Zero discharges to sea from the petroleum activities

Status and recommendations
2003

Report by the Zero Discharge Group
SFT, OLF, OD

Merknad [w1]: Sett inn logoer

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1. INTRODUCTION

This report is a result of cooperation between the industry and the authorities in the Zero Discharge Project that was started on the initiative of the SFT (Norwegian Pollution Control Authority) in 1998 and continued in 2002-2003. The Zero Discharge Group is an advisory cooperation group for the Norwegian Pollution Control Authority (SFT), the Norwegian Petroleum Directorate (NPD) and the Norwegian Oil Industry Association (OLF). The work is led by SFT, which also functions as the secretariat. The fishery authorities have been represented by the Institute of Marine Research (HI) in the final phases of the work on the present report.

Ever since the term "zero discharges" was introduced in Storting White Paper No. 58 (1996-1997), the term has been the subject of discussions and interpretations. It has always been clear that a literal interpretation of the goal for all types of discharges and emissions is not necessarily the optimal solution for the environment, nor can it be implemented within the current framework conditions. Therefore, the zero discharge goal in the White Paper was adapted to the existing challenges. Minimizing discharges may be sufficient if there are strong reasons to justify this. Operating in a way that is consistent with the intentions of the White Paper is, however, not something that is new. The operators have over a long period worked systematically to reduce discharges to sea to a minimum.

The report is divided into three parts:

Goals and definitions
This section describes how the political and legal framework on which the work on zero discharges is based, can be operationalized. The industry has emphasized that the goal must be reached within an acceptable framework as regards environmental risk, safety, technology, field-specific factors and economic framework conditions. Since the preconditions differ, all installations on the Norwegian Continental Shelf must set their own objectives. This will be described in the operators' zero discharge reporting to the SFT.

There are three sources of emissions of environmentally harmful substances:

- environmentally harmful chemicals added during operational processes
- environmentally harmful substances that are contaminants in chemicals (see Chapter 2.2 Definitions)
- naturally occurring environmentally harmful substances in produced water

The approach and measures required to achieve zero discharges for these three groups will be different.

SFT, NPD and the industry have agreed that the following zero discharge targets for 2005 will be used as a basis for the work:

<u>For discharge of added chemicals</u>

A. No discharges of chemicals for priority actions, environmentally hazardous chemicals (substances on the authorities' list[1]) and substances in SFT's black and red categories[2]).
B. No discharges of other chemicals if the discharges can lead to adverse effects on the environment (substances on SFT's yellow and green categories (PLONOR)).
C. No discharges, or minimization of discharges of chemicals for priority actions, environmentally hazardous or potentially environmentally hazardous substances that are contaminants in chemicals.

Substances on the authorities' list[1] of chemicals for priority action or in the black or red categories, and chemicals that are contaminated with substances on the authorities' list[1] of chemicals for priority action can be used under permit from the SFT, if this is necessary due to critical technical or safety considerations. The user is obliged to select chemicals with the least possible risk of pollution.

1) Prioritized chemicals in the Storting's White Paper on *The environmental state of the realm,*

2) SFT's information letter to the operators, dated 27 December 2001

Chemicals must be selected and used so that the environmental risk is minimized. Environmentally harmful substances must be evaluated based on the substances' intrinsic properties.

<u>For discharge of oil and other naturally occurring substances</u>:
A. No discharges, or minimization of discharges of chemicals for priority actions (the authorities' list).
B. No discharges of other substances if the discharges can lead to adverse effects in the environment.

The political objectives in Storting White Paper No. 58 (1996-1997) applied immediately to new projects, and shall be achieved by the end of 2005 for existing installations. The above objectives are an operationalization of these.

Guidelines for reporting in 2003
The second part of this document contains guidelines for the operators' reporting in the summer of 2003 concerning the status with regard to discharges, work done and additional plans for achieving the zero discharge target by the end of 2005. However, conditions differ from field to field. This can make direct comparisons difficult, even though all reporting is carried out according to the same requirements.

Documentation of costs will be a key element in the reporting. A detailed review, however, requires extensive work. The cost estimates will also have varying degrees of uncertainty. Cost-effectiveness and environmental efficiency, with concepts such as NOK/ΔEIF over remaining field lifetime will be central elements for the operators when choosing zero discharge measures.

Technical solutions

The last part of this document provides an overview of technical solutions that have either been established or are under development on the Norwegian Continental Shelf. The list is not intended to be an overview of what is feasible on each individual field. The list represents the current status, and it will change over time.

The selection of technical solutions shall be based on an evaluation of potential solutions in each specific case. Grounds must be stated for selection of solutions and rejection of alternatives.

2. GOALS AND DEFINITIONS

2.1 Main sources, references and legal basis

The following documents are relevant for the zero discharge work:

- Storting White Paper No. 58 (1996-1997*) Environmental policy for a sustainable development*
- Storting White Paper No. 25 (2002-2003) *The government's environmental policy and the environmental state of the realm*
- Storting White Paper No. 12 (2001-2002) *Clean and rich seas*
- Storting White Paper No. 38 (2001-2002) *On the oil and gas activities*
- *The zero discharge report* (November 1998) **-** A cooperation between OLF and SFT to follow up Storting White Paper No.58 (1996-1997) and the requirement for limiting discharges to sea
- *Coexistence between fisheries, aquaculture, oil activities, shipping and environmental interests*. Final report from the Environmental Forum's working group on fisheries/oil (2002)

Storting White Papers are aimed at the public administration that is to ensure implementation of the guidelines and goals stated in the White Papers. In order to enforce these rules vis-a-vis the industry, amendments or resolutions are required under the (Norwegian) Pollution Control Act or the (Norwegian) Product Control Act. This is the basis for the use of policy instruments.

The legal basis for the zero discharge work is found in the Pollution Control Act and the Product Control Act, as well as in resolutions in the form of regulations and administrative decisions rendered pursuant to these statutes. The HSE regulations for the petroleum activities are particularly important in this context.

The petroleum activities shall be carried out with the least possible risk of pollution. This is stated in both the Pollution Control Act and in the HSE regulations for the petroleum activities. Several important principles are laid down in Chapter 3 of the Regulations relating to health, environment and safety in the petroleum activities (the Framework Regulations). The most important principles as regards the environment are described in Section 9:

- The risk of damage to the external environment shall be prevented or limited in line with HSE legislation. In addition to this, risk shall continuously be reduced insofar as possible.
- To reduce risk, one must select the technical, operational or organizational solutions that provide the best results according to an individual and joint evaluation of the impact potential and current and future use, as long as the costs are not significantly disproportionate in relation to the risk reduction achieved (BAT).
- If there is insufficient knowledge regarding the impact that use of the technical, operational or organizational solutions could have on health, safety and the environment, then solutions that reduce this uncertainty shall be selected (the precautionary principle).

- Factors that can cause harm or disadvantages for human beings, the environment or material assets shall be replaced with factors that, after an overall evaluation, have a lesser potential for harm or disadvantages (the substitution principle).

The Product Control Act stipulates a duty to exercise caution in order to prevent products, including chemicals, from leading to damage to health or disruptions to the environment in the form of e.g. disruptions to ecosystems and pollution (the duty of care), cf. Section 3 of the Product Control Act. In addition, anyone who uses products that contain chemical substances that can cause health damage or disruption of the environment is obliged to consider whether alternatives exist that entail less risk of such an impact, and to choose this alternative if this can take place without unreasonable cost and inconvenience (the duty of substitution), cf. Section 3a of the Product Control Act.

2.2 Definitions

BAT: Best available techniques (Appendix 1, OSPAR Convention).

BEP: Best environmental practice (Appendix 1, OSPAR Convention).

EIF: Environmental impact factor (factor that describes the risk of environmental damage).

Contaminants in chemicals: This means environmentally hazardous substances that have not been added deliberately, but which occur naturally in low concentrations in chemicals. These are not pollutants in the sense of the Pollution Control Act, but instead they are undesirable substances that can accompany chemicals (such as heavy metals in barite).

Chemicals: For the purposes of this report, chemicals mean substances and mixtures of substances that are added in connection with activities in the petroleum industry.

Chemical substances: refer to both chemicals and naturally occurring substances.

Environmentally hazardous substances: Substances or groups of substances with intrinsic properties such as toxicity, persistence (biodegradability), bioaccumulation potential and/or hormone disruption properties. The most dangerous of the environmentally hazardous substances are called chemicals for priority actions. The most important chemicals for priority actions are identified in the Storting White Papers on *The government's environmental policy and the environmental state of the realm* (RM). The authorities' list of chemicals for priority action is updated regularly. The list of chemicals for priority action from Storting White Paper No. 25 (2002-2003) is appended to this document (Appendix 4).

Merknad [w2]: Oppdateres ihht den nye RM. Finnes på MDs hjemmeside

Potentially environmentally hazardous substances: Substances or groups of substances that are not listed on the authorities' list of chemicals for priority action, but for which there is reason to believe that they are environmentally hazardous in relation to quantitative test criteria. The substances are to be evaluated on the basis of the precautionary principle.

SFT divides the chemicals into black, red, yellow and green categories according to their intrinsic properties (cf. SFT's information letter to the operators dated 27 December 2001). The most hazardous substances belong in the black category, while other environmentally hazardous chemicals belong in the red category.

Discharges that cause environmentally adverse effects: This term is used when we talk about the adverse effects a discharge can cause in each individual case. The potential for adverse effects is evaluated by using risk assessment models, and depends on factors such as volume discharged as well as time and location of the discharge. Environmentally adverse effects may result from a discharge of a hazardous substance, but it can also be due to the discharge of a substance without such intrinsic properties that it falls under the category of environmentally hazardous. An example of the latter could be drill cuttings from the petroleum activities which are not environmentally hazardous as such, but where discharges can cause adverse effects e.g. on coral reefs (covering them with cuttings).

Zero discharge of environmentally hazardous substances: No discharge of environmentally hazardous substances, neither from chemicals, contaminants in chemicals, oil nor naturally occurring substances.

Discharges that cause zero environmentally adverse effects: Discharges where an evaluation based on environmental risk assessment shows that there will be no adverse effects in the environment.

New installations: Installations with PDOs/PIOs approved after Storting White Paper No. 58 (1996-1997).

