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TRIP REPORT ON VISIT TO OIL SHALE PROCESSING ASSOCIATION

KOHTLA JARVE, ESTONIA

MARCH 21-25, 1994

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World Environment Center Trip Report

RAS KIVITER
Kohtla-Jarve, Estonia
March 21-March 25, 1994

SUMMARY

This report, prepared by Robert S. Kapner, describes the activities of the 5-day visit, March 21 - March 25, 1994, by a three member World Environment Center (WEC) team to the RAS KIVITER oil shale processing facility in Kohtla-Jarve, Estonia. (RAS KIVITER is the new name for the Oil Shale Processing Association [OSPA] at which WEC has assisted in the development of an extensive environmental program throughout 1993 and early 1994.) Team members during the present trip included Saul Elishewitz, Volunteer Expert, Reisterstown, Maryland, Robert S. Kapner, Consultant, Vero Beach, Florida and Thomas A. Pluta, Trip Leader, WEC, New York. During four prior trips in 1993/1994, WEC personnel and consultants assisted RAS KIVITER (or OSPA) in developing a waste minimization/pollution prevention program, offering advice and assistance in solving specific plant problems associated with pollution and guiding management and technical personnel in the selection of equipment to be purchased by WEC for the solution of specifically identified pollution problems.

The purpose of the present meeting was an assessment of RAS KIVITER's progress in structuring and managing its own pollution prevention\waste minimization program, to finalize equipment purchases and to summarize pollution reduction/minimization activities at the facility in which WEC participated. Another goal was to inform and provide some initial assistance to RAS KIVITER in the preparation of plans being developed by USAID for larger scale programs at the plant under contract with Camp Dresser McKee. This trip and report, then, represents the conclusion of WEC's program at RAS KIVITER except for some follow-up information related to the benefits realized by the plant with respect to future instrument use based on WEC purchases.

A major outcome of the present trip was the preparation of project summaries of pollution prevention/waste minimization projects with guidance by WEC. A total of 14 projects are summarized in three plant production areas (oil shale retorting, dephenolization and benzoic acid). These projects include work completed, in progress, or in the planning stage. A total investment of 844,725 EEK (about 61,000 USD) is involved in these 14 projects with net benefits estimated to be approximately 3,500,000 EEK (about 254,000 USD) having payback periods ranging from 0 to 15 months with most being less than 6 months. This information will be presented by RAS KIVITER and RAKVERE managements at a May 10, 1994 meeting in Tallinn on the Estonian "Environmental Impact Program" sponsored by USAID. Both these plants (RAS KIVITER/chemicals and RAKVERE/meat packing) have been the objects of WEC programs in pollution prevention/waste minimization programs in that country.

Instrument selection has been finalized at RAS KIVITER. A temperature control system for the benzoic acid plant (for the hot water recovery of benzoic acid by extraction from distillation column wastes) is being shipped to RAS KIVITER and, after much discussion during the current trip, a combined gas chromatograph/signal integrator has been selected for the oil shale retorting area (to measure and control gas composition from the retorts for the purpose of optimizing the retorting process).

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INTRODUCTION

WEC's major task under the present program was the development of a management structure for a pollution prevention/waste minimization effort at RAS KIVITER and extended from top technical and support managers down to production managers as well as to technical employees directly engaged in production activities. This was done in several ways:

(1) to stimulate interest in pollution prevention/waste minimization plant activities by describing similar efforts in advanced technical countries and the social and economic benefits to be derived from these activities.

(2) assist in the development of a Waste Minimization Committee (WMC) with responsibility to encourage managers and plant personnel identify and to recommend pollution prevention and waste minimization projects (especially no cost/low cost projects) and to provide suitable incentives and for the WMC to review, at regular intervals, such proposals.

(3) to hold practice sessions at all levels demonstrating methods by which pollution problems are identified (brainstorming, for example), how to prepare pollution prevention/waste minimization project proposals including project justification, costs and benefits.

(4) to assist plant personnel to solve some current no cost/low cost pollution problems thereby actively demonstrating pollution prevention/waste minimization techniques.

(5) to assist in the acquisition of instruments, within a limited budget, to aid in the solution of current pollution problems.

The major portion of this report of WEC's final visit was concerned with summarizing the effectiveness of the year-long program undertaken at RAS KIVITER as part of the pollution prevention/waste minimization program undertaken with the guidance of WEC. Activities during this visit included:

(1) Two meetings with the Waste Minimization Committee to critique their responsibilities and to examine its effectiveness during the past year.

(2) Meetings with area managers (Mr. Sergei Shilov, Retorts, Mr. Nikolai Sedov, Dephenolization, Mr. Rinat Magsumov, Benzoic Acid) to review pollution prevention\waste minimization projects that were either completed during the year, currently in progress, or in the planning stage.

(3) Meetings with the plant Technical Director, Mr. Ivar Rooks, the plant General Manager, Mr. Sonne, and the plant Environmental Manager, Mr. Rein Rahe to discuss and critique WEC experiences during the year-long program and to offer some final advice about continuing the environmental program after our departure.

MEETINGS WITH THE WASTE MINIMIZATION COMMITTEE

First Waste Minimization Committee Meeting

The first meeting with the Waste Minimization Committee (WMC) took place on arrival Monday morning, 21 March 1994. Tom Pluta explained to the assembled group that the current visit to RAS KIVITER was WEC's final visit and that this trip was to review and summarize accomplishments during the past year of work. He noted that the summary to be prepared during this visit was to be presented on 10 May 1994 in Tallinn to WEC's sponsors. He praised the recent letter

prepared by the WMC on pollution activities and accomplishments and distributed to plant personnel. Mr. Pluta emphasized the need for the committee to continue to provide similar reports at frequent periodic intervals to keep plant personnel fully informed about environmental activities and to sustain interest in improving environmental conditions at RAS KIVITER.

Mr. Pluta distributed three pages of material, prepared by WEC, for each of the three major production areas worked on during the past year, retorting, dephenolization and benzoic acid. These will be found in Tables 1-3 on the following pages. For each of these areas there is a list of pollution projects identified as being either completed, in progress or in the planning stage. Because WEC has emphasized, repeatedly, the need to carefully prepare well documented pollution project reports which include (a) a clear statement of the pollution problem and its solution and (b) costs and benefits for each project including an estimate of payback, a note was added to each project identified as to whether a written report was available or had not yet been written. As can be seen from Tables 1-3 most projects had no written documentation. In fact, the list of projects for all three area were gleaned from brief summaries prepared by Rein Rahe, the Environmental Manager, to WEC to indicate progress at RAS KIVITER. While these summaries were informative and illustrative of plant and WMC activities they were woefully incomplete on details of each project. The WMC was then informed that we (the WEC team) would require complete project writeups of each pollution project to assist us in the preparation of our final summaries and that we were prepared to work during the week with area managers to produce these reports.

