PN-ABZ-449

9315

PRIDE Project in Development and the Environment

Environmental Audits of Three Metal Finishing Facilities and a Tannery in Fès, Morocco

October 1996

Submitted to:
USAID/Morocco
Submitted by:
PRIDE

USAID Contract Number:
ANE-0178-Q-00-1047-00
USAID Project Number:
398-0365

Sponsored by:
USAID/G/ENV/EET
Implemented by:
Chemonics International Inc.
and its associates

1133 20th Street, NW, Suite 600, Washington, D.C. 20036
Telephone: (202) 955-3300 • Fax: (202) 955-3400

Environmental Audits of Three Metal Finishing Facilities and a Tannery in Fès, Morocco

By:

Abdelkarim Bennani
Serge Astaud
Saïd Bouanani

October 1996

TABLE OF CONTENTS

		Page
INTRODUCTION		1
REPORT I	ENVIRONMENTAL AUDIT: SOCIÉTÉ DES ARTISANS DINANDIERS DE FÈS (SADF)	
Executive Summary		i
Section I	Brief Description of the Metal Finishing Facility	I-1
Section II	Pollution Prevention Projects	II-1
Section III	Recommendations for a Successful Pollution Prevention Program	II-1
Annexes	A, B, C, D, E, F and G	
REPORT II	ENVIRONMENTAL AUDIT: SOCIÉTÉ DE DINANDERIE, D'ARGENTERIE ET DE QUINCAILLERIE (SODAQ)	
Executive Summary		i
Section I	Brief Description of the Metal Finishing Facility	I-1
Section II	Pollution Prevention Projects	II-1
Section III	Recommendations for a Successful Pollution Prevention Program	II-1
Annexes	A, B, C, D and E	
REPORT III	ENVIRONMENTAL AUDIT: DINANDERIE ET ARGENTERIE DE LALA IDOUNA	
Executive Summary		i
Section I	Brief Description of the Metal Finishing Facility	I-1
Section II	Pollution Prevention Projects	II-1
Section III	Recommendations for a Successful Pollution Prevention Program	II-1
Annexes	A, B, C, D and E	
REPORT IV	ENVIRONMENTAL AUDIT: TANNERIE SAÏS	
Executive Summary		i
Section I	Brief Description of the Tannery	I-1
Section II	Pollution Prevention Projects	II-1
Section III	Environmental Evaluation and Recommendations for a Successful Pollution Prevention Program	II-1
Annexes	A, B, C, D and E	
GENERAL ANNEX I	PROGRAM OF THE WORKSHOP HELD ON JULY 16, 1996	X-1
GENERAL ANNEX II	AUDITING FORM	X-3
GENERAL ANNEX III	HEALTH AND SAFETY RECOMMENDATIONS	X-9
ADDENDUM	ENVIRONMENTAL AUDITS PERFORMED IN THE METAL FINISHING FACILITIES	A-1

INTRODUCTION

A. General Context of the Study

The City of Fès is experiencing substantial industrial development, including the attendant pollution problems. With a decrepit, aging, and insufficient sewer system and limited or nonexistent infrastructure in the outlying districts and growth areas, the demographic and industrial growth in the city is having a detrimental effect on the general environment in Fès. Population growth has resulted in the ongoing growth of small-scale and larger industrial facilities throughout the urban area.

A1. Environmental Issues in the City of Fès

In the past, the Medina—the old section of Fès—was home only to small-scale facilities, but today it is the site of numerous semi-industrial units whose harmful impacts are damaging the traditional fabric of the city. They are also the source of considerable pollution, which jeopardizes the safety and well being of the inhabitants.

The liquid and solid discharges from these units, primarily located along the branches of the Fès River, are directly discharged into the stream system. Although in the past the flow from these waterways could be torrential, at this point, the flow pattern has dropped substantially, reducing their ability to dilute and thereby fostering the accumulation of deposits. Noise, odors, solid and liquid discharges into the waterways, reuse of wastewater in all sorts of small-scale industries, and poor sanitary and hygienic working conditions combine to cause ongoing dangers of contamination.

In the new part of town, modern industry has sprung up in the Dokkarat industrial district. Now these firms are moving into the industrial districts of Sidi Brahim, Ben Souda, Aïn Kaddous and Aïn Nokbi. Although 400 industrial units employ more than 22,000 full-time employees, measures to prevent pollution continue to be limited in Fès. Domestic and industrial waste is discharged directly into the sewer system, waterways, and onto the ground. The climate, in addition to the social, economic, and industrial development, make the repercussions from pollution even worse.

The impact of the discharges in Fès is causing structural deterioration of the sewer systems. This is evident in the city from the odors and unappealing appearance of the waterways. It is also evident downstream from Fès in the Sebou Valley, which is where all the fluids discharged by the city come to rest.

In the Ben Souda district, industrial waste pollutes the water table and contributes to a deterioration of the region's water resources. The Dokkarat industrial district is characterized by a high concentration of agribusinesses, 80 percent of which are oilseed-crushing mills. During the oilseed season, the impact of discharges from the Dokkarat industrial district on the sewer and stream system and on the Sebou Valley is quite significant. Tanneries are second in number after oilseed mills in the district. They do not recover the byproducts in their effluent, and thus their solid and liquid wastes goes into the sewer system or are simply disposed of without any controls. Studies for the Sewage Master Plan have shown that considerable amounts of chromium also are discharged every day downstream from the City of Fès.

The final outlet for all the liquid waste from the City of Fès is the Sebou River. Its drainage basin in northwestern Morocco covers an area of roughly 40,000 km^2. The Sebou rises in the mid-Atlas. A number of tributaries flow into it, before the river flows into the Atlantic Ocean about 500 km from its source. As it flows to the sea, several types of pollution enter the Sebou, including urban, industrial, and agricultural. The degree of severity varies from one section to the next and from one season to another. Some of the main sources of industrial pollution of the Sebou River Basin are agribusinesses, tanneries, paper factories, and refineries.

A2. An Overview of Liquid Industrial Waste from the City of Fès

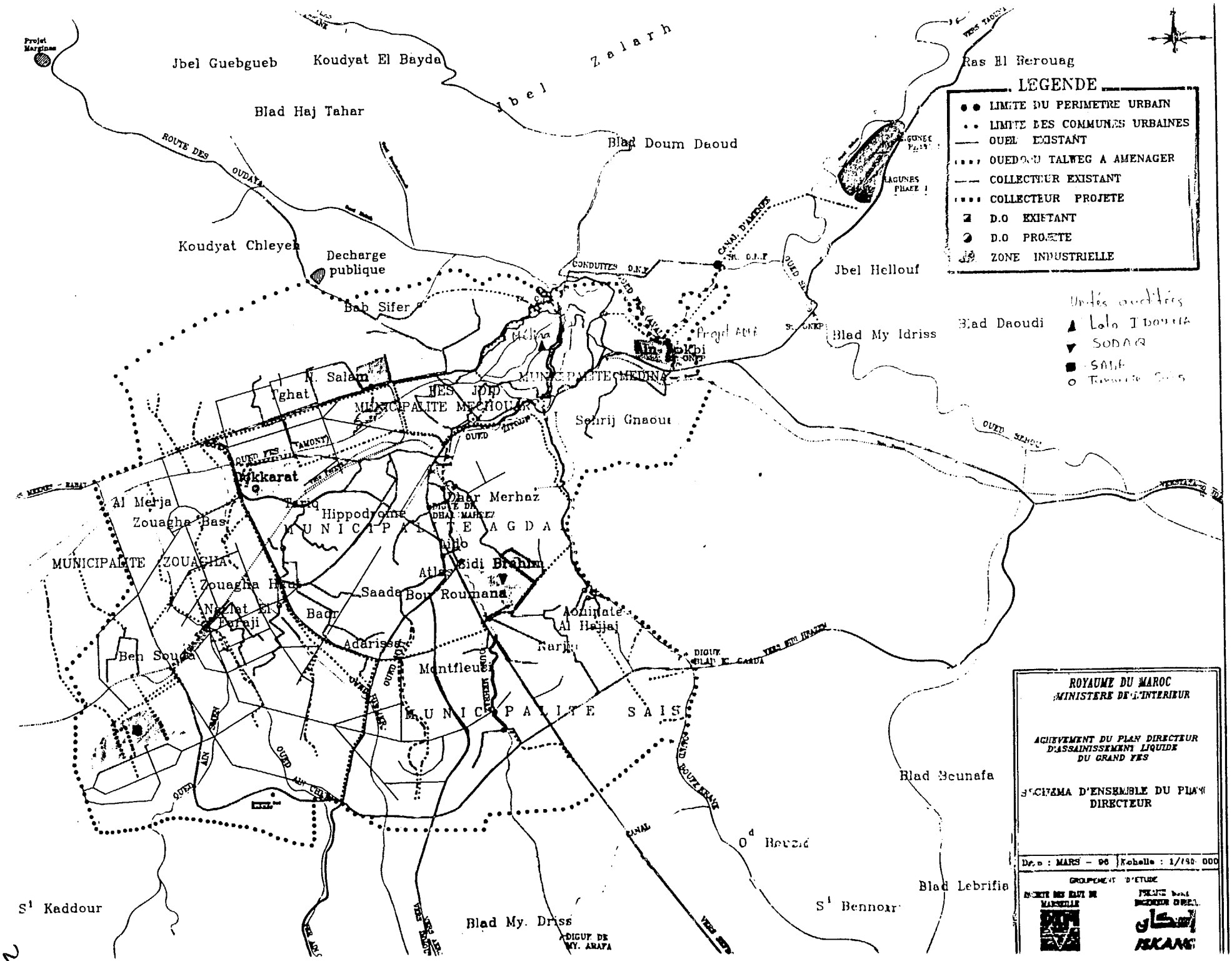
The Greater Fès Liquid Sewage Master Plan, which has just been prepared by the Régie Autonome de Distribution d'Eau et d'Electricité de Fès (Fès Water and Power Distribution District), includes plans for implementing technical solutions to address the issue of industrial pollution. Industrial pollution from the City of Fès for 1995 can be described as follows:

