A RAND NOTE

Policy Analysis of Water Management for the Netherlands

Vol. VIII, Assessment of Impacts on Industrial Firms

J. P. Stucker, P. J. A. Baan, W. A. Dorsman

February 1982

N-1500/8-NETH

Prepared for

The Netherlands Rijkswaterstaat

Rand
SANTA MONICA, CA. 90406

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PREFACE

For some time the Netherlands has had a problem with water quality, particularly salinity, eutrophication, and thermal pollution. Moreover, the future demand for fresh water is expected to exceed the supply. The growing demand for the limited supply of groundwater (GW) is leading to increased competition among its users: agriculture, industry, nature preserves, and companies that supply drinking water (DW). The supply of surface water (SW) is sufficient except in dry years, when there is competition not only among such users as agriculture, power plants, and shipping, but also among different regions.

Facing such water management problems, the Dutch government wanted an analysis to help draft the first national water management law and to select the overall water management policy for the Netherlands. It established the Policy Analysis for the Water Management of the Netherlands (PAWN) Project in August 1976 as a joint research project of Rand (a nonprofit corporation),[1] the Rijkswaterstaat (the government agency responsible for water control and public works),[2] and the Delft Hydraulics Laboratory (a leading Dutch research organization).[3]

The primary tasks of the PAWN project were to:

1. Develop a methodology for assessing the multiple consequences of water management policies.
2. Apply it to develop alternative water management policies[4] for the Netherlands and to assess and compare their consequences.
3. Create a Dutch capability for further such analyses by training Dutch analysts and by documenting and transferring methodology developed at Rand to the Netherlands.

The methodology and results of the PAWN project are described in a series of publications entitled Policy Analysis of Water Management for the Netherlands. The series contains the following volumes:

- Volume I, Summary Report (Rand R-2500/1)
- Volume II, Screening of Technical and Managerial Tactics (Rand N-1500/2)
- Volume III, Screening of Eutrophication Control Tactics (Rand N-1500/3)
- Volume IV, Design of Long-Run Pricing and Regulation Strategies (Rand N-1500/4)
- Volume V, Design of Managerial Strategies (Rand N-1500/5)
- Volume VA, Methodological Appendixes to Vol. V (Rand N-1500/5A)
- Volume VI, Design of Eutrophication Control Strategies (Rand N-1500/6)

- Volume VII, Assessment of Impacts on Drinking-Water Companies and Their Customers (Rand N-1500/7)
- Volume VIII, Assessment of Impacts on Industrial Firms (Rand N-1500/8)
- Volume IX, Assessment of Impacts on Shipping and Lock Operation (Rand N-1500/9)
- Volume X, Distribution of Monetary Benefits and Costs (Rand N-1500/10)
- Volume XI, Water Distribution Model (Rand N-1500/11)
- Volume XII, Model for Regional Hydrology, Agricultural Water Demands and Damages from Drought and Salinity (Rand N-1500/12)
- Volume XIII, Models for Sprinkler Irrigation System Design, Cost, and Operation (Rand N-1500/13)
- Volume XIV, Optimal Distribution of Agricultural Irrigation Systems (Rand N-1500/14)
- Volume XV, Electric Power Reallocation and Cost Model (Rand N-1500/15)
- Volume XVI, Costs for Infrastructure Tactics (Rand N-1500/16)
- Volume XVII, Flood Safety Model for the IJssel Lakes (Rand N-1500/17)
- Volume XVIII, Sedimentation and Dredging Cost Models (Rand N-1500/18)
- Volume XIX, Models for Salt Intrusion in the Rhine Delta (Rand N-1500/19)
- Volume XX, Industry Response Simulation Model (Rand N-1500/20)

Four comments about this series of publications seem appropriate. First, the series represents a joint Rand/Rijkswaterstaat/Delft Hydraulics Laboratory research effort. Whereas only some of the volumes list Dutch coauthors, all have Dutch contributors, as can be seen from the acknowledgments pages.

Second, except where noted, these publications describe the methodology and results presented at the final PAWN briefing at Delft on December 11 and 12, 1979. For Rand, this briefing marked the beginning of the documentation phase of the project and the end of the analysis phase. Rand and the Rijkswaterstaat (RWS) considered the results to be tentative because (1) some of the methodology had not become available until late in the analysis phase, and (2) the RWS planned to do additional analysis.

Third, the RWS is preparing its Nota Waterhuishouding, the new policy document on water management scheduled for publication in 1982, by combining some of the PAWN results from December 1979 with the results of considerable additional analysis done in the Netherlands with the PAWN methodology. Because the understanding gained in the original analysis led to improvements in the data--and, in some instances, the models--used to represent the water management system in the additional analysis, the reader is hereby cautioned that the numerical results and conclusions presented in the PAWN volumes will not always agree with those presented in the Nota Waterhuishouding or its companion reports. (It has not been possible to indicate such differences in the volumes since they are being written before the Nota is published.) Thus, the present series of publications puts primary emphasis on documenting the methodology rather than on describing the policy results.

Fourth, Vols. II through XX are not intended to stand alone, and should be read in conjunction with the Summary Report (Vol. I), which contains most of the contextual and evaluative material.

The present volume, Vol. VIII in the PAWN series, describes the impacts of water-management tactics on industrial firms. It contains summary documentation of the Industry Response Simulation Model (IRSM) (documented fully in Vol. XX) and explains the several applications of that model. The impacts on Dutch firms, their customers, and their competitors that would be induced by the set of primary PAWN cases are analyzed, as are cases designed to show the effects of major policy actions, such as changes in pricing rules. In particular, this volume analyzes the water-use and cost implications of the imposition of a hypothetical tax, ranging from 0.05 to 1.00 Dfl/m^3, on the GW extractions of industrial firms.

This volume should interest several different audiences. Analysts and policymakers for the water-management system of the Netherlands should find the chapters on results and implications helpful to their understanding of the range of probable effects from the major policy options facing their nation. Industry analysts should find those chapters, plus the chapter on methodology, helpful in understanding the special needs and problems of the industrial sector. Finally, the general methodologies employed here, as well as in other areas of the PAWN study, should interest students of policy analysis and those concerned with the evaluation of benefits arising from public investments and regulations.

NOTES

1. Rand had had extensive experience with similar kinds of analysis and had been working with the Rijkswaterstaat for several years on other problems.
2. The Rand contract was officially with the Rijkswaterstaat, Directie Waterhuishouding en Waterbeweging (Directorate for Water Management and Water Movement), but numerous other parts of the Rijkswaterstaat contributed to the analysis.
3. Delft Hydraulics Laboratory research was performed under project number R1230, sponsored by the Netherlands Rijkswaterstaat.
4. Each water management policy involved a mix of tactics, each a particular action to affect water management, such as building a particular canal or taxing a particular use. Four kinds of tactics were considered: building new water management facilities (infrastructure) or applying various treatments to the water (called technical tactics); using managerial measures (called

managerial tactics) to change the distribution of water among competing regions and users; and imposing taxes or quotas to affect the quantity or quality of water extracted or discharged by different users (called _price and regulation tactics_, respectively). A mix of tactics of the same kind is called a _strategy_. Thus, the overall policy could be conceived as a combination of technical, managerial, pricing, and regulation strategies.

SUMMARY

This volume in the PAWN series documents the impacts on industrial firms in the Netherlands that we expect would be brought about by the imposition of a set of proposed water-management policies. It describes the structure, data requirements, and major assumptions behind the computer models used to calculate the efficient distribution of GW and DW by simulating the water use of industrial firms. Then it analyzes the possible responses of Dutch industrial firms to changes in the availability or intake costs of GW, estimates the cost and water-use mix of their least-cost responses, and predicts how the European markets for industrial goods will allocate those resulting costs (and benefits) among the impacted firms, their competitors, and their customers. It finds that firms can respond in many ways to changes in their GW intake environment; that some responses cost considerably less than others; that little of the cost can be passed on to consumers, but that the government will pick up about one-third of it; and that the gross cost increases (including the government's share) approximate rather closely the industrial sector's contribution to the policies' total effects on the net economic welfare of the Netherlands.

ACKNOWLEDGMENTS

Many people from many institutions and firms contributed to this study. We can mention only a few of them here. During the first two years of the PAWN study, D. M. de Ferranti (of Rand), A. van Gameren (of the Delft Hydraulics Laboratory), and F. J. P. Heuer (of the Rijkswaterstaat) played important roles in identifying issues concerning industrial water use, structuring our first analyses, and initiating contacts with governmental agencies and industrial firms. S. C. Abraham, J. H. Bigelow, B. F. Goeller, and J. C. de Haven (all of Rand) supplied ideas throughout the study and helped to keep us in tune with the other parts of the PAWN study. F. Camm served as the formal Rand reviewer and provided many constructive suggestions for improving this volume.

The Rijksinstituut voor Drinkwatervoorziening contributed significantly to this study by drawing upon its experience in forecasting the sectoral breakdown of industrial water use. It also provided its REGWAT system for our use. The Rijksinstituut voor Zuivering van Afvalwater gave us technical information. Some regional divisions of the Rijkswaterstaat assisted us in contacting firms. Provincial authorities supplied data about industrial GW withdrawals. Representatives of the Ministry of Economic Affairs and the Ministry of Agriculture and Fisheries provided information on sectoral sales and price projections.

We are indebted greatly to the Verbond van Nederlandse Ondernemingen and its Bureau Milieuhygiene for providing general information and especially for introducing us to a large number of industrial firms. The information supplied by those firms provided the foundation for our analyses and findings.

Of course, the above-mentioned people and institutions cannot be held responsible for any shortcomings or mistakes in our analysis.

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GLOSSARY

BTW	Belasting over toegevoegde waarde (valued-added tax)
CBS	Central Bureau for Statistics
CPB	Central Planning Bureau of the Netherlands
Dfl	Dutch florin (guilder)
Dflm	Millions of Dutch florins
DHL	Delft Hydraulics Laboratory
DVK	Dienst Verkeerskunde, the shipping branch of the RWS
DW	Drinking water
DW companies	Firms that produce and distribute high-quality water
EEC	European Economic Community, the common market
GW	Groundwater
IRSM	PAWN's Industrial Response Simulation Model
MAXTACS	The set of nine dominant promising technical and managerial tactics presented at the final PAWN briefing
MSDM	PAWN's Managerial Strategy Design Model
m^3	Cubic meter (usually of water)
mcm	Million cubic meters (usually of water)
RESDM	PAWN's Response Design Model
RID	Rijksinstituut voor Drinkwatervoorziening, the Netherlands Institute for Drinking Water Supply
RIN	Rijksinstituut voor Natuurbeheer, the Netherlands Institute for the Management of Nature
RIZA	Rijksinstituut Voor Zuivering von Afvalwater, the Netherlands Pollution-Control Institute
RWS	Rijkswaterstaat, the Netherlands governmental agency for water control and public works
SW	Surface water: found in rivers, lakes, and canals
VNO	Verbond van Nederlandse Ondernemingen, the Netherlands Employers Association
yr	year

Chapter 1

INTRODUCTION AND SUMMARY

In this volume we analyze the possible responses of Dutch industrial firms to changes in the availability or the intake costs of GW, estimate the cost and water-use mix of their least-cost responses, and predict how the European markets for industrial goods will allocate those resulting costs (and benefits) among the impacted firms, their competitors, and their customers.

Sponsored by the Rijkswaterstaat of the Netherlands (RWS), our study investigates the impacts of water-management policies currently under consideration within that bureau. Later RWS must document the policies with the most favorable profiles in a "Nota Waterhuishouding" and propose specific projects to the Dutch Parliament. This volume documents the impacts of policies on industrial firms and the customers of those firms. It provides primary data, analyses, and conclusions for the Nota, and backup documentation for the parliamentary presentations.

We find that firms can respond in many ways to changes in their GW-intake environment; that some responses cost considerably less than others; that little of the cost can be passed on to consumers, but that the government will pick up about one-third of it; and that the gross cost increases (including the government's share) approximate rather closely the industrial sector's contribution to the full effect of the policies on the net economic welfare of the Netherlands.