An additional table, Table 4, related to energy production is added based upon information supplied by Mr. Yuri Utt, Energetics Manager. Although these projects are not strictly environmental by nature and are strictly in the planning stage, they will have an environmental impact and are included for completeness.

In three of the four Tables (excluding the Benzoic Acid area) additional projects will be found, described as "suggested by WEC". These were added by the WEC team at the same time the tables were prepared based upon our knowledge and understanding of process and pollution problems at RAS KIVITER but were not apparently being considered. These WEC recommended projects were discussed in turn with area project managers. In all cases, except one, the projects were rejected for cause or had been factored into other projects. The only one found acceptable was the recommendation to perform a plant-wide energy audit. In this case Mr. Utt, the Energy Department manager, noted that planning for such a project was being considered but had simply not been included in the information supplied to WEC.

Tables 1-4 were translated into Russian by Mr. Valdu Suurkask, a civil engineer with the Tallinn Technological Institute, who served as translator and interpreter during the visit, and distributed to all WMC members. Although WEC has repeatedly described how to write project reports and given many examples of how to accomplish this, there still appears to be considerable difficulty, if not resistance, for this task. The document shown as Appendix 1 was then produced, translated and distributed to all WMC members at this meeting to assist in preparing written projects.

Second Waste Minimization Committee Meeting

This second meeting took place Thursday afternoon 24 March 1994. Tom Pluta spent a few minutes thanking the Committee for its efforts and for the success of the program at RAS KIVITER. He then did something most unusual; he asked the Committee to brainstorm a problem. This technique had been used with considerable success at the plant personnel level in all three areas. The problem put to the Committee was "What are the obstacles to a waste minimization program at RAS KIVITER". The procedure he employed was to ask each Committee member in turn to specify what they considered an obstacle to the program. The

results were striking. Some of the responses to the question are offered below:

- o No motivation (*employee motivation was meant)*
- o Lack of materials
- o Lack of money
- o Poor perspective for industry (*in the country)*
- o Nobody cares, no money
- o Lack of incentive
- o Plant conditions are unstable, not sure of future
- o Poor relationship (*of the plant)* with the country, ministry
- o Bad technology, old equipment, low (*worker)* discipline, not sure of success
- o Bad technology, no money for new investment

Tom Pluta wisely restricted the brainstorming to a single go-around of all the Committee members present. The responses are striking not only for what was said but for what was not said. Some of the responses were clearly irrelevant, for example, bad technology, no money, lack of materials, unstable plant conditions. Other responses were clearly within the Committee's domain of responsibility to control, for example, no motivation, lack of incentive, and poor worker discipline. These were points that the WEC had tried to develop during the course of its work at the plant, that the WMC was responsible for developing employee motivation and worker incentive plans. The WEC had also repeatedly stressed that although major pollution projects required large investments there were many no cost/low cost pollution projects that could be developed which in aggregate could be very effective. It is clear that the Committee did not consider *itself* to be an obstacle for pollution prevention/waste minimization efforts. The fact that the Committee almost never met during the year, and that when it did it almost never met with all members present thus making a full-fledged concerted effort impossible was apparently not understood. Clearly, to the WEC at least, the lack of motivation by the Committee and plant management are key factors in the lack of substantial progress made in reducing pollution.

Despite this negative attitude on the part of the WMC towards its own work and the program in general, pollution prevention and waste minimization accomplishments at RAS KIVITER have been reasonably significant. It will be shown later in this report that about 254,000 USD has been saved after an investment of approximately 61,000 USD (of which 25,000 USD was for instrumentation supplied by WEC) and is represented by significant material savings (oil, benzoic acid, butyl acetate, toluene, fuel gas), reduced waste water loads, oil yield increases, and reduced disposal of toxic wastes such as fuses and spent oil shale and phenols. These are no mean accomplishments. However, the Committee members do not appear to understand this. When asked, in another go-round, to estimate what the plant savings were, individual estimates ranged from zero to 10 million EEK (725,000 USD). When told the magnitude of the estimated savings, no one believed it. What this shows is that the Committee still has no grasp of the usefulness of the program due, in large part, to its failure to work as a team and to communicate with plant personnel. No Committee member understands the nature of the Committees function.

TABLE 1. RETORT PRODUCTION AREA PROJECTS

PROJECT DESCRIPTION	STATUS		REQUIRES WRITEUP/EDITING
1. Decreasing specific yield of phenol waters from retort GGS-5.			
a. Elimination of recycle water leakages from condensation equipment.	completed		yes
b. Decreasing of water consumption for spraying oil separators.	completed		yes
c. Phenol water to spraying oil separators.	completed		yes
2. Internal waste water collection at pumping station No.3 for GGS-5.	suggested	yes	
3. Phenol water decrease at GGS-3 and GGS-4.	suggested	yes	
4. Process optimization of 1000 tpd retort.	in progress		yes
5. Fuses utilization.	testing	yes	
6. Fuses reprocessing.	completed	yes	
7. Fuses thermal treatment.	testing	yes	
8. Mechanical filtration of fuses to reduce oil content.	recommended by WEC	yes	
9. Condensing oil vapors with oil liquids in place of water.	recommended by WEC	yes	

TABLE 2. DEPHENOLIZATION PRODUCTION AREA PROJECTS

PROJECT DESCRIPTION	STATUS	REQUIRES WRITEUP/EDITING	
1. Increase in oil removal rate.	completed	yes	
2. Reduction of butyl acetate discharge to air.	completed	yes	
3. Equipment condition improvement.	completed	yes	
4. Return of drains for reprocessing.	completed	yes	
5. Flow diagram for startup operations.	completed	yes	
6. Utilization of water soluble phenols.	suggested	yes	
8. Acidifying phenol water to reduce phenol solubility.	suggested by WEC	yes	
9. Substitute toluene for butyl acetate as extraction agent.	suggested by WEC	yes	

TABLE 3. BENZOIC ACID PRODUCTION AREA PROJECTS

PROJECT DESCRIPTION	STATUS	REQUIRES WRITEUP/EDITING	
1. Benzoic acid additional recovery from residue.	in progress		yes
2. Use rain water as cooling water.	suggested	yes	
3. Solid waste utilization at crystallization unit.	suggested	yes	
4. Toluene leakages collection in main building and storage.	suggested	yes	
5. Benzyl benzoate production.	suggested	yes	