- Organic pollution estimated at 93 tons of COD per day as follows:
  - 45 percent from oilseed-crushing mills
  - 28 percent from agribusinesses
  - 12 percent from tanneries
  - 15 percent from other industries
- Toxic pollution estimated at 600 kg of chromium per day and 100 kg of heavy metals per day, mainly from tanneries and metal finishing facilities.
- Mineral pollution estimated at 1,500 kg of mineral matter per day.

This industrial effluent is discharged without any treatment into the natural environment, including quarries, waterways, the water table, etc. (see attached map of Fès). The master plan has adopted several measures, some of which are indicated below:

Project to eliminate pollution by spreading oilseed residues. The oilseed mills of Fès produce 126,000 tons of oil, which is half of Morocco's entire production. These mills discharge about 40,000 m^3 of residue per 100-day operating season. This pollution load amounts to 409,000 inhabitant-equivalents. Ninety percent of the waste from the mills is concentrated in the Dokkarat industrial district and discharged untreated into the sewer system or stream system. The result is an unpleasant sight, noxious odor, and, even worse, intense pollution of the water in the Sebou River, the one and only outlet for all of the liquid waste from Fès and a water supply source for people living along the river for more than 100 kilometers.

The project, which is now being implemented, involves collecting oilseed residues after they have been stored for four days in production units. The stored volumes will be collected using tank trucks with a capacity of 15 m^3 in the Dokkarat industrial district and 5 m^3 in the Medina and its environs. The residue will be trucked out and unloaded at a site north of town near the current landfill for domestic waste.



BEST AVAILABLE COPY

Treatment is comprised of residue storage in a 45,000 m^3 basin, with precipitation taken into consideration, and residue evaporation in three evaporation basins made waterproof with clay film. Calculation of the evaporation coefficient and residue evaporation experiments conducted in southern Spain, where the climate is similar to that of Fès, suggest that the residue will dry out well before the oilseed harvest of the following season. Once dry, the residue is scraped and placed in a landfill. Project implementation will begin with the next oilseed season.

Chromium and heavy metal recovery station for treating tannery waste. This station will be designed to treat all the chrome-laden waste from the village of Aïn Nokbi and from the tanneries of the Dokkarat industrial district. Tanneries in Fès have always discharged their chromium-laden effluent into the sewers directly without any cleaning and without recovery. The pollutants come to rest in the Fès and Sebou waterways. A plan recommended by the ADER project will recover 80 percent of the chromium in the waste or around 400 kg per day.

Heavy metal and cyanide elimination station. This project, also recommended by ADER, will be designed to treat heavy metals and cyanides from the copper plating facilities in Aïn Nokbi. The total volume of effluent to be treated is roughly 40 m^3 per day, and the amount of heavy metals and cyanides that can be eliminated are 5 kg per day and 6 kg per day respectively.

Lagooning of urban wastewater. The remaining primarily urban liquid effluent will be channeled to a lagooning site in the Sebou Valley, where it will be treated prior to flowing into the Sebou River.

Effluent treatment. It should be noted that, for industrial effluent treatment projects to be successful, all operators involved in the project must cooperate. Thus, for the oilseed residue treatment unit, the project monitoring committee includes members from the towns, the Ministry of Public Works, the Office National d'Eau Potable (ONEP/National Drinking Water Office) and RADEEF. This committee has assigned responsibilities for each phase of the project, such as monitoring oilseed residue collection, monitoring structures, and managing solid residue.

For the heavy metal treatment unit that is part of the project, there are plans to treat the effluent laden with heavy metals from those units in Ain Nokbi and from the tanneries and metal finishing facilities, which are located far from the treatment area in the Dokkarat and Sidi Brahim industrial districts. From the latter, effluent to be treated will be transported in tank trucks. Several players are involved in this project:

- ADER, which has an ambitious project that aims to move tanneries and metal finishing facilities from the Fès Medina to the Ain Nokbi small-scale industrial district.
- The Ministry of the Environment, which is conducting a study on implementing an experimental pilot project.
- Several donors, who are conducting programs to provide assistance to industry.

B. The PRIDE Contribution to Fès

B1. Earlier Contributions

International donors have expressed considerable interest in the environmental situation in the City of Fès. Many studies have been or are being conducted and many projects have been or are being implemented in the fields of sanitation and pollution treatment and prevention by several multilateral assistance programs, including the World Bank, the European Union, and UNEP. Bilateral organizations such as USAID, CFD, Sweden, and GTZ also have been active.

Through a number of programs, USAID has conducted audits to stem and prevent industrial pollution in the City of Fès. As a result, environmental audits have been conducted through the GEM Project in the following units:

- Tanning industry (see locations on the diagram):
  - Tannerie Wad Eddahab in the Ain Nokbi district
  - Tannerie Jallal in the Dokkarat district
  - Tannerie Chouarat in the Medina
- Metal finishing-silver plating industry—Unité Kabbaj in the Medina
- Textile industry—Complexe textile de Fès in the Sidi Brahim district

The GEM Project also has pre-audited around 20 other units.

As the work came to a close, USAID included a major future project for Fès in its portfolio entitled, "Water Resources Sustainability." This project will conduct a feasibility study for establishing pollution-prevention technologies in the tanning and metal finishing industries. A demonstration project will then support this project in an effort to broaden the use of these technologies in the appropriate industries.

This is the framework for the PRIDE environmental audits in Fès. The work scheduled for June 1996 was to conduct three environmental audits in the metal finishing industry and one in the tanning industry. The purpose of the audits is to obtain more information about the type and source of heavy metals and toxic waste generated by the tanning and copper plating facilities and to identify methods and procedures to minimize the waste by using pollution-prevention technologies.

B2. Selection Criteria for the Industrial Units to be Audited

Selections were based on the following criteria:

- Unit location (the Medina; Ain Nokbi small-scale industrial district and the Dokkarat, Ben Souda, and Sidi Brahim industrial districts).
- Unit size (industrial, small-scale production capacity).
- Complementarity with projects implemented by GEM.

- Process used (chromium tanning for the tannery. cyanide-based surface treatment for the metal finishing facilities).