1.1. OBJECTIVE, APPROACH, AND FINDINGS

The objective of industry impact assessment is to estimate the changes in the costs to and the water-use patterns of industrial firms when GW charges or quotas are imposed on those firms or on companies that produce and distribute DW, or when farmers are given priority for GW. We also estimate the distribution of those costs among producers and consumers and the net welfare burden imposed on the Netherlands.

Our primary tool of analysis is the Industry Response Simulation Model (IRSM is described in Chap. 2). IRSM simulates the behavior of individual firms as they seek out the least-cost options for water use in response to changes in the price of DW or the imposition of a tax on GW. Usually both the DW prices and the GW taxes selected as inputs to IRSM are the marginal costs of DW and the shadow prices of GW, respectively--output from PAWN's Response Design Model (RESDM). RESDM (which is documented in Vol. IV) jointly optimizes the GW and DW use of industrial firms and DW companies. IRSM computations then, when they are based on RESDM inputs, reflect water-use patterns and costs corresponding not to the current situation in the Netherlands, but to a situation where water is allocated efficiently to its most highly valued uses.

IRSM thus translates shadow prices into quotas for individual firms, quotas that could be used by the government to allocate GW among the industrial firms in an economically efficient manner.

The IRSM analyses of the impacts of water-management policies on the industrial sector of the Dutch economy assume that industrial output does not change. Changes in water costs, quality, and availability cause adjustments only in the water use of firms. Firms may switch to alternative water sources (or types) or they may reduce their total water-use requirements by either recirculating or altering their cooling processes.

All those changes cost money. They increase production costs for industrial goods, and these increased costs will increase product prices, lower profits, or both. Increased product prices reduce the welfare of households (and other firms) that purchase the products and increase the competitive position of competing firms and products, both Dutch and foreign.

We estimate the price changes for industrial products and the distribution of costs among producers and consumers, domestic and foreign, using benefit-estimating techniques common throughout PAWN. Those techniques are summarized in App. B and fully documented in Vol. X. Assumptions specific to the industrial sector include the existence of an EEC-wide market for all industrial goods and the lack of effective price regulations for those goods. In markets that conform with the assumptions, our benefit measures (which are based on first-order effects only and ignore output changes) capture over 95 percent of the total potential effects.

The general findings of this study are of three types: (a) the direct water-use and cost impacts of water-management policies on industrial firms; (2) the broad effects of general types of public policies; and (3) the specific impacts of one particular policy. Concerning the impacts of water-management policies on firms, we find:

- When GW quotas or taxes are imposed, industrial firms have many options, several of which appear to be quite effective, at least initially. For example, oftentimes simple recirculation techniques can substantially lower water-intake requirements at low cost.
- Nevertheless, the cost to industrial firms will increase, perhaps substantially, if the supply of GW is reduced, if GW priority is shifted to agriculture, if GW extraction fees are imposed, or if the demand for GW increases in the future.
- DW is not an economical substitute for GW when its full opportunity costs are taken into account; nor is surface water (SW) in most cases because of its poor quality.

On the broader issues of public policy associated with water use, we find:

- Basing DW prices on marginal costs rather than the current method of average-cost pricing would increase costs for the firms, but would increase the overall efficiency of water use and lower nationwide water costs. The effects would be slight now, but increase in the future when the value of water increases.
- Restricting GW extractions severely in order to raise GW levels and preserve scarce water sources for future use (or to otherwise benefit the current or future environment of the Netherlands) would impose rather high costs on industrial (and other) GW users; perhaps as much as 0.50 Dfl for each m^3 of GW conserved each year.
- Most cost increases caused by water-management policies will generate small but noticeable price increases. We estimate that less than 10 percent of the cost increases will be passed on to consumers. Small price increases also insure that competing producers (including those in neighboring countries) will receive only minor benefits.
- The cost impacts of water-management tactics on industrial firms, minus any GW taxes paid to the government, provide good estimates of the net Dutch welfare loss caused by those tactics.

And on the specific issue of imposing a nationwide tax on industrial extractions of GW, we find:

- Given the current situation, we estimate that a 20 cent tax on industrial extractions of GW, as has been proposed for the Netherlands, would reduce industrial use of GW by about 100 mcm/yr, and would increase the water-intake costs of firms by about 50 Dflm/yr.

1.2. PLACE WITHIN PAWN

This volume, documenting the effects of water-management tactics on industrial firms, is one of four PAWN volumes dealing with impact assessment. Volumes VII and IX cover the same ground for DW companies and shipping, respectively. Volume X contains the general PAWN methodology for evaluating benefits and costs, summarizes the impacts arising in the various individual sectors, and traces the resulting benefits and costs into the budgets of representative Dutch families.

This volume draws heavily on three PAWN volumes: Vol. IV, which documents the design of long-run pricing and regulation tactics, documents the RESDM model, and much of the general scenario detail for impact assessment; Vol. X, which develops the general evaluative procedures; and Vol. XX, which contains the primary documentation of the computer model used for industry impact assessment.

This volume is not intended to stand alone. It should be read in conjunction with Vol. I, with the other volumes cited above being consulted when more detail is desired.

1.3. OUTLINE OF THE VOLUME

The remainder of this volume contains three chapters and two appendixes. Chapter 2 discusses the methodology we employed in estimating the impacts of national GW and DW policies on industrial firms. It draws heavily on Vol. XX which documents the structure, limitations, and uses of IRSM. Chapter 2 contains only a summary of the construction of the model, the major input assumptions, the options available to firms in the different sectors for reducing their GW intake and their overall water-intake costs, and the cost-minimizing solution algorithm. Readers seeking more detailed information should consult Vol. XX.

Chapter 3 presents and discusses the findings of this study as they relate to Dutch industrial firms experiencing the initial impacts of water-management tactics. This chapter also documents the industrial aspects of the principal PAWN-wide analysis cases. Those cases are extensively discussed in Vol. I. Here we present them in the context of our general investigation into the behavior of industrial firms. The final chapter, Chapter 4, discusses the subsequent distribution of water-intake costs among the firms, their competitors, and their customers. Chapter 4 also investigates the effects of the proposed 0.20 Dfl/m^3 GW-extraction tax.

Supplemental tables and data are contained in Appendix A. Appendix B contains a summary of the benefit-estimating formulas we use in analyzing the industrial sector.

Chapter 2

METHODOLOGY AND SCENARIOS

Industry impact assessment covers:

- The effects of GW taxes and restrictions on the amount of GW, DW, and SW used by firms, and on their total water-intake (and use) costs.
- The effects of changes in DW prices on such cost and usage patterns.
- The sharing of those costs (or benefits) by the firms that are directly affected by the changes, their competitors, and their customers.

Because of lack of systematic data we could not model changes in the quality of the intake water of firms or of regulations concerning their water discharges. Nor did we look at the impacts of possible changes in the availability or extraction costs of SW.

This chapter documents our procedures for estimating the impacts of water-management tactics on industrial firms. It describes our industry models and the scenarios in which they were used. The subsequent distribution of the impacts is analyzed in Chapter 4.

First we give some context for the analyses. Section 2.1 addresses the question of "Why study industries?"; it summarizes the recent aggregate water-use patterns of industrial firms and identifies the sectors of importance. Section 2.2 discusses our primary industry model, IRSM (fully documented in Vol. XX), which we use to simulate the cost-minimizing behavior of individual industrial firms. In Sec. 2.3 we say a little about the applications of IRSM and the relations between our modeling procedures and the actual organization of industrial activity and water distibution in the Netherlands. Section 2.4 shows the values of the major policy and context variables used in our impact-assessment cases.

2.1. CURRENT INDUSTRIAL USE OF WATER

Industrial firms withdraw a large share of the Netherlands water and use significant amounts of all three major types. They use water for drinking purposes, food preparation, and toilet disposal, as well as for cooling and processing purposes. Policies affecting the availability or cost of water will cause many of these firms to alter their water-use practices and perhaps their pricing and profit policies.

Table 2.1 contains rough estimates of water consumption in 1976 by major user groups. Power plants are by far the largest users of SW. Industrial firms also consume a lot of SW, most of which is brackish. In addition, industrial firms take in a lot of GW, since over two-thirds of the DW they consume is probably manufactured from GW.

Table 2.1

PRINCIPAL USES OF WATER IN THE NETHERLANDS: 1976

	Intake, by Sector (mcm/yr of fresh water)		
Demand Sector	Surface Water	Ground-water	Drinking Water
DW companies	400	700	100
Households and Commercial firms	-	50	800
Industrial firms	3,000	350	200
Power plants	8,600	-	-
Shipping	-	-	-
Totals	12,000	1,100	1,100

SOURCE: Statistiek van de watervoorziening in Nederland 1976, Centraal bureau voor de statistiek, Table 2.

NOTE: A "-" represents an unknown but probably quite small quantity of water. SW estimates include brackish as well as fresh water, but not seawater.

More detail on the use of water by industrial firms is given in Table 2.2. There we disaggregate industry into seven groupings or "sectors" and distinguish between fresh and nonfresh water. Nonfresh water includes brackish SW and GW. Seawater is not included.

Chemical and petroleum plants (oil refineries) use the most water, both individually and collectively. Most of that water is SW, however, and much of it is brackish and taken directly from the mouths of rivers emptying into the North Sea. Firms in the basic metal sectors, principally steel and aluminum, also require very large amounts of water. These firms depend primarily on seawater, which is not in the table, although Hoogovens withdraws a significant amount of fresh SW from the Amsterdam-Rijnkanaal.

The other sectors we have listed all consume significant quantities of SW, GW, and DW, although none approaches the amounts taken in by the chemical and petroleum firms. The paper producers and processors require significant amounts of water, much of it of special quality. Most of this demand is met by taking in fresh GW. They use SW only if the available source is of constant and rather good quality.

Table 2.2

ESTIMATES OF THE COMPOSITION OF WATER WITHDRAWALS
BY INDUSTRIAL FIRMS: BY SECTOR, 1976

	Intake, by Sector and Type (mcm/yr)				
		Groundwater			
Sector	Surface Water	Fresh	Other	Drinking Water	Total Water
Mining	-	10	-	-	10
Food and luxuries	100	160	30	30	320
Textiles	10	10	-	10	30
Leather and rubber	10	20	-	-	30
Paper	100	60	-	10	170
Chemicals	1,550	60	20	50	1,680
Refineries	1,100	-	-	30	1,130
Building materials	10	10	-	-	20
Metal products	10	20	-	30	60
Basic metals	80	10	20	10	120
Other	-	-	-	10	10
Total industry	2,970	360	70	180	3,580

SOURCE: Statistiek van de watervoorziening in Nederland 1976, Centraal bureau voor de statistiek, Table 6.

NOTE: A "-" represents an unknown but probably quite small quantity of water. SW estimates include brackish as well as fresh water, but not seawater.

Other firms may also have special water needs. The food processing firms require high-quality water as much of what they use comes in contact with items produced for human consumption. Metal product firms are small and decentralized, often located where they are dependent on GW or DW, although most of their needs could be met with lower quality SW. The textile firms are concentrated in Overijssel and Noord-Brabant and they have no special quality requirements.

The costs associated with acquiring water and purifying or demineralizing it (if that is required, either because the water is of low quality or because it is to be used in special technical processes or for human consumption) also differ significantly among firms. Though SW involves minor pumping costs, it is often available at the firm's doorstep, which means there are no transport costs, and when it is used for cooling, it requires no treatment or special processing. Some firms, however, need the high quality water available only from DW companies, which is quite expensive. And some firms require even higher quality water, water that they have to process completely themselves or DW that they are able to use with some additional treatment.

Water-intake costs differ among firms because of differences in the price of water, differences in transport costs, differences in treatment costs, and differences in the amount of water used as well as differences in the way the water is used. Those differences result in the water-intake costs shown in Table 2.3. Water costs for the different sectors range from 8 to 100 Dflm/yr (in 1976 guilders). Expressed as a percent of total sectoral costs, they range from 0.1 to 0.5 percent.

Table 2.3

ESTIMATES OF 1976 WATER-INTAKE COSTS
FOR INDUSTRIAL FIRMS: BY SECTOR

		Water-Intake Cost	
Industrial Sector	Cooling Water as Percent of Total Water Use (%)	Annual Cost (Dflm/yr)	Relative to Sales (%)
Food and luxuries	69	50	0.1
Textiles	13	10	0.2
Paper	56	20	0.4
Chemicals	94	100	0.5
Refineries	98	60	0.4
Basic metals	85	20	0.3
Metal products	52	30	0.1
Other	57	20	0.1
Average	89	310	0.2

SOURCE: Estimates of the PAWN team.