TABLE 4. ENERGETICS PRODUCTION AREA PROJECTS

PROJECT DESCRIPTION	STATUS	REQUIRES WRITEUP/EDITING	
1. Install turbines to let-down boiler steam to plant working pressures while producing electricity.	suggested		yes
2. Install new 68 mW steam boiler.	suggested		yes
3. Perform energy audits to examine potential for saving steam and fuel gas	suggested by WEC	yes	

PROJECT SUMMARIES

During the period from 21 March through 24 March, 1994, meetings were held with the three area project managers to review each project described in Tables 1-4. Requested of each was that appropriate writeups be made available for those projects indicated in the tables as not having a suitable description. This was true even for projects that had already been completed. That also was the purpose for distributing Appendix 1, to broadly show how to produce project reports in case a lack of understanding of how to write a report was responsible for their absence. With the exception of 6 projects for which some written description were already available, these requests were not honored. In only two cases were fairly complete descriptions available and these corresponded to projects for which instrument requests had been made. Because of this it was necessary to hold repeated meetings with area managers simply to try to understand the nature of the projects proposed and to get a sense of economic costs and benefits and, in some cases, to determine the environmental benefits to be realized.

Of the 25 projects listed in Tables 1-4, only 14 were judged as suitable for inclusion in a final summary. Eleven projects, including 4 proposed by WEC and 3 from the Energetics area, were removed from the list. The 14 projects retained are described in Tables 5-8. Tables 5-7 list individual projects in each of the three project areas. Table 8 is a summary of information assembled in Tables 5-7. In each case investment costs to implement each project were estimated as were annual operating costs and benefits. Environmental outcomes of project implementation are shown in the last column of each table. Payback was estimated as

$$\text{Payback} = \frac{\text{investment costs}}{\text{annual benefits - annual operating costs}}$$

In other words, the denominator of the payback equation represents <u>net</u> annual benefits.

Projects listed in Tables 5-7 are identified by brief titles consisting of, at most, one line descriptions. They are too brief, of course, to clearly indicate the nature of each project. Appendix 2 attached to this report provides elaborated information about each project. Although still quite brief, these one paragraph descriptions attempt to describe the basic concept of each project in support of the tabular data.

TABLE 5. ECONOMIC AND ENVIRONMENTAL ANALYSIS OF RETORT AREA PROJECTS
POLLUTION PREVENTION/WASTE MINIMIZATION PROJECTS AT RAS KIVITER
(all economic benefits shown in EEK)

PRODUCTION AREA	INVESTMENT	OPERATING COST	ANNUAL BENEFIT	NET ANNUAL BENEFIT	PAYBACK PERIOD	ENVIRONMENTAL BENEFIT
1. Decreasing specific yield of phenol waters from retort GGS-5.						
a. Elimination of recycle water leakages from condensation equipment.	0	36,800	205,269	168,469	0 days	o avoided disposing of 12,000m³ of phenol water to waste treatment plant annually.
b. Reduce present water consumption for spraying oil separators.	0	860	611,208	610,348	0 days	o phenol water consumption reduced by 75 liters to 240 l/ton of raw shale.
c. Phenol water to spray oil separators.	0	2,280	814,967	812,687	0 days	o phenol water consumption reduced by 100 liters to 140 l/ton of raw shale.
2. Internal waste water collection at pumping station No.3 for GGS-5.	20,210	0	19,089	19,089	1 year	o 10 tons of oil saved and o 41 tons of fuses disposal avoided annually.
3. Optimization of 1,000 tpd retort	283,080*	53,920	367,726	313,806	0.90 yrs	o 10.8(10^9)kcal fuel gas saved o avoid disposing of 257 tons of fuses to waste pile annually. o increase yield of oil by 108 tons annually.
4. Fuses reprocessing for road paving material	70,330	121,323	429,000	307,677	83 days	o avoided disposing of 1,300 tons of fuses to waste pile.
5. Fuses utilization for backfeed to retort.	77,360	150,955	256,916	105,961	266 days	o avoided disposing of 998 tons of fuses to waste pile.
6. Phenol water decrease at GGS-3 and GGS-4.	200,000	0	516,974	516,974	142 days	o avoided disposing of 30,450m³ of phenol waste water.
TOTALS:	650,980	328,478	2,404,672	2,076,194	114 days	

* Of which 256,120 EEK (19,000 USD) were supplied by the World Environment Center for a critical instrument (gas chromatograph) to implement this project.

TABLE 6. ECONOMIC AND ENVIRONMENTAL ANALYSIS OF DEPHENOLIZATION AREA PROJECTS POLLUTION PREVENTION/WASTE MINIMIZATION PROJECTS AT RAS KIVITER
(all economic benefits shown in EEK)

PRODUCTION AREA	INVESTMENT	OPERATING COST	ANNUAL BENEFIT	NET BENEFIT	PAYBACK PERIOD	ENVIRONMENTAL BENEFITS
1. Reduce water used for [illegible]te distillation oil washing.	265	5,263	172,621	167,358	0.6 days	o reduced phenol water used to wash oil by 30,000 m^3. o increased oil yield.
2. Improved startup procedures.	850	0	29,980	29,980	10 days	o 7 tons of butyl acetate saved annually. o reduction of BOD and suspended solids in waste water discharge.
3. Return of drains for reprocessing.	750	0	35,512	35,512	8 days	o avoid loss of 2 t/y of butyl acetate.
4. Reduction of butyl acetate discharge to air.	500	0	6,391	6,391	29 days	o avoid loss of 0.38 tons of butyl acetate annually.
TOTALS:	2,365	5,263	244,504	239,241	4 days	

TABLE 7. ECONOMIC AND ENVIRONMENTAL ANALYSIS OF BENZOIC ACID PRODUCTION AREA PROJECTS
POLLUTION PREVENTION/WASTE MINIMIZATION PROJECTS AT RAS KIVITER
(all economic benefits shown in EEK)

PRODUCTION AREA	INVESTMENT	OPERATING COST	ANNUAL BENEFIT	NET BENEFIT	PAYBACK PERIOD	ENVIRONMENTAL BENEFIT
1. Recovery of benzoic acid process residue.	107,840*	0	1,001,187	1,001,187	39 days	o avoided discharge of 165 t/y of benzoic acid.
2. Solid waste utilization at crystallization unit.	81,540	0	121,440	121,440	245 days	o recovery of 22 t/y of benzoic acid.
3. Use of rainwater in place of cooling water.	1,000	0	106,788	106,788	3 days	o reduction of 129,593 m^3 of waste water. o conservation of an equal amount of lake water.
4. Toluene leakage collection in main building and storage.	1,000	3,500	6,740	3,240	1.23 yrs	o avoidance of 2 t/y of toluene losses.
TOTALS:	191,380	3,500	1,236,155	1,232,655	57 days	

* Of this capital investment, 80,880 EEK (6,000 USD) was provided by the World Environment Center for a steam control system with which to implement this project.