- Ability of managers to serve as leaders in their professions.

- Predisposition of managers to cooperate with the future USAID project (WRS).

B3. Selected Metal Finishing Facilities and Tannery

The following metal finishing facilities and tannery were selected for environmental audits:

- **SADF (Société des Artisans Dinandiers de Fès).** Justification of the choice:

  - This is a vertically-integrated company that carries out all metal finishing operations, which makes it interesting in terms of observing the gamut of effluent and waste found in this line of business.

  - The firm is located in the Ben Souda industrial district, which is not connected to the sewer system, and SADF discharges consequently pollute the water table.

  - The manager of this company is very much aware of environmental protection and has spared no effort to improve his unit's situation. He has installed a neutralization trench for water before it is discharged and uses a cyanide-free degreasing agent for the degreasing bath.

  - SADF is a role model for the metal finishing industry, and its owner is eager to learn and cooperate with any and all pollution-prevention projects.

- **SODAQ (Société de Dinanderie, d'Argenterie et de Quincaillerie).** Justification of the choice:

  - Another vertically integrated firm, SODAQ offers the same advantage as SADF in this regard.

  - SODAQ is located in the Sidi Brahim district, one of the industrial areas where liquid effluent will be trucked out under the ADER Project.

  - This company has vast potential in terms of process rearranging and enhancement.

  - SODAQ's manager is beginning to recognize the value of a pollution-prevention program.

- **Lala Idouna (Dinanderie et Argenterie de Lala Idouna, a subcontractor).** Justification of the choice:

  - This firm is owned by the professional dean of copper plating facilities association in Fès. As a result, his role as a leader of the profession is obvious.

- Lala Idouna is located in the Medina and with all other companies there will be relocated to the Ain Nokbi small-scale industrial district under the ADER Project. Recommendations made by the audit team can be considered when the new unit is built.

- This company specializes solely in surface treatment operations and is located in a heavily polluted area.

- The manager expressed great interest in USAID pollution prevention projects. He had already expressed interest during the GEM project's earlier activities in Fes.

- **Tannerie Saïs.** The choice of this tannery was justified on the following basis:

  - An industrial-scale tannery, it is one of the largest in Fès. Its production capacity can attain 2,700 sheepskins per day.

  - The business is located in the Dokkarat industrial district, considered to be the leading generator of pollution in Fès.

  - This firm uses chromium tanning and provided data in addition to that already obtained under the GEM project.

  - The firm's manager has an export-oriented strategy, and therefore is interested in upgrading product quality and limiting environmental pollution.

B4. Schedule of the PRIDE Environmental Audits

The audits were made according to the following schedule:

Introductory visit for the project and criteria selection, June 6, 1996. This meeting was attended by representatives of the Wilaya of Fès, the ADER, the Chambre de Commerce et d'Artisanat de Fès, the Chambre de Commerce et d'Industrie, the Ministry of the Environment, and the US/AID. During this session, the auditors presented the Project as well as their criteria for selection of enterprises to be audited.

Site visits to pre-identified electroplating facilities, June 10. During each visit of the pre-identified sites, the auditors held a work session to present details of the organization of the on-site audits and also to identify all necessary information.

SADF pre-audit and audit, June 11-13. The pre-audit of the SADF consisted in collecting general information about the company's manufacturing process. Particular attention was devoted to the surface finishing department, where specific information was collected, such as the nature and volume of chemical make-ups, the volume of waste generated, chemical bath specifications, and frequencies of bath make-ups. The complete audit of the surface finishing department allowed the auditing team to perform TDS, pH, and temperature measurements for each processing and rinse tank. The team took a schematic of each process line with tank dimensions, measured rinse water flow rates, and represented workflow graphically. To complete gathering the necessary information, the team observed the operating practices and measured approximate plating times for each recovery process (See also General Annex II: Auditing Form).

SODAQ pre-audit and audit, June 14-15. Pre-audit and audit campaigns were conducted in a manner similar to SADF with regard to on-site collection of information.

Lala Idouna pre-audit and audit, June 17-18. The auditing team conducted the pre-audit and audit campaigns in a manner similar to SADF and SODAQ with regard to on-site collection of information.

Sampling at the electroplating facilities, June 17-18. At each metal finishing plant, after identifying acceptably representative parameters, the team collected composite samples of the final effluent and individual samples of rinse waters and process tank solutions. Samples were immediately sent to the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement, for analysis.

Selection of the tannery to be audited, at the same time. The Tannery Saïs was selected, at the same time, and the team visited with the company's management to present the audit.

Tannery Saïs pre-audit and audit, June 19-21. The Tannery Saïs pre-audit and audit were performed according to the investigative protocol described above for the metal finishing facilities.

Tannery sampling, during the June 24 audit. A series of initial samples were taken and sent to the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement.

Second sampling from the electroplating facilities, June 24. This second sampling campaign was made to ensure that the samples were representative and to stabilize the pH of critical samples such as the waste waters final effluent.

Report writing, June 26-July 6. Technical evaluation and writing work, was supplemented by additional information, both technical and administrative, to validate the final recommendations.

Visit to audited companies, June 28. These visits, undertaken to benefit Mssrs Hanafi (USAID) and Kerby (COP WRS), were organized to allow a meeting with representatives of the Wilaya of Fès and the ADER.

Workshop presentation of preliminary reports, July 16. See General Annex I: Program of the Workshop held on July 16, 1996.

B5. Summary of the Audit Results

The following tables summarize the main results of the audits of the metal finishing facilities (SADF, SODAQ, and Lala Idouna) and the Tannerie Saïs.

It should be pointed out that, for these four audits, the audit team set the cost of water at 10 Moroccan Dirham (Dh) per m^3. This price reflects a regulation in Morocco that will soon take effect. It has already been approved on the national level, and adoption of the final regulation for

the Fès Region is pending.[1] Calculations for return time on investments took this fact into account.

Table 1. SADF Projects, 1996

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Project gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of copper cyanide discharges	Water 97 Copper 98.5 Cyanide 98	41,100	8,713	3,000	-5,713
2	Minimization of nickel discharges	Water 94 Nickel 97.7	41,100	7,926	1,100	-6,826
3	Minimization of silver cyanide discharges	Water 85 Silver 98.7 Cyanide 98.5	36,200	1,868	21,180	19,312
4	Minimization of gold cyanide discharges	Water 17 Gold 100 Cyanide 100	9,300	638	2,050	1,412
5	Minimization of organic content of waste-water from the degreasing process	Water 84	13,700	12,394	570	-11,824
	Total		141,100	31,539	27,900	-3,639

Table 2. SODAQ Projects, 1996

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating Expenses (Dh/year)	Project gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of copper cyanide discharges	Water 99.7 Copper 80 Cyanide 98	54,300	9,682	9,965	283
2	Minimization of nickel discharges	Water 99.7 Nickel 97.4	54,300	8,501	9,900	1,399
3	Minimization of silver cyanide discharges	Water 99.7 Silver 93 Cyanide 96.5	39,600	7,502	12,850	5,348
4	Minimization of gold cyanide discharges	Gold 100 Cyanide 100	9,300	931	6,000	5,069
5	Minimization of organic content of waste-water from the degreasing process	Water 99.5 Cyanide 100	22,500	13,645	15,000	1,345
6	Minimization of wastewater discharge in the chrome process	Water 100 Chrome 100	NA	NA	NA	NA
	Total		180,000	40,261	53,695	13,434

[1]Dahir #1-95-154 of August 16, 1995.