2.3 National environmental objectives

The zero discharge goal must be viewed in connection with strategic goals and national performance goals as regards the environment, as they are described inter alia in the Storting White Paper on the government's environmental policy and the environmental state of the realm.

Strategic goal for oil pollution: "A water quality shall be ensured in fresh water deposits and marine areas that contributes to maintaining species and ecosystems and which safeguards the consideration for human health and well-being".

National performance goals for oil: "Operational discharges of oil shall not lead to unacceptable damage to health or the environment".

Strategic goals for chemicals that are hazardous to health and the environment: "Discharge and use of chemicals that are hazardous to health and the environment shall not lead to health damage or an adverse impact on nature's ability to produce and renew itself. The concentrations of the most hazardous chemicals in the environment shall be brought down to the background level for naturally occurring substances, and as close to zero as possible for man-made compounds.

National performance goals for chemicals that are hazardous to health and the environment:

1. The discharge of certain hazardous substances (substances on the authorities' list[1] of chemicals for priority action) shall be stopped or significantly reduced by 2000, 2005 and 2010. The list is updated in each new RM.

2. Discharge and use of chemicals that constitute a serious threat to health and the environment shall be continuously reduced with the objective of stopping the discharges within one generation (by 2020).

3. The risk of discharge and use of chemicals causing damage to health and the environment shall be significantly reduced.

4. Pollution of soil, water and sediments caused by previous activities, incorrect disposal of waste, etc. shall not lead to potentially serious pollution problems.

The strategic goals have a long-term perspective and focus on the desired condition of the environment. The national performance goals focus on the discharges.

The zero discharge target for the petroleum activities' discharges to sea is more ambitious than the general goals.

2.4 Zero discharge targets

The operational zero discharge targets below apply immediately to new stand-alone developments, and by the end of 2005 for existing installations.

For discharge of added chemicals

A. No discharges of chemicals for priority actions, environmentally hazardous chemicals (substances on the authorities' list[1]) and substances in SFT's black and red categories[2)]).

B. No discharges of other chemicals if the discharges can lead to adverse effects on the environment (substances on SFT's yellow and green categories (PLONOR)).

C. No discharges, or minimization of discharges of chemicals for priority actions, environmentally hazardous or potentially environmentally hazardous substances that are contaminants in chemicals.

Substances on the authorities' list[1] of chemicals for priority action or in the black or red categories, and chemicals that are contaminated with substances on the authorities' list[1] of chemicals for priority action can be used under permit from the SFT, if this is necessary due to critical technical or safety considerations. The user is obliged to select chemicals with the least possible risk of pollution.

[1)]Prioritized chemicals in the Storting's White Paper on *The environmental state of the realm*

[2)] SFT's information letter to the operators, dated 27 December 2001

Chemicals must be selected and used so that the environmental risk is minimized. Definitions and requirements for the use and discharge of chemicals are found in Sections 56, 57 and 58 of the Activities Regulations, cf. Appendix 2. Reference is also made in this connection to the substitution requirements in Section 3a of the Product Control Act.

For discharge of oil and other naturally occurring substances:

A. No discharges, or minimization of discharges of chemicals for priority actions (the authorities' list).

B. No discharges of other substances if the discharges can lead to adverse effects in the environment.

The approach used in the formulation of the above targets concurs with the paramount objectives in the area of environmental protection.

After an overall evaluation, the companies will implement the measures that contribute most to reduction of the environmental risk associated with discharge of produced water by the end of 2005. As of today, there is no cleaning technology available that can eliminate the discharge of hazardous substances in oil and produced water (see Part III of the report for technology status), but technology is available that can reduce discharges significantly in many cases (see Appendix 2).

The installations that choose injection as a disposal solution for produced water will avoid discharges most of the time, depending on the facilities' regularity. Installations that choose appropriate cleaning solutions for produced water may also be able to achieve the target. These are solutions that, in addition to reducing the content of dispersed oil in produced water, can also reduce the content of elements such as PAH and alkyl phenols.

Residual discharges can be reduced even further by combining several technologies. In this manner, discharges can be forced down towards zero. However, it may be the case that zero residual discharges is not the optimum solution in regard to an overall evaluation. This could, for example, be the case in connection with increased consumption of chemicals, higher energy consumption with associated emissions to air, or disproportionately high costs.

In produced water, the content of most naturally occurring environmentally hazardous substances on the authorities' list of chemicals for priority action is already approaching background level concentrations, including most of the heavy metals. Oil, some heavy alkyl phenols and PAH are, however, found in concentrations that are higher than the background level.

3. BACKGROUND FOR THE WORK

3.1 Storting White Papers

The objective of zero discharges of environmentally hazardous substances to sea is formulated in two Storting White Papers addressing the environment. The goal applied immediately to new projects and shall be achieved by the end of 2005 for existing installations. Strong grounds can result in exceptions from complete goal achievement, but minimizing the discharges is a precondition. The administration is to ensure implementation of the goals in the White Papers.

Storting White Papers are prepared as documents from the government to the parliament (Storting). They are debated and adopted, with possible changes, by the Storting. When they have been adopted, they express the current political objectives in the relevant area. The Storting White Papers are aimed at the administration that is to ensure implementation of the guidelines and goals stated in the White Papers.

Because of the petroleum activities' substantial and increasing discharges to sea, the authorities have identified a need to formulate a strategic, general objective that can contribute to reducing the discharges beyond that which follows from national and international objectives for reduction of oil and chemical discharges. The objective of zero discharges to sea of potentially environmentally hazardous substances from the petroleum activities was established in Storting White Paper No. 58 (1996-1997) on environmental policy for sustainable development. The intention was to place special emphasis on the precautionary principle when evaluating discharges and to focus on more rapid achievement of the goals for phasing out environmentally hazardous substances. The objective applied to both new and old fields. Technical and reservoir conditions on existing fields may, however, mean that a minimization of the discharges will be the goal that can be achieved in practical terms, based on evaluations of environmental and cost-effectiveness.

The zero discharge target was repeated and emphasized in Storting White Paper No. 12 (2001-2002) “Clean and rich seas”, in which the government wanted to ensure that the goal was achieved within 2005 for existing fields. This White Paper emphasized that the goal also includes oil, added chemicals and naturally occurring chemical substances in produced water. Furthermore, it was expected that the operators were to be ambitious in their work to achieve this objective, and that they actively develop and implement new techniques that can ensure zero discharges to sea of environmentally hazardous chemicals.

3.2 The work in the Zero Discharge Group

Industry and the authorities are cooperating to contribute to rapid and coordinated achievement of the zero discharge target.

After the authorities' objectives were established in Storting White Paper No. 58 (1996-1997), SFT took the initiative of forming *the Zero Discharge Group* in which SFT, OLF, NPD, chemical manufacturers and suppliers of drilling fluids together looked into the possibilities of achieving zero discharges to sea from the petroleum activities. This work resulted in *the Zero Discharge Report* (November 1998). The report discussed the use of concepts and terms and also provided an overview of status and recommendations for further work.

On 24 June 1999, SFT ordered the operators to develop strategies for achieving zero discharges on their fields. The strategies were to contain binding action plans with deadlines for implementing the measures. These were sent to SFT on 1 March 2000 and have since been updated in annual reports. After the Storting White Paper on *Clean and rich seas* was published, the zero discharge work has intensified. In June 2002, the Ministry of the Environment asked SFT for a status report on the zero discharge work, and SFT submitted its report on 20 September 2002. The basis for the report was the company's zero discharge reporting in the annual reports.

In the summer of 2002, the Zero Discharge Group started a new review of the goals and mandate for the Zero Discharge Project. A mandate was established (Appendix 1) and it was decided that a new zero discharge report would be prepared in which the primary focus would be on updated reporting of the status of the zero discharge objective and development of technology to achieve zero discharges. In addition, the Group was to work on a proposal for a reporting format for the zero discharge reporting in 2003. The operators' zero discharge report for 2003 will form the basis for the authorities' evaluations of the operators' efforts, and it will also be an important element in a potential assessment of policy instruments to achieve the zero discharge objective.

For the purposes of the work on the new zero discharge report, the project participants were divided into the following working groups: 1. *Target terms and definitions*, 2. *Reporting 2003* and 3. *Technology development*. The group worked together in joint meetings with plenary discussions and clarifications. The technology group also held separate meetings. The Ministry of the Environment was invited to clarify the paramount objectives of the oil and chemical policy and what meaning the authorities attach to important terms. The result of the group work is summarized in this report.

3.3 Results and challenges

Discharges of added environmentally hazardous chemicals have been greatly reduced in recent years. Remaining challenges relate amongst other to chemicals for priority actions that are contaminants in products and naturally occurring chemical substances in oil and produced water. Active work is underway on many alternative solutions. Reduced water production, injection or improved cleaning of produced water are some of the many potential measures that can contribute to achieving the objective.

The companies report on status and plans with regard to zero discharges in the annual discharge reports to SFT. All of the operators are working actively to achieve the zero discharge objective.

Pursuant to Storting White Paper No. 58 (1996-1997), new fields shall, as a general rule, be developed with the objective of zero discharges of environmentally hazardous substances. The greatest challenge is associated with the older fields where discharges are greatest and implementations of measures are both expensive and technically challenging.

The content of chemicals for priority actions, environmentally hazardous and potentially environmentally hazardous substances in offshore chemicals used has been significantly reduced over the past 5-6 years. This is due to a proactive attitude on the part of the authorities, operators and many suppliers.

Another remaining challenge is a reduction in discharges of dope which contains small quantities of copper and lead. Elimination of these substances is difficult. Work is underway to develop alternatives that cause less harm to the environment without compromising technical or safety considerations.

Another challenge in the chemical work is contamination by environmentally hazardous substances in chemicals used in petroleum activities. The chemical that contributes most is the mineral-based weighting material barite, which is used in drilling fluid. Barite is contaminated with heavy metals to varying degrees. The industry is working to reduce these discharges, e.g. by reusing drilling fluid and by using other weighting materials such as ilmenite and hematite. These contain lower levels of heavy metal contamination. Barite from mines with less heavy metal can also be selected. Use of heavy brines can also replace the use of barite to some extent. This has been done successfully in connection with drilling in the North Sea and the Barents Sea.

