

*Use of a consultative forum or group of experts to determine significance of effects and disproportionate costs.*

In the *HMW 8 version 6 appraisals paper Consideration of the possible appraisal techniques involved in the designation process for HMW* the use of a consultative forum or group of experts is proposed to decide whether adverse effects are significant or costs are disproportionate. This approach will probably not work in a lot of cases, as the consideration of significance and costs is subjective and political. If you have a consultative forum with stakeholders and interest groups, such as farmers and environmental ngo's, the farmers will probably think that the adverse effects and the costs of the restoration measures in the Hagmolenbeek are significant and disproportionate and the ngo will find the opposite. With regard to the group of experts the question is what type of experts? Scientists, consultants, policy-making officials?? Are they independent enough with regard to the different interests at stake? We think that the discussion with stakeholders has been carried out already through the process of democratic decision-making and has taken shape in policyplans with regard to spatial planning and the designation of nature- or use-oriented functions of water. The fact that the Hegebeek has a nature function and the Hagmolenbeek a use-oriented function is the product of democratic decision-making and discussion with stakeholders.

*Procedure of HMW designation*

According to the EU HMW paper 7 version 2, the designation of Heavily modified water bodies (section 7.4) should be based on two different approaches, namely the physical alteration or the hydromorphological alteration of the water body. However, in section 7.3 the costs and feasibility of the different alternatives have been determined. It would be more logical to use this information to designate a waterbody as HMW or natural. Moreover, the Water Framework Directive states that a water can be designated HMW in case the costs of alternatives are disproportionate or not technically feasible. We recommend to base the designation of HMW on the collected information on alternatives and not on the physical or the hydromorphological alteration of the waterbody.

*Costs of restoration measure versus costs of alternative*

In the HMW designation procedure the costs have to be determined for alternatives for uses, which are negatively impacted by the hydromorphological changes needed to reach a good ecological status. If these costs are disproportionate, the water becomes HMW. The costs of the restoration measures themselves are not considered, although these costs can be high and can even be higher than the costs of the alternatives for the negative impact on uses. The fact that the costs of measures are not included in the disproportionate costs can lead to the following situation. A water has been designed natural or HMW with a certain GEP on the basis of the costs of alternatives, but later in the River Basin Management Plan route the costs of the restoration measures are considered too high and the water will be designated natural or HMW with a less stringent objective. This forest of different objectives makes the application of the WFD very complex.

Therefore, it is proposed to replace the less stringent objective by the possibility to have – for instance as a result of the considerations in the river basin management plan - a longer time period to achieve the GEP or GES. This means that the objectives remain the same (as determined in the designation procedure), but restoration measures that are too expensive can be carried out at a later period (as a result of the management plan).

*Technical versus societal feasibility*

It is difficult to determine the (technical) feasibility of certain measures and alternatives. Catchments and streams, which have been adapted to agricultural needs during centuries, can not be restored to their natural condition in 15 years. Furthermore, the implementation of most of the measures depends at the moment on voluntary cooperation and acceptability by the local public and the farmers. How this cooperation and acceptability will develop in the coming years is uncertain. Expropriation of land is presently only possible in the Netherlands to reduce the risk of floods, but not to improve the ecological quality of waters. Next to these local aspects, the global, European and national agricultural market and politics determine the possibility for the farmers to compensate yield reduction as a result of environmental measures (e.g. higher ground water levels, using less pesticides and nutrients) in higher prices (e.g. more expensive products from biological farming) or by obtaining subsidies (e.g. stimulation of biological farming).

At present, the agricultural sector is in a difficult economic position and probably a lot of space will become available, because farmers can not survive financially. This space will be used by the remaining farmers (who have to extensify) and for other functions (nature development, housing). On the other hand, the difficult economic position will probably reduce the willingness of the farmers to cooperate in ecological restoration projects, as the nature lobby is not considered to be a partner.

*HMW designation and the Dutch practice of spatial planning*

The designation of HMW waters conflicts with the Dutch policy of spatial planning.
The Hagmolenbeek has the function of perception water with relatively low ecological goals. The catchment of the Hagmolenbeek has agriculture as major function. This means that the function nature and ecology has a lower priority than the function agriculture. This way of spatial planning policy and function designation conflicts with the Water framework, in which each water should reach a good ecological status. Only if it is technically infeasible or if the costs are too high lower ecological goals can be set. To solve this problem spatial planning aspects should be incorporated in the framework directive. The spatial planning policy relates to the low feasibility with regard to stream morphology restoration. The space needed for restoration has to be bought on a voluntary bais, leading to delays and incomplete restoration. If the spatial planning policy would designate nature as most important function in the catchment, the waterboard would have more instruments to obtain the area along the stream.

*Administrative burden of designation of all waters in a catchment as natural, artificial or heavily modified*

This case-study gives some insight in the administrative burden with regard to the man-hours needed for designation of all waters in a catchment as natural, artificial or heavily modified and reporting the results to the European Union. The administrative burden for the Waterboard Regge & Dinkel is estimated to be:

- 1,3 man-year for the first designation;
- 0,26 man-year for the revision of the HMW designation after 6 years;
- increase of biological monitoring with regard to macrophytes and macro-invertebrates (from once in 4 to 8 years to once in 3 years) and starting the monitoring of phytoplankton and fish (from incidental monitoring to once in 3 years) in almost all waters.

The estimated time needed for the first designation, namely 1,3 man-year, is probably the minimum time needed, as a relatively large amount of data and information on the Hagmolen-Hegebeek were available for this case-study. Furthermore, this case-study has been carried out by persons, which are relatively good informed about the Water Framework Directive and the HMW designation procedure. Bearing this in mind, it is expected that on the average the Dutch waterboards will each need a time investment of 2 man-years to perform the first designation on their waters. This large administrative burden means a large investment of personal and financial means to the Water boards. Clear guidance on how to perform the designation and what information is to be collected are therefore needed.

*Search for a comparable water body to derive the MEP*

Part of the method for deriving a MEP is the search for a comparable water body. In most cases, it will be very difficult to find a water body that meets all criteria (comparability of waterbodies with regard to the general characteristics, hydromorphology corresponding with the MEP on the basis of the designation and availability of data on hydromorphology, water quality and biology in order to describe the MEP quantitatively). In case such a water body can be found (e.g. Ruenbergerbeek), it remains risky to base the MEP of your HMW water on the characteristics of the comparable water body, as two streams can be comparable to a certain extent, but they are never completely the same with regard to hydrology, morphology and ecology. It is concluded, that it is a better option to derive the maximal ecological potential from a reconstruction of a theoretical status. For this reconstruction a combination of different methods, such as the use of ecological prediction models, historical data or spatial reference waters could be used.

*Determination of GEP*

The Good Ecological Potential has been determined in a pragmatic way, as the instructions in the HMW paper 12 ver 3.2 Maximum and Good Ecological Potential for Heavily Modified Waterbodies to determine the GEP are relatively vague (page 13:"It is intended that member states within the HMW working group follow their own approach, including statistical or ecological approaches or a combination of the two"). The GEP has been defined on the basis of:

- The practicality of measures for the hydromorphology
- The value of present regional standards for water quality
- Application of the same definition of "slight deviation" between GEP and MEP for HMW waters as for the slight deviation between good ecological status and reference condition for natural waters. This means that the GEP is one class lower than the MEP based on an ecological assessment of 5 classes (having more or less the classes: very good, good, moderate, bad, very bad).

It is however uncertain, if this combination of hydromorphological, water quality and biological parameter values would match "in the real world". To relate the different parameters with each other a calibrated ecological model for running waters is needed, that predicts the biological values of a stream based on a certain hydromorphology and water quality. This model is not available (yet). Furthermore, more concrete instructions on how to determine the slight deviation from the MEP would be welcome.

*Distinction between basic and supplementary measures*

The measures to achieve the GEP should be divided in basic and supplementary measures. This distinction has not been made in this case-study, because the difference between the two types of measures is unclear. Comparison of the definition of both types of measures in the Water Framework Directive in article 11, part 3 and 4, revealed no clear difference, as:

- they both aim to achieve the ecological objectives described in article 4
- the definition of the basic measure (article 11, part 3) focuses on the objective of a measure and the definition of the supplementary measure (article 11, part 4) describes the instruments to be used in a non-exclusive list of supplementary measures in Annex VI, part B. As all possible type of instruments (legislative, economic etc.) are listed, all possible measures will fall under one of the instruments.

As the abovementioned measures all aim to reach the environmental objectives of article 4 and fall under one of the instruments listed in Annex VI, part B, it is not possible to make a distinction between both types of measures. We would recommend to provide clearer definitions and criteria for both types of measures.

# 10 Bibliography

Arcadis, 1998. De Regge, Blauwe slagader van Twente; Een visie voor het jaar 2020.

Elsevier Bedrijfsinformatie en Vereniging voor Landinrichting, 2000. Cultuurtechnisch Vademecum.

Grontmij, 1995. Onderhoudsplan Hagmolenbeek en Hegebeek.

OVB, 1998. Onderzoek naar de passeerbaarheid van sifons onder kanalen in Noord-Brabant en Limburg.

Schmidt, G., 1999. De selectie van stromende waterparels in Twente. Waterschap Regge & Dinkel.

Schmidt, G., 1997. Aquatisch-ecologisch onderzoek Ruenbergerbeek/Goorbach (Twente) (periode 1970-1995). Waterschap Regge & Dinkel. November 1997.

Tauw 2001, Analyse van het watersysteem van de Buurserbeek in relatie tot het Reggesysteem. Tauw Deventer.

Verdonschot, P., 1995. Beken stromen. Leidraad voor ecologisch beekherstel. STOWA document 95-03. STOWA

Verdonschot, P., 2000. Natuurlijke levensgemeenschappen van de Nederlandse binnenwateren. Deel 2 Beken. Achtergronddocument bij het Handboek Natuurdoeltypen in Nederland. Alterra

Witteveen+Bos, 2001. Waterhuishoudkundig onderzoek ROM-project Koningsdiep.

# 12 List of Annexes

## Appendix A

### 7A Results of definition hydromorphological changes needed to achieve the GES

### Vergelijking van de ecologische toestand, hydrologie en morfologie van de Hagmolenbeek met andere vergelijkbare beken

Hiervoor wordt het volgende rapport gebruikt: Schmidt, 1999. De selectie van stromende waterparels in Twente. Waterschap Regge & Dinkel. Hierin wordt een inventarisatie en prioritering van beken in het beheersgebied van Regge & Dinkel uitgevoerd. De beken zijn beschreven op basis van macrofauna en visgegevens en op basis van hun abiotiek:

- Stroming: permanentie, variatie stroming, stuwing
- Structuur: kanalisatie, normalisatie, beschaduwing, substraatdifferentiatie
- Waterkwaliteit: nutriënten zuurstof, SO4, Cl, kwaliteit waterbodem
- Onderhoud: wijze van onderhoud, frequentie van onderhoud waterbodem, talud en oevervegetatie

Dit overzicht aan beken kan goed gebruikt voor een vergelijking van de ecologie en hydromorfologie van de referentie beken, die een betere ecologische kwaliteit hebben dan de Hagmolen-Hegebeek (Zie tabel A1).

- Referentie bovenlopen voor Hegebeek:

⇒ Jufferbeek
⇒ Springdalsebeek
⇒ Bovenloop Mosbeek

- Referentie middenloop voor Hagmolenbeek:

⇒ Ruenbergerbeek

Deze vergelijking heeft tot doel om te achterhalen welke hydromorfologische parameter het meest beperkend is voor het bereiken van het GES:

- morfologie en substraat (meandering)
- natuurlijke oevers
- onnatuurlijke afvoer (te grote fluctuatie tussen lage en piekafvoeren)
- stroomsnelheid
- optreden van droogval (peil is nul)
- beperking migratie door stuwen

Door hierover meer informatie te verzamelen wordt duidelijker welke maatregelen essentieel zijn voor het bereiken van het GES (Bijvoorbeeld, wordt met alleen beekherstel ook al het GES bereikt?) of dat alle hydromorfologische parameters verbeterd moeten worden (samenspel van beekherstel, hydrologie verbetering en weghalen van stuwen). Hierbij moet rekening gehouden worden met het feit dat bepaalde maatregelen tegenstrijdig werken ten aanzien van een ecologische verbetering. Zo zijn stuwen aangelegd om de kans op droogval te verminderen, waardoor echter eerder stagnant water tussen de stuwen optreedt en er migratiebarrières ontstaan.