TABLE 8. SUMMARY OF ECONOMIC AND ENVIRONMENTAL BENEFITS BY PRODUCTION AREA POLLUTION PREVENTION/WASTE MINIMIZATION PROJECTS AT RAS KIVITER
(all economic benefits shown are in EEK)

PRODUCTION AREA	No. OF PROJECTS	TOTAL INVESTMENT	OPERATING COST	ANNUAL BENEFIT	NET BENEFIT	PAYBACK PERIOD	ENVIRONMENTAL BENEFITS
OIL SHALE RETORTING	6	650,980	328,478	2,404,672	2,076,194	114 days	o waste water reduction o oil yield increase o avoid fuses disposal o fuel gas saved
DEPHENOLIZATION	4	2,365	5,263	244,594	239,241	4 days	o avoid butyl acetate losses o oil yield increase o reduced BOD and SS in waste water
BENZOIC ACID	4	191,380	3,500	1,236,155	1,232,655	57 days	o increase benzoic acid yield o waste water reduction o reduce toluene losses o reduce fresh water use
TOTALS:	10	844,725	337,241	3,885,331	3,548,090	87 days	

INSTRUMENT ACQUISITION

Based on a reasonably detailed proposal from the retort area for an instrument to measure the composition of gases produced during the retorting process, it was decided to approve the acquisition of a gas chromatograph for this purpose. Proposals from several American companies were requested included Foxboro, HNU and SRI Instruments (Torrence, CA) based on specifications supplied by WEC and a restriction that the instrument not cost more than 19,000 USD. Other companies were approached but either would not quote on an instrument (Gow Mac, Hewlett Packard, Minneapolis Honeywell and Applied Automation) for a variety of reasons. The best bid came from HNU based on ability to perform the desired analysis, price, and the availability of company staff in Tallinn and a manufacturing and technical support operation in nearby Finland. HNU also agreed to supply personnel to assist in the on-site installation of the equipment and supply three days of training for RAS KIVITER personnel in Helsinki.

The intended purpose for this instrument is to control the fuel gas and combustion air used to heat and drive the kerogens from the raw oil shale as it passes through the retort heating zone (for the 1,000 tpd retort only). Because the kerogen content of the oil shale (supplied from four different mine sources) has considerable variation it is basically inappropriate to use a single fuel gas and combustion air flow for heating as is currently done. High kerogen content requires higher temperatures, hence higher flows, so the reasoning goes, and lower air and fuel gas flows are required to produce lower temperatures for low kerogen contents. In this way a more uniform kerogen content in the spent shale can be expected leading to greater oil recovery, less fuel gas consumption, lower fuses entrainment and carryover from the retorts and a higher fuel gas heating value. RAS KIVITER claims to have algorithms relating the composition of selected components of the fuel gas being produced in the retort with the raw shale kerogen content. Thus an instantaneous knowledge of fuel gas composition being produced can be used to control the proper fuel gas and combustion air flows to the retort. It is apparently RAS KIVITER's intention to analyze the gas stream chromatographically and to pass the analytical signal to a Russian built mainframe (SM 1803) control computer. The chromatographic analog signal will first be passed to an integrator which will convert the signal from analog to digital and then on to the mainframe which will interpret the signal according to known relationships between gas composition and combustion system parameters.

Several meetings were held with Mr. Rein Rahe, Mr. Sergei Shilov (Retort Area manager), Tatyana Dubakana (Environmental Chemistry Laboratory) and Mssrs. Looper (Analytical laboratory head), Valentin Nickolayev (Metallurgical Laboratory head), Kusnetz (Control) to discuss this proposal. The first meeting on Monday, 21 March 1994 was attended by a HNU sales representative from Tallinn. Additional information about the HNU instrument was obtained by telephone to technical staff at Helsinki, a great convenience.

Initially there was quite a bit of confusion as to RAS KIVITER's ability to use the instrument selected which consisted of a gas chromatograph interfaced with its own digital integrator. RAS KIVITER personnel initially claimed to require that only analog signals could be passed from the chromatographic system to the mainframe computer. This is patently not possible. The output from the chromatographic integrator is purely digital. Alternatively, if the chromatographic raw analog signals are passed, the mainframe must have a program which will integrate the analog signals, which in turn would then represent the analysis of the fuel gas components and permit the mainframe to operate on the integrated analysis. Although such programs exist they are expensive, require considerable maintenance and add a potentially troublesome step in the overall process. RAS KIVITER personnel believed it was only possible to accept an analog signal because their mainframe interface operated with an RS232 data port. Considerable time was spent trying to convince them that it would be a relatively easy task to input a digital signal to the mainframe from an external digital source. It was only after Mr. Valdu Suurkask placed a call to the Tallinn Technological Institute and confirmed the fact that the mainframe would accept

digital signals that the problem was resolved. Further, RAS KIVITER is acquiring a new Russian mainframe (CM 1810) which they *now believe* will be able to do the job.

This series of discussions were rather disheartening. It seems rather premature to consider controlling the fuel gas and combustion air by computer at this early stage of the retort project. Mr. Shilov stated that considerable additional experimental work would have to be undertaken before they could confirm that this approach might work at all. Further, there is some question as to whether the relatively high kerogen content in the spent shale is indeed due to a fixed fuel gas and air flow, the current practice. Shale oil processing experts visiting RAS KIVITER have suggested that absolute temperature level in the retort heating zone was not as important as proper temperature distribution within the combustion zone (see WEC trip reports 1 and 2 in 1993 for this point of view) for efficient kerogen removal. Also, the chromatographic system to be purchased, while quite serviceable, may not be entirely suitable for long term on-line analysis appropriate for control purposes. An on-line process chromatograph might be more appropriate but would also be much more expensive.

Nevertheless, it was decided that the benefits to be realized could be extremely valuable if the concept would work and the chromatographic system purchase was recommended. It is however recommended that RAS KIVITER use the chromatographic system initially to measure gas composition and simultaneously oil shale kerogen content for confirmation purposes without interfacing the system to a control computer. They are currently using a manually controlled fuel gas/combustion air firing system and should continue to do so, at least in the near term while they learn how to control corresponding fuel and air flows to "optimize" the system. It is also assumed that RAS KIVITER will be able to get assistance coupling the chromatograph to a mainframe either from HNU or from some other source when the appropriate time arrives..

APPENDIX

APPENDIX 1. WRITING THE POLLUTION PREVENTION/WASTE MINIMIZATION PROJECT REPORT

1. Project description and nature of the problem

One or two short paragraphs or sentences clearly stating (a) what the nature of the problem is and (b) what is your under-standing of the cause of the problem.