Injection of produced water is an efficient way to meet the zero discharge objective when it comes to oil and naturally occurring chemical substances. Studies and tests are underway for many fields to determine whether injection or reinjection of produced water is a cost-effective and environmentally-friendly solution. Issues that must be resolved include the risk of acidifying existing oil and gas reservoirs, reduced injectivity (pressure build-up), increased energy consumption and thus higher CO_2emissions, suitable disposal zones, etc.

Some fields have chosen to direct their efforts towards cleaning produced water. Development and qualification of new cleaning methods take a long time, but new cleaning technology has been put to use on several installations (see Appendix 2). Field-specific conditions can limit the selection of potential solutions, inter alia due to water rates, the size of the oil droplets in the water, salinity and pressure conditions in the reservoir.

Solutions in addition to injection and cleaning may include technical process and operational modifications, such as the selection of valves and further optimization of operations. For some fields it may be possible to separate out special waste streams and handle these separately in a cost-effective manner.

A significant percentage of the reported discharges of some of the naturally occurring environmentally hazardous substances in produced water and chemicals (e.g. barite) are based on analysis results that lie below the detection limit for the best available methods. According to Appendix 1 to the Information Duty Regulations, the discharges shall be calculated at 50 % of the detection limit. Introduction of zero discharge measures will not affect this factor to any great extent. Future analysis methods with lower detection limits will reduce this contribution.

Many operators currently achieve zero discharge from drilling production wells by injecting drilling waste. This cannot always be done for other well operations, such as completion, well testing and well treatment.

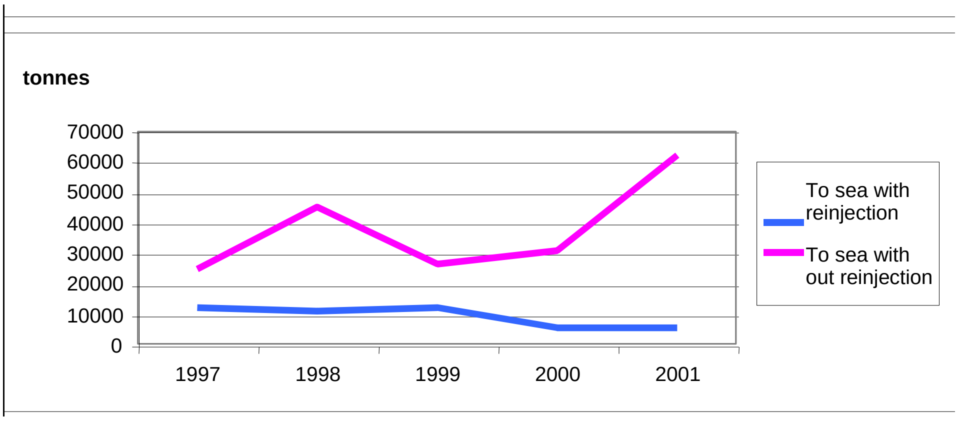


Figure 1. *Discharges of drill cuttings and drilling fluid with and without injection.*

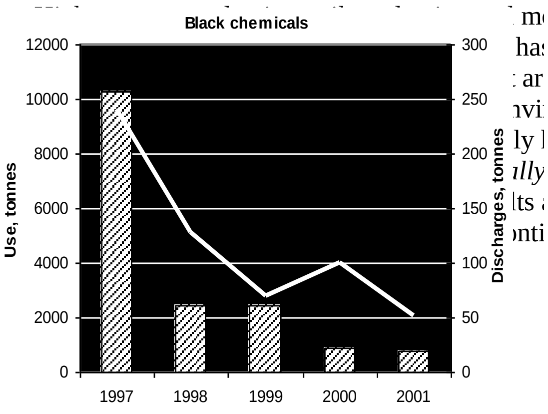
Figure 1 shows actual discharges (blue line) and the discharge as it would have been without injection (pink line). Example taken from Ekofisk.

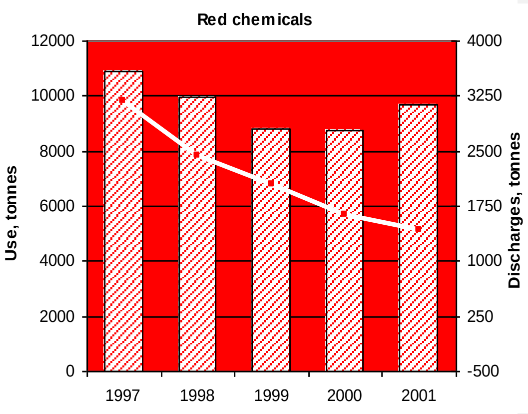
Exploration wells are often drilled using water-based drilling fluid with subsequent discharges of cuttings and drilling fluid. If drilling is carried out using oil-based drilling fluid then cuttings and drilling fluid are transported to land. It is not normally possible to inject from exploration rigs during drilling.

The chemical work

Increasing activity and aging fields lead to an increasing discharge of chemicals. The government's regulation and the industry's focus on the use of chemicals have, however, contributed to a decline in the percentage of environmentally hazardous chemicals that are discharged.

Use and discharge of chemicals in the petroleum activities has been regulated for many years.





methodology has been applied to all products over the entire period, and the environmental classification was made on the basis of ecotoxicological data registered in CHEMS.
Figure 2. *Consumption and discharge of chemicals in the black and red categories.*

The columns show consumption and the lines show discharges.

We can see from Figure 2 that chemicals in the black category have been reduced from about 250 tonnes in 1997 to 50 tonnes in 2001. Discharges of red chemicals have been cut approximately in half in the same period. Recorded total discharges of chemicals on the authorities' list of chemicals for priority action were from 500 - 600 kilos during the period 1997 - 2000. Total recorded discharges in 2001 amounted to 293 kilos and mainly consisted of copper and lead from dope.

Most of the discharges in the black and red categories are drilling and well chemicals and production chemicals.

If one looks at the historical development of discharges of some of the most environmentally hazardous substances, the following picture emerges

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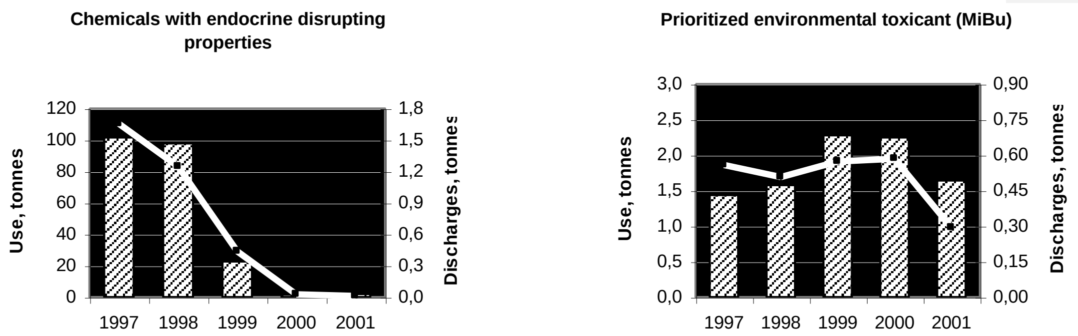

Figure 3. *Total consumption and discharge of hormone disrupting chemicals and chemicals on the authorities' list of chemicals for priority action. The columns show consumption and the lines show discharges.*

Hormone-disrupting substances have largely also been phased out on the Norwegian Continental Shelf. Discharges from one field were reported in 2001.

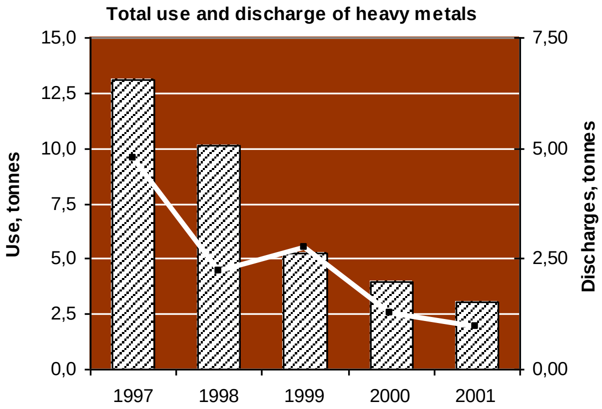

Figure 4. *Consumption and discharge of heavy metals added to products*. *The columns show consumption and the lines show discharges.*

Discharges of heavy metals as additives in products (mostly from dope) have also shown a significant decline during the period, and total discharges were less than one tonne in 2001. A similar trend has been noted for heavy metals that are contaminants in products (barite). For more detailed information we refer to OLF's report *Consumption and discharge of environmentally hazardous chemicals in a historical perspective*, (Novatech, 2002)

3.4 Forecasts

The total discharges of produced water are expected to increase up to 2010, and will then decline after a brief stable period. As a result of the zero discharge work, the burden on the environment will nevertheless be reduced.

The volume of produced water discharged to the North Sea has increased significantly since the beginning of the 1990s. As can be seen in Figure 6 below, the British discharges are more than double the volume of the Norwegian discharges. It is expected that the British discharges will be reduced as British fields are gradually shut down, while the Norwegian discharges are expected to continue to increase for a few more years.

The concentration of dispersed oil discharged with produced water has been fairly stabile over the past ten years. The total volume of oil discharged has therefore increased proportionately with the increase in discharges of produced water. Today about 12 % of the water is injected. The percentage of produced water that is injected is expected to increase in the future.

The total volume of chemicals used in production has been stabile in recent years, in spite of increased production of oil and produced water. The use of chemicals has become more environmentally efficient. The volume of chemicals linked to drilling is more dependent on the level of activity.

Measures that will be implemented as a result of the zero discharge targets will contribute to reducing the overall burden on the marine environment.