Daarnaast is voor de analyse naar maatregelen voor het bereiken van het GES van belang om te weten wat de **natuurlijke referentie** van de Hagmolenbeek is. Dit is echter niet goed bekend. Er zijn ook geen kwantitatieve gegevens beschikbaar. Het beekdal bestond in vroegere tijden uit moerasgebieden en natte heide velden. Ten aanzien van de natuurlijke afvoer kan hieruit wel afgeleid worden dat de Hagmolenbeek vanwege de natte omstandigheden in het beekdal waarschijnlijk wel watervoerend was in de zomer. Het was dus waarschijnlijk geen van nature droogvallende beek. Er hebben dus in het stroomgebied grotendeels irreversibele veranderingen plaatsgevonden, aangezien zowel het veen als de natte heiden voor een groot deel verdwenen zijn en er een algehele grondwaterstandsdaling heeft plaatsgevonden en herstel ervan ook niet op korte termijn realiseerbaar is. De grondwaterstanden in het stroomgebied kunnen wel verhoogd worden, maar de oorspronkelijke sponswerking van het veen en de heide kan niet meer op middellange termijn hersteld worden. Door deze sponswerking werd het water langzamer van het stroomgebied naar de beek getransporteerd.

Vergelijking Hagmolenbeek met de Ruenbergerbeek

Uit de vergelijking van de Hagmolenbeek met de Ruenbergerbeek in tabel A1 en expert-judgement door de ecoloog van het waterschap blijkt dat:

- De ecologische conditie van de Ruenbergerbeek beter is dan die van de Hagmolenbeek, maar het ecologische niveau op basis van EBEOSWA fluctueert over een periode van tien jaar tussen middelste, bijna hoogste tot hoogste niveau. Het middelste EBEOSWA niveau wordt veroorzaakt door de hoge abundantie van algemene soorten, waardoor het geheel aan soorten in EBEOSWA wordt uitgemiddeld tot het middelste niveau. Daarnaast is de EBEOSWA score afhankelijk van de hoeveelheid neerslag die er in een jaar valt: in natte jaren is de score hoger dan in droge jaren. De Ruenbergerbeek heeft wel een hoog aantal aquatische aandachtssoorten (aquatic species of particular significance). Ook komen er een aantal relatief zeldzame vissoorten voor, zoals de serpeling en de rivierdonderdpad. De ecologische kwaliteit wordt op basis van expert-judgement als matig tot goed ingeschat.
- De morfologie nog natuurlijk is: de beek is niet gekanaliseerd, genormaliseerd of verstuwd.
- Het afvoerpatroon van de Ruenbergerbeek in grote lijnen vergelijkbaar is met de afvoer van de Hagmolenbeek:
  - ⇒ Het zijn beiden regenbeken
  - ⇒ De oorsprong van beide beken wordt bepaald door een samenstroming van greppels
  - ⇒ Het landgebruik in beide stroomgebieden is vergelijkbaar: combinatie van landbouw en natuur.
  - ⇒ De Ruenbergerbeek blijft in de zomer water afvoeren. De Hegebeek is ook watervoerend in de zomer. Dus de verwachting is dat als de Hagmolenbeek weer meandert en het dwarsprofiel veel smaller is, de beek in de zomer watervoerend blijft. Waarschijnlijk stroomt er dan wel heel weinig water door heen.
  - ⇒ De Ruenbergerbeek en Hagmolenbeek verschillen wel in ondergrond: de Ruenbergerbeek heeft een ondergrond van keileem en er liggen grindbanken. De ondergrond van de Hagmolenbeek bestaat uit zand. Door de zandbodem is het wel waarschijnlijk dat in de Hagmolenbeek eerder droogval optreedt door de infiltratie van water.
- De verschillende ondergrond betekent, dat bepaalde soorten niet in allebei de beken voor zullen komen, omdat het kritische soorten zijn voor een bepaald ondergrond.
- De waterkwaliteit van de Ruenbergerbeek is iets beter dan die van de Hagmolenbeek wat betreft zuurstof en nutriënten, maar de waterkwaliteit van de Ruenbergerbeek voldoet niet aan de normen. In welke mate de zuurstofhuishouding verbeterd door een betere variatie in stroming is nog onzeker.

Op basis van de vergelijking tussen Hagmolenbeek en Ruenbergerbeek zou ten aanzien van maatregelen geconcludeerd kunnen worden, dat herstel van de morfologie (door beekherstel) en een verbetering van de waterkwaliteit voldoende zijn om de beek weer te herstellen tot minimaal het middelste ecologisch niveau van de Ruenbergerbeek. Om de ecologische conditie van de Hagmolenbeek blijvend te verbeteren naar de goede of zeer goede ecologische status zijn waarschijnlijk aanvullende maatregelen nodig om de hydrologie te verbeteren, zoals het aankoppelen van oorspronkelijke stroomgebieden en herstel van de hydrologie van het stroomgebied.

Een argument voor de aanname, dat een verbeterde morfologie sterk positief op de ecologische kwaliteit werkt, is dat de Duitse bovenloop van de Hegebeek helemaal gekanaliseerd is en door een voor de landbouw aangepast gebied met sloten loopt. Het feit dat de ecologische kwaliteit van het daarop volgende natuurlijke Nederlandse deel van de Hegebeek nog behoorlijk goed is, duidt erop dat de natuurlijke morfologie een duidelijk positief effect heeft op de ecologie.

Bovenstaande voorspelling blijft echter onzeker. In literatuur over beken (5S model, Verdonschot et al., 1995) wordt hydrologie en stroming namelijk als dominante factor aangegeven voor beekecosystemen aangegeven. Ook al zijn structuur en waterkwaliteit goed, als de stroming onvoldoende is dan kan geen beekherstel optreden.

Vergelijking van de bovenloop van de Hegebeek met Jufferbeek, Springendalsebeek en Bovenloop Mosbeek

Uit de vergelijking van de Hegebeek met de Jufferbeek, Springendalsebeek en Bovenloop Mosbeek in tabel A1 en expert-judgement door de ecoloog van het waterschap blijkt dat:
- De referentiebeken een hogere ecologisch niveau (in EBEOSWA) hebben dan de bovenloop van de Hegebeek. De Springendalse beek heeft bijna overal het hoogste ecologisch niveau.
- Er permanent stroming en variatie in stroming bestaat. Bij de Springendalse beek staan, net als bij de Hegebeek, geen stuwen in de beek. Bij de bovenloop van de Hegebeek is de permanentie in stroming kritisch.
- De morfologie is bij alle beken natuurlijk.
- De waterkwaliteit van de referentiebeken is redelijk tot goed (het beste bij de Springendalse beek)

De ecologisch kwaliteit van de Hegebeek in 1998 is voor macrofauna gemiddeld genomen over alle onderdelen het bijna hoogst niveau (zie tabel 6.1). Dat betekent dat voor macrofauna de goede ecologische toestand al bereikt is en dat geen extra hydromorfologische maatregelen noodzakelijk zijn. Deze conclusie is echter onzeker, omdat 1998 ook een nat jaar was, waardoor de ecologische kwaliteit altijd hoger is. Gemiddeld over de periode 1990-1998 is de ecologische kwaliteit van de Hegebeek het middelste ecologische niveau. Beperkend voor het continue bereiken van het bijna hoogste of hoogste niveau in de Hegebeek is de hydrologie (permanentie in stroming kritisch), de waterkwaliteit (lage zuurstofgehaltes, hoge trofie graad) en eventueel het groot aantal migratie barrieres naar de Hegebeek toe.

Ten aanzien van de vis wordt geconcludeerd dat van de stromend watergebonden visfauna alleen bermpje en de riviergrondel voorkomen. Dit zijn weinig milieukritische, vrij algemeen voorkomende soorten. Verder domineren vooral de stagnante water soorten. Wat de beperkende factor voor het niet voorkomen van typische beekvissen is (bijv. permanentie van stroming, migratiebarrieres, zuurstofgehalten) zou door nader onderzoek uitgezocht moeten worden.
Op basis van dit onderzoek kunnen dan maatregelen in het Nederlandse of Duitse deel van het

stroomgebied afgeleid worden. Om de hydrologie en waterkwaliteit te verbeteren zijn maatregelen in het stroomgebied van Duitsland nodig.

**Conclusie**

De Hegebeek heeft een matige tot goede ecologische kwaliteit en zou als natuurlijk water kunnen worden aangewezen. Ten aanzien van de matige kwaliteit van de vis is extra onderzoek nodig naar de oorzaken ervan. Eventueel zou de status natuurlijk met een minder strenge doelstelling gekozen kunnen worden, aangezien nader onderzoek nodig is en de meeste maatregelen waarschijnlijk in het Duitse deel genomen moeten worden.

De Hagmolenbeek haalt niet de goede ecologische status. Hiervoor zijn maatregelen noodzakelijk om de morfologie en hydrologie te verbeteren. Een vergelijking met een referentiebeek laat zien dat herstel van de beekmorfologie (hermeandering, profielwijziging, stuwen weghalen) al tot een aanzienlijke verbetering van de lage tot een middelste ecologische kwaliteit zou kunnen leiden. Om een goede ecologische status (bijna hoogste ecologische kwaliteit) te bereiken zullen maatregelen op het gebied van de hydrologie (herstel hydrologische eenheden en hydrologisch systeem) nodig zijn. De hydrologie van de Ruenbergerbeek is vergelijkbaar met die van de Hagmolenbeek en is dus niet natuurlijk (de afvoer van beiden wordt bepaald door een samenstroming van greppels en het landgebruik in beide stroomgebieden is vergelijkbaar en bestaat uit een combinatie van landbouw en natuur).

Tabel A1. Vergelijking van Hagmolen-Hegebeek met de referentiebeken.

| | | Jufferbeek | Springdalsebeek (noord en zuidloop) | Bovenloop Mosbeek | Ruenbergerbeek | Hegebeek bovenloop | Hegebeek benedenloop | Hagmolenbeek |
|---|---|---|---|---|---|---|---|---|
| Ecologie macroinvertebraten | *stroming* | Bijna hoogste | Hoogste | Hoogste | Bijna hoogste | Middelste | | Laagste |
| | *saprobie* | Middelste | Hoogste | Bijna hoogste | Bijna hoogste | Middelste | | Bijna hoogste |
| | *trofie* | Bijna hoogste | Hoogste | Bijna hoogste | Hoogste | Middelste | | Laagste |
| | *substraat* | Middelste | (Bijna) hoogste | Bijna hoogste | Middelste | Middelste | | Laagste |
| | *voedsel* | Middelste | Hoogste | Hoogste | Bijna hoogste | Middelste | | Laagste |
| Natuurbetekenis vissen | | Matig | | | Hoog | Matig | Matig | |
| Natuurbetekenis fauna | | Matig | Matig | Hoog | Hoog | Hoog | | Laag |
| Aanwezigheid vissoorten | | | | | serpeling, rivierdonderpad | | | |
| Stroming | *permanentie* | permanent | permanent | permanent | kritisch | kritisch | kritisch | permanent |
| | *variatie stroming* | ja | ja | ja | ja | ja | nee | nee |
| | *stuwing* | ja | nee | ja | nee | ja | ja | ja |
| Structuur | *kanalisatie* | nee | nee | nee | nee | nee | ja | ja |
| | *normalisatie* | nee | nee | nee | nee | nee | ja | ja |
| | *beschaduwing* | veel | veel | matig | veel | veel | matig | matig |
| | *substraatdifferentiatie* | veel | veel | veel | veel | veel | matig | matig |
| Onderhoud | *wijze onderhoud* | | | hand | hand | machinaal | machinaal | machinaal |
| | *frequentie water(bodem)* | | | pleksgewijs | pleksgewijs | 2 keer per jaar | 2 keer per jaar, 1 zijde niet | 2-3 keer per jaar |
| | *frequentie oever* | | | | | 2 keer per jaar | 2 keer per jaar, 1 zijde niet | 2-3 keer per jaar, deel talud niet |
| Waterkwaliteit | *NH4* | Bijna hoogste | Hoogste | Hoogste | Bijna hoogste | | | Beneden laagste |
| | *O2* | Hoogste | | | Hoogste | | | Bijna hoogste |
| | *t-P* | Beneden laagste | Hoogste | Middelste | Bijna hoogste | | | Middelste |
| | *NO3* | Bijna hoogste | Beneden laagste | Beneden laagste | Middelste | | | Beneden laagste |
| | *Cl* | Bijna hoogste | Hoogste | Bijna hoogste | Bijna hoogste | | | Bijna hoogste |
| | *SO4* | Middelste | Bijna hoogste | Middelste | Middelste | | | Middelste |
| | *kwaliteit waterbodem* | | | Hoogste | Hoogste | | | |

**Appendix B**

**Hydromorphological measures to achieve the GES**

## 7B.1 Effect van maatregelen op hydrologie en morfologie

### 7B.1.1 Inleiding

De Hagmolenbeek is in de loop der tijd hydromorfologisch sterk veranderd. Hierdoor is de ecologische waarde van de beek sterk negatief beïnvloed. Om de oorspronkelijke hydromorfologie te herstellen zijn een aantal maatregelen mogelijk:

- Herstel morfologie door beekherstel (fysieke maatregelen).
- Herstel voormalige stroomgebieden.
- Herstel hydrologie in stroomgebied door systeembenadering.