NOTES: Full water-related costs, including treatment and discharge costs, may be 2 to 5 times the amounts shown in this table. Cost computations assume intake costs of 0.03 Dfl/mcm for SW (except 0.30 Dflm/mcm for 30 mcm of semi-treated water for the basic metals industry), 0.10 Dflm/mcm for GW, and 1.00 Dflm/mcm for DW.

Current water-intake costs are typically a small percentage of total costs, but for some individual firms the percentages may be much larger than the averages shown here. And, even when the percentage is low, they can still represent large amounts of money.

Each of the sectors identified in these tables differs from the others in its water-use patterns, and each requires separate attention as we estimate the impacts of water-management tactics on the firms.

2.2. MODELING WATER DEMAND AND USE

Our industry models resulted from a three-step procedure. First, we gathered as much information as possible. We searched public data files; we talked with many government agencies, including the Drinking Water Institute (RID), the Pollution-Control Institute (RIZA), the Ministry of Economic Affairs, and a number of provincial authorities; and we met with many individual firms as well as the Employers Association, VNO.

Second, we developed a computer model that simulates the effect on industrial firms of available alternatives to the use of GW. We started by describing the general alternatives available to firms in all sectors, including all of the costs and effects of those alternatives. Then we specified particular alternatives that were only appropriate for certain sectors, or certain sizes of firms. Much of this step was actually completed before step 1 was finished. We completed the "standard" version of IRSM early in the project; the "modified" version was constructed after the industry visits were completed.

Finally, we used the computer model to estimate the responses of firms to water-management policies affecting the prices and the availability of water. We assumed that the firms always selected the cheapest alternative available to them. The model aggregated the water-use and cost impacts of individual firms into sector and province totals. These steps are described below; the output of the computer runs is discussed in Chap. 3.

2.2.1. Contacts with Firms

Our first step was to identify the relevant sectors of the economy to be studied. The important GW-using sectors were identified using CBS statistics (at that time, the 1972 data) and information from RID. Later we received data on the GW extractions of individual firms from the provincial governments. At that later date, those individual data were used to seek out the largest GW-withdrawing firms for personal contacts. Most of those contacts, however, were made after the standard version of IRSM was completed. Table 2.4 shows the most important GW-using sectors and the number of GW-withdrawing firms in each.

Those sources also identified the largest individual withdrawers in each sector and in each province. During the study we contacted as many of the major withdrawers as possible. We were able to meet with over 40 of the largest. Their combined withdrawals covered at least 30 percent of all industrial GW withdrawals in each province. These contacts were coordinated with VNO, RID, RIZA, the Ministries of Economic Affairs and of Agriculture and Fisheries, and the various divisions of RWS.

Table 2.4

SECTORS OF THE ECONOMY IMPORTANT FOR PAWN ANALYSES

Sector	Percent of Fresh GW	Number of Withdrawers
Food	50	520
Chemicals	16	100
Paper	15	40
Metal products	8	150
Basic metals	3	25
Textiles	3	60
Other	5	220
Total	100	1,115

SOURCE: PAWN analyses of data from CBS and RID.

2.2.2. The Industry Response Simulation Model

IRSM estimates the responses of firms to changes in GW availability and cost under various scenarios for DW prices. It can be used alone to estimate the effects of a GW tax, or it can be used in conjunction with RESDM (PAWN's Response Design Model described in Vol. IV) or RIDDWM (the DW Model we borrowed from RID that is documented in Vol. VII) to estimate the effects of a GW quota. The latter two models produce "shadow prices" for GW which are associated with the desired GW intakes for the firms and DW companies in each district. We then input those shadow prices to IRSM as the GW tax. When using IRSM alone, we specify taxes independently, and directly input them to IRSM.

We modeled the alternatives available to firms using GW in two steps. First we described the general alternatives for all firms, attempting to include all possible effects and their costs. Then we restricted the alternatives by specifying the ones that were not appropriate for particular industrial sectors (or firms).

Our major assumption is that firms always select the cheapest available alternative.

Figure 2.1 gives an overview of IRSM, showing the major inputs, outputs, and workings of the model.

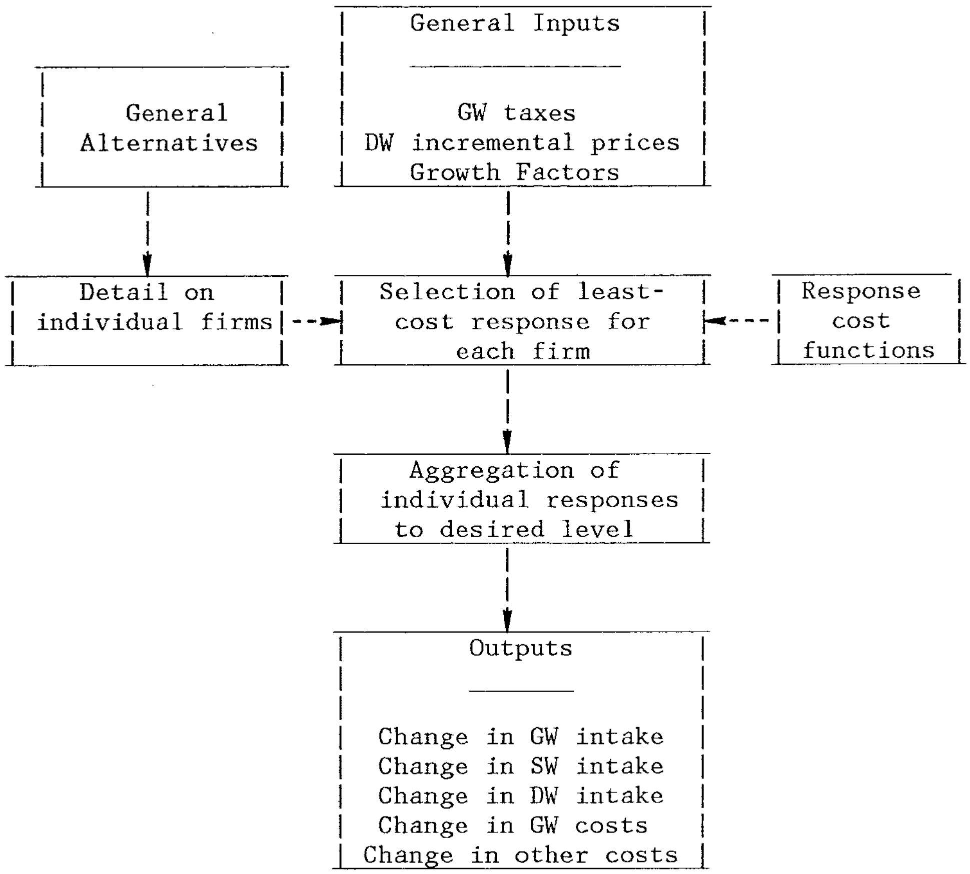

Figure 2.1--Overview of IRSM

IRSM aggregates impacts by industry sector and PAWN district, province, or pseudo-province. It outputs information on changes in the use of DW, GW and SW, and on several categories of costs. The initial or standard version of IRSM was constructed before all contacts with firms had taken place. After completing those contacts, we developed a modified version that is less optimistic in estimating low-cost options available to firms. It generally forecasts less GW intake reductions and higher industry costs.

We believe IRSM is reasonably accurate for GW taxes of up to about 1.00 Dfl/m^3. Taxes above that level would probably induce technology and production changes that are not foreseen in IRSM. Consequently, some IRSM estimates reported in Chapter 3, especially those where GW extractions are severely limited, may contain costs that are significantly overestimated.

2.2.2.1. Inputs to the Model. IRSM requires a large quantity of input data, and many assumptions concerning structural parameters must be specified. The major data sources are documented below.

Information on GW extractions and the percentage used for cooling purposes and for process purposes came from confidential data on individual firms we obtained from the provincial governments.

RID data provided the breakdown of the firms into classes that are roughly equivalent to the SIC (Standard Industrial Classification) classes used in the United States.

Two of the most important assumptions concerning the model are (1) that most cooling water is at present used "once through," and (2) that process water quantity cannot be reduced (only the source can be changed). The first assumption defines the opportunities for recirculating cooling water. It is a liberal assumption. The second restricts the scope of the model. It is a conservative assumption regarding possible water savings. Both assumptions are generally supported by the information we have accumulated. Exceptions based on particular information obtained from individual firms are discussed later.

We independently estimated the distance from each firm to the nearest source of SW.

We assumed that large firms in the basic metals, chemicals, and paper sectors were in operation 24 hours a day. All other firms worked only 8 hours each day.

Information on current and recent DW prices by DW company and by tariff class was obtained from a publication by Krachtwerktuigen (Ref. 2.1). RESDM or RIDDWM estimated changes in DW production costs by province in response to the PAWN tactics and scenarios.

Changes in DW costs caused by changes in industry demand or by changes in the availability of GW were estimated using RIDDWM or RESDM.

We assumed (in the standard version of IRSM) that all GW selected for process use must be pretreated. And we assumed that, in general, low temperature cooling water is not required.

We assumed that the growth of GW intake by each sector is the same as was estimated for RESDM. See Vol. IV for details.

And finally, we went along with the other areas of the PAWN study and assumed that each PAWN district is assigned to one, and only one, province. As many of the PAWN districts are composed of land located in two (or perhaps even more) actual provinces, this aggregation rule resulted in the creation of "pseudo-provinces" that do not exactly correspond with the actual provinces but are quite close. Almost all of the results presented in this report that are on less than the national level are by pseudo-province.

2.2.2.2. Alternatives to GW Use. Firms use GW for cooling and in their productive processes. Our model assumes that firms can use SW or DW for cooling in place of GW, or they can recirculate. To save process GW, we assume (in the standard IRSM) they can switch to SW or DW or they can reuse cooling water for process.

Further assumptions are that (1) paper and food firms cannot use SW because the quality is too low; and (2) that basic metal and metal product firms that currently do not use SW cannot obtain SW because of access problems--they are located in urban areas.

For each of these options, we developed cost-estimating equations. For example, the SW option cost relationship specifies SW withdrawal costs as a function of withdrawal capacity and the distance from the firm to the SW source. These cost relationships form an integral part of IRSM.

2.2.2.3. The Modified Version of IRSM. We programmed the standard version of IRSM and made a number of production runs while our contacts with firms were still under way. Extensive talks with industry representatives and officials of individual firms informed us that further use of cooling water in process is hardly possible and that low temperature cooling is needed in many sectors. Those contacts convinced us of the need to modify the basic model since we had constructed the standard version of IRSM on opposite assumptions.

In the modified version we assumed that:

- There is no further option to use cooling water for process.
- Low-temperature cooling water is needed in 75 percent of the food sector and in 50 percent of the chemical and "other" sectors.
- Paper firms, except those located in Gelderland, can use SW as they desire.

We also used specific information for several large firms. Estimates for these firms were computed separately from IRSM, and then aggregated with the model output in a post-processing step.

The modified IRSM model aggregates only to the actual province level; it does not produce estimates for pseudo-provinces. Comparisons with standard IRSM are possible, however; and the national totals are strictly comparable.

2.2.3. Additional Required Calculations

IRSM estimates the direct cost changes induced by changes in water management policies, but it does not compute the full cost effects of those policies. It ignores some DW costs. IRSM estimates costs only for the DW that replaces GW. But many of the water-management policies we investigate induce changes in the price of all DW. To estimate full DW costs to firms in those cases we must apply any change in the DW price to all of the DW consumed by the firms.

Information on basic industrial DW demand is available by sector and province from CBS, but cannot be integrated into IRSM because it is not specific as to particular firms. We must make those calculations as an additional post-processing step.

For this analysis we assume that the basic DW demand by firms is not sensitive to the DW price. Price changes then affect total DW payments but the quantity consumed remains constant.

We use 1976 data on industrial DW intake by sector and (real) province from CBS and 1978 DW prices from Krachtwerktuigen (Ref. 2.1). To estimate the 1990 basic DW demand by province, we take the average between RID's high and low estimates for 1990, and then divide that over the sectors according to the CBS 1976 actual proportions.