2. Project goal(s)

A short paragraph clearly stating what you believe to be the goals of the project. For example, reduction of phenol water production or reduction of fuses sent to waste pile.

3. Method of solving the problem

A short paragraph clearly describing how you propose to solve the problem. Be as specific as you possibly can and include a diagram if it will assist in the explanation. Please remember that your reading audience may not be as technically informed about the project as you are. Be clear and thorough.

4. Economic analysis

Include here both costs to implement the project and economic benefits to be achieved. Costs should include such items as equipment purchase, installation costs (outside contractor), costs of project research and development, energy and labor costs, etc.

Economic benefits should include all benefits such as, for example, the cost benefit of waste reduction (reduction of waste charges), waste transportation costs, value of resources saved and increased process efficiencies to be expected, etc.

Include in this section a simple payback period calculation.

If exact costs and benefits are not known, provide appropriate estimates and indicate that estimates are being used, not hard data. Whenever numbers are used please indicate the source of the numbers and the time period for which the numbers are valid. For example, in the reduction of phenol water if the current amount of phenol water produced is stated please indicate the source of the data used. Estimates of costs and benefits should always include the method(s) used to arrive at the estimates.

5. Time frame

Provide information (estimates) on when the project is to be implemented and the time to completion. Describe any interruptions in production schedules anticipated and their costs. If the project has been completed please include follow up data (actual measurements) on the actual savings achieved compared with initial estimates.

6. Submission

Submit the project report to your manager for review and approval. Request that the project report be submitted to the Waste Minimization Committee (WMC) for action. Respond to your manager's and/or the WMC's request for additional information and editing of the report. Resubmit the project report.

Please remember that although completeness and accuracy are important, a project report that is too long will be difficult to follow. Be as thorough as possible but also try to make the report short and readable. This is difficult

to do but practice and critical editing of your own writing is important to achieve your goal of having the project proposal approved.

APPENDIX 2. PROJECT DESCRIPTIONS

In the body of this report projects are mainly identified by titles with no detail about each. This appendix is for the purpose of providing some detail about each of these projects. Information about the projects reported in this appendix comes mainly from short statements specifically requested during three days of the current WEC visit. Prior information was available only from management in response to instrument requests; Project 3 in the Retort Area (Optimization of 1,000 tons/day retort) and Project 1 in the Benzoic Acid Area (Recovery of benzoic acid process residue). Other principal sources used were two reports sent to WEC about March 9 and March 15, 1994 by RAS KIVITER's Environmental Manager, Mr. Rein Rahe. Unfortunately, Mr. Rahe's reports consisted mainly of lists of projects and were exceptionally brief. This necessitated receiving additional information from area personnel during this trip.

Copies of the two reports sent by Mr. Rahe and the detailed reports presented during the current visit supporting the material in this appendix are available from WEC.

Retort Area Projects

Project 1. Decreasing specific yield of phenol waters from retort GGS-5.

Vaporized heavy and light oils produced during the pyrolysis of oil shale are cooled and condensed as they exit the retorts and then extracted with water to remove phenols present in the oils. Part of the condensing system consists of indirect air coolers (for the heavy oil fraction), water cooled condensers and also by spraying the oil with water, particularly recycled phenol water. In 1992, the amount of phenol water produced at the various retort stations are tabulated below (data from WEC January 25-29, 1993 trip report):

Retort Station	Raw Shale Processed (tons/year)	Phenol Water Produced (m^3/year)	Phenol Water per ton Shale (l/ton)
GGS-3	271,200	51,760	191
GGS-4	301,500	52,831	175
GGS-5	545,500	251,077	460
1000t/d	234,100	38,725	165
GGS-6	91,200	30,816	338

RAS KIVITER suggests that a ratio of 180-200 liters of phenol water produced/ton shale processed (specific water consumption) is normally acceptable, a range which the table above roughly agrees with. The table also shows that an excessive amount of phenol water is produced at retort stations GGS-5 and GGS-6. The reduction of phenol water produced at GGS-5 is the goal of this project. The project was implemented in three stages.

a. Elimination of recycle water leakages from condensation equipment. This first stage reduced specific water consumption to 315 l/ton by repairing six leaking water coolers. Annual charges of 36,800 EEK (3,800 USD) were reported against benefits of 205,269 EEK (almost 15,800 USD).

b. Reduce present water consumption for spraying oil separators. This second stage reduced specific water consumption to 240 l/ton from 315 l/ton by adjusting (optimizing?) the quantity of recycled phenol water and middle fraction oil used to spray and condense heavy oil.

Annual charges of 860 EEK (66 USD) were reported against benefits of 611,208 EEK (47,000 USD).

c. Phenol water to spray oil separators.
This third stage reduced specific water consumption to 140 l/ton from 240 l/ton by changing from fresh (?) water for condensing oil to recycled phenol water. The previously used water was then diverted to quench spent coke from the retorts. Annual charges of 2,280 EEK (175 USD) were reported compared with benefits of 814,967 EEK (62,700 USD).

No capital investment costs were reported for any of the implemented project stages and annual charges for each include raw materials (unspecified), energy costs, and wages.

Total annual charges for all three stages amounted to almost 39,940 EEK (3,072 USD). Benefits include the reduction in waste water charges and improved efficiency of the dephenolization process, both directly due to the large reduction of phenol water produced at the retorts and total about 1.63 million EEK (125,500 USD)[1].

Project 2. Internal waste water collection at pumping station No.3 for GGS-5.

Oil leaks from pumps located at pumping station No. 3 in retort area GGS-5 contaminates the local area (soaking the soil) and represents lost oil production, about 10 tons/year. In order to control the problem, sand is placed on the surface and, when saturated, added to the fuses produced by the retorting process. This procedure is labor intensive and adds to the fuses disposal burden, about 40 additional tons/year. RAS KIVITER has solved the problem by building a drainage system around the affected area and then collecting and storing the spilled oil for recycling to process.

Capital cost of this project was about 20,210 EEK (about 1,555 USD). Cost benefits include avoided sand purchase (23.60 EEK/ton), avoiding the cost of transporting and disposing of the fuses (about 272 EEK) and avoided labor costs of collection and disposal (24.6 EEK/ton). Total avoided costs are about 19,100 EEK/year (1,468 USD/year).

Project 3. Optimization of 1,000 tons/day retort.

A rather detailed description of this project will be found in the main text of this report, page 13. Only salient features of the project will be restated here.