De maatregelen kunnen afzonderlijk of in combinatie met elkaar uitgevoerd worden. Om de effecten van herstel van de morfologie van de Hagmolenbeek door fysieke maatregelen en herstel van het oorspronkelijk stroomgebied beek te bepalen is gebruik gemaakt van de simulatieprogramma´s Duflow en RAM. Duflow is een oppervlaktewaterstromingsmodel. RAM is een neerslagafvoermodule dat een onderdeel vormt van het duflowpakket. Het herstel van de hydrologie in het stroomgebied op basis van een systeembenadering wordt niet gemodelleerd, maar op basis van expert-judgement uitgewerkt.

In onderstaande paragraaf worden de resultaten van de modelberekeningen gerapporteerd. Allereerst wordt ingegaan op algemene aspecten ten aanzien van de modelbouw. Vervolgens worden de doorgerekende scenario's beschreven. Tenslotte worden de modelresultaten beschreven en worden de conclusies gepresenteerd.

### 7B.1.2. Maatregel herstel morfologie en aankoppeling beek

#### 7B1.2.1Beschrijving modelbouw

Met het model wordt de afvoerpatroon in de beek gesimuleerd in de bestaande situatie en in de situaties na uitvoering van de maatregelen. Karakteriserend voor een natuurlijke beek is stromend water. Bovendien is de Hagmolenbeek van nature een beek die niet droogvalt. Met het model wordt inzicht verkregen in de stroomsnelheden die in de beek voorkomen en de mate waarin het water in de beek vastgehouden wordt na een piekbui. Naast beoordeling van de maatregelen op aspecten die met name van toepassing zijn op het ecologisch herstel van de beek, is tevens beoordeeld of de maatregelen een significant negatief effect hebben op de gebruiksfuncties in het stroomgebied. Hiertoe is nagegaan wat het risico´s zijn op inundatie in de bestaande situatie, alsmede in de situaties na uitvoering van de maatregelen.

Het model heeft niet ten doel om een nauwkeurige beschrijving te geven van de effecten van de maatregelen, maar is vooral ingezet voor het verkrijgen van een indicatie van de effecten. Hiertoe is de Hagmolenbeek sterk geschematiseerd uitgewerkt in het oppervlaktewaterstromingsmodel. In de schematisatie zijn de afmetingen van de beek (dwars- en lengteprofiel) en de hierin aanwezige kunstwerken opgenomen. Het stroomgebied van de Hagmolenbeek is voor de studie onderverdeeld in een aantal deelstroomgebieden. Met de RAM-module wordt de neerslagafvoer in de deelstroomgebieden bepaald na een neerslaggebeurtenis. Gekozen is voor het toepassen van de neerslagafvoermodule, omdat hiermee inzicht verkregen wordt op de mate waarin het water 'vertraagd' afgevoerd wordt op de beek. Bij de berekeningen is (arbitrair) een neerslaggebeurtenis gehanteerd met een herhalingstijd van één keer per jaar (14,2 mm, neerslagduur: 1 uur).

De neerslagafvoer (tijdreeks) die berekend wordt met de RAM-module wordt vervolgens gekoppeld aan het oppervlaktewatermodel (duflowmodel), waarmee de stromingspatroon in de beek vastgesteld wordt. In tabel B1 wordt aangegeven waar de afvoer van de deelstroomgebieden op de Hagmolenbeek is opgenomen in het model.

**Tabel B1: Afvoer deelstroomgebieden en locaties van afvoer**

| Afvoer | | Locatie van invoer in oppervlaktemodel |
|---|---|---|
| 1. | Afvoer Duits stroomgebied en stroomgebied Hegebeek, verdeeld door verdeelwerk | Splitsing Hagmolenbeek-Rutbeek |
| 2. | Afvoer eigen stroomgebied (1) | Instroompunt Laarhuiswatergang |
| 3. | Afvoer eigen stroomgebied (2) | Instroompunt Beckumerbuitenbeek |
| 4. | Afvoer stroomgebied Dekkerstrang | Instroompunt Dekkersstrang |
| 5 | Afvoer stroomgebieden Nieuwlandsbeek and Wolfkaterbeek | Instroompunt Nieuwlandsbeek |

Voor het bepalen van het risico's op inundatie is afgeweken van de bovenstaand vermelde aanpak. Hiervoor is namelijk gebruik gemaakt van meetgegevens van het debiet in de Hagmolenbeek ter hoogte van het uitstroompunt op de Twentekanaal. Gekozen is voor het gebruiken van meetgegevens, omdat hiermee een meer nauwkeurig beeld verkregen wordt van het risico's op inundatie. De meetgegevens kunnen niet gehanteerd worden voor de neerslagafvoermodule, omdat de invoer hiervan de neerslagintensiteit is. Op basis van de oppervlaktes van de deelstroomgebieden is een debietsverdeling gemaakt: het debiet is verdeeld over de stroomgebieden naar rato van de oppervlakte van het stroomgebied. In tabel B2 worden de oppervlaktes van de deelstroomgebieden vermeld.

**Tabel B2: Oppervlakte deelstroomgebieden Hagmolenbeek**

| Deelstroomgebied | | Waterloop | Ha | % |
|---|---|---|---|---|
| - | Duits stroomgebied | | 860 | 9,3 |
| A | Hegebeek | 20-5-1 | 1528 | 16,5 |
| B | Eigen stroomgebied | 20-5-5 | 3617 | 39,1 |
| C | Wolfkaterbeek | 20-6-1 | 792 | 8,6 |
| D | Eigen stroomgebied | 20-5 | 880 | 9,5 |
| E | Dekkers strang | 20-5-2 | 1057 | 11,4 |
| F | Nieuwlandsbeek | 20-6 | 522 | 5,6 |
| Totaal stroomgebied | | 20-5 | 9256 | 100 |

Het risico's op inundatie zijn vastgesteld bij de specifieke afvoeren met herhalingstijden van één keer per jaar en één keer per honderd jaar (oftewel de maatgevende en dubbele maatgevende afvoer). In tabel B3 worden de eigenschappen van deze specifieke afvoeren in de Hagmolenbeek vermeld. Het model is stationair doorgerekend met deze specifieke afvoeren.

**Tabel B3: Beschrijving specifieke afvoeren Hagmolenbeek**

| Debiet | Beschrijving | Wijze van vaststelling |
|---|---|---|
| 5,45 m3/s | Maatgevende afvoer; afvoer met een herhalingstijd van 1 keer per jaar | Meetgegevens 1979-2000 |
| 10,90 m3/s | Dubbele maatgevende afvoer; afvoer met een herhalingstijd van 1 keer per 100 jaar | Berekend: 2 x maatgevende afvoer |

### 7B1.2.2. Beschrijving doorgerekende scenario´s herstel morfologie en aankoppeling beek

De volgende scenario´s zijn doorgerekend met het model:

1. Bestaande situatie. Hierin zijn de afmetingen van de beek en de kunstwerken ingevoerd overeenkomstig met de bestaande situatie. Een belangrijke parameter voor de stromingspatroon is de weerstandsfactor K-manning, die ingevoerd moet worden. Voor de bestaande situatie wordt een waarde van 30 gehanteerd (representatief voor een relatief schoon en matig begroeide oppervlak). In bijlage D worden de afmetingen van de beek en de hierin aanwezige kunstwerken weergegeven.
2. Herstel morfologie door beekherstel. Het herstel van de morfologie door beekherstel is in het model ingevoerd als een maatregelenpakket, waarbij:
   - Uitgegaan wordt van hermeandering. De hermeandering is in het model ingevoerd als tracevérlenging (door de meandering neemt de totale lengte van de beek toe). Een typerende tracéverlenging van een middenloop door meandering is 1,5 keer het bestaande traject en is alszodanig verwerkt in het model.
   - Uitgegaan wordt van het verwijderen van de stuwen. In het model zijn de stuwen verwijderd, alsmede de bodemvallen. Hierdoor ontstaat er een relatief constant verhang in de waterbodem waarbij de bodemhoogte bovenstrooms van de bestaande stuwen lager komt te liggen en benedenstrooms van de bestaande stuwen hoger.
   - Aanbrengen van een tweefasenprofiel. Door het verwijderen van de stuwen, zal het niet mogelijk zijn om met de bestaande afmetingen (dwarsporfiel) van de beek voldoende water vast te houden. Bij een tweefasenprofiel wordt uitgegaan van een smalle zomerbed, waarmee voldoende waterdiepte gehandhaafd wordt voor de waterfauna. In het model is voor het winterbed hetzelfde profiel (breedte op maaiveld, talud) aangehouden als in de bestaande situatie. In bijlage II wordt het profiel van het zomerbed, zoals opgenomen in het model weergegeven.
   - Het winterbed is onder normale omstandigheden droog, waardoor de begroeiing hier zal toenemen. Hierdoor zal de waterstroming meer weerstand ondervinden. In het model is voor het winterbed een hogere weerstand ingevoerd (weerstandsfactor K–manning: 25).
3. Herstel oorspronkelijk stroomgebied door koppeling Buurserbeek. Mogelijk stroomde in het verleden (natuurlijke situatie) water vanuit de Buurserbeek-Rutbeek naar de middenloop van de Hagmolenbeek. Waarschijnlijk stroomde het water hierbij vanuit het Buurserbeek-Rutbeeksysteem via moerasgebieden bij hoogwater richting de Hagmolenbeek. Gekozen is om de aankoppeling van de Buurserbeek-Rutbeek op de Hagmolenbeek in het model in te voeren als 10 procent extra afwaterend oppervlak/debiet op de Hagmolenbeek ter hoogte van de koppeling met de Rutbeek.
4. Herstel morfologie door beekherstel en herstel oorspronkelijk stroomgebied door koppeling Buurserbeek. In dit scenario wordt uitgegaan van zowel herstel van de morfologie door beekherstel als herstel van oorsponkelijk stroomgebied. De uitwerking van de maatregelen zijn in het model opgenomen conform scenario 2 en

### 7B1.2.3. Modelresultaten herstel morfologie en aankoppeling beek

**Resultaten stroomsnelheden en waterdiepte**

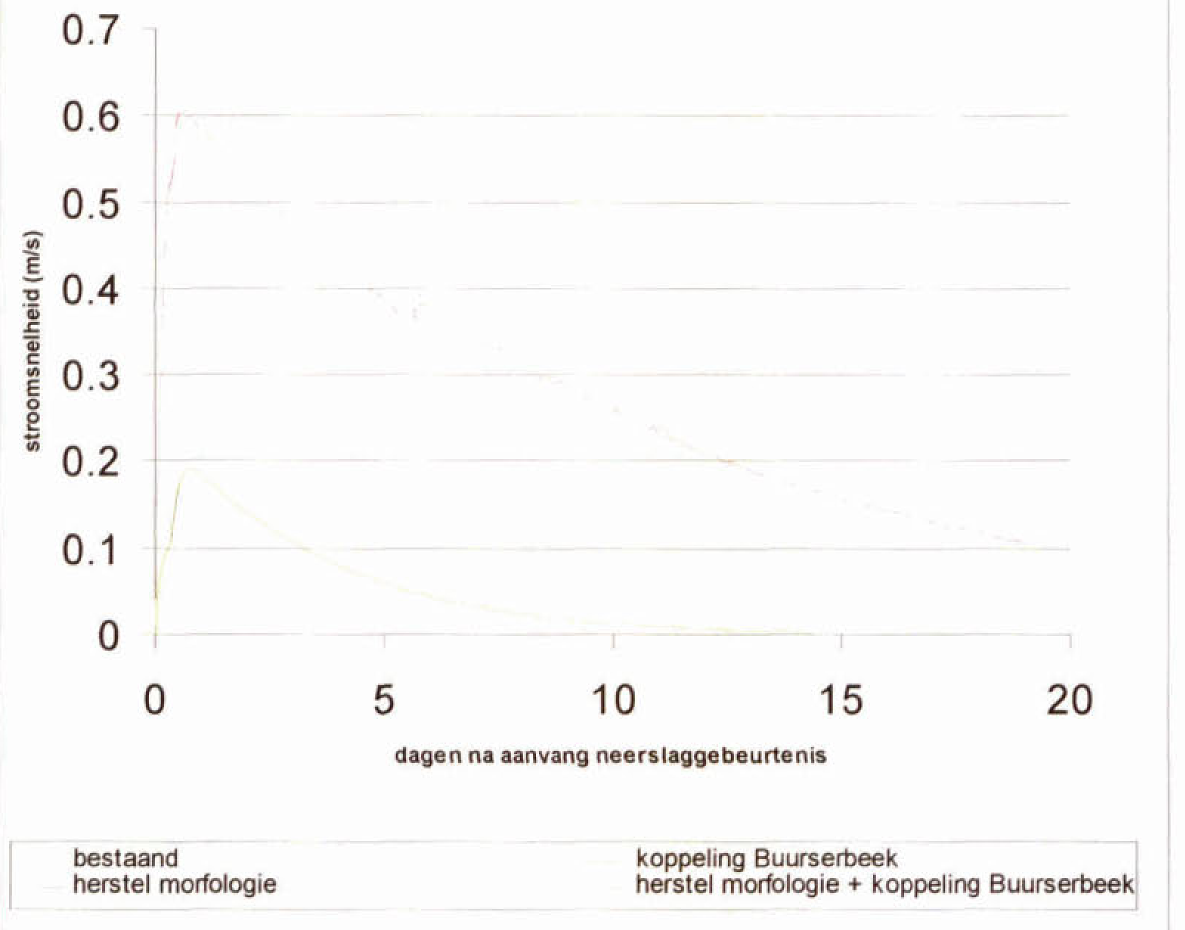
In tabel B4 worden de resultaten ten aanzien van de stroomsnelheden op een viertal locaties weergegeven. In tabel wordt weergegeven wat de maximale stroomsnelheid is, alsmede de periode waarin de stroomsnelheid groter dan 5 cm/s is. De gewenste minimale stroming in een beek is namelijk 5 cm/s. De gekozen locaties zijn verdeeld over de lengte van de Hagmolenbeek en geven gezamenlijk een representatief beeld van de stromingspatroon in de beek.