Table 3. Lala Idouna Projects, 1996

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating Expenses (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of nickel discharges	Water 98.7 Nickel 96	60,200	4,438	4,600	162
2	Minimization of silver cyanide discharges	Water 99.2 Silver 85 Cyanide 95	54,300	3,651	4,000	349
3	Minimization of organic content of waste-water from the degreasing process	Water 93.4 Cyanide 100	24,000	6,643	10,800	4,157
	Total		138,500	14,732	19,400	4,668

Table 4. Tannerie Saïs Projects, 1996

No.	Name of project	Type of savings	Value in income (Dh/year)	Invest-ment (Dh)	Return time (months)	Environmental impact		
						% Chrome	% Sulfur	% Volume
1	Minimization of water use during soaking	Water	314,000	7,000	Immediate			26
2	Sodium sulfide recovery	Sulfur+lime	156,000	20,000	1.5	36	33	
3	Optimization of chromium fixation	Cr sulfate	24,000	12,000	6	50		
4	Direct chromium recycling	Cr sulfate	34,000	12,100	5			
5	Separation of effluent	Prevention		30,000				
	Total		528,000	81,100	12.5	86	33	26

Environmental Audit:
Société des Artisans Dinandiers de Fès (SADF)

By:

Abdelkarim Bennani
Serge Astaud
Saïd Bouanani

October 1996

ACKNOWLEDGMENTS

The Project in Development and the Environment (PRIDE) and the audit team wish to thank Abderrafii Tahiri, managing director of Société des Artisans Dinandiers de Fès (SADF) of Fès, Morocco, for his hospitality and assistance while the team conducted an environmental audit of that metal finishing facility in June 1996.

In addition, we wish to thank the SADF employees and associates, Mr. Brahim in particular, for their willingness to help with the testing and for the time they spent with the auditor-engineers collecting data and performing tests.

We also wish to extend our special gratitude to the Moroccan Ministry of Environment and to the staff at the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement, it would not have been possible to complete this report without them.

The following people conducted the audit of the metal finishing facility:

- Abdelkarim Bennani, team leader, Ph.D. chemical industries, and consultant in energy and the environment;
- Serge Astaud, international consultant and pollution prevention specialist for the surface treatment industry; and
- Saïd Bouanani, Ph.D. chemical engineering and consulting engineer in energy and the environment.

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		i
SECTION I	BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY	
	A. Introduction to SADF	I-1
	B. Brief Description of the Process	I-1
	C. Metal Finishing Facility Discharges	I-4
SECTION II	POLLUTION PREVENTION PROJECTS	
	A. Project N°1. Minimization of Copper Cyanide-bearing Waste Stream	II-1
	B. Project N°2. Minimization of Nickel-bearing Waste Stream	II-4
	C. Project N°3. Minimization of Silver Cyanide-bearing Waste Stream	II-7
	D. Project N°4. Minimization of Gold Cyanide-bearing Waste Stream	II-10
	E. Project N°5. Minimization of the Organic Content of Waste Water from the Degreasing Process	II-11
SECTION III	RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM	
	A. Specific Recommendations	III-1
	B. General Recommendations	III-2
ANNEX A	TABLES ILLUSTRATING THE STAGES OF THE PROCESS	A-1
ANNEX B	TABLE ILLUSTRATING FEATURES OF THE BATHS	B-1
ANNEX C	DIAGRAM OF LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS	C-1
ANNEX D	OPERATING EXPENSES	D-1
ANNEX E	BIBLIOGRAPHY	E-1
ANNEX F	INVENTORY LISTING	F-1
ANNEX G	EKASIT - KW	G-1

12

EXECUTIVE SUMMARY

This report presents the findings of an environmental audit of Société des Artisans Dinandiers de Fès (SADF) located at 47, Lot Industriel Bensouda, Fès, Morocco. SADF, along with two other metal finishing/silver plating facilities in Fès, was selected to receive technical assistance under the USAID-funded Project in Development and the Environment (PRIDE).

A team, composed of Mr. Abdelkarim Bennani and Mr. Saïd Bouanani, domestic consultants, and Mr. Serge Astaud, an international consultant, conducted the audit, working in close cooperation with company employees. The team carried out the on-site work in two phases: a pre-audit phase on June 11, 1996, and a testing phase on June 12 and 13, 1996.

The audit enabled the team to identify five projects that would minimize the environmental impacts of the surface treatment department's operations. Implementing these projects would allow the company to make the following reductions:

- Wastewater volume by 17 percent and water consumption by the same percentage
- The amount of heavy metals in its effluent by 98.3 percent
- Its toxic discharges (cyanides) by 98.8 percent

The five projects can be implemented in three stages. The first stage would involve setting up a deionized water production unit in the form of an ion exchanger. The unit would provide rinsewater and make-up water for the plating baths.

In the second stage, the company would install two electrowinning cells for recovering heavy metals in the three rinse tanks that are located where the rinse lines begin after copperplating, nickelplating, and silverplating. SADF would use one of the electro-winning cells exclusively for recovering nickel metal ions and the other for both copper and silver. The final stage would be a reorganization of each of the rinse lines, including a conversion to counterflow rinsing.

The combined investment for the five projects would amount to 141,100 Moroccan Dirham (Dh) with annual operating expenses of 3,639 Dh per year. This investment, which would allow SADF to lower the toxicity of its discharges by 98.8 percent, provides no opportunity for direct return.

In the regional context of the City of Fès, however, studies have demonstrated[1] that, for this kind of private-sector investment, the total internal rate of return would be greater than 8 percent for the Kingdom of Morocco. Moroccan authorities, therefore, are considering investment incentives such as direct funding and tax breaks. Such measures would have an obvious positive impact on the rate of return for pollution prevention investments, as described below. In addition, SADF might also consider the following intangible benefits:

[1] Scandiaconsult International AB, *Etude d'impact des rejets industriels sur la qualité des eaux de l'Oued.*

- Fewer requirements for handling chemicals such as bleach, contaminated rinsewater, and final effluent
- Fewer requirements for storing a variety of chemicals
- Improvement in rinsewater quality, which in turn would stabilize product quality
- Fewer impurities in the copperplating bath
- Less liability associated with discharging wastewater
- Protection from future laws that may be enacted to regulate toxic discharges under the water code
- Compliance with European and American environmental production standards (ISO-9000n and ISO-14000), which would in turn guarantee a good position for selling in these markets.

The three tables on the following pages describe the overall projects and include a few additional comments as well.

In this audit, the team's recommendations were primarily aimed at decreasing the environmental impact of wastewater discharged from the SADF surface treatment department. All businesses have certain economic, human, technological, legislative, and other requirements; consequently, they prioritize implementation of their plans to upgrade their facilities. For the purposes of this audit report, the team presents two approaches that indicate the minimum level of investment necessary to meet the economic requirements, on the one hand, or the environmental requirements on the other.

Economic approach. This approach identifies projects with the best profitability to environmental impact ratio. See Table 2. Economic Approach.

Environmental approach. This approach identifies projects that provide the best environmental impact to profitability ratio. See Table 3. Environmental Approach.

The results in Table 1. indicate that only Projects 3 and 4, the silverplating and goldplating lines respectively, would permit a return on investments, which is explained by the following:

- Silver and gold are precious metals with a high salvage value.
- The rinse line after silver already has a tank heated to 80°C.
- The electrowinning cell is capable of reducing silver ions to the metallic state at the rate of 4.024 gr/amp/hour (as opposed to 1.186 for copper and 1.095 for nickel).
- Recommendations for the goldplating line mainly involve eliminating all the rinse equipment.

All calculations in this report are based on readings and measurements taken on-site and on information collected directly from the plant managers.

14

The audit team based its recommended investment figures on purchasing equipment from specialized vendors. Because of the relatively low-technology profile of the recommended equipment, it would be possible for the SADF engineering department to manufacture some of the equipment, such as the electrowinning cells. This option should make it possible to reduce the total investment figure by about 50,000 Dh.

Table 1. Overview of Five Pollution Prevention Projects for SADF

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating costs (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of toxic copper cyanide discharges	Water 97 Copper 98.5 Cyanide 98	41,100	8,713	3,000	-5,713
2	Minimization of toxic nickel discharges	Water 94 Nickel 97.7	41,100	7,926	1,100	-6,826
3	Minimization of toxic silver cyanide discharges	Water 85 Silver 98.7 Cyanide 98.5	36,200	1,868	21,180	19,312
4	Minimization of toxic gold cyanide discharges	Water 17 Gold 100 Cyanide 100	9,300	638	2,050	1,412
5	Minimization of organic concentrations of wastewater in the degreasing process	Water 84	13,700	12,394	570	-11,824
	Total		141,100	31,539[2]	27,900[3]	-3,639

[2] Detailed information on how the operating expenses were computed appear in Annex D.
[3] Detailed information on how the earnings w ere computed appear in the description of each project.