Oil in Kukersite oil shale is released at high temperatures produced by burning fuel gas with air. In addition to the oil released, a gas is produced that is partly recycled as the fuel gas required to produce the high temperatures. As currently operated, the fuel gas and air needed are supplied in a fixed ratio and flow sufficient to just produce the needed temperatures. Unfortunately, oil shale used is not consistent in quality, either from the same source or among the several different mine sources used. This means that at the same processing conditions, variable results can be expected. Actually, when the shale has a high oil content greater heat is necessary to remove it from the shale and this would require higher flow rates and different ratios of air and fuel gas. Conversely, for lower quality shale lower flow rates and different ratios of air and fuel gas are required.

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[1]. There is a considerable difference in costs for the three phase project presented here (also see Table 5, main text) and in the March 9, 1994 report from Rein Rahe. The reason for these differences was never established.

Depending upon the oil shale composition and the retort conditions during processing, the composition of the gas produced will vary. RAS KIVITER claims to have data which relate gas composition to oil shale composition. They believe that they can adjust the flows and ratios of fuel gas and air to optimize the processing of oil shales of varying composition.

To accomplish this RAS KIVITER requires an instrument (gas chromatograph) to rapidly analyze the gas leaving the retort and then to adjust the air and fuel gas flow to optimally process the oil shale depending on gas composition.

Capital costs for the project include a gas chromatograph, 247,000 EEK (19,000 USD provided by WEC) and an additional 26,960 EEK (2,100 USD) for instrument housing and site preparation paid for by RAS KIVITER. Operating costs are estimated as 53,920 EEK/year (4,100 USD/year) for materials, maintenance and labor. Benefits could reach about 368,000 EEK/year (28,300 USD/year) for decreased fuel gas consumption, higher oil production, and avoided costs of fuse disposal due to reduced fuse production, and avoided fuse transportation costs.

Project 4. Fuses reprocessing for road paving material.

The production of fuses, a mixture of oil shale dust with oil and water, during the retort process is a serious problem at RAS KIVITER. In 1992 almost 4,500 tons of this material was produced. Disposal of fuses in the plant waste pile for 1992 amounted to 6,700 tons at 18 EEK/ton and a total disposal cost of almost 121,000 EEK (about 9,200 USD). Disposal costs of 180 EEK/ton are anticipated for 1993.

Because of the cost and environmental hazard associated with fuse disposal (as well as lost oil) RAS KIVITER has mounted a major program to solve, or at least reduce, the fuse problem. One method is to produce a saleable product in the form of a road paving material. This has been done occasionally in the past but depends upon federal mandates for road building and the funds to finance such projects. However, between April 1 and October 1, 1993 some 1,300 tons of fuses were homogenized and sold for road building purposes.

Capital costs of 70,330 EEK (5,400 USD) were expended for this project, whether for new equipment or rebuilding homogenization equipment is not stated. Operating costs for the 1,300 tons produced amounted to 121,300 EEK (9,300 USD) for energy consumed (electricity, thermal), labor, transportation. The sale value of the fuses, at 150 EEK/ton, was 195,000 EEK (15,000 USD) and the benefit due to avoided waste disposal charges was 234,000 EEK (18,000 USD) based on a waste disposal charge of 180 EEK/ton. It is interesting to note that the avoided disposal cost was greater than the sale value of the fuses.

Project 5. Fuses utilization for backfeed to retort.

As explained in Project 4 above, the sale of homogenized fuses for road paving accounted for only 1,300 tons in 1993. The remainder of fuses produced must still be disposed of in waste piles at high waste charges and the loss of valuable oil content. One other project currently undergoing testing to reduce the impact of waste fuses is to collect and backfeed the fuses to the retorts. The idea here is to simply add the fuses to oil shale lumps being charged to the retorts. Apparently it is hoped that the heat of the retort will release the oil content of the fuses while retaining the shale ash in the new shale feed as it descends.

Tests appear to have been performed on the 1,000 tpd retort in December 1993 and January 1994 but no results are reported as of March 1994. Nor is the method of feeding the fuses to the retort described. Nevertheless, the new process is scheduled to begin in April 1994.

This process has been discussed with WEC and recommendations were made to

RAS KIVITER as to how to best feed fuses to the retort. Among these suggestions was to agglomerate the fuses into briquettes to prevent unformed fuses from simply being carried out of the top of the retort unchanged along with oil and gas flow. It was also suggested that instead of feeding the fuses directly into the top of the retort along with fresh shale feed, the fuses might better be injected somewhere down the retort. The purpose of this suggestion was to ensure that while the oil could be removed by the heat in the retort, it would be more difficult for the shale ash in the backfeed to be carried out due to the torturous path to reach the top through the descending shale. Whether either of these suggestions was considered is not known. Nor is the backfeed method actually employed known.

Calculations of annual benefits were made based on the assumption that the entire burden of fuses produced by the 1,000 tpd retort would be fed to the retort and 10% consumed. This estimate seems unlikely. One could actually assume greater fuse production. At the very least the tests should have shown how much additional oil were produced by backfeeding fuses and what quantity of fuses were produced during backfeeding.

Capital investment for the project was estimated as 77,360 EEK (about 6,000 USD). Capital investment was described only as design, equipment and construction, with no details. Operating expenses were estimated as almost 151,000 EEK/year (11,600 USD) for utilities (electricity and heat). Benefits were estimated as 257,000 EEK/year (19,800 USD) for reduced fuse waste charges, avoided fuse transportation costs and additional oil recovery.

Project 6. Phenol water decrease at GGS-3 and GGS-4.

This project is rather poorly described. It would appear, though, that water used to cool retort gas and cool and condense retort light oil, for GGS-3 and GGS-4, is sent to thermal settlers to recover its small oil content. This water has a low phenol content, about 1 g/l and, after oil separation, some of it is currently used to quench hot spent shale as it exits the retorts. This project would instead recycle to GGS-3 and GGS-4 the low phenol content water, after oil removal, to further cool and condense gas and light oil rather than use it for hot shale quenching. The proposal suggests that the new arrangement would avoid disposing of 30,450m^3 of phenol waste water. How this comes about is not explained especially since the current source of cooling water is not stated.

RAS KIVITER data show that GGS-3 and GGS-4 currently produce normal and satisfactory amounts of phenol water, roughly in the 180-200 l/ton of shale processed region as shown above in the table associated with Project 1. This suggests that there are no serious leaks in the cooling and condensing equipment at these stations and that recycling is already practiced. It would appear that the project is mainly concerned with replacing the current source of cooling water and by so doing avoids eventually discharging a considerable amount of phenol waste water for biological treatment. Without a clear description of current practice, though, this is not known with any certainty.