**Tabel B4: Resultaten stroomsnelheden**

| Scenario | Locatie (bovenstrooms) *: | Stuw200 | Stuw401 | Stuw607 | Stuw707 |
|---|---|---|---|---|---|
| Bestaand | Max. stroomsnelheid (cm/s) | 39 | 19 | 11 | 11 |
| | Duur > 5 cm/s (dagen) | 10 | 7 | 6 | 6 |
| Morfologie | Max. stroomsnelheid (cm/s) | 55 | 60 | 43 | 47 |
| | Duur > 5 cm/s (dagen) | 26 | 19 | 16 | 17 |
| Koppeling | Max. stroomsnelheid (cm/s) | 39 | 19 | 14 | 12 |
| | Duur > 5 cm/s (dagen) | 10 | 7 | 6 | 6 |
| Morfologie en koppeling | Max. stroomsnelheid (cm/s) | 56 | 61 | 45 | 48 |
| | Duur > 5 cm/s (dagen) | 27 | 21 | 16 | 17 |

* Locatie is bovenstrooms genomen van de stuw. In het scenario's met beekherstel zijn de stuwen verwijderd.

Ter illustratie wordt in grafiek B1 weergegeven hoe de stroomsnelheid bovenstrooms van de bestaande stuw 401 verloopt na een neerslaggebeurtenis.




**Grafiek B1: Verloop stroomsnelheden bij bestaande situatie en na beekherstel**

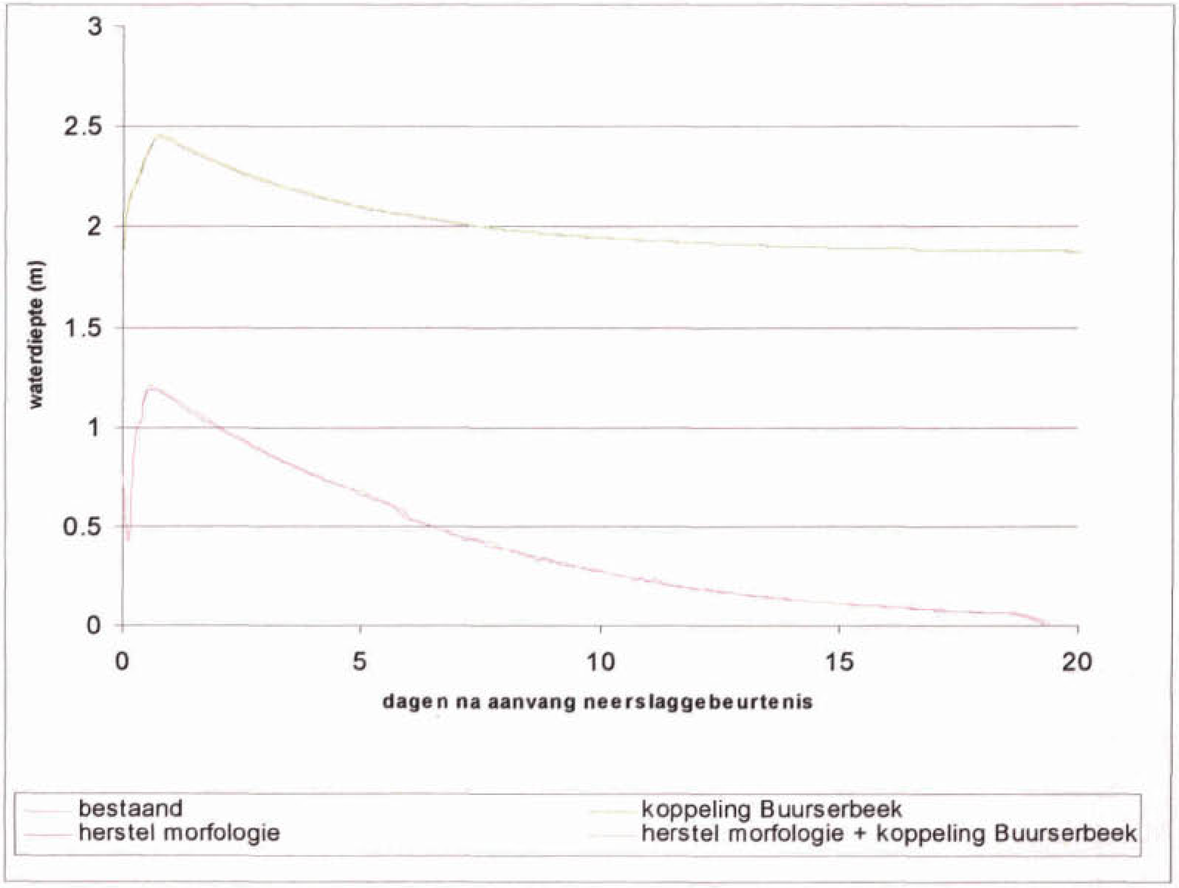
In tabel B5 worden de resultaten ten aanzien van de waterstanden op een viertal locaties weergegeven. In de tabel worden de maximale en minimale waterdieptes weergegeven. De waterstanden die in de tabel vermeld staan zijn afgerond op 5 cm. In de tabel wordt tevens weergegeven hoe lang de waterdiepte meer dan 0,25 m is. Gekozen is voor 0,25 m, omdat bij lagere waterstanden problemen voor de waterfauna voorzien worden.

**Tabel B5: Resultaten waterdiepte**

| Scenario | Locatie (bovenstrooms) *: | Stuw200 | Stuw401 | Stuw607 | Stuw707 |
|---|---|---|---|---|---|
| Bestaand | Max. waterdiepte (m) | 1,70 | 2,44 | 1,35 | 1,65 |
| | Min. waterdiepte (m) | 1,15 | 1,70 | 0,90 | 1,05 |
| Morfologie | Max. waterdiepte (m) | 1,55 | 1,20 | 0,75 | 0,75 |
| | Min. waterdiepte (m) | 0 | 0 | 0 | 0 |
| | Duur > 0,25 m diep (dgn) | 15 | 18 | 10 | 11 |
| | Duur > 0 m diep (dgn) | 26 | 19 | 16 | 17 |
| Koppeling | Max. waterdiepte (m) | 1,71 | 2,45 | 1,39 | 1,71 |
| | Min. waterdiepte (m) | 1,15 | 1,70 | 0,90 | 1,05 |
| Morfologie en koppeling | Max. waterdiepte (m) | 1,62 | 1,26 | 0,78 | 0,78 |
| | Min. waterdiepte (m) | 0 | 0 | 0 | 0 |
| | Duur > 0,25 m diep (dgn) | 15 | 12 | 10 | 11 |
| | Duur > 0 m diep (dgn) | 27 | 21 | 16 | 17 |

* Locatie is bovenstrooms genomen van de stuw. In het scenario's met beekherstel zijn de stuwen verwijderd.

Ter illustratie wordt in grafiek B2 weergegeven hoe de waterdiepte bovenstrooms van de bestaande stuw 401 verloopt na een neerslaggebeurtenis.




**Grafiek B2: Verloop waterdiepte bij bestaande situatie en na beekherstel**

**Conclusie stroming**
Door de aanwezigheid van de stuwen in de bestaande situatie is er nauwelijks verhang in de waterlijn. Hierdoor neemt de stroomsnelheid na een neerslaggebeurtenis slechts beperkt toe. Na verloop van tijd is er sprake van een stagnante situatie.

Na koppeling van de Buurserbeek-Rutbeeksysteem neemt de stroomsnelheid na een neerslaggebeurtenis in beperkte mate toe. De toename wordt veroorzaakt doordat het debiet dat door de beek stroomt groter wordt, terwijl de bestaande afmetingen van de Hagmolenbeek en de hierin aanwezige kunstwerken gehandhaafd blijven.

Na uitvoering van de maatregelen gericht op aanpassing van de morfologie van de beek, neemt de stroomsnelheid sterk toe. Dit wordt mede veroorzaakt door het verwijderen van de stuwen, waardoor het water vrijer door de beek kan stromen zonder hinder van barrières. Bovendien zijn de bodemvallen verwijderd, waardoor de stroming bepaald wordt door het verhang in de waterbodem. Het water in de beek stroomt hierdoor totdat het droogvalt.

Door naast uitvoering van morfologische maatregelen tevens het Buurserbeek-Rutbeeksysteem te koppelen aan de Hagmolenbeek neemt de stroomsnelheid nog iets verder toe.

**Conclusies waterdiepte**
De aanwezigheid van stuwen in de bestaande situatie zorgt ervoor dat een deel van het water lang vastgehouden wordt. Met het hydraulisch model wordt voor de bestaande situatie geen droogval gesimuleerd in de Hagmolenbeek. Dit komt door de stuwen en het matige verhang in de bodemlijn (de kruinhoogte van de stuwen ligt over het algemeen hoger dan de bodemhoogte in het bovenstroomse gedeelte van de desbetreffende beekpand). In werkelijkheid kan wel droogval plaatsvinden door infiltratie.

Door koppeling van de Buurserbeek-Rutbeeksysteem, neemt de maximale waterdiepte na een neerslaggebeurtenis toe. Dit komt doordat bij de berekeningen uitgegaan is van handhaving van de bestaande afmetingen van de Hagmolenbeek en de hierin aanwezige kunstwerken, terwijl het debiet dat door de beek zal stromen groter is.

Uit de modelberekening blijkt dat na uitvoering van de morfologische maatregelen, de beek door het verwijderen van de stuwen na verloop van tijd droog valt. Dit betekent dat er bij een aanhoudende droogte er een risico op droogval van de beek. Dit in tegenstelling tot de bestaande situatie, waarbij de beek niet of nauwelijks droogvalt en tijdens droge perioden vooral bestaat uit stagnant water.

Door naast het uitvoeren van de koppeling van het Buurserbeek-Rutbeeksysteem kan het risico op droogval enigszins beperkt worden.

De vraag is in hoe vaak en hoe lang er na verwijdering van de stuwen droogval zal optreden. De referentie voor de Hagmolenbeek, de ongestuwde Ruenbergerbeek, blijft in de zomer water afvoeren, hoewel het wel weinig water is. Volgens G. Schmidt van het Waterschap Regge & Dinkel zijn de regenwaterkarakteristieken van de Ruenbergerbeek in grote lijnen vergelijkbaar met die van de Hagmolenbeek (zie voorgaande analyse maatregelen voor bereiken GES). Alleen in extreem droge situaties zal er in de Ruenbergerbeek droogval optreden. De Hegebeek is watervoerend in de zomer. Verwacht wordt dat na uitvoering van de maatregelen ook de Hagmolenbeek watervoerend zal zijn. De waterdiepte zal tijdens de droge perioden echter minimaal zijn. De Ruenbergerbeek en Hagmolenbeek verschillen wel in ondergrond: de Ruenbergerbeek heeft een ondergrond van keileem en er liggen grindbanken. De ondergrond van de Hagmolenbeek bestaat uit zand. Door de zandbodem is het wel waarschijnlijk dat in de

Hagmolenbeek eerder droogval optreedt dan in de Ruenbergerbeek door de infiltratie van water.