2.3. ANALYTICAL PROCEDURES

We use IRSM in two entirely different modes. For the analysis of GW taxes in today's world reported in Chap. 4, we simply simulate the cost-minimizing behavior of firms when their GW-intake costs are increased by the amount of the tax. IRSM was designed with this use in mind; those calculations require no inputs from other PAWN models.

Usually, however, PAWN has used IRSM in conjunction with RESDM to investigate efficient allocations of GW, and DW, when water use in the industrial and DW-sectors is jointly optimized. All of the results presented in the following chapter are based on this joint-optimization procedure.

When IRSM is used in conjunction with RESDM, the first step is to input district-level GW-extraction quotas and any desired GW taxes into RESDM. RESDM optimizes the joint use of GW by industrial firms (on a district basis) and DW companies (at the provincial level), and generates district-by-district "shadow prices," indicating the value of the marginal cubic meter of GW, and provincial level DW prices, equal to the marginal production costs of DW. These price estimates are then used to generate inputs to IRSM, and that model is run to determine the impacts, by firm, of the quota and tax structure under investigation.

The shadow price of GW input to IRSM represents the true opportunity cost to each firm of its GW withdrawals. And the RESDM-determined shadow price of GW induces firms in each district to withdraw the jointly-determined proper amount of GW. When used in conjunction with RESDM, IRSM does not separately optimize, but is used to produce more detailed impact estimates for the industrial sector.

Note that while we include the price of DW in our cost calculations for industrial firms, we do not count the shadow price of GW, since we assume that GW will never be allocated by prices set by a governmental agency. Instead, we assume it will be allocated by licenses or quotas issued by such an agency. The cost calculations in this volume thus may be understated, since they do not include GW prices or the administrative costs of an allocating agency.

All of the PAWN cases discussed below use the joint-optimizing mode of IRSM and RESDM. The impacts identified there as being generated by the imposition of, say, a 0.20 Dfl/m^3 tax on industrial GW extractions, therefore, must be viewed very carefully. They are not equivalent to the impacts we would expect from that tax if it were to be imposed in today's world where there is no district or national optimization of GW use either among firms or between firms and DW companies. PAWN investigates efficient allocations of water, and the different PAWN cases compare different efficient allocations. Only in Chap. 4 do we examine the effects of a GW-extraction tax in today's world.

PAWN investigated industry impacts for two time periods or "contexts"--a 1976 context that is based almost completely on actual historical data, and a 1990 context based on many projections but designed to represent the time period when water-management policies implemented now (for example, the construction of a new canal or pumping station) would be completed and fully operational. The principal PAWN cases are in the 1990 context but this volume discusses both contexts.

Other applications of IRSM are possible, but were not attempted within the PAWN study.

2.4. CONTEXT AND POLICY VARIABLES

Once the data had been obtained and were judged to have been based on the best estimates available, the analysis procedure itself was relatively straightforward. It consisted of choosing input values for cases to be run on IRSM and then analyzing the results. Below we outline the specific values to which we set key variables, define our basic case, and finally explain the scheme we used for altering those values and making the runs.

Time and cost considerations prevented us from making runs for a very large combination of variable values, so for each variable of interest we chose two or three significant values as shown in Table 2.5.

As can be seen from Table 2.5, many of the imputs to IRSM (namely the optimal prices for DW and GW) come from runs of the RESDM model and thus depend on the specifications of the RESDM runs. Table 2.6 shows the RESDM inputs that were instrumental in generating the GW and DW prices for use in IRSM.

Table 2.5

PRINCIPAL VALUES OF VARIABLES USED IN IRSM

Variable	Value	Reason for Selection
DW price	Base	Current situation
	Optimum	Amounts approximating the prices required to induce industrial firms to choose the mix of GW and DW deemed optimal by the RESDM runs. (DW prices are based on marginal replacement costs and differ significantly from current prices which are based on average historical costs.)
GW price	Zero	Current situation
	Optimum	An amount representing the price required to induce industrial firms to choose the mix of GW and DW deemed optimal by the RESDM runs.
	Optimum after 0.20 Dfl/m^3 tax is imposed	An amount approximating the maximum tax to be levied on industry in the proposed GW law (under debate at the time of writing) is added to intake costs, then the optimum allocation and prices are recomputed. Taxes can be imposed on industry alone, industry and DW companies, or DW companies alone.
Industrial-production growth rates	High	Based on CBS projections for industrial growth by sector. Assumes that water demands vary linearly with production output, and that production output increases at a average rate of 4.3% per year to 1990. Rates are input to IRSM by sector.
	Zero	Used for 1976 context

SOURCE: Discussions between PAWN and RWS personnel.

Table 2.6

PRINCIPAL VALUES OF VARIABLES USED IN RESDM
TO GENERATE INPUT PRICES FOR IRSM

Variable	Value	Reason for Selection
GW quota	1.0 x RID Extractable Amounts (a)	RID's best estimate of the available GW in each district. Total for the Netherlands is 2030 mcm of GW per year.
	0.25 x RID Extractable Amounts	Compromise between RID's lower-bound estimate (0.5x) and RIN's desire to return to the quota of the 1950s (zero); this quota thus defines a case giving high priority to the environment.
	1.5 x RID Extractable Amounts	RID's upper-bound estimate
	Variable	Amount remaining when agricultural GW extractions--depending on the scenario chosen (d)--are subtracted from a 1.0 quota.
GW tax	Zero	Current situation
	.20 Dfl/m^3	An amount approximating the maximum tax to be levied on industry in the proposed GW law (under debate at the time of writing). Can be imposed on industry alone, industry and DW companies, or DW companies alone (b).
GW priority (c)	Industry & DW cos.	Current situation (farmers are compensated for losses if they are damaged by the GW withdrawls of DW companies, which implies DW companies and industries get first priority).
	Agriculture	Amounts equal to agricultural extractions --depending on scenario chosen (d)--are subtracted from GW quotas in each district, giving industry and DW companies the remaining water. Conceptually, these cases represent other ways of varying the GW quota.
Industrial-production growth rates		
	High	Based on CPB projections of production by industrial sector. We assume that water demands vary linearly with production output, and that production output increases at an average rate of 4.3% per year to 1990. Rates input to RESDM by district.

	Low	Assumes that production output increases at 4.3% per year only to 1980, thereafter decreasing linearly to zero percent by 1990.
	Zero	Used for 1976 context
DW demand	1990 context	RID's best estimates for 1990 (assuming current pricing practices continue).
	1976 context	Actual DW production in 1976

SOURCE: Volume IV.

(a) GW extractable amounts by district are given in Vol. VII, and by pseudo-province in Table 3.1 of that volume.

(b) This feature was never used on the grounds that imposing a tax on DW companies alone would be politically infeasible; however, it could be considered as part of a general across-the-board scheme to conserve GW, if that were ever found necessary. (We also investigated a case where a GW tax is imposed on agriculture and where agriculture is given GW-extraction priority over industry and DW companies.)

(c) Technically not an input variable, but nevertheless an important determinant of conditions for a case.

(d) Four agricultural scenarios were explored; they are:

Scenario	Waterboard Plans Implemented	GW-Sprinkler Intensity
RNONE/GWLOW	None	Low
RNONE/GWMED	None	Medium
RNONE/GWHI	None	High
RALL/GWHI	All	High

The next chapter describes our impact-assessment cases and discusses their output.

REFERENCE

2.1. Vereniging Krachtwerktuigen, Krachtkroniek No. 35, den Haag, April 12, 1978.

Chapter 3

ANALYSES AND FINDINGS

In constructing cases for investigation we had three main aims:

- To show and assess the impacts arising in the industrial sector from the introduction of water-management policies, including PAWN's primary and GW cases.
- To show whether those impacts are sensitive to some of the assumptions underlying the input data.
- To show the detailed impacts that would arise in the industrial sector from the imposition of the principal PAWN-wide analysis cases.

Accordingly our runs are organized into three groups: the first consists of 4 runs investigating the basic responses of firms to changes in GW availability and industrial growth. The second group contains 12 sensitivity-analysis runs, which vary three particular variables in the direction of greatest uncertainty (for example, the willingness of the Netherlands to adopt marginal-cost based pricing of DW is quite uncertain, so sensitivity-analysis runs were made using average-cost pricing). The three variables are the pricing base, GW taxes, and a mix of structural assumptions for the water-using firms combined under the heading of IRSM version. The third group of runs form the complete "GW cases" of the PAWN study.

Every case discussed in this chapter uses RESDM inputs and assumes joint optimization of GW and DW use in the industrial and DW sectors. We discuss the three groups of runs in the following three subsections.

3.1. THE BASIC INDUSTRY CASES

Table 3.1 presents the basic industry cases and, for each, the values to which we set the key independent variables.

Output for the basic industry cases is presented in Tables 3.2 and 3.3. Note that all of these cases (1) use the standard version of IRSM, (2) involve marginal-cost pricing of DW, (3) contain no GW charges levied by the government on any users, and (4) give industrial firms and DW companies higher priority for GW use than is given to farmers. The conditions that differ among cases are shown in the heading of the table: Cases I.1 and I.2 are for the 1976 context while Cases I.3 and I.4 are for the 1990 context; Cases I.1 and I.3 are based on the full RID GW quotas while Cases I.2 and I.4 are based on 25 percent of those quotas.

Table 3.1

KEY INDEPENDENT VARIABLES
FOR THE BASIC INDUSTRY CASES

Run No.	GW Quota	GW Tax (Dfl/m^3) on Firms	DW-Co.	Farms	GW Extr. Priority	Context	Price Base	IRSM Version	DW Aggr. Level
I.1	1.0	0	0	0	I/D	1976	MC	STD	PP
I.2	.25	0	0	0	I/D	1976	MC	STD	PP
I.3	1.0	0	0	0	I/D	1990	MC	STD	PP
I.4	.25	0	0	0	I/D	1990	MC	STD	PP

NOTES: GW quotas are expressed in fractions of the RID extractable amounts. I/D stands for industry and DW companies. Run 1 is also the "basic case." MC stands for marginal-cost pricing. STD indicates the standard version of IRSM was used. PP indicates the output is aggregated to the pseudo-province level.

Table 3.2

AGGREGATE IMPACTS ARISING IN THE INDUSTRIAL SECTOR
IN RESPONSE TO BASIC PAWN INDUSTRY CASES:
1976 CONTEXT

Item	1976 Actual	Impacts, by Case: I.1 1.00	I.2 0.25
Water consumption (mcm/yr)			
Groundwater	350	-53	-200
Drinking water	200	1	24
Surface water	3,000	0	13
Total water	3,550	-52	-163
Industry costs (Dflm/yr)			
GW taxes	0	0	0
Other costs	-	-18	95
Total cost	-	-18	95

SOURCE: IRSM output computed at DHL.

NOTES: Costs are in 1977/78 Dfl. An "-" indicates we have no information on the base-level costs of an item.

The output of IRSM consists of changes in water use, by type, and in industry costs, broken down into payments for GW taxes, DW payments, and other. These impacts are all output as changes from their 1976 calibration levels. In the tables we show both the changes and the calibration values in order to illustrate more clearly the size of the changes. For example, in case I.2, when the GW quota is reduced by 75 percent, IRSM estimates a reduction of 200 mcm/yr in GW use and an increase of only 13 mcm/yr in SW use. Those changes gain additional perspective when we are reminded that the basic GW use was less than 400 mcm/yr while about 3,000 mcm/yr of SW was originally taken in by industrial firms.

We have no reliable information on the reference water-related costs of industrial firms, except that current GW charges paid to the government are zero. The cost-change estimates, however, are quite meaningful in their own right.