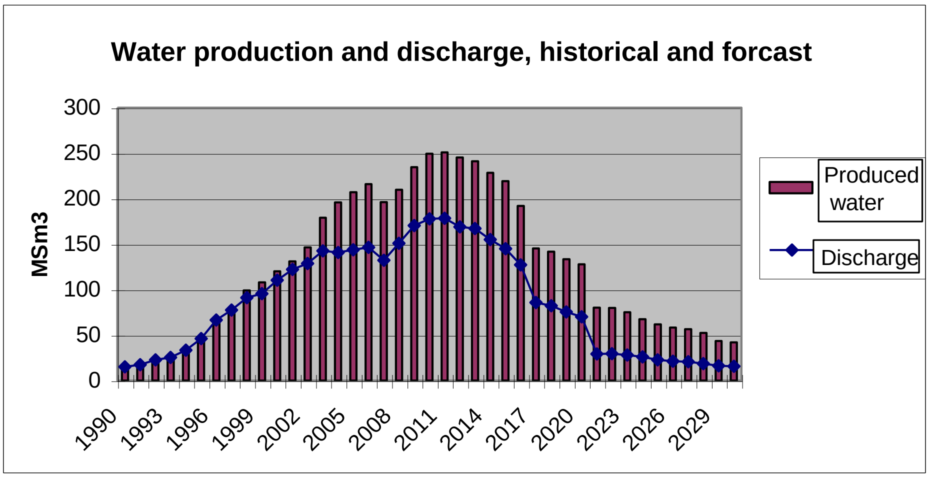

Figure 5. *Historical and forecast volumes of produced water and discharge volumes on the Norwegian Continental Shelf.*

The difference in production and discharges is due to the anticipated increase in the use of injection as a method of handling produced water.

The figure below shows historical and forecast discharges of produced water from Norwegian and British installations to the North Sea. Data from the British Continental Shelf relates only to the period 1991 - 2006. The forecasts for the British Continental Shelf do not include reduction measures that will be implemented to achieve the OSPAR goal of a 15 % reduction.

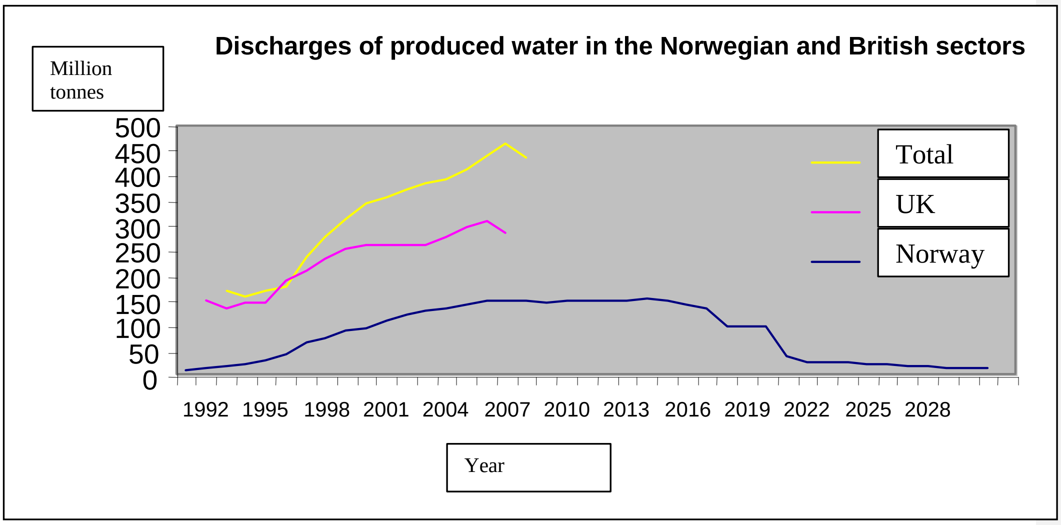

Figure 6. *Historical and forecast discharges of produced water from the Norwegian and British Shelves, as well as total discharges.* Source: DTI and UKOOA

4. THE WORK TOWARDS THE GOAL OF ZERO DISCHARGES

The operators systematically review the discharges to sea in order to implement measures and reach the zero discharge target.

Figure 7. *Flowchart showing the principles in the operators' evaluation elements in relation to the zero discharge work. Implementation by the end of 2005.*

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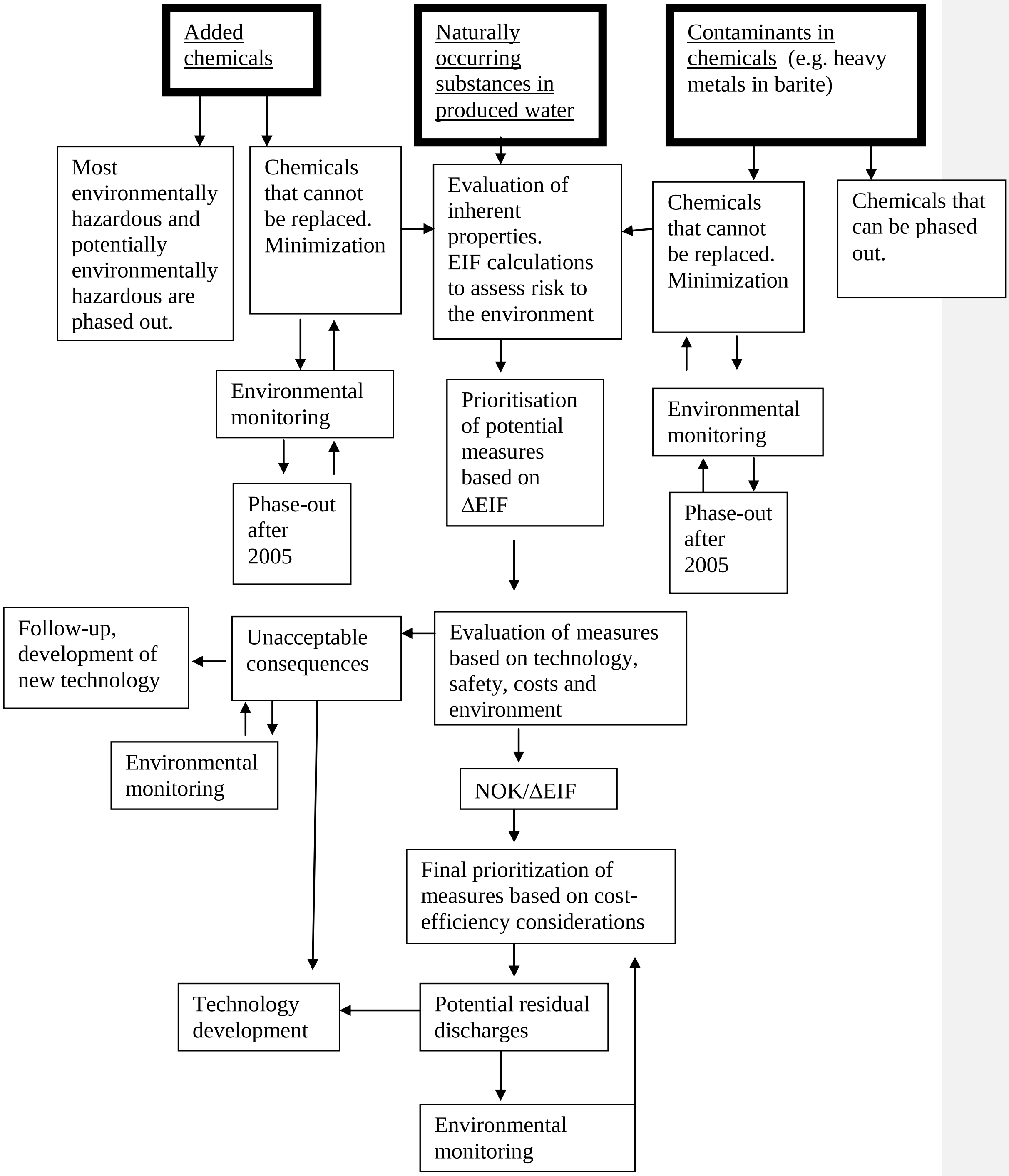


4.1 What has been done so far?

An overview of the most important zero discharge measures implemented, or being considered by, the operators on the Norwegian Continental Shelf is provided in Appendix 2. In addition to these, the companies have implemented a number of other measures in connection with chemical substitution and development of new, less environmentally hazardous chemicals, testing of new cleaning technology, optimization of existing processes and equipment, water cut-off, improvements with regard to materials and process choices and re-use of drilling fluids/chemicals. This work is performed as a natural part of the environmental work on the part of the operators, and also as follow-up of regulations and administrative decisions by the authorities.

One of the preconditions for a risk-based approach is that the environmental risk is thoroughly assessed using a suitable model tool. Factors that are used as a basis include the composition of the discharges, the substances' intrinsic properties, recipient factors, and the volume and spread of the discharges. Another important precondition is that potential effects and spread can be monitored, inter alia to verify the environmental risk assessments.

As regards produced water, the environmental benefit of such a measure will be reflected in the reduction in environmental risk provided by the measure in the form of a reduced Environmental Impact Factor (EIF). The DREAM model (Dose related Risk and Effect Assessment Model) forms the basis for EIF. The model was developed to evaluate the risk of damage from discharges of produced water on the Norwegian Continental Shelf. EIF is computed for the total discharge, and thus includes both added chemicals and naturally occurring components. The DREAM model has now been validated by independent experts, and will contribute to improvement of the model. It is now being developed to include other areas as well.

The risk-based approach means that there will be substantial variation in the selection of appropriate solutions from field to field. With the exception of substitution of added environmentally hazardous chemicals, which is a general goal for all fields, a company that operates several fields may compare costs of measures on an overall basis and choose the measures which yield the greatest cost-effectiveness. In addition to the environmental risk assessments, reservoir, technical, operational, financial and resource-related factors will vary from field to field, which will have an impact on the prioritization. Discharges of naturally occurring substances in produced water cannot be phased out in the same manner as added chemicals. Injection of produced water is an example of a type of measure where natural and technical requirements will vary, and undesirable side effects such as increased emissions of CO_2 and discharges of chemicals can occur if, for example, the produced water cannot be used for pressure support.

4.2 How is work currently done?

Environmental management

All operators on the Norwegian Continental Shelf work according to international standards for environmental management (ISO 14001 or EMAS). Not all of the companies are formally accredited, but all of them do have environmental management systems that are in accordance with these systems. This means that HSE requirements, both internal and statutory, objectives and standards are safeguarded and considered in all planning, such as HSE programs, annual plans, investment plans, field planning, etc.