### 7B1.2.4. Effect van aankoppeling van beek op andere gebruiken van beek : kans op inundatie

Op basis van het lengteprofiel van de beek zijn een viertal risicolocaties voor inundatie geselecteerd. In tabel B6 worden de waterstanden op deze locaties van de beek weergegeven bij de maatgevende en de dubbele maatgevende afvoer. Tevens wordt de maaiveldhoogte weergegeven. Waterstanden boven maaiveldhoogte worden '**vet**' aangegeven in de tabel. De gerapporteerde waterstanden zijn afgerond op 5 cm en zijn slechts indicatief, omdat het model niet gekalibreerd is.

**Tabel B6: Resultaten waterstanden in m + NAP bij typische afvoeren op een viertal risicolocaties (MA: maatgevende afvoer, 2 MA: dubbele maatgevende afvoer)**

| Scenario | Locatie (bovenstrooms) *: | Stuw 401 | Stuw 500 | Stuw 601 | Stuw 704 |
|---|---|---|---|---|---|
| Bestaand | MA | 18,45 | 20,60 | 22,75 | 25,65 |
| | 2MA | **18,80** | 20,75 | 23,00 | 25,90 |
| Morfologie | MA | 18,55 | 20,50 | 22,60 | 25,55 |
| | 2MA | **19,00** | **20,80** | 22,90 | 25,80 |
| Koppeling | MA+10% | 18,49 | 20,60 | 22,76 | 25,66 |
| | 2MA+10% | **18,90** | **20,80** | 23,03 | 25,93 |
| Morfologie en koppeling | MA+10% | 18,55 | 20,50 | 22,65 | 25,57 |
| | 2MA+10% | **19,03** | **20,84** | 22,92 | 25,86 |
| Hoogte maaiveld: | | 18,67 | 20,78 | 23,08 | 25,93 |

* Locatie is bovenstrooms genomen van de stuw. In het scenario's met beekherstel zijn de stuwen verwijderd.

**Conclusies inundatie**

Door koppeling van de Buurserbeek-Rutbeeksysteem neemt het debiet in de Hagmolenbeek toe, waardoor de waterstanden bij hoogwatergolven hoger komen te liggen. Hierdoor neemt het risico op inundatie toe.

Door de morfologische maatregelen worden de waterstanden bij hoogwatergolven op bepaalde locaties hoger en op andere locaties lager. Dit komt door het weghalen van de stuwen en wijziging van het bodemprofiel (bovenstrooms van de bestaande stuwen wordt de bodemhoogte verlaagd en benedenstrooms van de bestaande stuwen wordt de bodemhoogte verhoogd).

Als naast de morfologische maatregelen ook het Buurserbeek-Rutbeeksysteem gekoppeld wordt, dan worden hogere waterstanden berekend. Hierdoor neemt lokaal het risico op inundatie toe.

### 7B1.3. Maatregel aankoppeling van de Hagmolenbeek aan de Reggebeek door middel van een onderlegger onder het Twente kanaal

Bij de aanleg van het Twentekanaal is de Hagmolenbeek van de Regge afgekoppeld en watert de beek af in het kanaal. De aankoppeling kan gebeuren door middel van een onderleider onder het Twentekanaal. Het bovengronds aankoppelen van de Hagmolenbeek is niet mogelijk vanwege de scheepvaartfunctie op het Twentekanaal. Deze maatregel heeft nauwelijks invloed op de afvoerkarakteristiek van de Hagmolenbeek, omdat het benedenstroomse deel van de Hagmolen-beek aan de Regge wordt gekoppeld (de maatregel heeft dus vooral effect op de afvoer en waterkwaliteit van de Regge). De maatregel kan wel positieve effecten hebben, omdat:

- Het continuum tussen de Hagmolenbeek en de Regge hersteld wordt. Momenteel is het Twentekanaal een barrière voor de migratie van vissen en macrofauna door het stroomgebied. Een onderleider onder het kanaal door zal de migratiemogelijkheden wel verbeteren, maar waarschijnlijk minder goed dan in het geval van een volledig herstel van de oorspronkelijke situatie door het bovengronds aankoppelen. Uit onderzoek naar de passeerbaarheid van syphons onder kanalen in Noord-Brabant blijkt dat vissen deze onderleggers wel passeren (OVB, 1998). Door de inrichting van deze onderleggers aan te passen aan de wensen van vissen (plaatsen van licht, lagere stroomsnelheden) kan de passeerbaarheid vergroot worden.
- Het oorspronkelijke stroomgebied hersteld wordt. De stroomgebiedsvisie is heel belangrijk binnen de KRW en herstel van stroomgebieden is ook een belangrijke beleidslijn van het WS Regge & Dinkel. Het herstel van het stroomgebied betekent echter niet automatisch, dat ook de ecologische toestand van het benedenstroomse traject van de Hagmolenbeek en de Regge verbetert. Dit hangt af van de verandering van de afvoerkarakteristiek door de aankoppeling, maar ook van de habitateigenschappen van dat traject. Dit benedenstroomse stroomgebied noordelijk van het Twentekanaal heeft hetzelfde karakter als het benedenstroomse deel van de Hagmolenbeek zuidelijk van het Twentekanaal; het is ook sterk naar de wensen van de landbouw ingericht (stuwen, profiel, drainage). Naar het tracé voor de koppeling van de Hagmolenbeek met de Regge is een studie uitgevoerd. Er zijn meerdere alternatieve tracés bestudeerd. Over het uiteindelijke tracé is nog geen keuze gemaakt door het WS Regge & Dinkel.

Er heeft geen kwantitatieve hydrologische modellering van afvoer van het benedenstroomse deel plaatsgevonden, omdat:

- Het bij deze maatregel gaat om een mogelijke toekomstige maatregel, dus momenteel hoort het aan te koppelen stroomgebied niet bij de Hagmolenbeek;

- De koppeling nauwelijks effect zal hebben op de afvoer van de Hagmolenbeek, maar vooral op de afvoer van de Regge;

- Het definitieve tracé nog niet gekozen is. De alternatieven bestaan uit verschillende tracés, waarbij ook het aantal onderleiders varieert van één tot twee. Dit bemoeilijkt de uitvoering van een kwantitatieve modellering, omdat het tracé, het profiel en het aantal onderleiders de hydrologie van de beek zullen beïnvloeden.

### 7B1.4 Maatregel herstel hydrologie van stroomgebied

#### 7B1.4.1. Beschrijving maatregel

Doel van de maatregel is het bereiken van een natuurlijker afvoerverloop van het stroomgebied, dus aftopping van de piekafvoeren en het verhogen van de basisafvoer en het verlengen van de periode waarin de basisafvoer voorkomt. Dit kan gerealiseerd worden door het verhogen van de grondwaterstand in het stroomgebied en het verminderen van de hoeveelheid ontwateringmiddelen, waardoor het overtollige water minder snel uit het gebied wordt afgevoerd. Uitvoeringsmaatregelen binnen dit kader zijn bijvoorbeeld het verhogen van de slootbodems en het dempen van sloten en greppels.

Door het verminderen van de ontwateringmiddelen, in combinatie met het verhogen van de ontwateringbasis, zal de gemiddelde grondwaterstand stijgen. Het effect hiervan is dat de potentiële berging in de bodem afneemt. Bij verzadiging van de bodem zal de neerslag sneller tot (oppervlakte)afvoer komen. De piekafvoeren nemen daardoor in principe toe. Anderzijds zal door het (gedeeltelijk) ontbreken van ontwateringmiddelen, het water minder snel via de beek tot afvoer komen doordat de sponswerking van de bodem toeneemt. Dit zal tot een netto verlaging van de piekafvoeren leiden. Door de toename van de hoeveelheid water in de bodem zal de basisafvoer van de beek toenemen en ook langer duren. Dit vertraagt of voorkomt het droogvallen van de beek in droge perioden.

**7B1.4.2. Beïnvloeding grondwaterstand**

Het stroomgebied van de Hagmolenbeek bestaat in de beekdalen voornamelijk uit lemige eerdgronden en plaatselijk (middenloop Hagmolenbeek) uit venige beekdalgronden. De dekzandwelvingen bestaan overwegend uit podzolgronden en dikke eerdgronden. Natte gronden, met een gemiddelde hoogste grondwaterstand van minder dan 40 cm – mv (grondwatertrap III), komen voor langs de Hagmolenbeek, de Hegebeek en andere waterlopen in het noorden en het westen van het stroomgebied. De dekzandwelvingen in het gebied zijn over het algemeen beter ontwaterd (grondwatertrap V en VI), met name de enkeerdgronden (grondwatertrap VII).

Op basis van een studie die Witteveen+Bos heeft uitgevoerd naar beekherstel van het Koningsdiep (Witteveen+Bos, 2001) en op basis van expert-judgement van de hydrologen van Witteveen+Bos, wordt verwacht dat een grootschalige aanpak nodig is voor het herstel van de oorspronkelijke hydrologische situatie. De verwachting is dan ook dat een reductie van 70 tot 80% van de drainagecapaciteit vereist is voor het herstellen van het oorspronkelijke stromingspatroon. Deze reductie van de drainage zal leiden tot een stijging van de grondwaterstand. De bestaande grondwatertrappen wijzigen daardoor van III, V, VI en VII naar grondwatertrappen I, II en III.

De verwachte stijging van de grondwaterstand wordt bevestigd door modelberekeningen die uitgevoerd zijn in het kader van de visie van het stroomgebied van de Regge voor het jaar 2020, verwoord in het rapport 'De Regge, Blauwe slagader van Twente' (Arcadis, 1998). Uit deze modelberekeningen blijkt dat de grondwaterstand, door het verhogen van de ontwateringbasis, 20 - 50 cm zal stijgen.

**Discussie ten aanzien van voorspellingen van hydrologisch en morfologisch effect van de maatregelen**

De modelberekeningen geven geen absolute waarden ten aanzien van de waterdiepte, stroomsnelheid en waterstand, maar alleen relatieve veranderingen in waterdiepte, stroomsnelheid en waterstand als gevolg van een maatregel ten opzichte van de bestaande situatie. Dit komt omdat er geen calibratie van het model heeft plaatsgevonden; de invoer is niet gebaseerd op een neerslagmeetreeks maar op een imaginaire bui en het model is niet gecalibreerd op gemeten waterstanden en/of debieten. Hierdoor kan geen uitspraak gedaan worden over de mate waarin het model de werkelijkheid benadert. Bovendien zijn met het model alleen maatregelen in het beeksysteem zelf doorgerekend. Hydrologische maatregelen gericht op het vast-houden van water in het stroomgebied zijn niet doorgerekend met het model. Voor het bepalen van de effecten van dergelijke maatregelen dienen berekeningen uitgevoerd te worden met een grondwatermodel, waarbij het grondwatermodel gekoppeld is met het oppervlaktewaterstromingsmodel.

Gezien de beperkte middelen voor het realiseren van de rapportage is gekozen voor een relatief eenvoudige benadering zonder calibratie en zonder het doorreken van hydrologische maatregelen in het stroomgebied. De modelbenadering geeft wel goede handvatten voor het inschatten van de effecten van maatregelen. Het model is immers gebruikt als middel waarmee nagegaan kan worden of mogelijke verbeteringsmaatregelen daadwerkelijk een verbetering voor de Hagmolenbeek betekenen.

## Appendix C

### 7B.1.5 Kosten van maatregelen

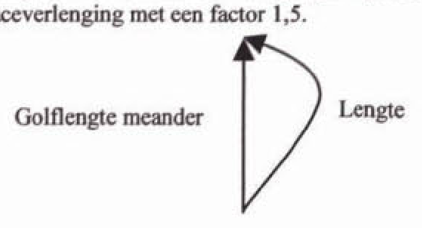
### 7B1.5.1 Herstel morfologie

*Aankoop grond*

Bij beekherstel van middenlopen wordt uitgegaan van een extra ruimtebeslag van 15 m aan weerszijden van de beek (Nieuwland Advies, 2000). Deze extra ruimte is nodig voor de meandering van de beek (Zie onderstaand Intermezzo).