15

Table 2. Economic Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected Cashflow (Dh/year)
3	Minimization of toxic silver cyanide discharges	Water 85 Silver: 98.7 Cyanide 98.5	36,200	1,868	21,180	19,312
4	Minimization of toxic gold cyanide discharges	Water 17 Gold 100 Cyanide 100	9,300	638	2,050	1,412
	Total	Water 2.6 Metals 25 Cyanide: 54	71,900[4]	2,506	27,900	20,720

Note: This approach still requires a supply of deionized water to prevent contaminating the gold bath; therefore, the purchase of an ion exchanger is strongly recommended. The other equipment is the same as in the individual descriptions for Projects 3 and 4.

Table 3. Environmental Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of toxic copper cyanide discharges	Water 97 Copper 98.5 Cyanide 98	41,100	8,713	3,000	-5,713
3	Minimization of toxic silver cyanide discharges	Water 85 Silver 98.7 Cyanide 98.5	36,200	1,868	21,180	19,312
	Total	Water 7.4 Metals 69.7 Cyanide 97.9	103,700[5]	10,581	24,180	13,599

Note: The ion exchanger is included in this scenario as well to optimize the amount of time that the metal recovery cycles last before it is necessary to drain the first rinse basin.

[4] This figure includes 26,400 Dh, which amounts to 60 percent of the cost of buying the ion exchanger.
[5] This figure includes 26,400 Dh which amounts to 60 percent of the cost of purchasing the ion exchanger.

16

SECTION I

BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY

SECTION I
BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY

A. Introduction to SADF

Société des Artisans Dinandiers de Fès (SADF) is a corporation founded in 1982. With 200 employees, an installed capacity of 160 KVA, and 2,000 m^2 of covered facilities, it is one of the largest firms in Fès specializing in the manufacture of decorative products using silverplating and goldplating. The company is vertically integrated and comprises all stages of treatment from cutting to electrowinning and finishing, including all intermediate stages of production. SADF processes an average of 400 workpieces per day of different shapes and sizes, including teapots and trays. This amounts to an equivalent of 45 m^2 per day of raw material surface area (brass sheets, bars, and tubing). The company is open for business from Monday through Friday. Normal working hours are from 8 a.m. to 4 p.m., which amounts to 8 hours per day and 286 days per year.

SADF uses around 134,218 kWh of electricity per year at a cost of 183,900 Moroccan Dirham (Dh) including tax. The company has a well, and its water tower meets its entire requirement for water. The amount of water used is not metered, but the audit team estimated that SADF consumes about 1,300 m^3 per year[1].

The Bensouda district, where SADF is located, has not yet been connected to the sewer system. This creates serious problems for the company in terms of discharging its wastewater, since the wastewater is often relatively toxic. PRIDE considered this fact when deciding which metal finishing facilities to audit.

SADF uses different chemicals at an approximate total cost of 650,000 Dh per year (See Annex F: Inventory Listing).

B. Brief Description of the Process

B1. Production and Preparation of the Workpieces

The production process is comprised of the following phases:

Cutting. The brass sheets vary in thickness according to the item produced. They are cut using a template and scissors or a jigsaw.

Straightening. The workpieces become slightly misshapen when cut. To prepare them for stamping, they are straightened in manually operated presses.

Stamping. The workpieces are shaped during this phase.

Shaping. This is the stage in which the workpieces take on their final geometric shape.

Brazing. This is done with bronze or brass for assembling some of the items.

---

[1]Flow rate estimations were made by measuring the time it took to fill a known volume with the water stream.

18

Lathe work. The accessories for the items are produced in this facility.

Mounting, welding, and assembly. The item takes on its final shape before being sold.

Cleaning and polishing. Some items, teapots in particular, are descaled on the inside using nitric acid; the others proceed directly to the polishing stage. The items are polished using brushes mounted on lathes, and each machine has two brushes. The brushes are dipped in spent motor oil from time to time, to cool them, and are also dipped into polishing grease. Once they are polished, the items are cleaned by hand with kerosene, dried with sawdust[2], and then polished by hand with whiting.

Hammering, printing, and decoration. This work is impressive because it is done entirely by hand with a degree of accuracy and craftsmanship that is absolutely remarkable.

Foundry. All the metal cut-offs that are produced during the mechanical phases are melted down and reused to make accessories. The molds are prepared by hand in the shape of a packet (terzak) made with red earth that is baked over a wood fire.

B2. Surface Treatment

Degreasing. When received, workpieces are hung on hooks and dipped in a cyanide-free electrolytic solution (contrary to other facilities that use basal solutions of sodium cyanide and caustic soda). They are dipped for a given amount of time (5 minutes) to remove all the grease and prepare them for the next stage, nickel plating. Direct voltage with 250 amps and 7 volts passes through the solution. Current adjustments are made depending upon the number of workpieces and their surface area. The solution is completely replaced every 290 hours of work or every 36 days.

Rinsing. The workpieces are removed from the degreasing tank and then rinsed off in a series of three static tanks that contain 480 liters of water. The rinse water is dumped after every seven days of operation.

Copper plating. Copper plating is used to promote adhesion on welded areas of the parts and improve deposit quality. All the items are placed in an alkaline solution (pH=10.8) of copper cyanide (47.2 g/l) and sodium cyanide (75 g/l), and direct current of 100 amps and 2 volts passes through it from eight copper anode parts. The solution is heated to a temperature of 55°C using an immersion heater placed directly in the bath. The anodes are consumed at the rate of 28.4 kg per year, while 8 kg of sodium cyanide and 5 kg of copper cyanide are added every 192 hours (24 days) of use.

Rinsing. The workpieces are removed from the copper plating tank and then rinsed off in a series of three tanks, each containing 480 liters of water. The third rinse is also used for the first rinse in the nickel plating process for partially oxidizing the cyanides. These rinse tanks are dumped every seven days of operation.

Nickel plating. Nickel plating is performed in two process tanks with a volume of 1,800 liters and 640 liters of solution respectively. These acidic solutions (pH=4.2) are comprised of

[2]The sawdust is bought from local wood working shops.

19

nickel sulfate (120.6 g/l), nickel chloride (47.5 g/l) and boric acid (23.0 g/l). The purpose of boric acid is to produce and maintain an acid pH somewhere between 3.5 and 4.5. Ten nickel anodes (6 in the small tank), passivated by $NiCl_2$, carry the electrical current required for nickel plating. Additives are regularly mixed in the solution makeup, such as brighteners to enhance finish, leveling agents to ensure even deposit thickness, and wetting agents to minimize internal stress by reducing solution viscosity.

It takes about 10 minutes for the items to be plated. As a rule, the solution should be heated to 60°C for best results. Different makeup salts are added every 192 hours (24 days) at the rate of 43.75 kg for nickel sulfate (14 for the small tank), 9.25 kg for nickel chloride (6 kg for the small tank), and 6.7 kg for boric acid (3 kg for the small tank). All the nickel anodes are replaced for both baths at the rate of 855 kg/year. Nickel plated items eventually are either silver plated or gold plated.

Rinsing. The items are removed from the nickel plating tank and then rinsed off in a series of four static tanks containing 480 liters of water each. The first and the third rinse tanks are the same and are also used for the copper plating rinse; the final rinse is the same as the first one for the silver rinse. The shared rinses cause partial oxidation of the cyanides. The rinsewater is dumped every seven days of operation.

Silver pre-plate. This is the stage just before silver plating and involves exposing the items to a solution containing 20 g/l of silver cyanide and 180 g/l of potassium cyanide in a 780 liter bath for a very short period of time, 10 seconds. Makeup salts are added after every 120 hours (15 days of operation) at the rate of 1 kg for silver cyanide and 12 kg for potassium cyanide.

Silver strike. Silver plating takes place in a 780-liter bath made-up of silver cyanide (25 g/l) and potassium cyanide (180 g/l). Processing time is approximately 2 minutes. A brightener is also added to the solution. One kg of silver cyanide and 6 kg of potassium cyanide are added after 120 hours of operation or 15 days. A 10 amp, 1 volt current circulates between eight silver anodes and the workpieces to be treated. The anodes are replaced every six months.