In both Case I.1 and Case I.2 industrial firms intake less GW than they actually did in 1976, and they substitute only a small amount of other types of water. Case I.1 is especially interesting. It appears to be similar to the calibration, or actual 1976, situation, but it differs in three significant ways: (1) DW prices are based on the marginal cost of production, rather than average cost; (2) modest GW reallocations are introduced in Utrecht and Zuid-Holland, along with more substantial reallocations in Noord-Holland, in order to allocate more optimally the limited GW supplies among industrial firms and DW companies; and (3) all firms are assumed to have had time to implement completely any water-saving or water-cost-reducing options that are available to them in the model and that are economically justified. The latter assumption, especially, allows Case I.1 to show water savings. Due to the Biesbosch constraint, the DW marginal cost is lower than its average cost in Zuid-Holland. This gives the negative cost shown in the table.[1]

Case I.2 illustrates what would happen under our joint-optimization scheme if the GW quota for each district was cut to one-quarter of its original value. GW intake by firms is, of course, cut substantially; but costs increase. The decreased availability of GW increases its value, causing the production costs and hence the price of DW to increase. Firms adopt costly water-saving devices, principally recirculating systems, to offset the higher water prices. They purchase only small additional amounts of DW and SW to substitute for the reduced GW intake; DW is too costly to purchase, while SW is too costly to purify.

Table 3.3 contains output for the basic cases in the context of the estimated 1990 industrial, commercial, and household use of water. The basic (calibration) water intake by industrial firms is about 1,000 mcm/yr greater than for the 1976 context, while the RID GW quotas are unchanged. This results in higher shadow prices for GW, higher marginal costs for DW, and increased costs for firms. Case I.3, which is similar to Case I.1 in all aspects except the basic water intake, displays costs that are 43 Dflm/yr higher. The increased basic GW

Table 3.3

AGGREGRATE IMPACTS ARISING IN THE INDUSTRIAL SECTOR
IN RESPONSE TO BASIC PAWN INDUSTRY CASES:
1990 CONTEXT

Item	1990 Estimate	Impacts, by Case: I.3 1.00	Impacts, by Case: I.4 0.25
Water consumption (mcm/yr)			
Groundwater	570	-132	-400
Drinking water	240	15	78
Surface water	3,700	5	34
Total water	4,500	-112	-288
Industry costs (Dflm/yr)			
GW taxes	0	0	0
Other costs	-	25	252
Total cost	-	25	252

SOURCE: IRSM output computed at DHL.

NOTES: Costs are in 1977/78 Dfl. A "-" indicates we have no information on the base-level costs of an item. Expected DW demands for 1990 are based on RID estimates.

intake demands, of course, cause the model to estimate larger GW savings, since the supply quota is unchanged.

These four basic cases provide the first major conclusions of our industry study. They suggest that:

- GW intake by industrial firms can be reduced 10 or 15 percent below its 1976 level at very low (perhaps negative) cost. In fact, this probably has already occurred.
- DW is not an economical substitute for GW when its full opportunity costs are taken into account, nor is SW, because of its poor quality.
- Normal population and production growth will increase the value of water and cause the water-intake costs of industrial firms to increase.[2]
- Restricting GW extractions severely in order to raise GW levels and preserve scarce water sources for future use, or to otherwise benefit the current or future environment of the Netherlands, would impose rather high costs on industrial (and other) GW users--possibly more than 0.50 Dfl for each m^3 of GW conserved each year.

In the following section we test the sensitivity of these findings. Then we will present and discuss the industrial impacts associated with the principal PAWN GW cases.

3.2. THE SENSITIVITY CASES

We performed two general types of sensitivity analyses. First we tested the sensitivity of our estimates to modeling and data assumptions; then we tested their sensitivity to policy variables.

We tested the sensitivity of our results to modeling and data assumptions by comparing the standard version of IRSM with the modified version. (Runs I.13 - I.16)

We tested the sensitivity of our results to policy variables by comparing the basic findings with cases where a GW tax is applied to industry and DW-company extractions of GW (Runs I.5 - I.8), and by comparing the results obtained from marginal-cost pricing of DW with those resulting from average-cost pricing (Runs I.9 - I.12). Those analyses are discussed below.

Detail on the structure of the sensitivity-analysis runs is presented in Table 3.4, along with the basic industry cases, for easy reference.

Table 3.4

STRUCTURE OF THE SENSITIVITY CASES

Run No.	GW Quota	GW Tax (Dfl/m^3) on Firms	DW-Co.	Farms	GW Extr. Priority	Context	Price Base	IRSM Version	DW Aggr. Level
				Basic Industry Cases					
I.1	1.0	0	0	0	I/D	1976	MC	STD	PP
I.2	.25	0	0	0	I/D	1976	MC	STD	PP
I.3	1.0	0	0	0	I/D	1990	MC	STD	PP
I.4	.25	0	0	0	I/D	1990	MC	STD	PP
				Sensitivity-Analysis Cases					
I.5	1.0	.20	0	0	I/D	1976	MC	STD	PP
I.6	.25	.20	0	0	I/D	1976	MC	STD	PP
I.7	1.0	.20	.20	0	I/D	1976	MC	STD	PP
I.8	.25	.20	.20	0	I/D	1976	MC	STD	PP
I.9	1.0	0	0	0	I/D	1976	AC	STD	PP
I.10	.25	0	0	0	I/D	1976	AC	STD	PP
I.11	1.0	0	0	0	I/D	1990	AC	STD	PP
I.12	.25	0	0	0	I/D	1990	AC	STD	PP
I.13	1.0	0	0	0	I/D	1976	MC	STD	P
I.14	1.0	0	0	0	I/D	1976	MC	MOD	P
I.15	.25	0	0	0	I/D	1976	MC	STD	P
I.16	.25	0	0	0	I/D	1976	MC	MOD	P

NOTES: GW quotas are expressed in fractions of the RID extractable amounts. I/D stands for industry and DW companies. Run 1 is also the "basic case." MC stands for marginal cost, AC for average cost. STD refers to the standard version of IRSM, MOD to the modified version. P stands for province, PP for pseudo-province.

3.2.1. Sensitivity to GW Taxes

Table 3.5 shows the impacts for the cases with and without the tax of 0.20 Dfl/m^3 on GW withdrawn for use. Impacts for both the full and the one-quarter GW quota cases are shown. No GW taxes are imposed in Cases I.1 and I.2. In Cases I.5 and I.6 taxes are imposed on industrial firms but not on DW companies (or farmers). Both firms and DW companies pay taxes in Cases I.7 and I.8.

Note first that the water-allocation effects of the GW taxes are quite minor when the GW quota is set at 0.25. GW is so scarce, and its value so correspondingly high, that a 0.20 Dfl/m^3 tax does not further restrain it use. And when the tax is applied only to firms, it reallocates only about 13 mcm/yr of GW to DW production. Note also that at the 0.25 quota, when the tax is assessed against all users (Case I.8) it does not change the water allocations at all compared to the no-tax case.

Table 3.5

AGGREGATE IMPACTS ARISING IN THE INDUSTRIAL SECTOR IN RESPONSE TO CASES TESTING SENSITIVITY TO A 0.20-Dfl/m^3 GW TAX: 1976 CONTEXT

	Impacts, by Case					
	Quota = 1.00			Quota = 0.25		
	I.1	I.5	I.7	I.2	I.6	I.8
GW tax on firms	0.00	0.20	0.20	0.00	0.20	0.20
Item / GW tax on DW companies	0.00	0.00	0.20	0.00	0.00	0.20
Water Consumption (mcm/yr)						
Groundwater	-53	-171	-155	-200	-213	-200
Drinking water	1	14	1	24	34	24
Surface water	0	6	6	13	16	13
Total water	-52	-151	-148	-163	-163	-163
Industry Costs (Dflm/yr)						
GW taxes	0	33	36	0	25	27
Other costs	-18	-4	26	95	104	95
Total cost	-18	29	62	95	129	122

SOURCE: IRSM output computed at DHL.
NOTE: Costs are in 1977/78 Dfl.

When the quota is set at 1.0, taxes have strong water-allocation effects. Note that the cost (to firms) of DW is higher in Case I.7 than in I.5, even though the amount used is less. The higher price of DW, induced by the tax, is the cause.

3.2.2. Sensitivity to the Pricing Scheme

Table 3.6 contains the findings on average-cost pricing. Basing prices of DW on average (replacement) costs of production rather than marginal (replacement) costs, decreases industry costs. But remember that this increases total-system costs, since the allocation of DW and GW is no longer optimal. This becomes more important when GW extractions are limited or when demand increases.

When GW is relatively abundant (the industry/DW-priority cases) average-cost pricing has very little effect on the composition of water intake by industrial firms. The major effect is the price paid for industry's "basic" DW consumption.

When GW is quite scarce (the low-quota or agricultural-priority cases) average-cost pricing causes industrial firms to substitute large amounts of DW for GW.

Table 3.6

AGGREGATE IMPACTS ARISING IN THE INDUSTRIAL SECTOR IN RESPONSE TO CASES TESTING SENSITIVITY TO AVERAGE-COST PRICING INSTEAD OF MARGINAL-COST PRICING

	Impacts, by Case							
	1976 Context				1990 Context			
	1.00 Quota		0.25 Quota		1.00 Quota		0.25 Quota	
	I.1	I.9	I.2	I.10	I.3	I.11	I.4	I.12
Item	MC	AC	MC	AC	MC	AC	MC	AC
Water consumption (mcm/yr)								
Groundwater	-53	-53	-200	-260	-132	-134	-400	-521
Drinking water	1	1	24	86	15	17	78	199
Surface water	0	0	13	12	5	4	34	33
Total water	-52	-52	-163	-162	-112	-113	-288	-289
Industry costs (Dflm/yr)								
GW taxes	0	0	0	0	0	0	0	0
Other costs	-18	-5	95	80	25	6	252	251
Total cost	-18	-5	95	80	25	6	252	251

SOURCE: IRSM output computed at DHL.
NOTE: Costs are in 1977/78 Dfl.

3.2.3. Sensitivity to the Structural Assumptions

Findings relating to the use of the modified version of IRSM are presented in Table 3.7. Use of that version, which is based on more industrial information and thus perhaps more realistic than the standard version, produces estimates of reductions in GW use by industry that are lower, and estimates of industry costs that are higher, than the estimates produced by the standard version of IRSM. Some comparative figures will be shown later when specific GW charges are discussed.

Table 3.7

AGGREGATE IMPACTS ARISING IN THE INDUSTRIAL SECTOR IN RESPONSE TO CASES TESTING SENSITIVITY TO STRUCTURAL ASSUMPTIONS: 1976 CONTEXT

	Impacts, by Case			
	Quota=1.00		Quota=0.25	
	I.13	I.14	I.15	I.16
Item	STD	MOD	STD	MOD
Water consumption (mcm/yr)				
Groundwater	- 55	-2	-177	-157
Drinking water	1	0	1	0
Surface water	2	0	13	29
Total water	- 52	-2	-163	-128
Industry costs (Dflm/yr)				
GW taxes	0	0	0	0
Other costs	-17	-16	72	96
Total cost	-17	-16	72	96

SOURCE: IRSM output computed at DHL.

NOTES: These runs are based on real province detail rather than the PAWN-created pseudo-provinces. National impacts such as are reported here, however, should be comparable among all cases. Costs are in 1977/78 Dfl.

3.2.4. Implications of the Sensitivity Analyses

These sensitivity runs increase our knowledge of the workings of the PAWN industry models, and generally increase our confidence in our good understanding of the probable behavior of firms. Specifically, we see that:

1. GW taxes of 0.20 Dfl/m^3 would increase firm's costs by perhaps 30 to 80 Dflm/yr. With current GW quotas, the taxes would induce firms to use about 100 less mcm/yr of GW. If a strict 0.25 quota was already existing, the taxes would induce no further industrial GW conservation.

2. Compared to the norm of marginal-cost pricing for DW that is used in our models, average-cost pricing would have minor effects when the liberal quota is in effect, but, when the strict quota is enforced, would cause firms to substitute rather large amounts of GW for DW.
3. The modified version of IRSM, based on improved knowledge of the water-use possibilities of industrial firms, indicates that the standard version may be overestimating the possibilities for firms to reduce water intake and underestimating the costs of that reduction.

We further study these effects in Sec. 4.1 below. There we investigate the responses of firms in today's world (that is, without marginal-cost pricing or joint optimization). We will compare the output of the two versions of the model for taxes ranging from zero to 1.00 Dfl/m^3.

3.3. THE PRINCIPAL PAWN INDUSTRY CASES

The basic industry cases and the sensitivity analyses performed on them provide information on the pattern and severity of the water-use and cost impacts of water-management policies on industrial firms. In the remainder of this chapter we focus on the impacts of the cases selected for primary investigation by the full PAWN team, and on cases based explicitly on GW policy variables. The structure of these cases is summarized in Table 3.8.