When planning for fields in operation, the companies make a systematic review of:

- Substitution of all chemicals in SFT's red or black category, both for drilling and well operations, pipe operations and production
- Injection of produced water
- Injection of drainage water
- Injection of drilling fluids and cuttings
- Technical process improvements leading to less use of chemicals or reduced discharges
- Cleaning of produced water before discharge to sea
- Other relevant measures to reduce discharges

The operators also have key performance indicators. The installations are evaluated based on whether the environmental objectives are achieved or not. Such performance indicators can include:

- Oil content in produced water
- Compliance with other requirements in connection with discharges
- Substitution of chemicals in red or black categories
- Number of acute discharges

Reduction in discharge of added chemicals

Most hazardous chemicals are no longer discharged on the Norwegian Continental Shelf due to strong focus on the chemicals' intrinsic properties such as degradability, potential for bioaccumulation and acute toxicity (see Chapter 2.5). The goal is that use and discharge of environmentally hazardous chemicals shall be zero by the end of 2005. Use of environmentally hazardous chemicals may still be necessary when very strong grounds indicate this.

Merknad [w4]: Her ville jeg normalt forvente "weighty reasons"

SFT is the responsible regulatory authority, and regulates the use and discharge of added chemicals on the Norwegian Continental Shelf through discharge permits, and now also through the HSE regulations for the petroleum activities. In addition, requirements for ecotoxicological testing and evaluation requirements have been effective driving forces for reduction of the most environmentally hazardous substances. The results from testing of the substances with regard to degradation, potential for bioaccumulation and acute toxicity are used as a basis for prioritization for substitution. A common testing and reporting system (Harmonized Offshore Chemical Notification Format - HOCNF) developed through the Oslo-Paris Convention (OSPAR) is used.

The operators have plans and follow-up systems for reduction of consumption and discharge of chemicals. The goal is no discharges of chemicals in the red and black category by the end of 2005.

Only if there are strong reasons for such use will permits be granted for consumption and discharge of environmentally hazardous chemicals. In the zero discharge work linked with use of small amounts of chemicals, the resource consumption should be weighed against the environmental benefit achieved.

Cost assessments

In some cases, there may be a conflict between requirements for environmentally friendly solutions and requirements for efficient resource exploitation. The industry must also consider cost-effectiveness in relation to its activities. When planning large, cost-driving measures consequences of e.g. shortened lifetime must be taken into account.

The energy authorities require that operations on the Norwegian Continental Shelf shall ensure efficient exploitation of the oil and gas resources. The industry on the Norwegian Continental Shelf plays an important role in the management of significant national wealth, and it is in everyone's interest that these assets are exploited efficiently. The state and the industry share revenues and expenses, and it is in the interest of the larger society that the resources are exploited in the most cost-effective manner possible. Therefore, it is a precondition that the activities are carried out according to good business principles.

If some measures are so costly that they come at the expense of the individual field's lifetime, then this means the risk of significant loss of revenues. Even if environmental measures seem to be both correct and sensible from the viewpoint of the environmental framework, the industry has a mandatory and independent responsibility to evaluate the environmental benefits against the disadvantages that the measures might entail. This could be incompatible with the environmental objectives.

However, it is important to exercise caution as regards the impact the activities have on the environment. This applies particularly to the long-term effects that can be quite difficult to discover with today's monitoring methods. Long-term effects are defined as effects on more than one generation for organisms, or more than one natural cycle for a biological system. Important issues in this context are addressed in the research program on *Long-term effects of discharges to sea from the petroleum activities* – PROOF under the direction of the Research Council of Norway.

Focus on technology

The zero discharge work has increased the focus on technological solutions for discharge reductions. There is no single solution that can solve all the discharge problems. In terms of technology, 100 % effective cleaning cannot be achieved.

Technological development can help to reduce the industry's impact on the environment. The technology that may provide the greatest contribution to reducing discharges to sea is the injection of produced water. This requires a suitable geological formation. Using the produced water as pressure support is most cost-effective. Water injection requires substantial amounts of power and contributes to emissions of CO_2 and NO_X.

Technological measures down in the well that reduce the volume of produced water may include chemical or mechanical water shut-off and possible separation of water. Such solutions are, however, dependent on the well and formation. In addition, they are complex and cost-intensive for old wells. All measures down in the well are difficult to monitor and maintain.

Water-soluble oil components such as PAH or alkyl phenols are more difficult to clean than dispersed oil. The industry has a good overview of existing cleaning technology and technology that is in the experimental stage. Today, there is no single technology that can clean all organic components in produced water. A likely development is that the cleaning plants will be made smaller and tailored to each specific field. Several cleaning plants have been implemented that have the potential of removing up to 90 % of certain organic components in produced water. In terms of technology, 100 % effective cleaning cannot be achieved.

Environmental monitoring

Monitoring of the seabed around the installations on the Norwegian Continental Shelf over the past 15 years shows that the environment normalizes after cease of oily drilling fluid discharges. It is however difficult to document negative impact of discharges in the water masses, in spite of extensive work to find suitable methods for such monitoring.

Today, environmental monitoring is carried out pursuant to Sections 49, 51 and 52 of the Activities Regulations, cf. Appendix 1. The results are evaluated by SFT's expert group composed of representatives of the University of Oslo, NIVA and the Institute of Marine Research. The results are reviewed with the operators each year before the plans for the next year's studies are laid. The cooperation between the industry, public administration and research, in addition to the extent of the data material, has attracted international attention.

The environment on the seabed has been regularly monitored since 1982. The results showed early on that discharges of oil-based drilling fluid had a negative impact on the seabed. The contaminated area of the seabed has, however, been reduced after these discharges were halted. The environmental condition of the seabed in the central North Sea Basin and northwards has been thoroughly mapped, and the seabed is less contaminated from discharges from the Norwegian petroleum activities than was the case ten years ago. In 1998, monitoring of the water column was included.

Laboratory tests initiated by the industry show that certain alkyl phenols that can occur in produced water may have a hormone-disrupting effect on fish. The concentrations of these components in produced water are, however, very low. Environmental monitoring of the water masses is a prioritized area, and significant resources are dedicated to finding suitable methods for discovering possible effects.

In the research program *Long-term effects of discharges to sea from the petroleum activities* – PROOF, the industry and the authorities are working together to enhance knowledge of some of the high-priority issues. The program is run by the Research Council of Norway. It started in 2002 and will run through 2008 with an annual budget of approx. NOK 20 million.

5. GUIDELINES FOR ZERO DISCHARGE REPORTING IN 2003

Pursuant to Storting White Paper No. 58 (1996-1997), the operators conducted a thorough review of potential measures to reduce discharges to sea from the petroleum activities the spring of 2000. The status of this work was included in the companies' annual discharge reporting in 2001 and 2002. A more comprehensive and concrete status report will be prepared in 2003, with action plans to achieve the objective by the end of 2005.

5.1 Scope of the reporting

The zero discharge reporting in 2003 comes in addition to the ordinary discharge reporting pursuant to Section 9 of the Information Duty Regulations, cf. appendix.

Who is to report:

- The operators of all existing installations or natural groups of installations.

- Operators of installations where development has been approved (with approved PDO/PIO) prior to 1 January 2003.

Operators of installations that will be shut down before the end of 2005 shall prepare reports that can be less comprehensive. The status with regard to zero discharges and potential measures that can be implemented over the short term shall be described.

The zero discharge goal applies to all installations offshore, including satellite developments and installations that have processing/discharges on other installations. The main installation shall coordinate the evaluation of measures for any tied-in installations, and report such measures in its report. The reporting shall be carried out in accordance with the principles that are used in the discharge permits, i.e. that discharges shall be described and evaluated on the installation or the field where they physically occur. Activities that are covered shall be divided into drilling and well operations, production and discharge from pipelines.

All relevant measures to achieve the zero discharge target shall be described and evaluated in accordance with the criteria below. The report shall also contain binding plans for meeting the objective, no later than by the end of 2005.

Deadline for reporting:
The report shall be sent to the SFT with a copy to the NPD by 1 June 2003.

5.2 Contents of the report

Summary
The most important measures, the most important results and the distance to the goals in Chapter 2.4 shall be highlighted in the summary.

Introduction
The introduction shall provide a brief description of the field/installations that are covered under the reporting. Relevant information that can be linked to discharges to sea may include

the field's development history, the main activities that take place on the field, the field's status and plans for further development (e.g. phase-in of new satellites) and the field's estimated lifetime.

Discharge status and forecasts
A brief summary of the discharges from start-up through 2002 shall be provided, along with forecasts with both current discharge configuration and planned measures. The forecasts shall be established from and including 2003 and for the remainder of the installation's lifetime. The results should be presented as figures in the report, and the tables can be attached.

The figures should also show the development of the EIF over the field's lifetime with and without measures, but shall as a minimum show Δ EIF in 2006. In cases where this does not provide sufficient information about the field's development, the operator shall provide information about further planned measures to achieve the zero discharge target (e.g. where water production starts after 2006). A pie chart showing the various contributions to environmental risk for the years 2000, 2002 and 2006 shall be included.

When reporting is done for discharges of naturally occurring substances in produced water, both volumes discharged and concentrations in the discharges shall be included and these data shall be discussed in relation to the natural background level. If the concentrations are lower than the detection level, the same reporting principle shall be used as in the annual report.

Table 1-3 specifies what is to be reported as regards discharges to sea.