Rinsing. After the workpieces are removed from the silver plating process tank, they are rinsed, in a series of two static rinse tanks filled with 480 liters of water each. They are then immersed in a round tank heated to 80°C. The first and the fourth rinse tanks are shared with the nickel plating rinse line. The baths are dumped and replaced every seven days of operation.

Gold strike. Gold strike takes place in a 480 liter tank containing a gold cyanide solution (1.04 g/l) and potassium cyanide solution (41 g/l). The process usually takes from 20 to 30 seconds. Gold brightener is also added to the solution. One hundred grams of gold cyanide and 4 kg of potassium cyanide are added every 192 hours or 24 days. The gold strike bath is maintained at a temperature of 90°C.

Rinsing. After being removed from the gold plating bath, the parts are rinsed off, first in a tank filled with 480 liters of water at room temperature, secondly by immersion in the round tank heated to 80°C (also used for the silver final rinse stage). These rinse tanks are dumped and replaced every seven days of operation.

Drying. All workpieces are dried with sawdust. They are then individually inspected, polished using whiting, and finally dried using compressed air. Used sawdust and whiting amount to 2 kg and 4 kg per day, respectively.

Solution filtering. SADF uses a mobile solution filtering system. It is applied successively to each process bath in an effort to remove impurities, thereby extending the bath's service life. Impurities pathways can be classified as follows:

- Metallic structures -can be minimized by preventing splashes from the tank.
- Anode quality -the nickel anodes should be pure.
- Addition of dirt -can be curtailed by improving rinsing.
- Makeup water containing high levels of dissolved salts -use deionized water.
- Airborne particles falling in the tank -use tank lids when not operating.

C. Metal Finishing Facility Discharges

Aware of the potential toxicity of its metal finishing waste waters, SADF's upper management has implemented a waste treatment method that attempts to:

- Oxidize cyanides, by addition of lime
- Neutralize pH to a 6.0 to 9.0 range by addition of caustic soda
- Haul away the batch-treated effluents for off-site disposal outside the immediate neighborhood.

The treated waters are apparently dumped in the ground and eventually absorbed in the aquifer. SADF is not equipped with analytical capabilities, or laboratory facilities. Make-up and monitoring of the process baths is accomplished on the basis of weight, volumes and pH of the various solutions and components.

C1. Liquid Effluent

Amounts. According to our estimates, SADF uses 1,325 m^3 of water per year[3] broken down as follows:

Process	m^3/yr
Surface treatment	
Rinsing	244.5
Makeup solution	9.0
Bath evaporation	31.5
Subtotal	**285.0**
Cleaning	325.0
Supply water	429.0
Other	286.0
Total	**1,325.0**

[3]Flow rate estimates were made by measuring the time it took to fill a known volume with the water stream.

21

The most heavily polluted discharges of water are rinsewater, amounting to 244.5 m^3 per year. This represents about 20 percent of the total volume discharged, which is considered to be a relatively low volume compared with what is commonly discharged by other metal finishing facilities in the area. Since SADF is not connected to the sewer, it has constantly attempted to lower the volume of its toxic discharges.

Some of the steps that SADF has already taken to minimize the impact of its work on the environment are listed below:

- Static rinsing is always used, and there is no discharge.
- Downstream treatment with bleach partially oxidizes the cyanides and makes them less toxic.
- After treatment, the water is discharged in locations far from urban areas.

Contaminants. The contaminants are primarily heavy metals such as Cu, Ni, Ag, and Au, in addition to cyanides. These contaminants are dragged out as salts by the rinse operations. According to the auditing team's estimates,[4] SADF would appear to discharge the following quantities in kg per year:

Contaminants	kg/yr
Heavy metals	
Copper	34
Nickel	22
Silver	19
Gold	0.02
Total	**75.02**
Cyanides	**119.5**

C2. Solid Waste

Solid waste is comprised of the following materials:

- Cut-offs, including shavings and burrs from all mechanical operations, are re-melted, to produce molded accessories.

- Sawdust used for drying the items during polishing and plating is contaminated with oils and hydrocarbons from the polishing process and with rinse water from the metal finishing operations. Approximately 10 kg of this type of waste is generated per day, and disposal is made in a local public landfill.

- Whiting powder, used to improve surface finish after polishing and to dry parts after plating, is contaminated with oils and hydrocarbons (from polishing) and with rinse

[4]These estimates have been derived from TDS measurements, and validated or corrected by the laboratory analytical results.

water (from plating). Approximately 12 kg of this waste, generated per day, are disposed of in a local public landfill.

- Towels, used for polishing and finishing, are contaminated with grease and kerosene and are also disposed of in a local public landfill.

C3. Exhaust

Atmospheric emanations are mainly composed of the fumes from the wood fires, used to bake earth molds. The cyanide-free degreasing process tank does not generate undesirable fume emanations into the workplace. For the other process baths containing dissolved metal salts, the hydrogen and oxygen evolving at the cathode and anode respectively, do not entrap a significant mist requiring air emission control equipment.

SECTION II

POLLUTION PREVENTION PROJECTS

SECTION II
POLLUTION PREVENTION PROJECTS

A. Project N°1. Minimization of Toxic Copper Cyanide Discharges

Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water 97 Copper 98.5 Cyanide 98	41,100	8,713	3,000	-5,713

A1. Recommendations

- Install a deionized water production unit for makeup water for the rinse tanks and the copper plating bath.
- Install a counterflowing rinse system comprised of three rinse tanks.
- Install an immersion heater in the first rinse tank after copper plating to evaporate the excess water from the counterflow.
- Install a metal reinforcement structure to maintain the integrity of the first PVC rinse tank which will be heated to a temperature of 45° C.
- Install an electrowinning cell to recover the copper ions in nontoxic metal form, oxidize and destroy the cyanides.
- Modify the parts rinse system after copper plating by rearranging the tanks.

A2. Description

Currently the operating method involves using three static rinse tanks after copper plating. These tanks are gradually contaminated over a seven-day production cycle. At the end of the cycle, the rinsewater is drained into a common retaining tank for pretreatment prior to discharge. Each rinse tank contains 480 liters of well water characterized by measuring the total suspended solids (TSS); this figure is between 600 and 675.

The copper plating bath that uses cyanide does not generate a contamination cycle. Since SADF was founded 10 years ago there has never been any need to replace it. Despite the introduction of impurities from well water, air, treated items, etc., it appears that no replacement has been necessary. The bath is sufficiently "purged" by the drag-out the solution that is removed when the workpieces are taken out of the bath. The bath, heated to 45° C, is equipped with anti-evaporation balls.

A3. Projected Savings

The above mentioned equipment will make it possible to change the environmental impact of the copper plating line as follows:

- Annual water consumption for this process will drop by 56 m^3 or 97 percent.
- 33.5 kg of copper out of the 34 kg currently generated by the rinse line, or 98.5 percent, will be recovered per year.
- 53 kg of cyanide out of the 54 kg generated by this line will be destroyed per year, or 98 percent.

The savings for the copper plating operation will be 3,000 Dh per year, broken down as follows:

- 560 Dh for water based on 10 Dh/m^3.
- 340 Dh for recovered copper based on 10 Dh/kg of copper.
- 2,100 Dh of savings in bleach processing to destroy the cyanides.