Project investment is estimated as 200,000 EEK (about 15,400 USD) and at this cost level suggests rather major changes. Annual costs are not given and benefits of almost 517,000 EEK/year (about 40,000 USD/year) are estimated consisting of reduced dephenolization costs, biological treatment costs and waste charges. As of the time this report was produced the project was reported to be in the design stage.

Dephenolization Area Projects

Project 1. Reduce water used for coke distillation oil washing.

Light and heavy coke oil fractions, containing about 5% water, are treated to remove phenols and fuses by washing and then separated in thermal settlers. Effluents from the thermal settlers ideally consists of 3 phases: a top phase consisting of purified oil, a bottom phase consisting of water and fuses, and a middle phase consisting of phenol water. Unfortunately, the separation is often not satisfactory, especially in the sense that there is too much oil, up to 0.7 g/l, in the phenol water layer which is sent on to dephenolization. High oil content in phenol water will dissolve excessive amounts of butyl acetate used to extract phenols and add an excessive burden to the waste water treatment plant.

RAS KIVITER has analyzed the problem and decided that there are two principal reasons for the poor separation and the high oil content in the phenol water layer. One reason is associated with a variation in oil density possibly due to variations in shale quality and processing conditions. Under these conditions a single separation procedure is insufficient to accommodate these variations. A second reason is the high throughput imposed on the thermal settlers. This last condition is due partly to the rather large amounts of water, consisting of 130,000 m^3/year of phenol water and 30,000 m^3/year of fresh water, used to wash the oils.

Proposed solutions to the problem involve a reduction in the quantity of water used to wash the oils, by eliminating the fresh water wash, which will reduce the throughput rate by 20% and hopefully allow a reduction in the presence of oil in the phenol water leaving the thermal settler. This procedure corresponds with a suggestion by WEC in the March 23-30, 1993 trip report. In that report it was suggested that a reduction in water used to extract phenols from mixed light and heavy oils produced at the retorts would effectively increase phenol concentration in the phenol water extract. The goal was to increase the dephenolization efficiency by increasing phenol concentration in phenol waters. This same strategy would also increase holding time in the thermal settlers (decrease throughput) thus also decreasing the oil content of the phenol water. The second method of reducing the throughput in the thermal settler is to separate light and heavy oils before washing. This presumes that most of the phenols reside in the light oil fraction. The untreated heavy fraction and the phenol extracted light oil fraction would then be recombined for further processing.

Costs to implement this program are estimated as 265 EEK (20 USD for materials and installation) and 5,263 EEK (405 USD) for increased annual operating costs (electricity). Project benefits are three-fold: (a) reduction in the cost of extracting phenols by using 30,000 m^3/year less water (161,937 EEK/year), (b) reduction in waste water charges due to reduced phenol in dephenolization effluent (4,727 EEK/year) and (c) increased efficiency[2] of dephenolization, to 96% from 95%, due to higher phenol concentration and lower oil content of influent phenol waters for processing (2,957 EEK/year). These estimates assume 18,326 EEK/1000 m^3 of water used to extract phenols from oil at a 30% extraction efficiency, 221 EEK/ton of phenol in discharged waste water and a 75% efficiency for biological waste water treatment. The total savings for the project are 172,621 EEK/year (about 13,000 USD/year). According to the project description, project implementation began May 5, 1993.

Project 2. Improved start-up procedures.

For some unstated reason(s), the dephenolization plant, which is supposed to run continuously, is subject to 24 start-ups and shut-downs annually. Whether

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[2]. In 1993 the average phenol concentration in influent phenol waters to the dephenolization process was 5.4 g/l (see Table 8, WEC, January 25-29, 1993 trip report) and average effluent phenol concentration was .0117 g/l. This corresponds to a phenol extraction efficiency of 99.78%. Where the figures of 95% and 96% extraction efficiency for this project come from is not known.

these occur at uniform intervals (for example, 2 per month) or are irregularly spaced is not known. Also not known is a precise reason for such occurrences despite repeated requests for an explanation.

What is known, however, are the consequences of such occurrences. During start-ups extracted phenol water is sent to the waste treatment plant with 2,500 mg/l of butyl acetate, the only extraction solvent used to remove phenols from the phenol waters produced at the retort area. During stable operation of the dephenolization process, the average discharge level of butyl acetate is reported to be 11.7 mg/l which favorably compares with the legally mandated limit of 25 mg/l. Butyl acetate concentrations in excess of the legal limits is harmful to the biological wastewater treatment plant microorganisms thereby decreasing the treatment plant operating efficiency for BOD and suspended solids removal. It is estimated that the waste water treatment facility efficiency decreases about 10% for a 3 day period after encountering an excessive butyl acetate content. High butyl acetate concentration occurring during these start-up periods persist for [illegible] hours and involve about 120 m^3 of waste dephenolization water.

In addition to the environmental benefit of decreasing or avoiding high butyl acetate discharges to the waste water treatment plant, reducing high solvent losses involve benefits associated with the value of butyl acetate saved (at 3,600 EEK/ton) and the decrease in waste water discharge fees (currently 581 EEK/day). Butyl acetate that could be saved by reducing waste water concentrations from 2,500 mg/l to 11.7 mg/l in 24 discharges annually, each consisting of 120 m^3 of waste water amounts to 25,800 EEK/year and would also reduce waste charges by 4,180 EEK/year. Total savings would amount to almost 30,000 EEK/year (about 2,300 USD/year).

Several proposals have been made to decrease the occasionally high butyl acetate effluents as recommended by RAS KIVITER:

(a) "recirculate dephenolized water to phenol water tanks *(during start-ups)* until the regeneration column is completely operational",
(b) "install the steam heater to heat dephenolized water before the regeneration column",
(c) "recirculate dephenolized water to the extraction column until the regeneration column is completely operational".

Proposals (a) and (c) appear to be sensible recommendations though proposal (b) is a bit inscrutable since details of the dephenolization process and the appearance of the excess butyl acetate is not known in any detail. An estimate of the cost to implement these proposals (new steel pipe, pipe valve, installation is quoted as 850 EEK (65 USD) without regard to the specific method used. No decision to reduce excess butyl acetate effluent has yet been made and, indeed, RAS KIVITER suggests that it needs to "research other proposals".

Although these proposals appear sound, WEC has recommended a more fundamental approach; that of determining the cause of the numerous annual start-ups and then to eliminate or reduce them. In this way the problem might be avoided rather than simply allowing them to occur and reducing their effect after they happen.

Project 3. Return of drains for reprocessing.

Leaks from dephenolization area process pumps and valves are currently collected in an underground storage tank and removed to a waste water tank for either reprocessing or are discharged to the treatment plant. The phenol in these leaks is water soluble whereas the butyl acetate is soluble in oils but not in water. About 80% of butyl acetate dissolved in oil is lost to waste waters.