These cases are fully documented in Vol. I. Here we simply present their structure and findings in the same manner and context as our other industry results. Readers should refer to the summary volume for details on the rationale and implications of these cases.

The impacts of the principal PAWN industry cases on industrial firms are illustrated in the following table. We show the mix of water intake and use by the firms for each case, and we show the industry costs that can be attributed to the water-management policies. Only national totals are discussed here; provincial detail is shown in App. A.

The impacts up to now have been expressed as changes from the basic 1976 or 1990 calibration values of IRSM. In the PAWN summary volume, where impacts from all sectors are compared, we express impacts as changes from the basic (1990) PAWN reference case, Case A. Table 3.9 relates the industrial impacts to that reference case. Recall that we also always express the cost to industrial firms as net of the GW shadow prices. Only GW taxes that are levied in addition to the RESDM-generated shadow prices are counted, the assumption being that the basic allocation of GW among industrial firms is accomplished by fiat rather than by pricing. Table 3.9 contains the values used in the summary and the benefit-distribution volumes, Vols. I and X.

Table 3.8

THE PRINCIPAL PAWN INDUSTRY CASES

Run No.	GW Quota	GW Tax (Dfl/m^3) on Firms	DW Co.	Farms	GW Extr. Priority	Context	Price Base	IRSM Version	DW Aggr. Level
				Basic Industry Cases					
I.1	1.0	0	0	0	I/D	1976	MC	STD	PP
I.2	.25	0	0	0	I/D	1976	MC	STD	PP
I.3	1.0	0	0	0	I/D	1990	MC	STD	PP
I.4	.25	0	0	0	I/D	1990	MC	STD	PP
				Principal PAWN Industry Cases					
A(a)	1.0	0	0	0	I/D	1990	MC	STD	PP
F(a)	1.0	0	0	0	I/D	1990	MC	STD	PP
G	.25	0	0	0	A(b)	1990	MC	STD	PP
L	1.0	.20	0	.20	I/D	1990	MC	STD	PP
M	1.0	.20	0	.20	A(c)	1990	MC	STD	PP
P	1.0	0	0	0	A(c)	1990	MC	STD	PP
Q	1.5	0	0	0	I/D	1990	MC	STD	PP

SOURCE: Discussions between PAWN and RWS personnel.

NOTES: GW quota is expressed as a fraction of RID's estimates of the GW extractable amounts. I/D = industry and DW companies; A = agriculture; MC = marginal-cost basis. All runs involve the marginal-cost pricing of DW, use the standard (STD) version of IRSM, and aggregate output to the pseudo-province (PP) level. Run A is also the "reference case."

(a) Cases A and F are equivalent to Case I.3. They are listed separately here only to avoid confusion in comparisons with other PAWN volumes.

(b) With agricultural-demand scenario "RNONE/GWLOW" (no waterboard plans implemented, low GW-sprinkler intensity).

(c) With agricultural-demand scenario "RALL/GWHI" (all waterboard plans implemented, high GW-sprinkler intensity).

The cases summarized in Table 3.9 are all 1990 cases, and the estimates are shown relative to the reference 1990 case, Case A, which we have seen before as Case I.3. Case P differs from case A only in that priority for GW extractions (in addition to reference level sprinkling requirements) is given to farmers. This makes industry costs increase by 25 Dflm/yr as firms must intake additional (higher-cost) DW and SW to replace the GW now given to farmers. Cases L and M differ from Case A by including a GW tax of 0.20 Dfl/m^3. (Note that this is an arbitrary, exogenously imposed tax, not a shadow price used to induce an optimal allocation of GW.) This tax causes (1) about 50 Dflm/yr in taxes to be transferred from industrial firms to the state government and (2) about 25 Dflm/yr in other water-related costs to be incurred by industry. These other costs are primarily for the purchase of DW to replace a portion of the now-higher-priced GW.

Case G restricts the GW quota to one-fourth of the basic RID estimates. (It differs from Case I.4 only in giving GW priority to farmers.) This severe GW restriction again causes large increases in industry costs as firms do some switching to DW and SW but mainly rely on reducing their water intake. Total water intake falls by about 175 mcm/yr and costs increase by 230 Dflm/yr compared to Case A.

Case Q represents the other extreme. It is similar to A in all respects except that the GW quota is increased to 150 percent of the RID estimates. This induces firms to use more GW rather than less, and decreases their water-related costs by about 20 Dflm/yr. This is a very rough estimate, since our models were not really designed to examine possibilities where GW could be substituted for DW or SW. The substitution effects and cost savings are both probably under-estimated.

Table 3.9

RELATIVE IMPACTS ON INDUSTRIAL FIRMS OF PRINCIPAL PAWN INDUSTRY CASES

	Impact, by Case				
Impact	G	L	M	P	Q
Total industrial water consumption (mcm/yr)					
GW intake	-284	-170	-189	-79	33
DW intake	77	20	29	16	-14
SW intake	30	9	16	14	-3
Total intake	-177	-141	-144	-49	16
Total industrial cost increases (Dflm/yr)					
GW taxes	0	54	50	0	0
Other costs	232	20	24	25	-19
Total cost	232	74	74	25	-19

SOURCE: IRSM output computed at DHL.
NOTE: Costs are in 1976 Dfl. All values are relative to the reference case, Case A.

Note that Table 3.9 expresses costs in 1976 Dfl rather than in the 1977/78 vintage Dfl of the previous tables.

The tables here focus on aggregate or national impacts. Tables A.3 and A.4 in App. A show the details of water use and cost changes for these principal cases.

NOTES

1. The Biesbosch is a large reservoir fed mainly by the Maas River that supplies DW to Rotterdam and surrounding communities. This DW is said to be of high quality and to taste pleasant. However, it is a higher-cost DW source than several GW-based alternatives. In view of its existence, and its alleged superior quality, we constrained the RESDM model to always use the Biesbosch as the first element supplying DW for Zuid-Holland.
2. Note that artifically restraining the price of water is not a realistic cure for this condition. Such prices would further stimulate the demand for water while misallocating the available supply and necessarily imposing an even greater burden on the nation.

Chapter 4

SOME IMPLICATIONS

We can summarize the impacts on industrial firms of the cases we have analyzed as follows:

- When GW quotas or taxes are imposed, industrial firms have many options, several of which appear to be quite effective, at least initially. For example, oftentimes simple recirculation techniques can substantially lower water-intake requirements at low cost.
- Nevertheless, the costs to industrial firms will increase, perhaps substantially, if the supply of GW is reduced, if GW priority is shifted to agriculture, if GW extraction fees are imposed, or if the demand for GW increases in the future.
- DW is not an economical substitute for GW when its full opportunity costs are taken into account. Nor is SW, because of its poor quality.
- Basing DW prices on marginal costs rather than the current method of average-cost pricing would increase costs for the firms, but would also increase the overall efficiency of water use and lower nationwide water costs. The effects would be slight now, but would increase substantially in the future when the value of water increases.
- Severely restricting GW extractions in order to raise GW levels, preserve scarce water sources for future use, or to otherwise benefit the current or future environment of the Netherlands, would impose rather high costs on industrial (and other) GW users--perhaps as much as 0.50 Dfl for each m^3 of GW conserved each year.

In the remainder of this chapter we address two other issues of current interest to the Netherlands. Both refer to the proposed GW legislation that could impose extraction taxes on GW use by industrial firms. First, we estimate the costs that firms would initially incur (given the current organizational structure of the country, AC pricing of DW, and the absence of a national allocation or pricing scheme for GW). Then, we investigate how the burden of those costs would probably be partially shifted to the customers of the affected firms and to other competing firms.

4.1. THE EFFECTS OF GW TAXES IN TODAY'S WORLD

As there has been much recent discussion of a tax on GW extractions in the Netherlands, we now investigate the effects on industrial firms of a single nationwide tax on industrial extractions of GW. We assume the tax is not applied to DW companies or to farmers.

We attempt to model current industry and DW-company practices as accurately as possible. We use the 1976 context and assume that DW prices would remain at their calibration levels. We use both the standard and the modified versions of IRSM, and we allow firms and DW companies as much GW as they actually consumed in 1976.

Our findings are illustrated in Figs. 4.1 and 4.2. The figures show the increased costs and reduced GW consumption of industrial firms which result from the imposition of taxes of up to 1.00 Dfl/m^3.

We find that a GW tax of only 0.20 Dfl per cubic meter of GW extracted will release about 100 mcm of GW from the industrial sector. The cost impacts of this water diversion are quite significant, but they are not as large as some prior estimates have suggested.

The most commonly discussed estimate, originally formulated by the employers organization, assumes that GW usage will not decrease. The estimate is then computed simply by multiplying the base-period extractions by the tax.

Firms have many options that are less costly than the do-nothing-but-pay-the-tax approach. Nevertheless, at the 0.20-Dfl/m^3 tax level, the do-nothing approach probably only slightly overestimates the true costs. At higher tax rates, we estimate that actual costs may be less than one-half of the do-nothing costs.

Low taxes will induce most of the feasible reductions in water intake. A tax of 0.20 Dfl/m^3 induces between 25 and 50 percent of the maximum reduction. A tax of 0.40 Dfl/m^3 induces about 70 percent of the maximum reduction. In the main, higher taxes cause firms to replace GW with DW which is primarily derived from GW, so that total GW conservation is increased little.

4.2. DISTRIBUTION OF THE COST CHANGES

The cost changes we have been referring to are incurred directly by industrial firms. And under some conditions the full effect is retained by the firms, but that is not usually the case. Even if product prices do not change and the full cost impact results in a direct change in the profits of the firms, a portion of the effect is transferred to the government as a change in the tax paid by the firms on their profits.

In most cases, however, product prices do change, if only by a small amount. This allows some of the effects to be passed along to consumers, both domestic and those in foreign countries who import the products. Competing firms will also benefit or incur losses as the price changes affect their sales and profits. And the government may also notice a change in its BTW collections. Our procedure for estimating all of these effects if fully documented in Vol. X; the specific estimators used for the industrial sector are summarized in App. B of this volume.