Table 1. *Discharges of naturally occurring environmentally hazardous substances, NPD and dispersed oil in produced water to sea.*

Water to sea 2000 (m^3)	Water to sea 2002 (m^3)	Expected water to sea 2006 (m^3)

	2000		2002		Expected 2006 without measures		Expected 2006 with measures	
	Conc.[1)] (mg/l)	Discharge (kg)	Conc.[1)] (mg/l)	Discharge (kg)	Conc.[1)] (mg/l)	Discharge (kg)	Conc.[1)] (mg/l)	Discharge (kg)
Arsenic								
Lead								
Cadmium								
Copper								
Chrome								
Mercury								
PAH - 16								
BTEX								
C8-Phenol								
C9-Phenol								
NPD								
Dispersed oil in water[2)]								

1) *Field-specific concentration factors shall be used.*
2) *According to the same method as used for annual discharge reporting.*

Table 2. *Discharge of added chemicals from production and pipeline activities*

		2000	2002	Expected 2006
		Discharges (tonnes)	Discharges (tonnes)	Discharges (tonnes)
Chemicals in black category				
	Arsenic			
	Lead			
	Cadmium			
	Copper			
	Chrome			
	Mercury			
	PAH - 16			
	C8-Phenol			
	C9-Phenol			
Chemicals in red category				

Table 3. *Discharges of added chemicals from drilling*

		2000	2002	Expected 2006
		Discharges (tonnes)	Discharges (tonnes)	Discharges (tonnes)
Chemicals in black category				
	Arsenic			
	Lead			
	Cadmium			
	Copper			
	Chrome			
	Mercury			
	PAH - 16			
	C8-Phenol			
	C9-Phenol			
Chemicals in red category				

Evaluation of relevant measures

When reviewing the measures, the principles in the decision matrix (Fig. 7) shall be followed. Comments shall be given on both 1st priority measures, 2nd priority measures, etc. The chapter shall deal with

- which selection of measures has been subject to more detailed evaluation

- why the measure was selected or rejected
- how the measures have been assessed in relation to each other
- which measures have been approved for implementation

Relevant measures considered for implementation shall be described in relation to the above criteria, and the conclusion drawn shall be stated. In cases where the measure has been rejected, reasons for this shall be stated.

The descriptions shall be brief. Supplemental information shall appear in Tables 4a and 4b, which are to be appended. If needed, the tables can cover one measure per page.

Table 4 a *Criteria for evaluation*

Measure	Criteria for evaluation				
	Discharge reduction (appropriate unit, see Tables 1 and 2)	Change in emissions to air (CO_2 and NOx tonnes and % change)	Cost of measure (NOK)	Cost-effectiveness (NOK/ reduction in environmental risk)	Other consequences

Table 4 b *Conclusion*

Measure	Conclusion			
	Already implemented	Approved for implementation	Further work, feasibility studies	Rejected

Explanation of Table 4a Criteria for evaluation

Each measure should be evaluated in relation to the following criteria:

- *Discharge reduction*. For environmentally hazardous substances, the changes in kilograms shall always be stated for all types of discharges (drilling, production, pipes). For produced water, the environmental effect of the measure shall be measured in ΔEIF. For other types of discharges than produced water, the discharge reductions should be stated in both m^3 (or tonnes) and as a percentage reduction compared with if the measure had not been implemented. For drilling, the discharge reduction shall be stated in kilograms of environmentally hazardous substances per drilled meter.

- *Cost of measures.* The following cost elements shall be included when calculating the cost of measures:
  - Investment costs
  - Increased operating costs as a result of measures, with the deduction of any savings or increased revenues. An agreed man-year cost shall be used as a basis.
  - The value of changed emissions of CO_2 and NO_X as a result of the measure. An environmental cost of NOK 300 per tonne CO_2 shall be used as a basis (based on the current CO_2 tax) and NOK 20 per kg NO_X (based on estimated cost of measures to meet international commitments).

  The estimates for the costs of measures can be rough if more accurate estimates would require resource-intensive analyses. The estimated range of uncertainty for the estimates shall be stated. The estimates shall be presented in a manner that is clear and easy to understand. A spreadsheet that can be used to aid in these estimates is included in Appendix 3.

  The costs of measures that are expected to be triggered at various points in time shall be converted into present value 2003 and totaled at net present value. The discount rate shall be 7 %. As a general rule, the economic lifetime for the investment shall be equal to the field's economic lifetime. The investment's anticipated sales value after the field's economic lifetime shall be included in the calculation. If the technical lifetime of the investment is expected to be shorter than the field's economic lifetime, then the economic lifetime of the investment shall be set as being equal to the anticipated technical lifetime of the investment.

  In addition to the present value for 2003, an anticipated annual cost for the year the measure is implemented shall also be calculated. Here the investment costs shall be converted into annual costs using the annuity method. Interest and economic lifetime shall be retained as assumed above.

- *Cost-effectiveness.* For produced water, the cost-effectiveness shall be calculated as:

  (a) (Net present value of the cost of measures) / (total reduction in environmental risk over the lifetime of the measure), and
  (b) (Annual cost in the year the measure is implemented) / (reduction in environmental risk for 2006)

  It is only relevant to calculate cost-effectiveness for measures that are considered to be technically feasible.

- *Other consequences.* Reduction of discharges to sea can entail consequences for other factors than emissions to air and costs, e.g. safety and working environment consequences, consequences for reservoir, resource or production factors, consequences of delayed production and field lifetime, or a displacement of the environmental problem to other locations, such as to land facilities. These types of consequences shall be described and an evaluation of the significance of implementing the measure shall be provided.

Commitments till the end of 2005
The plans the operators have for studies as a basis for decisions and implementation of zero discharge measures till the end of 2005 shall be described. Preliminary evaluations of measures that may be relevant after 2005 shall be included.

The measures shall also be presented in table form, stating the time when the various measures will be implemented. The table below shall be used.

Table 5. *Prioritized measures.*

Measure	Status as of 1 June 2003	Schedule for implementation	Responsible unit
Injection of produced water on the field.	Implementation approved.	By 15 June 2005	Petra field

Description of distance from the target
The anticipated discharge situation on the field as of the end of 2005 viewed in relation to the zero discharge objective (Chapter 2.4) shall be described. A basis for the evaluations shall be stated.

6. TECHNOLOGICAL EVALUATIONS

6.1 Introduction

It is recommended that the evaluation of alternative discharge-reducing technologies be done systematically. This chapter provides advice on how this can be done. The principle that forms the basis for the decision matrix for selecting zero discharge measures in Figure 7 should be followed for the reporting to SFT.

The text in Chapter 6 should be compared with the table in Appendix 2 which provides a selection of relevant technologies that are either in use or under development, and the table in Appendix 4 which provides an overview of the most important zero discharge measures already implemented on the Norwegian Continental Shelf.

The chapter also provides a brief discussion of important evaluation criteria that all parties with an interest in the zero discharge work should be aware of. All measures implemented on existing installations will have consequences for production, the reservoir, safety, the environment or in some other way. It is important for the operator to be aware of the consequences associated with the various measures, while at the same time it is also important for other players to know that the operator has evaluated the measures based on the best available knowledge about potential consequences.

6.2 Resource- and costrelated consequences of zero discharge measures

Resource consequences and cost-related consequences of zero discharge measures are closely related. Expensive measures can reduce the field's profitability and lead to an earlier shutdown than planned, with loss of resources as a consequence. Measures to achieve the goal of zero discharges must be evaluated in relation to the field's optimal drainage strategy.

Implementation of measures on existing installations can require considerable investments and, in some cases, higher operating costs as well as great technical challenges. If the use of mobile rigs is necessary, this will also have an impact on the cost level. Similar measures in new projects will normally be less cost-intensive, but will not provide an environmental benefit until after the field produces significant water volumes, which often does not occur until after several years of production.

In order to avoid or reduce water production, various methods for water shut-off, both chemical and mechanical, can be used in some cases. Several factors can have an impact on the selection of the solution, such as temperature and pressure, completion type, flow behind casing and the nature of the formation (e.g. fissures, danger of well collapse).

Injection of produced water can take place after separation on the installation, on the seabed or down in the well. Injection for pressure support can partially or completely replace seawater injection, and will thus not entail additional energy consumption. For injection, consideration must be given to the fact that mixing seawater and produced water can lead to scaling both in the process equipment and in the reservoir, and low-level radioactive scale can be formed. With injection, the risk of production of H_2S, increases, which could lead to increased corrosion. If a separate well must be drilled to dispose of produced water, this will require considerable investments, higher operating costs and increased emissions to air.

Downhole separation and seabed separation are solutions that are being developed. Maintenance of equipment down in the wells and on the seabed will be more demanding than if the equipment were placed on the platform.

A high regularity (85-95 %) is normally expected with injection of produced water. In order to maintain production also when the injection facility is down, there will be a need for cleaning when the water is discharged to sea.

Cleaning measures should preferably be performed for the most environmentally hazardous substances in the water. Selection of the cleaning technology shall be based on BAT. There is no single cleaning technology available today that removes all environmentally hazardous substances and other substances that can lead to harm to the environment. Installation-specific solutions must therefore be selected. Consideration must also be given to the need to increase other discharges (such as added chemicals) that will lead to a higher risk of environmental damage.

In some cases it will be difficult to replace environmentally hazardous chemicals with less environmentally hazardous substitutes without problems e.g. in relation to production.

Implementation of zero discharge technology is expected to have little impact on the risk level associated with safety on the installations as compared with other technical changes. However, this must be evaluated in each individual case.

6.3 Principles for selection

Appendix 4 provides an overview of various technologies that can contribute to achieving the goals in Chapter 2. A schematic decision matrix is also appended for selection of technology.

The technology overview has been prepared on the basis of available literature and existing knowledge on the part of OLF, the industry and the authorities. The overview is not necessarily exhaustive on all points. Emphasis has been placed on technology where development is complete, or which is expected to be ready for implementation in the near future.

The overview is divided into the following focus areas:
- Production produced water, drainage water, well operations, sand removal
- Chemicals
- Drilling and wells
- Pipelines

In each area, the relevant technology is listed in a sequence according to principles for selection, i.e., technology that will reduce the volume of produced water is listed before cleaning technology. This has been done to highlight technology that can contribute the most towards achieving the goals that are to be prioritized.