**Intermezzo: Relatie tussen sinuositeit van 1,5 en 15 m grondaankoop**

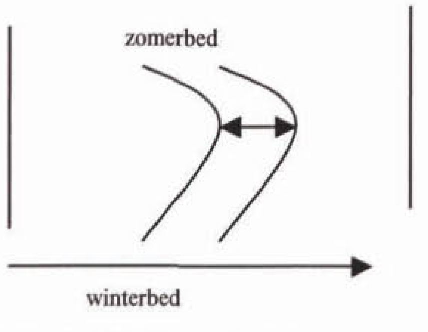
Van een meanderende beek is sprake als de lengte van de meander minimaal 1,5 keer zo groot is als de golflengte van de meander (ook wel een sinuositeit van 1,5 genoemd). Omdat de Hagmolenbeek een genormaliseerde beek is, kan voor de golflengte de lengte van de bestaande watergang aangehouden worden. Bij meandering met een sinusiteit van 1,5 betekent dit een traceverlenging met een factor 1,5.




Figuur: Schets golflengte en lengte van een meander

De benodigde ruimte is mede afhankelijk van de type meandering dat toegepast wordt. Bij mesomeandering vindt de meandering plaats binnen de beekbedding (bij hermeanderen vindt de meandering plaats binnen het winterprofiel). Indien het winterbed valt binnen de breedte van de bestaande watergang is in feite geen extra ruimte nodig bij mesomeandering. Bij de aanname van aankoop van het grond met 15 m is niet zozeer de (meso)meandering als uitgangspunt gehanteerd, maar de extra grond die nodig is voor:

- het verruimen van het winterbed in verband met de drooglegging;
- het realiseren van een meer natuurvriendelijke oeverprofiel;
- het lokaal toepassen van macromeandering (van macromeandering is sprake als ook het winterbed een slingerend verloop heeft).




Figuur: Bovenaanzicht beek met winter- en zomerbed bij mesomeandering

Literatuur: Inrichting bovenloop Groote Moolenbeek, Waterschap Peel en Maasvallei, Oranjewoud (1999).

De totale lengte van de middenloop van de van de Hagmolenbeek bedraagt ca. 13 km. Het grondgebruik langs de beek is voornamelijk landbouw en zal aangekocht moeten worden. In Twente ligt de gemiddelde prijs voor agrarische gronden op 80 kf per ha (Nieuwland Advies, 2000). Dit resulteert in een bedrag van 3,1 Mf eenmalige kosten voor aankoop van de grond.

*Grondverzet*

Naast kosten voor aankoop van de grond worden bij beekherstel tevens kosten gemaakt voor grondverzet. Het grondverzet is met name nodig voor het verlagen van de zone langs de beek, waarin de beek kan meanderen.

Voor het grondverzet wordt uitgegaan van 5 m3 per m beek. Uitgaande van een prijseenheid voor het grondverzet van f5,-- per m3 (Nieuwland Advies 2000), bedragen de kosten voor herprofilering eenmalig ca. 325 kf.

### 7B1.5.2. Herstel oorspronkelijk stroomgebied

Herstel van het stroomgebied zal vorm krijgen door koppeling van de Hagmolenbeek aan de aan de Buurserbeek en koppeling van Hagmolenbeek aan het stroomgebied van de Regge.
De kosten voor de aanleg van de onderlegger onder het Twente kanaal om de Hagmolenbeek met de Regge te verbinden worden geschat op 4 millioen gulden.
Over het historisch tracé van de koppeling van de Buurserbeek met de Hagmolenbeek is thans weinig bekend. Het vermoeden bestaat dat water vanuit de Buurserbeek-Rutbeeksysteem via een moerasgebied stroomde richting de Hagmolenbeek. De kosten van koppeling van de Buurserbeek-Rutbeeksysteem aan de Hagmolenbeek kunnen op dit moment niet goed ingeschat worden en zijn sterk afhankelijk van de wijze waarop de koppeling uitgewerkt wordt. De kostenraming is daarom slechts indicatief.
Een mogelijk koppeling van de Buurserbeek aan de Hagmolenbeek kan uitgevoerd worden door het graven van een vloeiveld tussen De Buurserbeek en watergang 20-5-0-32, die via watergang 20-5-31 gekoppeld is met de Hagmolenbeek. Hiertoe zal grond aangekocht moeten worden en dient grondverzet plaats te vinden. Uitgegaan wordt van aankoop van 2 ha grond en grondverzet van 10.000 m3. Voor de aankoop van grond resulteert dit in 160 kf en voor het grondverzet 50 kf. Dit is omgerekend naar euro een totaal bedrag van 103.800 euro

Schadevergoedingen aan de agrariërs voor het gebruik van hun grond als retentiegebied voor hoog water worden berekend op basis van het oppervlak aan geplande retentiegebieden in het stroomgebied van de Hagmolenbeek en een gemiddelde waarde aan betaalde schadevergoedingen aan boeren in het Dinkeldal. Het oppervlak aan geplande retentiegebieden in het stroomgebied van de Hagmolenbeek is 3% van het stroomgebied, dus 3% * 9256 ha= 277 ha. De gemiddelde compensatie kosten voor overstroming zijn F550,--/ha *jaar. De totale kosten zijn dan F153.000,-- per jaar.

### 7B.1.5.3 Opbrengstderving voor de landbouw door herstel stroomgebied

Het plangebied is overwegend in gebruik voor landbouw (naar schatting 90%), voornamelijk grasland. Op het aanwezige bouwland wordt voornamelijk snijmaïs verbouwd ten behoeve van de (melk)veehouderij. Een verandering van de grondwaterstand heeft droogteschade of wateroverlast ten opzichte van de huidige situatie tot gevolg. De som van droogteschade en wateroverlast wordt uitgedrukt in een percentage opbrengstderving voor verschillende bodemtypen. Met behulp van de HELP-tabellen (Cultuurtechnisch Vademecum, 2000) is deze opbrengstderving gekwantificeerd. In de HELP-tabellen is de opbrengstdepressie gerelateerd aan de opbrengstniveau op het grondsoort, waarop de grootste opbrengst van het gewassoort verkregen wordt. Voor grasland is dit op zavel en eerdgronden, de potentiële opbrengst op deze gronden is gemiddeld 13.500 kg droge stof (d.s.) per hectare per jaar. De opbrengstdepressies van alle gronden zijn aan dit maximumniveau gerelateerd.

Voorbeeld: voor grasland op podzolgrond met grondwatertrap V, bedraagt de som van schade door wateroverlast en droogteschade 15%. De potentiële opbrengst is dus 11,5 ton d.s.per hectare per jaar (=0,85*13.500 kg d.s.).

In tabel C1 wordt de bestaande potentiële opbrengst van grasland voor de meest voorkomende grondsoorten/grondwatertrappen in het plangebied vermeld.

**Tabel C1 Potentiële opbrengst grasland (bestaande situatie)**

| **Grondsoort:** | **Lemige eerdgrond** | **Podzol** | **Podzol** | **Enkeerd** |
|---|---|---|---|---|
| **GW-trap:** | **III** | **V** | **VI** | **VII** |
| Schade door wateroverlast (%) | 17 | 7 | 0 | 0 |
| Droogteschade (%) | 5 | 8 | 16 | 10 |
| Potentiële opbrengstniveau (%)[1] | 78 | 85 | 84 | 90 |
| Potentiële opbrengst (ton d.s./ha/jr) | 10,5 | 11,5 | 11,3 | 12,2 |

1) 100%, verminderd met schade bij wateroverlast en droogteschade.

2) Uitgaande van een praktisch potentieel saldo van 13,5 ton droge stof, lit.1)

De ontwatering voor het grasland is in het stroomgebied van de Hagmolenbeek over het algemeen redelijk tot goed te noemen. Op basis van kaartmateriaal (Grontmij, 1995) wordt uitgegaan van een verdeling van de grondwatertrappen III, V, VI en VII in het stroomgebied van de Hagmolenbeek van resp. 20%, 40%, 30% en 10%. De gewogen gemiddelde opbrengstdepressie door wateroverlast en droogteschade bedraagt voor de bestaande situatie globaal ongeveer 15 %. De opbrengstdepressie is lokaal groter op de natte eerdgronden.

In tabel C2 is de opbrengstdepressie weergegeven na uitvoering van de herstelmaatregelen. De in de tabel vermelde genoemde grondwatertrappen zijn inschattingen en zijn in de praktijk sterk afhankelijk van de locatie en de uitgevoerde maatregelen.

**Tabel C2: Potentiële opbrengst grasland (na herstelmaatregelen)**

| **Grondsoort:** | **Lemige eerdgrond** | **Podzol** | **Podzol** | **Enkeerd** |
|---|---|---|---|---|
| **GW-trap (aanname):** | **Van III naar II** | **Van V naar II** | **Van VI naar III** | **Van VII naar III** |
| Schade door wateroverlast (%) | 37 | 37 | 17 | 17 |
| Droogteschade (%) | 2 | 1 | 3 | 3 |
| Potentiële opbrengstniveau (%) | 61 | 62 | 80 | 80 |
| Potentiële opbrengst (ton d.s./ha/jr) | 8,2 | 8,4 | 10,8 | 10,8 |

Door verhoging van de grondwaterstand in het plangebied zal de opbrengstdepressie toenemen. De gewogen gemiddelde opbrengstdepressie door wateroverlast en droogteschade na uitvoering van de maatregelen wordt geschat op 30%. Lokaal zou de opbrengstdepressie door droogteschade af kunnen nemen door een grondwaterverhoging, maar gemiddeld genomen nemen de opbrengsten over het hele stroomgebied af.

De in de HELP-tabel, in percentages weergegeven opbrengstdervingen, kunnen in geldelijke opbrengstdervingen worden vertaald door middel van het praktisch potentieel saldo. Voor beweid grasland is het praktisch potentieel saldo f 3.360,--/ha/jr (Cultuurtechnisch Vademecum, 2000). Dit is de verwachte winstderving voor de agrarier door het verhogen van de grondwaterstand. Het genoemde saldo is van toepassing op bedrijven die niet zelfvoorzienend zijn in de ruwvoederbehoefte. In het saldo zijn de maïsaankoop, oogst- en transportkosten verrekend.

Op basis van de oppervlakte landbouwgebied en uitgaande van overwegend gebruik van het landbouwgebied als grasland, wordt de inkomstenderving door de grondwaterstandverhoging geschat op 4,0 Mf per jaar. Bij de berekening is uitgegaan van een oppervlakte van het stroomgebied van 9256 ha, 85% landbouw in het gebied (overwegend grasland), 15% extra opbrengstdepressie door grondwaterstandverhoging en een praktisch potentieel saldo van grasland van f3.360,--/ha per jaar.

## Appendix D

## Bepaling administratieve belasting

Doel is om inzicht te geven in de "administratieve" belasting van de waterbeheerders in het geval veel, of alle watersystemen beschreven moeten worden op een wijze die nu onderwerp van studie is. Naast inzicht in de technische en ecologische informatie, die noodzakelijk is bij een eerste indeling van een watersysteem in de categorie "heavily modified", is ook inzicht gewenst in de administratieve- en rapportageverplichtingen, die verbonden zijn aan het toedelen van water aan deze categorie;

De extra administratieve- en rapportageverplichtingen, die er onstaan als een water als HMW wordt aangewezen in plaats van natural, zijn:
1. Uitvoering van de eerste aanwijzing als HMW
2. Herziening van de aanwijzing om de 6 jaar
3. Monitoring van HMW wateren

Ad 1. Eerste aanwijzing als HMW

Voor het eerste stroomgebiedsplan moet de aanwijzing als HMW uitgevoerd worden in een aantal stappen, zoals in de case-study Hagmolenbeek gedaan is. Om de administratieve belasting van de aanwijzing als HMW te bepalen moeten die stappen worden meegenomen, die alleen voor de aanwijzing als HMW worden uitgevoerd. Deze stappen worden onderstaand als **vetgedrukt** weergegeven. De stappen, die zowiezo voor een stroomgebiedsplan gedaan moeten worden, worden bij de bepaling van de administratieve belasting dus niet meegenomen (deze stappen zijn *schuingedrukt*) (tussen haakjes staat het onderdeel volgens Bijlage VII van de KRW):

1. *Identification of Water Bodies (onderdeel A1.1. stroomgebiedsplan)*
2. *Description of physical alterations resulting from the pressures and uses (A.2)*
3. **Description of changes in the hydromorphological characteristics resulting from the physical alterations**: Extra onderdeel, want hydromorfologie hoeft strikt genomen niet beschreven te worden voor de KRW, maar waarschijnlijk zal in kader van nieuwe monitoring en beoordelingsmethode wel de hydromorfologie beschreven worden, dus dan hoeft alleen de link met de physieke veranderingen gelegd te worden.
4. *Description of Ecological Status on the basis of the biological and physico-chemical parameters (A 4.1)*
5. **Prediction of necessary hydromorphological changes and resulting measures to achieve Good Ecological Status**: Voorspelling van hydromorfologische veranderingen moet op basis van modellering of expert-judgement gebeuren. Dit zal in veel gevallen een lastige klus zijn, aangezien er waarschijnlijk verschillende veranderingen op verschillende plaatsen in zowel stroomgebied als waterlichaam hebben plaatsgevonden. Als de hydromorfologische veranderingen eenmaal voorspeld zijn is de vertaling naar maatregelen soms goed uitvoerbaar, maar soms is hiervoor ook modellering of expert-judgement noodzakelijk.