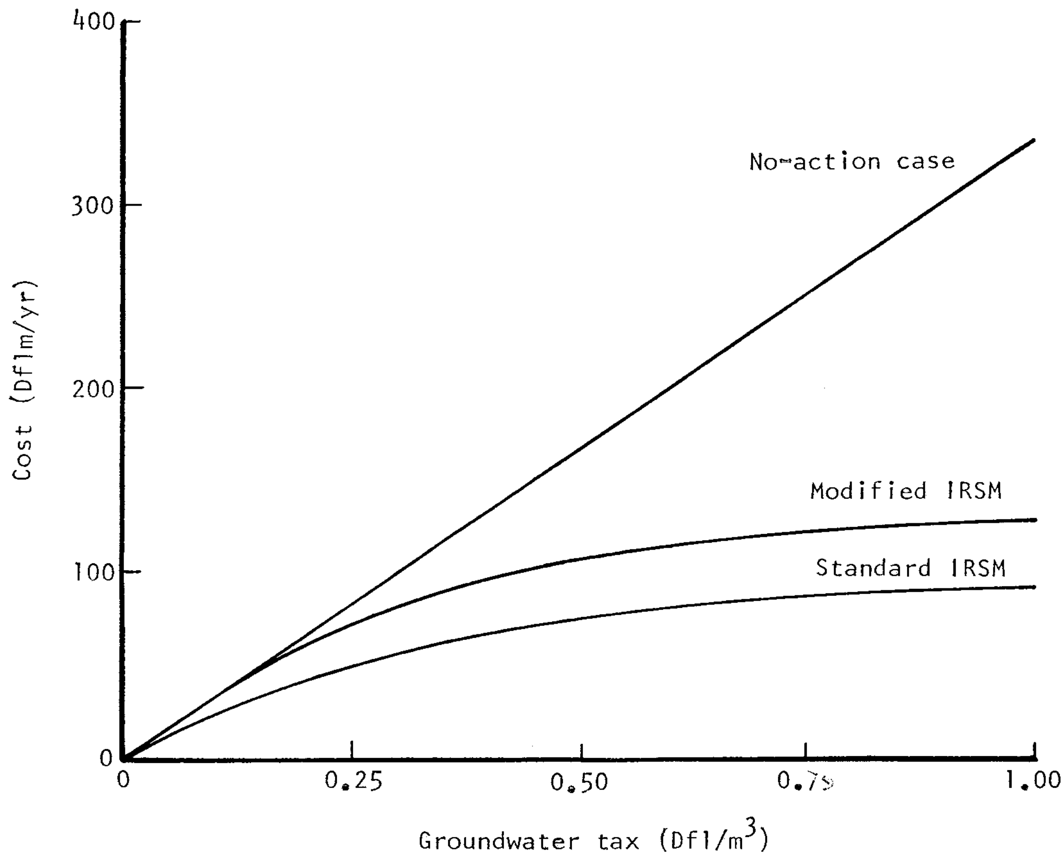

Fig. 4.1--Costs to industry of groundwater taxes

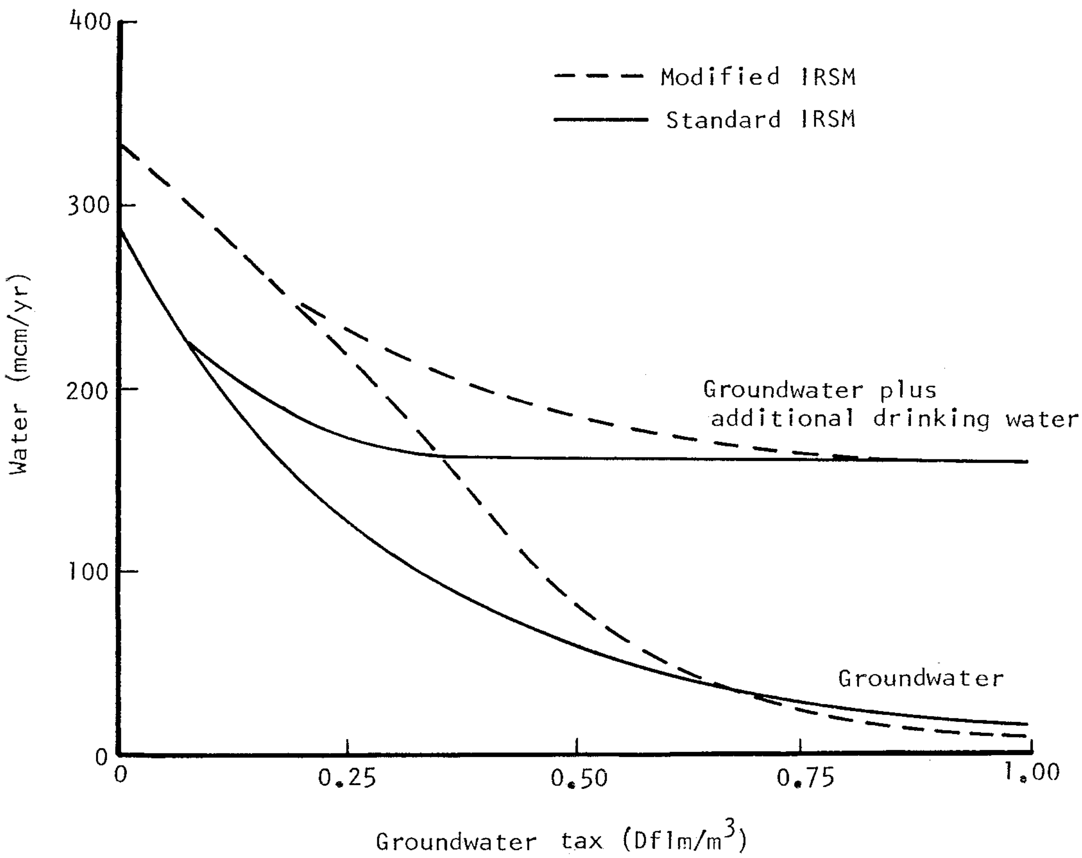

Fig. 4.2--Water use by industry when groundwater taxes are imposed

Our estimates of the distribution of the cost changes associated with the principal PAWN industry cases are shown in Table 4.1. These estimates are based on an aggregate demand elasticity of -1.0 and an aggregate supply elasiticity of 10.0. We also assume international markets for most of the industrial products produced and sold in the Netherlands. It is this last assumption that is most important in deriving the results.

Table 4.1

DISTRIBUTIONAL EFFECTS OF PRINCIPAL INDUSTRY CASES

	Impact Values, by Case	
Effect	A	G
Industry cost increases (Dflm/yr)		
GW costs	0	0
Other costs	23	255
Total cost	23	255
Distribution of the cost increases		
Domestic distribution		
Producers	13	145
Consumers	1	15
Government	9	94
Total Dutch	23	254
Foreign distribution		
Producers	-12	-130
Consumers	23	260
Government	-11	-125
Total foreign	0	5
Net welfare costs	23	259

SOURCE: Computations of PAWN personnel.

NOTE: Estimates presented in 1976 Dfl and computed using formulas and parameter estimates from App. B.

We show distributional effects in Table 4.1 for Cases A and G, the only two cases we cover in this volume that are also extensively investigated in Vol. X (the study of distributional effects arising in all sectors of the Netherland's economy).

The consumers feel only small effects from the cases. In the EEC-wide markets we assume that there are many alternative sources of supply for these industrial products. Consequently, the Dutch producers, when faced with increased costs, can raise prices for their products only a small amount, or they will lose sales to foreign producers. This insulates the consumers, both domestic and foreign, from sharing significantly in the cost impacts.

The Netherlands government does share a major portion of the cost increases. Since we assume an average profit tax rate of 40 percent, the government bears 40 percent of costs that firms are not able to pass along to consumers. It does, however, collect slightly more BTW on industrial sales because of the price increases. As we mentioned before, we assume that GW is allocated by quotas rather than price, so the government receives no revenue from GW taxes in these two cases.

Note that the net Dutch effect (254 for Case G) is nearly equivalent to the cost impact (255) and the net welfare effects (259). We find this correspondence in all the cases we have examined.

Foreign effects net nearly to zero, but individually they appear rather large. That is because most of the product markets are located outside the Netherlands, so that even when the price changes are quite small, many items and many producers and consumers are involved, causing the total effects to be significant. The foreign effects are caused when the original cost changes for the Dutch producers induce some (small) change in EEC-wide prices. But after that there is little interaction between the Dutch and foreign effects. Foreign effects are composed almost entirely of transfers from foreign consumers to foreign producers, and those producers then pass the added profits tax on to their governments.

Only costs (or benefits) arising in the industrial sector are included in this table and in these calculations. Associated costs, such as changes in DW-production costs or government revenue derived from DW companies, should be accounted for in the sector where they originate. Vol. X combines costs from all sectors and shows their net effects on consumers and taxpayers.

4.3. SUMMARY

The additional findings documented in this chapter can be summarized as:

- Most cost increases caused by water-management policies will generate small but noticeable price increases. We estimate that less than 10 percent of the cost increases will be passed on to consumers. Small price increases also insure that competing producers (including those in neighboring countries) will receive only minor benefits.
- The cost impacts of water-management tactics on industrial firms, minus any GW taxes paid to the government, provide good estimates of the net Dutch welfare loss.
- Given the current situation, we estimate that a 20 cent tax on industrial extractions of GW, as has been proposed for the Netherlands, would reduce industrial use of GW by about 100 mcm/yr, and would increase the water-intake costs of firms by about 50 Dflm/yr.

Appendix A

SUPPLEMENTARY TABLES

Table A.1

CHANGES TO THE PRICE OF DRINKING WATER THAT WERE INPUT TO IRSM FOR THE BASIC PAWN INDUSTRY CASES

	Input Price Changes, (Dfl/m^3) by Case			
	1976		1990	
	I.1	I.2	I.3	I.4
Pseudo-Province	1.00	0.25	1.00	0.25
Groningen	0.03	0.52	0.03	1.27
Friesland	0.06	0.78	0.06	1.13
Drenthe	0.06	0.45	0.06	1.46
Overijssel	0.16	0.62	0.16	1.15
Gelderland	0.09	0.52	0.09	0.52
Utrecht	0.14	0.80	0.26	0.80
Noord-Holland	0.02	0.14	0.14	0.14
Zuid-Holland	-0.33	0.13	0.13	0.20
Zeeland	-0.08	0.09	-0.08	0.09
Noord-Brabant	0.01	0.66	0.01	0.66
Limburg	0.06	0.44	0.06	0.51

SOURCE: RESDM output computed at Rand.

Table A.2

GROUNDWATER TAXES THAT WERE INPUT TO IRSM
FOR THE BASIC PAWN INDUSTRY CASES

	Input Shadow Prices, (Dfl/m^3) by Case			
	1976		1990	
	I.1	I.2	I.3	I.4
PAWN District	1.00	0.25	1.00	0.25
1 FRIELAND	0.00	0.72	0.00	1.07
2 HETBILDT	0.00	0.72	0.00	1.07
3 LAUWMEER	0.00	0.72	0.00	1.07
4 UITHUIZN	0.00	0.49	0.00	1.24
5 EEMSKANN	0.00	0.49	0.00	1.24
6 OLDAMBT	0.00	0.49	0.00	1.24
7 WESTWOLD	0.00	0.90	0.16	2.38
8 NWDRENTE	0.00	0.39	0.00	1.22
9 WESKWART	0.00	0.49	0.00	1.24
10 NEDRENTE	0.00	0.39	0.00	1.40
11 SEDRENTE	0.00	0.39	0.00	1.84
12 SWDRENTE	0.00	0.39	0.00	1.40
13 VOLENHOV	0.00	0.46	0.00	0.99
14 NEPOLDER	0.00	0.46	0.00	0.99
15 MASTBROK	0.00	0.46	0.00	0.99
16 OVIJVECT	0.00	0.46	0.00	0.99
17 DINKEL	0.00	0.31	0.00	0.38
18 TWENTHE	0.00	0.46	0.00	0.99
19 SALLAND	0.00	0.46	0.00	0.99
20 TWENTKAN	0.00	0.46	0.00	0.99
21 SHIPBEEK	0.00	0.46	0.00	0.99
22 IJSELGEB	0.00	0.43	0.00	0.43
23 NEVELUWE	0.00	1.21	0.00	1.21
24 BERKEL	0.00	0.43	0.00	0.43
25 OUDEIJSL	0.00	0.43	0.00	0.43
26 ARNHEM	0.00	0.43	0.00	0.43
27 SEVELUWE	0.00	0.79	0.26	0.79
28 SWVELUWE	0.00	0.43	0.00	0.43
29 NWVELUWE	0.00	0.43	0.00	0.43
30 FLEVLAND	0.10	0.38	0.22	0.45
31 WIERGMER	0.45	0.57	0.57	0.57
32 AMSTLMER	0.45	0.57	0.57	0.57
33 MEDMBLIK	0.45	0.57	0.57	0.57
34 HOORN	0.45	0.57	0.57	0.57
35 SCHERMER	0.45	0.57	0.57	0.57
36 WATRLAND	0.45	0.57	0.57	0.57
37 NZKANGEB	0.45	0.57	0.57	0.57
38 RIJNLAND	0.02	0.48	0.48	0.75

Table A.2 (continued)

PAWN District	Input Shadow Prices, (Dfl/m^3) by Case			
	1976		1990	
	I.1	I.2	I.3	I.4
	1.00	0.25	1.00	0.25
39 AMSTLAND	0.05	0.11	0.11	0.11
40 GOOI	0.45	0.57	0.57	0.57
41 KROMRIJN	0.05	0.71	0.17	0.71
42 LEIDRIJN	0.05	0.71	0.17	0.71
43 WOERDEN	0.02	0.48	0.48	0.55
44 LOPIKWAR	0.05	0.71	0.17	0.71
45 KRIMPWAR	0.02	0.48	0.48	0.55
46 SCIELAND	0.02	0.44	0.44	0.51
47 DELFLAND	0.02	0.48	0.48	0.55
48 VORNE	0.02	0.48	0.48	0.55
49 GOEREE	0.02	0.48	0.48	0.55
50 IJSLMOND	0.02	0.48	0.48	0.55
51 HOLNDIEP	0.00	0.65	0.00	0.65
52 DORDRECT	0.02	0.48	0.48	0.55
53 ABLASWAR	0.02	0.48	0.48	0.55
54 BIESBOSH	0.00	0.65	0.00	0.65
55 TIELWARD	0.00	0.43	0.00	0.43
56 DENBOSCH	0.00	0.65	0.00	0.65
57 BETUWE	0.00	0.43	0.00	0.43
58 MAASWAAL	0.00	0.65	0.00	0.76
59 RECMAASN	0.00	0.43	0.00	0.43
60 RECMAASM	0.00	0.38	0.00	0.45
61 MASKANTE	0.00	0.65	0.00	0.65
62 MASKANTW	0.00	0.65	0.00	0.94
63 AA	0.00	0.65	0.00	0.65
64 DEPEEL	0.00	0.38	0.00	0.45
65 RECMAASS	0.00	0.57	0.00	0.75
66 ROERMOND	0.00	0.38	0.00	0.45
67 SLIMBURG	0.00	0.38	0.00	1.15
68 MLIMBURG	0.00	0.38	0.00	0.45
69 EDOMMEL	0.00	0.65	0.00	0.65
70 MDOMMEL	0.00	0.65	0.00	0.94
71 WDOMMEL	0.00	0.55	0.00	0.55
72 NDOMMEL	0.00	0.65	0.00	0.65
73 DONGE	0.00	0.65	0.00	0.65
74 MARK	0.00	0.65	0.00	0.65
75 ROSENDAL	0.00	0.65	0.00	0.65
76 ZOOM	0.00	0.65	0.00	0.65
77 SCHOUWEN	0.54	0.71	0.54	0.71
78 MARKWARD	0.10	0.38	0.22	0.45
NETH.	0.02	0.52	0.06	0.72

SOURCE: RESDM output computed at Rand.