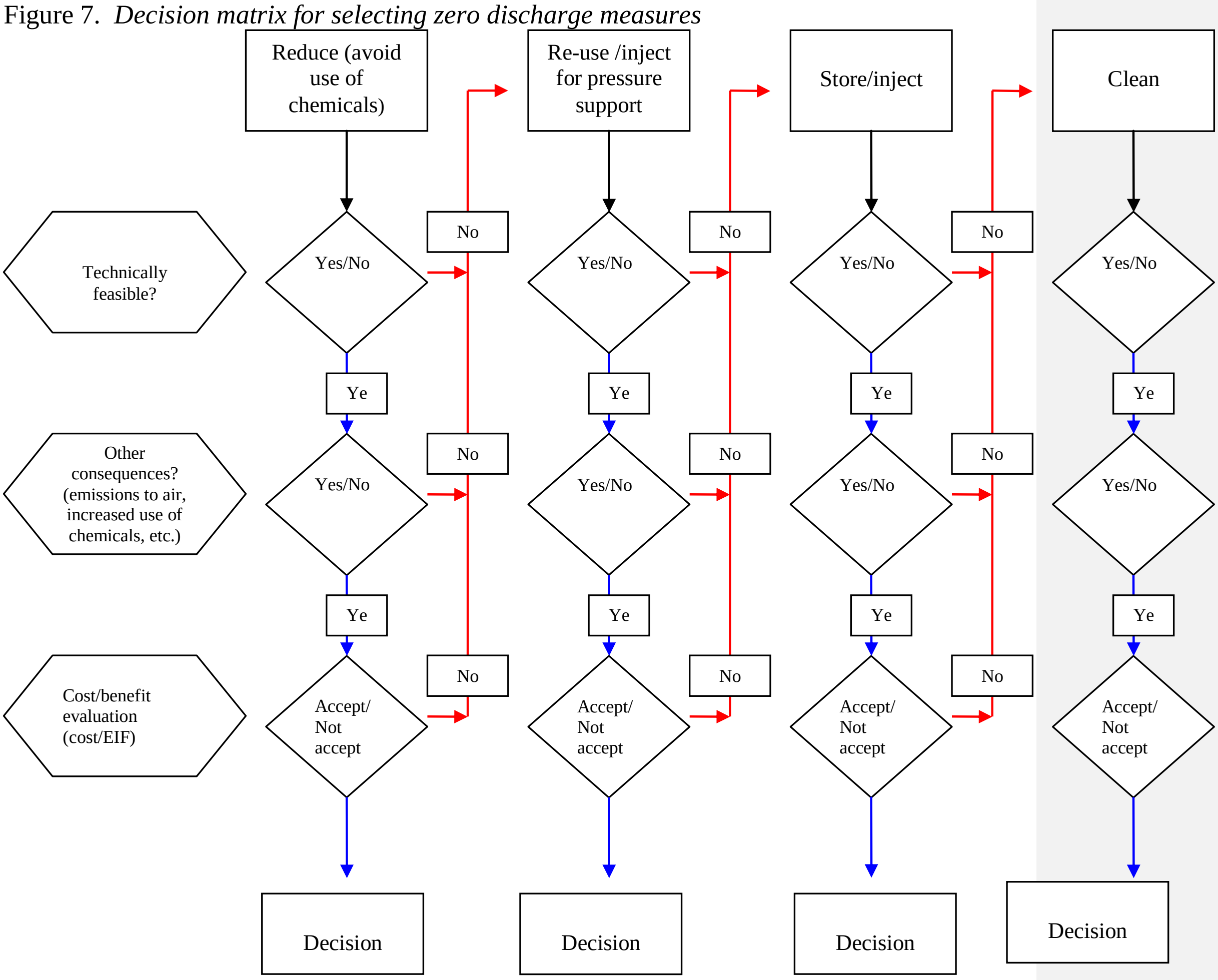
6.4 Principles and decision matrix

The following principles apply to evaluation and selection of technology (in priority order):

Principle 1: Reduce (prevent from occurring)
Principle 2: Reuse (practical reuse, e.g. injection for pressure support)
Principle 3: Disposal/injection (e.g. disposal on land or injection in Utsira, see Appendix 4)
Principle 4: Cleaning (remove what should not be discharged)

A decision matrix has been prepared for selecting zero discharge measures that follow the above principles.

Figure 7. *Decision matrix for selecting zero discharge measures*



REFERENCES

The list below contains an overview of the most important documents that form the basis for the work on the report.

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OLF/SFT (November 1998) – The Zero Discharge Report. A collaboration between OLF and SFT to follow-up Storting White Paper No. 58 (1996-1997) and the requirement for reducing discharges to sea.
Not published. May be obtained upon inquiry to OLF or SFT.

OLF (2002) – Coexistence between fisheries, aquaculture, oil activities, shipping and environmental interests. Final report from the Environmental Forum's working group on fisheries/oil. *The Norwegian Oil Industry Association (OLF), Stavanger*.

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Appendix 1

Mandate for the work in the Zero Discharge Group
(24 September 2002)

The Zero Discharge Group is an advisory cooperation group for the Norwegian Pollution Control Authority (SFT), the Norwegian Petroleum Directorate (NPD) and the Norwegian Oil Industry Association (OLF). Other authorities, research institutions and representatives of the industry may be invited to participate in working groups, etc. as needed. The work is led by SFT, which also functions as the secretariat.

The group shall ensure a common understanding of the authorities' objectives for the zero discharge work and shall function as an information channel between the authorities and the industry. It shall contribute to mapping existing measures in order to achieve zero discharges and be a driving force for development and implementation of new measures. When evaluating measures, the group shall make comprehensive evaluations of both positive and negative aspects for the environment. The Zero Discharge Group can give advice to the industry and the authorities about measures than can help achieve the objective of zero discharge of potentially environmentally hazardous substances to the sea from the petroleum activities. The Group can also propose methods of evaluating and following up the zero discharge measures.

The Group shall contribute to follow-up of Storting White Paper No. 12 (2000-2001) "Clean and Rich Seas" by providing input to the work on comprehensive administration plans for the sea areas. It is particularly relevant that the Group contribute advice in connection with use of the zero discharge target when evaluating areas where certain activities are not permitted. There is also a need for mapping how zero discharges can contribute to improve coexistence with other interests in the sea areas. Input can be provided in connection with the sector-specific impact assessments of the sea areas and/or to the project groups and the management group for preparation of comprehensive administration plans.

Over the short term the Group shall:

- Perform a new review of the zero discharge concept and propose amplifications and examples that can make the concept and term easier to use. The review shall result in proposed guidelines for how the term is to be used.

- Discuss the reporting format for zero discharge reporting in 2003, with particular consideration for ensuring verifiable reporting and documentation of evaluations and measures. Map potential performance indicators for achieving the zero discharge objective and identify advantages and deficiencies. The results shall be laid down in a recommendation to the authorities.

- Discuss how to ensure that the zero discharge target is achieved in 2005 and how one can verify that potential reasons for lack of measures are valid (technical/financial). Conduct a review of technology status and expected technological development.

- Evaluate criteria for identifying zones where certain activities or discharges should not be allowed.

- Map and communicate further use of the environmental risk models as tools to achieve the objective and identify advantages and deficiencies associated with such models.

Appendix 2

Overview of zero discharge measures per field

Fields that have not started operations | Fields that have been shut down.

Field	Operator	Type	PDO	Prod. start	Extract of important zero discharge measures		Comments
					Drilling	Production	
Albuskjell		Oil/gas	25.04.75	26.05.79			Shut down 26.08.98
Balder	Esso	Oil/gas	02.02.96	02.10.99		Injection of produced water and drainage water	The wells are drilled from a drilling rig. Drilling on the field is complete.
Borg	Hydro		29.06.99	01.07.99			Included in Tordis
Brage	Hydro	Oil /gas	29.03.90	23.09.93	Injection facility for cuttings and slop	Injection of produced water EPCON approved for implementation.	
Cod		Gas /oil	04.05.73	26.12.77			Shut down 05.08.98
Draugen	Shell	Oil /gas	19.12.88	19.10.93	Discharge of barite eliminated during drilling of Rogn South in 2002 due to transition to ilmenite. Plan use of ilmenite in future drilling in the Draugen area	PECT-F installed, Produced water strategy established 2002. PWRI being evaluated Material quality in Garn West and Rogn South oil pipelines eliminate use of corrosion inhibitor.	EMAS certified 1999, recertified 2000
Edda		Oil /gas	25.04.75	02.12.79			Shut down 05.08.98
Ekofisk	Phillips	Oil /gas	15.06.71	01.03.72	Ilmenite as weighting material, dedicated injection well. Injection of cuttings since 1996 as well as completion operations.	Pilot for testing of reinjection produced water in operation in 2002. Test of PECT-F and EPCON. Reinjection of prod.w. with used H_2S scavenger implemented in 1998.	Participate in development of C-Tour, possible back-out to injection. Decision made to install EPCON. Reinjection of used H_2S scavenger significant contribution to reducing environmental risk.
Eldfisk	Phillips	Oil /gas	25.04.75	08.08.79	Have used ilmenite injection of cuttings since 2000.	Small volume of discharges. PECT-F tested. Considering further cleaning measures/injection.	
Embla	Phillips	Oil /gas	14.12.90	12.05.93	Cuttings are transported to Ekofisk or Eldfisk for		Produces to Eldfisk.

					injection.		
Fram	Hydro	Oil /gas	23.03. 01	Production not started.			Subsea installation to be tied to Troll C.
Frigg	TotalFina Elf	Gas	13.06. 74	13.09. 77		Injection of produced water since 1987. 100 % regularity	Shutdown planned for 2003.
Frøy	TotalFina Elf	Oil /gas	18.05. 92	15.05. 95		Produced water discharge stopped in March 2000, water routed to oil export pipeline for treatment downstream due to conflict in capacity for cleaning equipment and produced water volume in tail production phase.	Wellstream processed on Frigg. Shut down 05.02.01. Removed in 2002.
Glitne	Statoil	Oil	08.09. 00	29.08. 01		Injection of produced water will start in 2003	The wells are drilled from a drilling rig. Drilling on the field is complete. Problems starting injection of produced water.
Grane	Hydro	Oil	14.06. 00	Production not started.	Plan injection of cuttings.	Will inject produced water.	
Gullfaks	Statoil	Oil /gas	09.10. 81	22.12. 86	Implemented injection of cuttings. Increased reuse of drilling fluids. Changed well design	Environmentally friendly H2S removal. Participates in dev. of C-Tour. Decided to install equipment for cleaning produced sand	
Gullfaks Sør	Statoil	Oil /gas	29.03. 96	10-10-98			Gullfaks satellite, incl. in Rimfaks and Gullveig. See Gullfaks
Gungne	Statoil	Gas condensate	29.08. 95	21.04. 96	Well drilled from Sleipner A		Satellite to Sleipner Øst
Gyda	BP	Oil /gas	02.06. 87	21.06. 90	Injection of drilling fluid and cuttings since 1991		
Heidrun	Statoil	Oil /gas	14.05. 91	18.10. 95	PETEK-CETCO cleaning technology for back flow from well treatment/start-up of wells tested but major operations problems. Considering	PWRI pilot, fullscale decided Sulfate removal plant EPCON test underway	Has complex wells, but have tried many measures to reduce discharges Problems with PETEK-CETCO Have tested "most everything" as regards prod. water