6. **Determination of impact of measures on water uses and significant adverse effects:** De impact van de maatregelen op andere watergebruik kan meestal wel door middel van expert-judgement bepaald worden. Om te bewijzen of de impact ook significant is moet het andere watergebruik ofwel:
   - van groot publiek belang zijn (veiligheid, drinkwater)
   - er wordt met kwantitatieve en relatieve getallen aangetoond dat impact significant is (% opbrengst verlies ten opzichte van totaal, % verlies aan land). Daarvoor moeten dus kwantitatieve gegevens verzameld worden.

7. **Determination of impact on the wider environment**: In deze stap worden de negatieve effecten van de maatregelen op related waterbodies beschreven. Dit kan door middel van expert-judgement.

8. **Identification and definition of the beneficial objectives served by the modified characteristics of the water body**: Beschrijving van doelen en functies, die gediend worden door het veranderde karakter van het water. In veel gevallen zijn dit dezelfde doelen als waarvoor de physical alteration is uitgevoerd, maar daarnaast kunnen er nog meer doelen en functies zijn. Dit kan door middel van expert-judgement en gegevens over landgebruik en functies in het gebied.

9. **Determination of alternatives to the existing "water use" and their costs, technical feasibility and environmental effects in a wider context**: Hiervoor moeten allerlei alternatieven beschreven worden en de kosten, technische haalbaarheid en milieugevolgen. Bij de alternatieven gaat het zowel om alternatieven voor functies als om mitigerende maatregelen tegen negatieve effecten op functies. Voor deze stap moet expert-judgement toegepast worden ten aanzien van het bepalen van alternatieven en hun technische haalbaarheid en moet veel informatie verzameld worden over de kosten ervan. Dit kost dus veel tijd.

10. **Designation of Heavily Modified Water Bodies**: op basis van de verzamelde informatie in de voorgaande stap wordt een waterlichaam aangewezen als natuurlijk of HMW. Dit gebeurt op basis van expert-judgement en kost relatief weinig tijd.

11. **Determining Maximum Ecological Potential: measures for achieving MEP + comparison with comparable water body**: MEP wordt bepaald op basis van de haalbare maatregelen uit de HMW aanwijzing en alle bestaande, mitigerende maatregelen. Vervolgens moet een vergelijkbaar waterlichaam worden gezocht om het MEP te beschrijven. De beschrijving moet worden gebaseerd op 1) ruimtelijke referentie 2) modelstudies of een combinatie van beide methoden. Als dat niet mogelijk is dan mag expert-judgement gebruikt worden. De stap is vrij complex en zal vrij veel tijd vragen.

12. **Definition of Good Ecological Potential**: Hier moet het GEP beschreven worden, dat in lichte mate afwijkt van het MEP. Bij de bepaling van het GEP mag uitgegaan worden van de praktische uitvoerbaarheid van de mitigerende maatregelen. Daarnaast is aangegeven dat er gebruik gemaakt moet worden van een ecologische of statistische aanpak om het GEP te bepalen.

13. **Identification of basic and supplementary measures for achieving GEP**: Alle maatregelen die nodig zijn voor het GEP worden hier opgesomd. De maatregelen moeten ingedeeld worden in basis ane aanvullende maatregelen.

In onderstaande tabel staan de stappen voor de aanwijzing tot HMW, de benodigde activiteiten, het soort activiteit en de schatting van de benodigde tijd voor een gemiddeld waterlichaam. Een waterlichaam heeft een vergelijkbare hydromorfologie, vergelijkbare menselijke veranderingen en een vergelijkbaar management. Op basis daarvan wordt ervan uitgegaan dat de grootte van het waterlichaam geen grote invloed heeft op de benodigde tijd voor de aanwijzing, omdat het waterlichaam homogeen is en dus als één lichaam wordt beschreven. Bij dit gemiddelde waterlichaam wordt uitgegaan van er gegevens bestaan over de hydrologie, morfologie, ecologie. Er zijn voor het gemiddelde waterlichaam nog geen uitgebreide (model)onderzoeken en scenariostudies zijn uitgevoerd naar effecten van maatregelen en kosten. Wel kan de waterbeheerder gebruik maken van een gestandardiseerd handboek. In dit handboek staat per type water een overzicht van mogelijke maatregelen voor veel voorkomende hydromorfologische ingrepen, de negatieve effecten en mogelijke alternatieven en een lijst met kengetallen voor kosten van de alternatieven. Dit handboek voorkomt veel dubbel werk en uitgevonden wielen en zal de totale administratieve belasting verminderen. Bovendien kan er gebruik gemaakt worden van ecologische voorspellingsmodellen voor de voorspelling van maatregelen, MEP en GEP. Indien de modellen niet gebruikt kunnen worden, wordt expert judgement toegepast.

| Step in procedure | Activities | Type of activity | Estimated time needed for an average water body |
|---|---|---|---|
| 3. Description of changes in the hydromorphological characteristics resulting from the physical alterations | – Description of hydromorphology (probably part of ecological assessment)<br>– Describing relation with physical alteration | Expert-judgement and literature | 0,5 day |
| 5. Prediction of necessary hydromorphological changes and resulting measures to achieve Good Ecological Status | – Prediction of necessary hydromorphological changes to reach GES on the basis of expert-judgement or modelling<br>– Prediction of measures to achieve hydromorphological change | Expert-judgement or modelling | 0,5-10 days depending on the use of expert-judgement or modelling and on the available information |
| 6. Determination of impact of measures on water uses and significant adverse effects | – Description of impact of measures on water uses<br>– Determination of significance by giving relative quantitative numbers (% of loss) or describing the public importance of function (safety, drinking water) | - Expert-judgement<br>- Data collection<br>- Calculations | 0,5-2 days depending on how many values have to be collected and calculated |
| 7. Determination of impact on the wider environment | Describe negative impact on related waterbodies | Expert-judgement and literature | 0-2 hours depending if there is negative impact on related waterbodies |
| 8. Identification and definition of the beneficial objectives served by the modified characteristics of the water body | Description of objectives and functions of the hydromorphological changed waterbody:<br>– some objectives are described already by step 2 (Description of physical alterations resulting from the pressures and uses)<br>– some objectives came after the phyical alterations and are served by the modified characteristics | Expert-judgement and literature | 1-4 hours |
| 9. Determination of alternatives to the existing "water use" and their costs, technical feasibility and environmental effects in a wider context | - Determination of alternatives to the existing "water use: both alternatives for the use as mitigation measures to reduce the significant adverse effects<br>- Determination of the technical feasibility of the alternatives<br>- Determination of the costs of the alternatives | Expert-judgement<br>Literature<br>Data collection<br>Calculations<br>Standardised<br>Handbook on HMW | 1-10 days (or more) depending on:<br>– The number of alternatives<br>– The way the costs are determined, ranging from expert-judgement to quantitative costs analysis |
| 10. Designation of Heavily Modified Water Bodies | Designation of Heavily Modified Water Bodies on the basis of expert-judgement and information on the feasibility and costs of the alternatives | Expert-judgement | 0,5 day |
| 11. Determining Maximum Ecological Potential | * MEP is made of: Hydromorphological changes of HMW designation + measures being technical feasible and having no disproportionate costs + best practice mitigation measures + comparison with comparable water body<br>* Activities to be carried out are:<br>- Determination of the feasible | Expert-judgement<br>Literature<br>Data collection<br>Modelling | 1-5 days depending on the method used to find a comparable waterbody |

| | | | |
|---|---|---|---|
| | measures and the best practice mitigation measures<br>- Search for a comparable water body on the basis of a spatial reference or modelling or a combination of both. In case that is impossible expert-judgement may be used<br>- Desciption of MEP by the relevant biological parameters | | |
| 12. Definition of Good Ecological Potential | - GEP differs slightly from the MEP<br>- The practicability of measures may be used to determine GEP<br>- Use of ecological or statistical approaches or both to determine GEP | Expert-judgement<br>Literature<br>Data collection<br>Modelling | 0,5-2 days depending on approach used |
| 13. Identification of basic and supplementary measures for achieving GEP: | – Identification of measures to achieve GEP<br>– Classification of measures into basic or supplementary | Expert-judgement | 0,5-2 days depending on the number of measures |
| Total number of days | | | 6 days minimum<br>37 days maximum<br>15 days average |

Het totale aantal dagen van de eerste aanwijzing komt daarmee op minimaal 6 en maximaal 37 dagen voor een gemiddeld waterlichaam. Het gemiddelde aantal dagen wordt geschat op 15 dagen. Het lijkt echter onwaarschijnlijk dat de aanwijzing voor alle wateren individueel uitgevoerd zal gaan worden, er zullen gropen van waterlichamen met een vergelijkbare problematiek en vergelijkbare doelstelling onderscheiden worden, waarvoor de aanwijzing als groep uitgevoerd zal gaan worden. De deskundigen van het waterschap schatten in dat er ±20 groepen waterlichamen onderscheiden kunnen worden. Als het aantal groepen vermenigvuldigd wordt met de gemiddelde benodigde tijd voor een waterlichaam (15 dagen) dan komt de totale belasting voor de eerste aanwijzing van wateren als HMW voor een waterschap als Regge & Dinkel op 300 dagen of 1,3 manjaar (40 uur per week).

<u>Ad 2) Herziening HMW aanwijzing</u>

Voor ieder vervolg-stroomgebiedsplan (om de 6 jaar) moet de aanwijzing herzien worden. Dit is afhankelijk van:

- Wijzigingen in hydromorfologie als gevolg van de uitvoering van maatregelen. In dat geval moet stap 3 (Description of changes in the hydromorphological characteristics resulting from the physical alterations) aangepast worden. *Inschatting tijdsbesteding per beekwaterlichaam: 0,5 dag*

- Wijzigingen in de "beneficial objectives served by the modified characteristics of the water body". Zo is mogelijk dat de oorspronkelijk reden voor de fysieke veranderingen aan het waterlichaam verdwenen is (bijv. merendeel van landbouw is verdwenen uit gebied of rivier wordt niet meer voor scheepvaart gebruikt). Dat betekent dat de analyse van alternatieven, kosten en haalbaarheid zal veranderen.

- Wijzigingen ten aanzien van alternatieven voor de door de herstelmaatregelen negatief beïnvloede gebruiksfuncties en de kosten en technische haalbaarheid van de alternatieven. Na 6 jaar kunnen nieuwe alternatieven mogelijk zijn. Hiervan moeten de kosten en technische haalbaarheid beschreven worden. *Inschatting tijdsbesteding per beekwaterlichaam: 1-5 dagen*

- Als er nieuwe alternatieven zijn, de technische haalbaarheid is verbeterd, de kosten zijn veranderd of een andere inschatting van onevenredige kosten wordt gemaakt, dan kan de aanwijzing tot HMW veranderen:

  ⇒ Als het waterlichaam natuurlijk wordt dan is herziening van HMW aanwijzing niet meer nodig

  ⇒ Als het MEP moet worden aangepast omdat meer maatregelen haalbaar zijn, moeten stap 11 (MEP), 12 (GEP) en 13 (maatregelen) opnieuw uitgevoerd worden. *Inschatting tijdsbesteding per beekwaterlichaam: 1-5 dagen (minder dan eerste aanwijzing omdat hier alleen naar de opgetreden wijzigingen moet worden gekeken).*

De totale tijdsbesteding komt hiermee voor de herziening van de aanwijzing op 1 tot 10,5 dagen afhankelijk of het water natuurlijk wordt of MEP en GEP aangepast moeten worden. Gemiddeld zal de tijd voor de herziening van de aanwijzing 3 dagen zijn. Waarschijnlijk hoeft maar een aantal wateren herzien te worden en zal er voor veel wateren niets veranderen. Als er van uit wordt gegaan dat er wel binnen elke groep vergelijkbare waterlichamen een HMW water herzien moet worden dan komt de totale tijdsbesteding voor de herziening op 60 dagen, oftwel 0;25 manjaar (20 maal 3 dagen).