Table A.3

CHANGES IN THE WATER USE OF INDUSTRIAL FIRMS INDUCED BY THE PRINCIPAL PAWN CASES, BY PSEUDO-PROVINCE

	Water Intake and Use (mcm/yr), by Case					
Water type, Province	Ref	G	L	M	P	Q
Groundwater						
Groningen	-8	-42	-10	-10	-11	-4
Friesland	-4	-25	-24	-24	-4	-4
Drenthe	-10	-29	-18	-18	-10	-10
Overijssel	-6	-43	-32	-32	-28	-6
Gelderland	-40	-121	-70	-80	-62	-17
Utrecht	-10	-11	-12	-12	-11	-3
Noord-Holland	-6	-6	-7	-7	-6	-6
Zuid-Holland	-15	-16	-18	-18	-16	-15
Zeeland	0	0	0	0	0	0
Noord-Brabant	-27	-78	-83	-83	-27	-27
Limburg	-6	-45	-28	-36	-36	-6
Total GW	-132	-416	-302	-321	-211	-99
Drinking water						
Groningen	0	7	0	0	0	0
Friesland	0	0	0	0	0	0
Drenthe	0	9	0	0	0	0
Overijssel	0	1	0	0	4	0
Gelderland	14	59	15	24	25	0
Utrecht	0	0	0	0	0	0
Noord-Holland	0	0	1	1	0	0
Zuid-Holland	0	1	2	2	0	0
Zeeland	0	0	0	0	0	0
Noord-Brabant	1	7	17	17	1	1
Limburg	0	8	0	0	1	0
Total DW	15	92	35	44	31	1
Surface water						
Groningen	3	6	3	3	3	0
Friesland	0	0	0	0	0	0
Drenthe	0	0	0	0	0	0
Overijssel	0	8	3	3	4	0
Gelderland	0	7	5	5	2	0
Utrecht	0	0	0	0	0	0
Noord-Holland	1	1	1	1	1	1
Zuid-Holland	1	1	1	1	1	1
Zeeland	0	0	0	0	0	0
Noord-Brabant	0	3	0	0	0	0
Limburg	0	9	2	8	7	0
Total SW	5	35	14	21	19	2
Total water use	-112	-289	-253	-256	-161	- 96

SOURCE: IRSM output computed at DHL.

NOTE: Detail may not sum to total due to rounding.

Table A.4

INCREASED COSTS FOR INDUSTRIES INDUCED BY THE PRINCIPAL PAWN INDUSTRY CASES, BY PSEUDO-PROVINCE (Dflm/yr)

	Industrial Cost Increases, by Case					
Impact	Ref	G	L	M	P	Q
Groningen	1	44	8	8	2	0
Friesland	1	18	4	4	1	1
Drenthe	0	25	4	4	0	0
Overijssel	2	23	9	9	8	2
Gelderland	6	63	27	27	12	2
Utrecht	2	6	3	4	4	0
Noord-Holland	3	3	4	3	3	0
Zuid-Holland	11	16	13	6	11	0
Zeeland	-1	2	-1	-9	-1	-1
Noord-Brabant	-1	34	15	14	-1	-1
Limburg	1	20	12	12	12	1
Total	24	254	97	100	49	4

SOURCE: IRSM output computed at DHL.

NOTE: Detail may not sum to total due to rounding. Costs are expressed in 1976 Dfl.

Appendix B

BENEFIT ESTIMATION AND DISTRIBUTION FORMULAS[1]

Our industrial process models, described here and in Vol. XX, provide estimates of the total benefits and costs of PAWN water-management policies affecting the industrial sector. Manual calculations then distribute those benefits among producers, consumers, and governments, both foreign and domestic.

When GW is restricted or its price is increased, industrial firms can substitute lower-quality SW or higher-cost DW. Perhaps they will adjust their water-using equipment, invest in new water-cooling processes, or move to recirculate the water they use for cooling or in their productive processes. All of these actions will cost the firms money. Most of these costs will be retained by the firms in the form of reduced profits, but some will be passed on to the consumers of the firms' products in the form of higher prices, and some will be passed on to the government when the profits, and thus profit taxes, fall. The exact distribution of the benefits will, of course, depend on production patterns and the elasticities of supply and demand.

The general benefit-estimating equations are derived in Vol. X; here we present only the specific equations that were applied to the industrial sector. As we use manual calculations in this sector, we will base our estimates only on first-order terms. Based on Eqs. C.20, C.21, C.29 through C.33, and the definition of dC, the estimating equations are shown below. Note that we are assuming an EEC-wide market for all products, so we have replaced the export demand function with a European (less Dutch) demand function and the import supply function with a European (less Dutch) supply function. These new functions allow us to compute the full effects of the Dutch policies on EEC producers, consumers, and governments.

$$\text{delta CS} = - dC \frac{Q^{d}_{\bullet}}{Q_{\bullet}} \frac{E^{s}}{E} (1+t_{vd}) \qquad \text{(B.1)}$$

$$\text{delta ECS} = - dC \frac{Q^{ed}_{\bullet}}{Q_{\bullet}} \frac{E^{s}}{E} (1+t_{vm}) \qquad \text{(B.2)}$$

$$\text{delta PS}^{i} = dC^{i} \left(\frac{Q^{i}_{\bullet}}{Q_{\bullet}} \frac{E^{s}}{E} - 1\right) (1-t_{ud}) \qquad (i=1,...,n) \qquad \text{(B.3)}$$

$$\text{delta EPS} = dC \frac{Q^{es}_{\bullet}}{Q_{\bullet}} \frac{E^{s}}{E} (1-t_{um}) \qquad \text{(B.4)}$$

$$\text{delta GS} = t_{vd} \left(\frac{\text{delta PS}}{1-t_{ud}} + dC\right) + \frac{t_{ud}}{1-t_{ud}} (\text{delta PS}) \qquad \text{(B.5)}$$

$$\text{delta NS} = t_{vm} \left(\frac{\text{delta EPS}}{1-t_{um}}\right) + \frac{t_{um}}{1-t_{um}} (\text{delta EPS}) \qquad \text{(B.6)}$$

$$\text{where } E = E^{s} - E^{d}$$

$$dC = dS\, Q^{s}_{\bullet}$$

CS = the Dutch consumers' surplus

ECS = the foreign (European but non-Dutch) consumers' surplus

PS = the total Dutch producers' surplus or profits

$(PS)^{i}$ = the surplus or profit of individual Dutch producers

EPS = the surplus or profits accruing to foreign producers

GS = the Dutch governmental budget

NS = the foreign government budget

Q = quantity produced or consumed

Q^{i} = quantity produced by a particular group of Dutch producers

Q^{s} = total amount produced by Dutch producers

Q^{es} = amount produced in Europe except for the Netherlands

Q^{m} = amount imported into the Netherlands

$Q = Q^{s} + Q^{m}$ = amount available in the Netherlands

Q^{e} = amount exported from the Netherlands

Q^{d} = amount consumed in the Netherlands

Q^{ed} = amount consumed in Europe outside the Netherlands

$Q = Q^{d} + Q^{e}$ = total consumption of Dutch product

dS = the (exogenous) per-unit change in supply price

dC = the change in production costs arising from a tactic assuming that the production level does not change

E^d, E^e = elasticity of demand--usually the same for Dutch and foreign

E^s, E^m = elasticity of supply--usually the same for Dutch and foreign

E = summary measure of market flexibility

t_{ud} = Dutch income tax rate

t_{um} = foreign income tax rate

t_{vd} = Dutch value-added tax rate

t_{vm} = foreign value-added tax rate

• = subscript referring to base period amounts

Note that this formulation assumes there are no price supports for industrial products. That assumption conforms reasonably well with the actual situation in the EEC. Furthermore, as we assume an EEC-wide market for all of these products, the price changes we compute are all quite small; so the results are not sensitive to the free-market assumption.[2] Ignoring second- and higher-order terms also has little effect on the estimates.[3]

Some of the cases we investigate in the industrial sector involve GW taxes. In evaluating those cases a third term must be added to the government benefit equation reflecting the receipt of GW taxes paid by Dutch firms. The cost of those taxes to the firms will, of course, already be included in the cost changes estimated by the process models.

NOTES

1. This appendix presupposes a knowledge of Apps. C and D of PAWN Vol. X.

2. Parameters used in the industry analysis follow. (Quantity estimates are expressed in value terms representing millions of guilders per year.)

$$Q^{s}_{\bullet} = 189{,}601 \qquad Q^{e}_{\bullet} = 76{,}791 \qquad Q^{m}_{\bullet} = 53{,}268$$

$Q^{i}_{\bullet}$ =

Groningen	14,985
Friesland	5,858
Drenthe	3,758
Overijssel	12,084
Gelderland	17,219
Utrecht	7,251
Noord-Holland	31,111
Zuid-Holland	50,885
Zeeland	5,866
Noord-Brabant	28,149
Limburg	12,435

$$Q_{\bullet} = Q^{s}_{\bullet}/0.06 = 3{,}160{,}017$$

$$Q^{d}_{\bullet} = Q^{s}_{\bullet} + Q^{m}_{\bullet} - Q^{e}_{\bullet} = 166{,}078$$

$$Q^{ed}_{\bullet} = Q_{\bullet} - Q^{d}_{\bullet} = 2{,}993{,}939$$

$$Q^{es}_{\bullet} = Q_{\bullet} - Q^{s}_{\bullet} = 2{,}970{,}416$$

$$E^{s} = E^{m} = 10.0 \qquad E^{d} = E^{e} = -1.0$$

$$t_{vd} = t_{vm} = 0.18 \qquad t_{ud} = t_{um} = 0.40$$

SOURCE: Production detail was taken from <u>regionale economische jaarcijfers 1975</u> (SBI sectors 4-20) and inflated by 15 percent to represent 1976. Imports and exports for 1975 were taken from the <u>nationale rekeningen 1977</u>, pp. 126-127 (input-output sectors 3-17), and inflated by 15 percent. Total, foreign, and domestic consumption as well as foreign production were derived from the other estimates.

3. The second-order term is typically much smaller than the first-order term. For example, the complete expression for consumers' surplus is

$$\text{delta } CS = - dC \frac{Q^d_{\bullet}}{Q_{\bullet}} \frac{E^s}{E} (1+t_{vd}) - 1/2 \, dC \frac{\text{delta } Q^d}{Q_{\bullet}} \frac{E^s}{E} (1+t_{vd}).$$

In all of the cases we analyze, the change in Dutch consumption (or production) is only small fraction of total initial Dutch consumption. Dutch consumption of industrial goods is about 5 percent of total EEC consumption. The second-order term thus usually represents only 1 or 2 percent of the total effect, and we can safely ignore it.

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