					inj. of cuttings, slop and drain. Ilmenite being considered to replace barite		
Heimdal	Hydro	Gas/condensate	10.06.81	13.12.85	None Not drilling	Injection of produced water	Some own production, mostly hub for gas pipelines
Hod	BP	Oil /gas	26.06.88	30.09.90			
Huldra	Statoil	Gas /oil	02.02.99	21.11.01			Produces to Veslefrikk
Jotun	Esso	Oil /gas	10.06.97	25.10.99	Reinjection of drilling fluid and cuttings	Injection of produced water and parts of drainage water Test of PECT-F	
Kristin	Statoil	Gas/ condensate	17.12.01	-	Ilmenite and heavy saline solutions being considered	No planned injection of produced water	Drilling start-up in July 2003 Field with high pressure and temperature
Kvitebjørn	Statoil	Gas/ condensate	14.06.00	-	Injection of cuttings planned	Injection of produced water planned, 100 % injection, low emissions to air	
Lille-Frigg		Gas /oil	06.09.91	13.05.94		Produced water injected in the Frigg reservoir since 1994.	Subsea development tied in to the Frigg field. Shut down 25.03.99. Removed 2001.
Mikkel	Statoil	Gas	14.09.01	-	Plan is to drill using water-based drilling fluid	Will produce to Åsgard B	Permit for drilling and completion granted 31.07.02
Mime		Oil /gas	25.10.90	06.11.92			Shut down 09.11.93
Murchison	Kerr-McGee	Oil /gas	15.12.76	28.09.80			All discharges in British sector
Njord	Hydro	Oil	12.06.95	30.09.97	General evaluations to be made, otherwise no special measures	No special measures, has very little produced water	According to Hydro, Njord has zero discharges in practice Will start drilling again at end of 2002
Nordøst Frigg		Gas	12.09.80	01.12.83		Produced water injected in the Frigg reservoir since 1983.	Subsea development tied in to the Frigg field. Shut down 08.05.93. Removed 1997.
Norne	Statoil	Oil /gas	09.03.95	06.11.97	Uses ilmenite as weighting material	Partial reinjection of produced water Moved injection point for wax content => stopped discharges Subsea separation being considered for future satellites that are to produce to Norne	Problem with PWRI due to strong acidification and subsequent H2S formation. Can be resolved with so-called AMIOR additive (nitrite), but additive volume will be very substantial in connection with future (increased) water volumes. PETEK decision Nov./Dec. 02.

Odin		Gas/ Cond.	18.07. 80	01.04. 84			Shut down 01.08.94
Oseberg Field Center	Hydro	Oil /gas	05.06. 84	01.12. 88	Equipment for cuttings injection installed on OSB	EPCON tested and decision made to install	
Oseberg Sør	Hydro	Oil /gas	10.06. 97	05.02. 00	Injection of cuttings, LRA and slop water	Injection of produced water	
Oseberg C	Hydro	Gas /oil	23.12. 88	09.10. 91	Injection of cuttings and slop water	Injection of slop water	Online oil in water meter as process control tool
Oseberg Øst	Hydro	Oil /gas	11.10. 96	03.05. 99	Injection of cuttings, LRA and slop water	Injection of produced water › 90 %	
Ringhorne	Esso	Oil /gas	01.11. 99	-		Reinjection of drilling fluid and cuttings	Reinjection of produced water
Sigyn	Esso	Gas/ Cond.	31.08. 01	-			Subsea installation that produces to Sleipner
Skirne/Byggve	TotalFina Elf	Gas	PDO 2002	2004	Reuse of oil-based drilling fluid.	Injection of produced water. Recovery of MEG.	Two separate single well subsea developments to be tied in to the Heimdal Gas Center.
Sleipner Vest	Statoil	Gas/ cond.	14.12. 92	29.08. 96	Implemented injection of oily cuttings in 1996		
Sleipner Øst	Statoil	Gas/ cond.	15.12. 86	24.08. 93	Installation of C-Tour on SLA/SLT being considered		
Snorre TLP	Statoil	Oil /gas	27.05. 88	03.08. 92	Considering injection of cuttings	Evaluating injection of produced water and cleaning technologies. EPCON being installed in connection with Vigdis. Methods of H_2S removal being evaluated	
Snorre B	Statoil	Oil /gas		Fall 2001	Injection of cuttings	Injection of produced water and oil sand	Has cleaning plant for produced sand
Snøhvit	Statoil	Gas/ cond.	07.03. 02	-			
Statfjord	Statoil	Oil /gas	16.06. 76	24.11. 79	Injection of oily cuttings on A+B+C. Increased reuse of drilling fluids. Changed well design	Pilot injection of produced water implemented on SFC. Expanded injection to 18,000 m3/day from fall 2003. C-Tour – successful test in October 2002, prolonged test in 2003. Preproject for cleaning	A+B+C ▼

						of oily sand More robust hydrocyclones yield good cleaning effect. Replacement program underway.	
Statfjord Nord	Statoil	Oil /gas	11.12. 90	23.01. 95			Statfjord satellite, see Statfjord
Statfjord Øst	Statoil	Oil /gas	11.12. 90	24.09. 94			Statfjord satellite, see Statfjord
Sygna	Statoil	Oil	30.04. 99	01.08. 00			Produces to Statfjord, see Statfjord
Tambar	BP	Oil /gas	10.04. 00	15.07. 01	Injection of cuttings since 2001	Reinjection of produced water on Ula	
Tommeliten Gamma		Oil /gas	12.06. 86	03.10. 88			Shut down 05.08.98
Tor	Phillips	Oil /gas	04.05. 73	28.06. 78	Cuttings are transported to Ekofisk or Eldfisk for injection.	Small volume of discharges. Considering further cleaning measures/reinjection.	Included in Ekofisk.
Tordis	Statoil	Oil /gas	14.05. 91	03.06. 94			Produces on Gullfaks, see Gullfaks.
Tordis Øst	Statoil	Oil /gas	13.10. 95	12.12. 98			Included in Tordis
Troll Troll B and Troll C	Hydro	Gas /oil	15.12. 86	19.09. 95		Troll Pilot subsea separator on Troll C separates oil and water for three wells. Drainage from Troll C is cleaned in EPCON. C-Tour and MPPE being evaluated.	Reinjection is a qualified, but very expensive solution for Troll.
Tune	Hydro	Gas /oil	17.12. 99	-			Subsea template producing to Oseberg
Ula	BP	Oil /gas	30.05. 80	06.10. 86	Injection of cuttings since 1994	Injection of water with 91 % efficiency in 2001	EMAS certified 1997, recertified in 2001
Vale	Hydro	Oil /gas	23.03. 01	31.05. 02			Processes on Heimdal
Valhall	BP	Oil /gas	02.06. 77	02.10. 82	Injection of cuttings since 1993 and drilling fluid from 1996 Evaluating ilmenite	Injection of produced water starting in 2003	
Varg	Pertra	Oil	03.05. 96	22.12. 98	No drilling activity Water shut-off during operation in 2001	No special measures beyond optimizing the cleaning facility	Has a new operator: Pertra (will drill)
Veslefrikk	Statoil	Oil /gas	02.06. 87	26.12. 89	Reinjection of drilling fluid and cuttings since 1995	Further evaluation of relevant cleaning technologies	

Vest Ekofisk		Gas /oil	04.05. 73	31.05. 77			Shut down 25.08.98
Vigdis	Statoil	Oil /gas	16.12. 94	28.01. 97			Produces to Snorre TLP
Visund	Statoil	Gas /oil	29.03. 96	21.04. 99	Reinjection of cuttings and sand	Injection of produced water start-up 1.11.02.	
Yme		Oil	06.01. 95	27.02. 96	All wells plugged in the first half of 2001.	Injected produced water	Shut down 17.04.00
Øst Frigg		Gas	14.12. 84	01.01. 88			Shut down 22.12.97
Åsgard	Statoil	Gas /oil /cond.	14.06. 96	19.05. 99	Injection of oily cuttings Studying use of ilmenite Brine, seawater and slop from completion centrifuged and filtered before discharge to sea.	MPPE tested but installation rejected EPCON being tested in 2002 for cleaning of slop water. Framo contactor installed on Åsgard B Amine facility for removal of H_2S	Problems with leakage of OBF Using anti-foam agent that is not silicon-based Depending on results of testing consideration will be given to installing an EPCON unit for cleaning any prod. water and slop water on Åsgard A/B The original (low) water forecasts from the PDO have been cut in half as of Oct. 2002.

Appendix 3

Spreadsheet that can be used to calculate costs of measures

Investment	kr 500,00	(sett inn)
Interest	7 %	
Economic lifetime	20	(sett inn)
Annual cost	**(kr 47,20)**	

Year	Iinvestment	Operating cost, net increase	Change in CO2,emmisions,tonnes	CO2-cost	Change in NOX-emissions, kg	NOX-cost	Value of lost production	Total cost
2003	200							200
2004	200							200
2005	200							200
2006	0	10	100	30000	10	200		30210
2007	0	10	100	30000	10	200		30210
2008	0	10	100	30000	10	200		30210
2009	0	10	100	30000	10	200		30210
2010	0	10	100	30000	10	200		30210
2011	0	10	100	30000	10	200		30210
2012	0	10	100	30000	10	200		30210
2013	0	10	100	30000	10	200		30210
2014	0	10	100	30000	10	200		30210
2015	0	10	100	30000	10	200		30210
2016	0	10	100	30000	10	200		30210
2017	0	10	100	30000	10	200		30210
2018	0	10	100	30000	10	200		30210
2019	0	10	100	30000	10	200		30210
2020	0	10	100	30000	10	200		30210
2021	0	10	100	30000	10	200		30210
2022	0	10	100	30000	10	200		30210
2023	0	10	100	30000	10	200		30210
							N P V	**248 586**

N P V= net present value