The proposed solution to this problem is to install a separate pipeline

from sources of these leaks "... from pumps and valves and to pump them to phenol water pumps rather than to intermediate tanks". Savings are estimated to be 35,512 EEK/year (about 2,700 USD/year) based on assumptions that the leak rate is 0.4 m^3/hour, 8,160 operating hours/year, 80% of the leak consists of oil containing 0.8 mg/l of butyl acetate, and 17,000 EEK/ton as the cost of butyl acetate). No monetary benefit was given for the environmental benefit of reducing butyl acetate discharge to the waste water treatment plant. Implementation costs are estimated as 750 EEK (58 USD) for pipe valve and installation.

Project 4. Reduction of butyl acetate discharge to air.

Some equipment in the dephenolization processing area are vented directly to the atmosphere leading to losses of butyl acetate and phenol. Reduction of these losses can be effected by connection to an existing vent system in the first dephenolization section of the recovery plant. This existing vent system includes an atmospheric condenser using cold phenol water. Three existing tanks and three coolers, currently vented directly to the atmosphere, were connected to the existing vent condensing equipment thus further reducing uncontrolled emissions.

Cost of implementing the project was about 500 EEK (about 38 USD); there are no annual operating costs. Benefits are estimated at 6,391 EEK (492 USD/year) represented by the value of about 0.38 tons/year of recovered butyl acetate with a current purchasing price of 17,000 EEL/ton (1,308 USD/ton). Not included is the atmospheric pollution avoided by recycling previously vented butyl acetate. No cost benefit is reported because of the very low current air pollution charge.

Benzoic Acid Projects

Project 1. Recovery of benzoic acid process residue.

According to the benzoic acid plant manager, Mr. Rinat Magsumov, residue after distillation to recover the principle product, benzoic acid, also contains unrecovered benzoic acid, catalyst and some small amounts of benzoyl benzoate and terephthalic acid. Presently, about 50 tons of mixed distillation tower bottoms containing about 50% benzoic acid are sent to the waste pile every month.

RAS KIVITER has devised a plan to recover additional quantities of benzoic acid from still bottoms by extraction with hot water. It was estimated that distillation column bottoms of benzoic acid could be reduced from 50% to 30% or less if column bottoms were mixed with hot water held at 97° +/- 1°C. In order to do this, RAS KIVITER requested, and WEC approved, the purchase of temperature control equipment which included a steam control valve, temperature measuring and control equipment (thermocouple, insertion tube and temperature recorder - controller) to be mounted on an available tank. WEC also included a steam flow measuring device.

Equipment supplied by WEC was purchased from Honeywell (in the U.S.) for a total cost of 6,000 USD and delivery arranged for early April 1994 during RAS KIVITER's annual maintenance period. Installation cost was assumed by RAS KIVITER at an estimated 1,000 USD.

The principle benefit of this project is the value of recovered benzoic acid which was estimated at 70,650 USD/year assuming 157 tons/year of benzoic acid recovered having a value of 450 USD/ton. An additional benefit is the reduction in solid waste disposal quantity and cost. The environmental benefit turns out to be an almost negligible 22 USD/year considering waste reduction of 157 tons/year and a current waste charge of only 1.8 EEK/ton.

Project 2. Solid waste utilization at crystallization unit.

Details of the benzoic acid recovery system after this material is formed by catalytic oxidation of toluene are not intimately known. However, it is reported that solid benzoic acid remains in crystallization (and ventilation?) equipment during equipment cleaning due to difficulties with equipment operation and the properties of benzoic acid. About 2 tons/month of unrecovered benzoic acid waste are produced in this manner. This project had as its purpose the recovery of these benzoic acid solid wastes.

The solution appears to involve collecting these solid benzoic acid wastes, melting them and recycling the melt to a separator connected to tanks which supply benzoic acid for purification by distillation. A diagram, describing this project, shows the separator is aspirated (to remove low boiling, easily removed impurities?) and the remaining melt dropping to the tank supplying filtered benzoic acid for distillation. Information supplied estimates the cost of implementing the project as 81,540 EEK (about 6,300 USD) for the separator, a pneumatic valve, pipe and fittings, fan and tank for delivering recovered benzoic acid to distillation. A single benefit is assumed, recovery of benzoic acid worth an estimated 121,440 EEK/year (9,300/year USD) which is derived from the 2 tons/month recycled, 5,520 EEK/ton benzoic acid, 11 months/year operating time. There may be an additional (environmental) benefit if the waste benzoic acid, instead of being recovered, was disposed of as solid waste but, in any case, this benefit is nominal as shown above.

Project 3. Use of rainwater in place of cooling water.

Groundwater, storm-runoff waters and leakage from buried pipelines, in the area of the benzoic acid plant, are naturally mixed on the plant grounds and pass to the wastewater treatment plant for cleanup. At the same time, local lake water is used for process cooling purposes. The goal of this project was to examine the possibility of substituting storm waters for lake cooling water, but only after chemical analysis of the storm waters showed them to be sufficiently clean for this purpose.

To implement this project it was only required to pump storm waters into the circulating cooling water system. It was judged necessary to regularly analyze the new cooling water source to determine if any chemical adjustments were required.

Benefits for this project are all environmental related to the savings of fresh cooling water from the lake and reduction of bio-treatment cost at the treatment plant. Cooling water savings were estimated to be 42,000 EEK/year (based on about 119,000 m^3/year of lake cooling water saved at 0.354 EEK/m^3). Waste water treatment costs saved were estimated to be about 56,000 EEK (based on 119,000 m^3/year at a treatment cost of 0.47 EEK/m^3). Total savings then are about 98,000 EEK ($7,500 USD). Capital investment costs to implement the project was estimated at about 1,000 EEK (77 USD) consisting mainly of new piping. No operating costs associated with increased water analysis were included.

Project 4. Toluene leakage collection in main building and storage.

This project is related to the irregular leakage of toluene, about 2 tons/year, from storage and during processing in the main operating building. Apparently the leakage encountered ends up in storm-runoff which is then sent to the waste treatment plant. In addition to the loss of valuable material, the plant is penalized for the release of toluene into waste waters. Toluene released to the atmosphere is not mentioned.

Solution to the problem is to collect storm water in the vicinity of the storage and processing area and to recycle toluene separated from the waters before sewering. The exact method of accomplishing this was not explained in any

detail.

Cost of the project was estimated as 3,000 - 4,000 EEK (230 - 300 USD) for new piping, pump and installation. Benefits include reduction of toluene losses, estimated as 6,740 EEK/year (518 USD/year) based on recovering 2 tons/year of toluene valued at 3,370 EEK/ton.