Ad 3) Monitoring

Ten aanzien van de monitoring van HMW wateren in vergelijking met de natuurlijke wateren wordt in Bijlage V, lid 1.3 het volgende gezegd:

Bijlage V, lid 1.3:

**Surveillance monitoring** programmes should provide information for:

- supplementing and validating the impact assessment procedure detailed in Annex II,
- the efficient and effective design of future monitoring programmes,
- the assessment of long-term changes in natural conditions, and
- the assessment of long-term changes resulting from widespread anthropogenic activity.

*Selection of monitoring points*

Surveillance monitoring shall be carried out of sufficient surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the river basin district. In selecting these bodies Member States shall ensure that, where appropriate, monitoring is carried out at points where:

- the rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2 500 $km^2$,
- significant bodies of water cross a Member State boundary,

Surveillance monitoring shall be carried out for each monitoring site for a period of one year during the period covered by a river basin management plan. Unless the previous surveillance monitoring exercise showed that the body concerned reached good status and there is no evidence from the review of impact of human activity in Annex II that the impacts on the body have changed. In these cases, surveillance monitoring shall be carried out once every three river basin management plans.

**Operational monitoring** shall be undertaken in order to:

- establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and
- assess any changes in the status of such bodies resulting from the programmes of measures.

The programme may be amended during the period of the river basin management plan in the light of information obtained as part of the requirements of Annex II or as part of this Annex, in particular to allow a reduction in frequency where an impact is found not to be significant or the relevant pressure is removed.

*Selection of monitoring sites:*
Operational monitoring shall be carried out for all those bodies of water which on the basis of either the impact assessment carried out in accordance with Annex II or surveillance monitoring are identified as being at risk of failing to meet their environmental objectives under Article 4 and for those bodies of water into which priority list substances are discharged. Monitoring points shall be selected for priority list substances as specified in the legislation laying down the relevant environmental quality standard. In all other cases, including for priority list substances, where no specific guidance is given in such legislation.

Monitoring points shall be selected as follows:
- for bodies at risk from significant point source pressures, sufficient monitoring points within each body in order to assess the magnitude and impact of the point source. Where a body is subject to a number of point source pressures monitoring points may be selected to assess the magnitude and impact of these pressures as a whole,
- for bodies at risk from significant diffuse source pressures, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the diffuse source pressures. The selection of bodies shall be made such that they are representative of the relative risks of the occurrence of the diffuse source pressures, and of the relative risks of the failure to achieve good surface water status,
- for bodies at risk from significant hydromorphological pressure, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the hydromorphological pressures. The selection of bodies shall be indicative of the overall impact of the hydromorphological pressure to which all the bodies are subject.

**Investigative monitoring**
Investigative monitoring shall be carried out:
- where the reason for any exceedances is unknown,
- where surveillance monitoring indicates that the objectives set out in Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives, or
- to ascertain the magnitude and impacts of accidental pollution, and shall inform the establishment of a programme of measures for the achievement of the environmental objectives and specific measures necessary to remedy the effects of accidental pollution.

**Frequency of monitoring:**
- For the **surveillance monitoring** period, the frequencies for monitoring parameters indicative of physico-chemical quality elements given below should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgement. For biological or hydromorphological quality elements monitoring shall be carried out at least once during the surveillance monitoring period.
- For **operational monitoring**, the frequency of monitoring required for any parameter shall be determined by Member States so as to provide sufficient data for a reliable assessment of the status of the relevant quality element. As a guideline, monitoring should take place at intervals not exceeding those shown in the table below unless greater intervals would be justified on the basis of technical knowledge and expert judgement. Frequencies shall be chosen so as to achieve an acceptable level of confidence and precision. Estimates of the confidence and precision attained by the monitoring system used shall be stated in the river basin management plan.

Het verschil tussen natuurlijk en HMW water ten aanzien van monitoring is:

- Dat voor natuurlijke wateren surveillance monitoring waarschijnlijk voldoende is, tenzij er kans bestaat dat de milieudoelstellingen niet gehaald worden
- Dat voor HMW wateren operationale nodig is, omdat de milieudoelstellingen (welke: GES of GEP?) waarschijnlijk niet gehaald worden en het effect van het maatregelenprogramma beoordeeld moet worden.

Het verschil tussen surveillance en operationale monitoring is dat:

- De frequentie van surveillance monitoring lager is voor hydrologische en biologische parameters dan van operationele monitoring. Voor de fysisch-chemische parameters is de frequentie hetzelfde. Voor surveillance monitoring moeten de hydromorfologische en biologische parameters tenminste om de 6 jaar en voor de operationele monitoring moet de biologie om de 6 maanden of om de 3 jaar (zie tabel) en de hydrologie continu of maandelijks gemeten worden.
- Het aantal meetlocaties wordt niet duidelijk beschreven, maar zal naar verwachting bij operationale monitoring groter zijn, omdat de selectie van meetpunten voldoende moet zijn om de omvang en het effect van de menselijke druk te beoordelen, terwijl de surveillance monitoring alleen voldoende moet zijn om de algemene toestand te beschrijven.

De verwachting is dat in Nederland er maar weinig wateren zijn, waarvan men zeker weet dat de milieudoelstellingen wel gehaald zullen worden (KLOPT DEZE AANNAME?) en dat dus voor de meeste wateren surveillance monitoring nodig zal zijn.

In onderstaande tabel staan de meetfrequenties voor de surveillance en operationele monitoring van fysisch-chemische parameters. Biologische en hydromorfologische parameters moeten bij surveillance monitoring ten minste een keer in de 6 jaar gemonitoord worden. Voor operationele monitoring gelden de onderstaande frequenties voor alle parameters als minimum. Ter vergelijking staan ook de huidige monitoring frequenties van het Waterschap Regge & Dinkel weergegeven. Hieruit blijkt dat ten aanzien van waterkwaliteit de minimum frequentie in de meeste wateren gehaald worden. Bij de biologische parameters wordt fytoplankton niet gemeten en vis alleen incidenteel en worden de minimumeisen voor macroinvertebraten niet overal gehaald. Dit zou betekenen dat de biologische parameters in de meeste wateren vaker gemonitoord moeten worden.

*Table representing the WFD requirements for rivers with regard to the minimum frequency of opertional monitoring.*

| **Parameter** | **WFD requirement for rivers** | **Monitoring Waterboard Hagmolenbeek** |
|---|---|---|
| **Biological** | | |
| Fytoplankton | 6 months | No measurements |
| Other aquatic flora | 3 year | 1 or 4 or 8 years depending on location |
| Macroinvertebrates | 3 year | 1 or 4 or 8 years depending on location |
| Fish | 3 year | Incidental |
| **Hydromorphological** | | |
| Continuity | 6 year | |
| Hydrology | Continuous | Only at certain locations |
| Morphology | 6 year | |
| **Physical-chemical** | | |
| Thermal conditions | 3 months | In most waters, not in all |
| Oxygenation | 3 months | In most waters, not in all |
| Salinity | 3 months | In most waters, not in all |
| Nutrient status | 3 months | In most waters, not in all |
| Acidification status | 3 months | In most waters, not in all |
| Other pollutants | 3 months | In most waters, not in all |
| Priority substances | 1 month | In most waters, not in all |

Samenvattend kan vastgesteld worden dat de administratieve belasting voor het waterschap als Regge & Dinkel geschat wordt op:

- 1,3 manjaar voor de eerste aanwijzing
- 0,25 manjaar voor de herziening van de aanwijzing bij ieder stroomgebiedsplan
- opvoeren van biologische monitoring van macroinvertebraten en waterflora in veel wateren van 4 of 8 jaarlijks naar driejaarlijks en starten met driejaarlijkse monitoring van fytoplankton en vissen.

Hierbij wordt de kanttekening gemaakt dat deze analyse een inschatting is gebaseerd op de ervaringen met de case-studie Hagmolenbeek. Ten aanzien van deze case-studie waren er veel gegevens beschikbaar. Bovendien waren de uitvoerders van deze studie ingewerkt in de Kaderrichtlijn en de aanwijzingsprocedure voor sterk veranderde wateren. Daarom wordt geschat dat de administratieve belasting voor de eerste aanwijzing van alle wateren in het beheersgebied voor een waterschap gemiddeld uit zal komen op 2 manjaar. Afhankelijk van hoeveelheid en complexiteit van de hydromorfologische ingrepen, het aantal alternatieven voor negatieve effecten op functies en de beschikbare informatie kan de bestede tijd hoger of lager zijn.

**Appendix E**

## Afmetingen Hagmolenbeek en hierin aanwezige kunstwerken

### Cross sections waterbody

| Distance from Twentekanaal (m) | Bottom level (m) | Bottom width (m) | Slope |
|---|---|---|---|
| 22 | 10,46 | 1,80 | 1:2 |
| 1034 | 11,35 | 1,80 | 1: |
| 1755 | 12,30 | 1,80 | 1:2 |
| 2985 | 13,40 | 1,80 | 1:2 |
| 3600 | 13,53 | 1,80 | 1:2 |
| 3743 | 14,70 | 1,80 | 1:2 |
| 4040 | 14,76 | 1,50 | 1:2 |
| 4961 | 15,09 | 1,50 | 1:2 |
| 5893 | 16,85 | 1,50 | 1:2 |
| 7557 | 19,30 | 3,00 | 1:1,5 |
| 7956 | 20,00 | 3,00 | 1:1,5 |
| 9308 | 21,36 | 3,00 | 1:1,5 |
| 10339 | 21,87 | 2,00 | 1:1,5 |
| 10870 | 23,08 | 1,70 | 1:1,5 |
| 11109 | 23,29 | 1,70 | 1:1,5 |
| 12396 | 25,31 | 1,70 | 1:1,5 |
| 12711 | 25,90 | 1,70 | 1:1,5 |
| 13179 | 26,95 | 1,70 | 1:1,5 |

### Weirs

| nr. | Distance from Twentekanaal (m) | Type | Crown height (m) | Crown width (m) |
|---|---|---|---|---|
| 101 | 20 | Spillway | 11,90 | 8,00 |
| 103 | 1034 | Spillway | 12,55 | 10,30 |
| 200 | 1755 | Spillway | 13,44 | 9,80 |
| 203 | 2985 | Spillway | 14,58 | 9,80 |
| 301 | 3743 | Spillway | 15,58 | 7,20 |
| 306 | 4040 | Spillway | 15,90 | 8,65 |
| 305 | 4961 | Spillway | 16,81 | 7,20 |
| 401 | 5893 | V-form | 17,84 | - |
| 403 | 6732 | V-form | 18,87 | - |
| 500 | 7557 | V-form | 20,00 | - |
| 501 | 7956 | V-form | 20,51 | - |
| 601 | 9308 | V-form | 22,20 | - |
| 607 | 10310 | V-form | 22,50 | - |
| 605 | 10870 | V-form | 23,43 | - |
| 708 | 11099 | V-form | 23,78 | - |
| 704 | 11693 | V-form | 25,20 | - |
| 705 | 12250 | V-form | 25,82 | - |
| 707 | 12711 | V-form | 26,66 | - |
| 802 | 13179 | V-form | 27,41 | - |

## Bijlage II: Afmetingen zomerbed (zoals opgenomen in het model)

### Cross sections summer bed

| Distance from Twentekanaal (m) | Floor level (m) | Floorwidth (m) | Depth (m) | Slope |
|---|---|---|---|---|
| 33 | 10,46 | 0,70 | 0,70 | 1:1,5 |
| 1551 | 11,35 | 0,70 | 0,70 | 1:1,5 |
| 2633 | 12,30 | 0,70 | 0,70 | 1:1,5 |
| 4478 | 13,40 | 0,60 | 0,60 | 1:1,5 |
| 5400 | 13,53 | 0,60 | 0,60 | 1:1,5 |
| 5615 | 14,70 | 0,60 | 0,60 | 1:1,5 |
| 6060 | 14,76 | 0,60 | 0,60 | 1:1,5 |
| 7442 | 15,09 | 0,60 | 0,60 | 1:1,5 |
| 8840 | 16,85 | 0,35 | 0,35 | 1:1,5 |
| 11336 | 19,30 | 0,35 | 0,35 | 1:1,5 |
| 11934 | 20,00 | 0,35 | 0,35 | 1:1,5 |
| 13962 | 21,36 | 0,35 | 0,35 | 1:1,5 |
| 15509 | 21,87 | 0,35 | 0,35 | 1:1,5 |
| 16305 | 23,08 | 0,35 | 0,35 | 1:1,5 |
| 16664 | 23,29 | 0,35 | 0,35 | 1:1,5 |
| 18594 | 25,31 | 0,35 | 0,35 | 1:1,5 |
| 19067 | 25,90 | 0,35 | 0,35 | 1:1,5 |
| 19769 | 26,95 | 0,35 | 0,35 | 1:1,5 |