A4. Operating Expenses

The proportion of total operating expenses originated by the installed equipment for this line can be estimated at 8,713 Dh per year based on the following:

- 5,878 Dh per year to improve evaporation in the first rinse tank, or 25 percent of the total cost of the electricity for the three immersion heaters
- 2,197 Dh per year for the electrowinning cell, or 33.5 kg of copper at 65.59 Dh/kg
- 638 Dh per year for deionized water supply, or 20 percent of the total operating expenses of the ion exchanger

A5. Investment

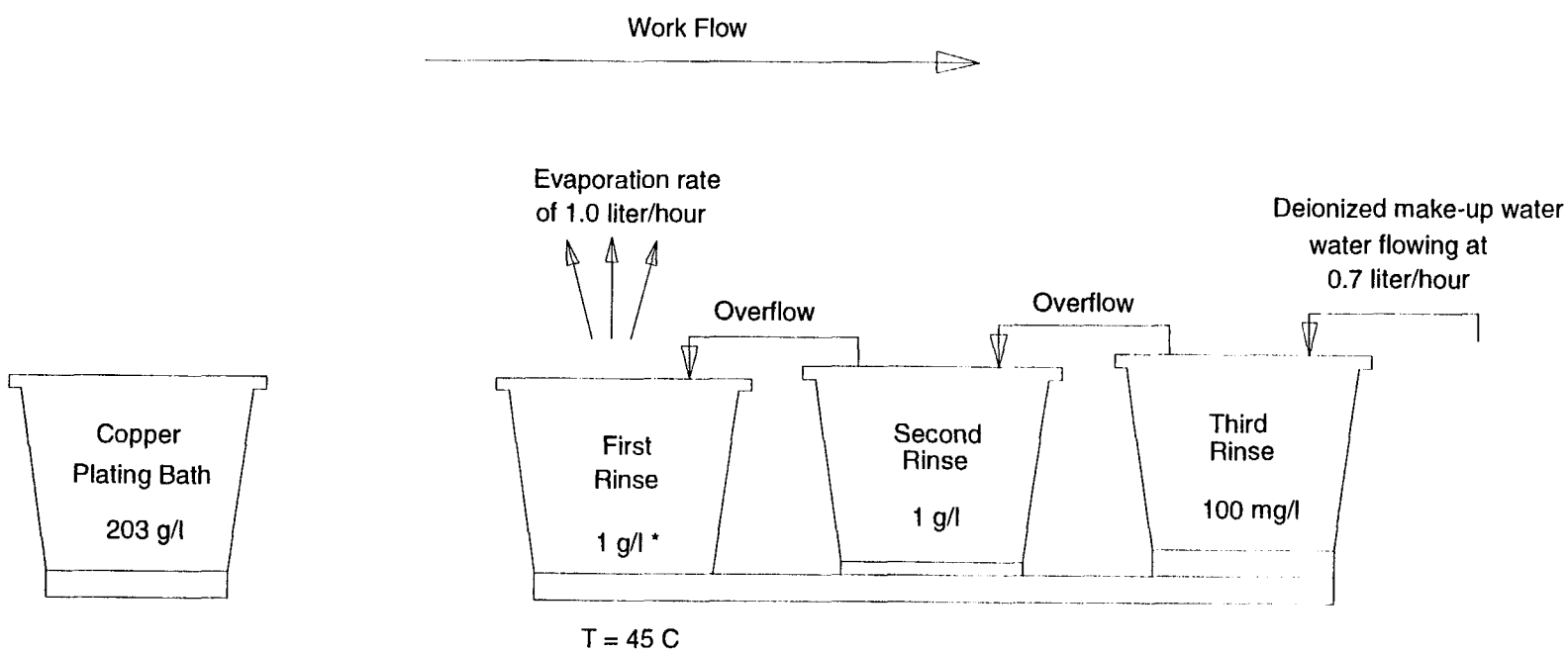
Total investment is estimated to be 41,100 Dh, broken down as follows:

- 26,400 Dh, which is 50 percent of the total purchase price of the electrowinning cell.
- 8,800 Dh, which is 20 percent of the total purchase price of the ion exchanger.
- 4,400 Dh for the immersion heater.
- 1,500 Dh to raise and reinforce the tanks.

A6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SADF Project No 1: Counterflowing rinse after copper plating



Note: The above-mentioned values were generated using a mathematic model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

27

B. Project N°2. Minimization of Toxic Nickel Discharges

Environmental impact (% of decrease)	Investment (Dh)	Operating costs (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water 94 Nickel 97.7	41,100	7,926	1,100	-6,826

B1. Recommendations

- Install a deionized water production unit for makeup water for the rinse tanks and the nickel bath.
- Install a counterflowing rinse system comprised of three rinse tanks.
- Install an immersion heater in the first rinse tank to evaporate the excess water from the counterflow.
- Install a metal reinforcing structure to maintain the integrity of the first PVC rinse tank that will be heated to a temperature of 55°C.
- Install an electrowinning cell to recover the nickel ions in nontoxic metallic form.
- Modify the rinse circuit for the workpieces after nickel plating by rearranging the tanks.

B2. Description

The nickel plating process is set up in a manner similar to copper plating. The rinse tanks are also static. The first rinse tank after nickel plating is also used for the third rinse for the previous stage of copper plating. Well water provides the makeup water for the bath and the rinse tanks; this in turn generates a degree of contamination that cannot be controlled.

The nickel bath appears to be kept at an acceptable level of contamination by "drag-out" since the nickel solution is removed with the workpieces as they are taken out of the bath. Since SADF was founded, it has never been necessary to replace the nickel bath. Both nickel baths, heated to 60°C, are equipped with anti-evaporation balls.

The current arrangement for the rinsing operations is not optimal for recovering metal ions using an electrowinning cell. In addition and in an attempt to recover and use the metals, we recommend complete separation of the rinse circuits after copper plating and nickel plating.

B3. Projected Savings

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 73 m^3 or 94 percent.
- On an annual basis, 21.5 kg of nickel will be recovered out of the 22 kg generated by the rinse line, or 97.7 percent.

The combined savings for this nickel plating operation amount to 1,100 Dh per year, broken down as follows:

- 730 Dh for water based on 10 Dh per m^3
- 370 Dh for recovered copper based on 17 Dh per kg of nickel

B4. Operating Expenses

The proportion of the total operating expenses originated by the installed equipment for this line may be estimated at 7,926 Dh per year on the following basis:

- 5,878 Dh per year to improve evaporation in the first rinse tank, or 25 percent of the total cost of the electricity for the three immersion heaters

- 1,410 Dh per year for an electrowinning cell (21.5 kg of nickel at 65.59 Dh/kg)

- 638 Dh per year for the deionized water supply, or 20 percent of the total operating expenses for the ion exchanger

B5. Investment

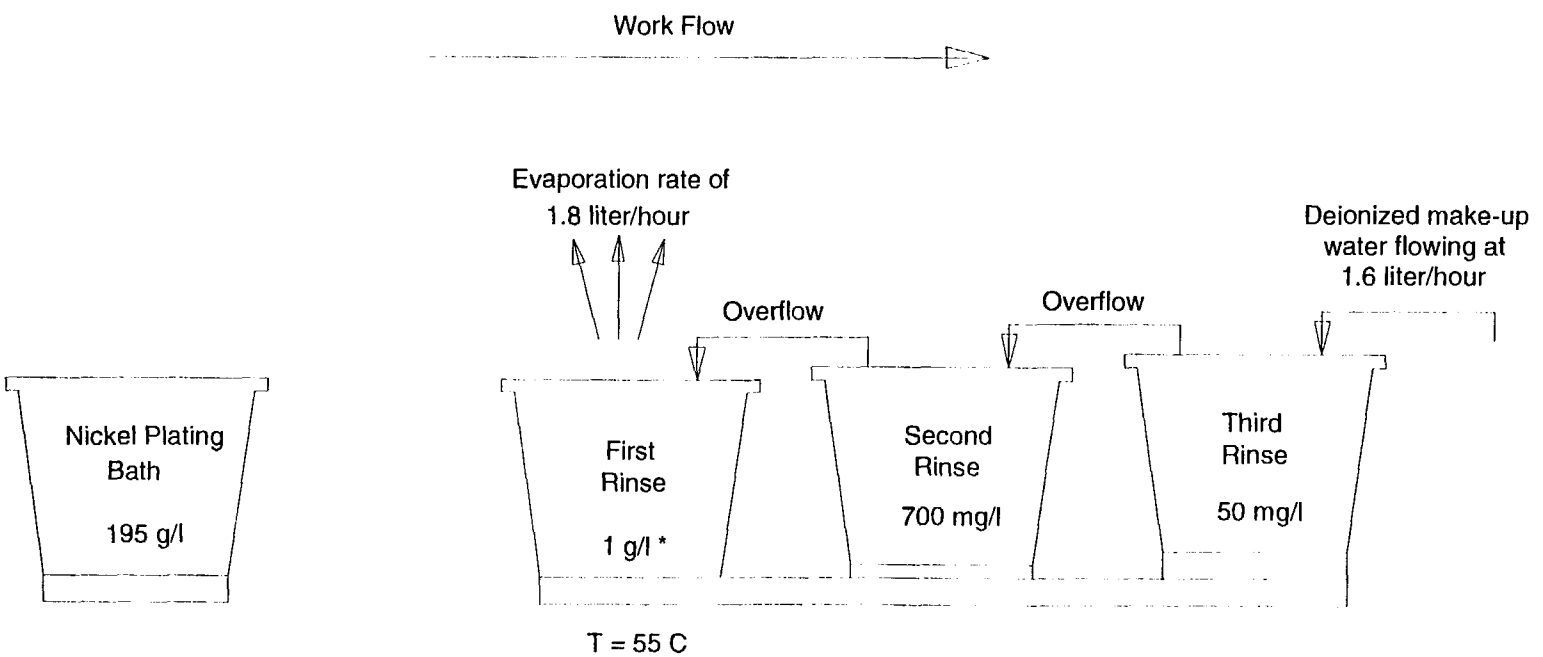
Total investment, estimated at 41,100 Dh, is broken down as follows:

- 26,400 Dh, or 50 percent of the total purchase price of the electrowinning cell.
- 8,800 Dh, or 20 percent of the total purchase price of the ion exchanger.
- 4,400 Dh for the immersion heater.
- 1,500 Dh to raise and reinforce the tanks.

B6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SADF Project No 2: Counterflowing rinse after nickel plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

C. Project N°3. Minimization of Toxic Silver Cyanide Discharges

Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected Cash flow (Dh/year)
Water 85 Silver 98.7 Cyanide 98.5	36,200	1,868	21,180	19,312

C1. Recommendations

- Install a deionized water production unit for makeup water for the rinse tanks and the silver plating bath.
- Install a counterflowing rinse system comprised of three rinse tanks.
- Install an electrowinning cell to recover the silver ions in nontoxic metal form.
- Modify the parts rinse system after silver plating by rearranging the tanks to use the heated round tank for the first rinse.

C2. Description

The silver plating process is set up in a manner similar to copper plating and nickel plating. The rinse tanks are also static. The first rinse tank after silver plating is also used for the fourth rinse for the previous stage of nickel plating. The final rinse tank after silver plating is heated to 80°C and used for the second rinse after gold plating. Well water provides the makeup water for the bath and the rinse tanks; this in turn generates a degree of contamination that cannot be controlled.

The silver bath is also kept at an acceptable level of contamination by "drag-out", as described above. It has never been necessary to replace it, since SADF was founded. The current rinse arrangement is not optimal for recovering metal ions using an electrowinning cell. Moreover, we recommend complete separation of the rinse circuits after silver plating, after nickel plating, and after gold plating.

C3. Projected Savings

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 33 m^3 or 85 percent.
- 18.75 kg out of the 19 kg of silver or 98.7 percent generated by this line will be recovered.
- 64 kg out of the 65 kg of cyanide or 98.5 percent generated by this line will be recovered.

All the savings combined for the copper plating operation amount to 21,180 Dh per year and are broken down as follows:

- 330 Dh of water based on 10 Dh/m^3.
- 18,750 Dh of silver recovered based on 1,000 Dh/kg of silver.
- 2,100 Dh savings in bleach treatment.

C4. Operating Expenses

The proportion of the total operating expenses originated by the installed equipment for this line may be estimated at 1,868 Dh per year on the following basis:

- There is no cost associated with the requirement to increase evaporation in the first rinse tank because we have recommended using the existing 80°C rinse tank.

- 1,213 Dh per year for the electrowinning cell (18.75 kg of silver at 65.59 Dh/kg)

- 638 Dh per year for the deionized water supply, or 20 percent of the total cost of operating the ion exchanger

C5. Investment

The total investment is estimated at 36,200 Dh, broken down as follows:

- 26,400 Dh for purchasing an electrowinning cell.

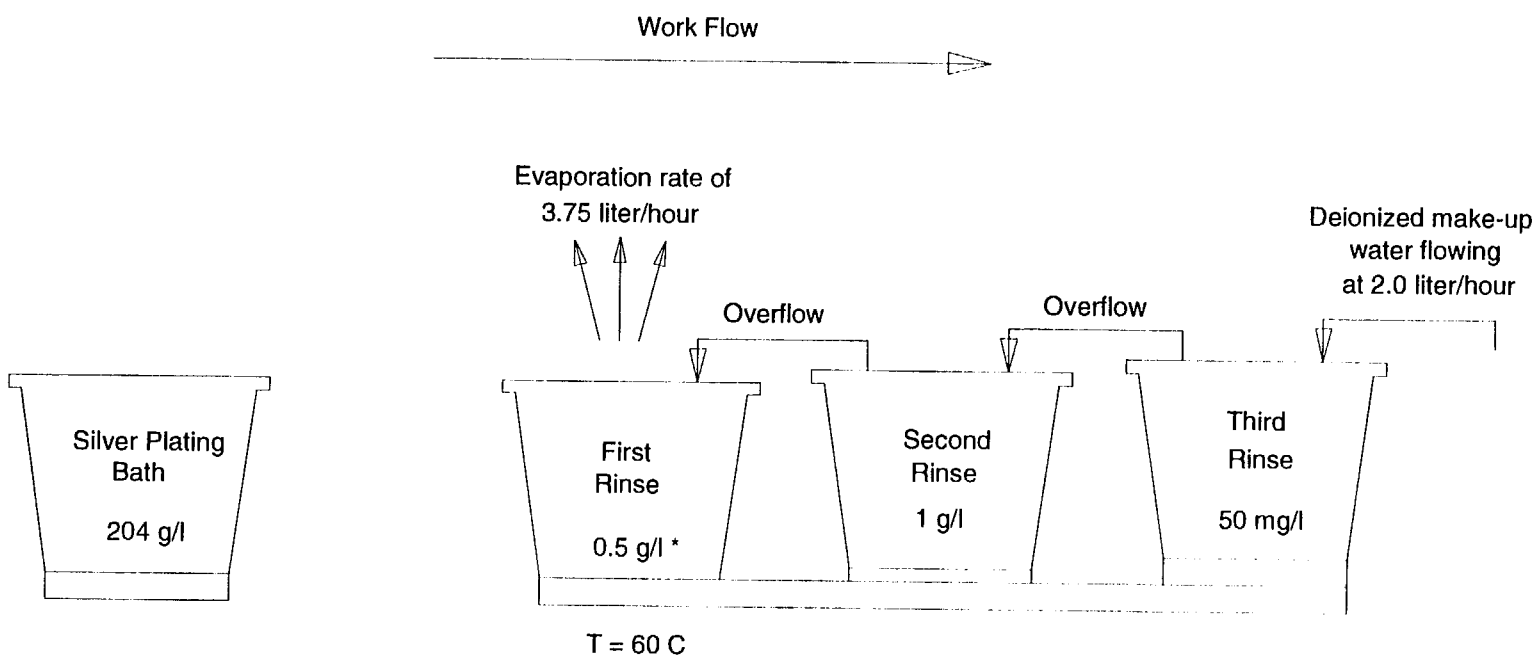
- 8,800 Dh which amounts to 20 percent of the total cost of purchasing the ion exchanger.

- 1,000 Dh to raise the rinse tanks so that the water can flow out by gravity in the direction opposite to the workpiece rinse.

C6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SADF Project No 3: Counterflowing rinse after silver plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

D. Project N°4. Minimization of Toxic Gold Cyanide Discharges

Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water 17 Gold 100 Cyanide 100	9,300	638	2,050	1,412

D1. Recommendations

- Install a deionized water production unit for makeup water for the gold bath.
- Eliminate all the rinse tanks.
- Rinse the workpieces above the water bath.

D2. Description

The gold plating process is only used occasionally. After the gold cyanide bath, the workpieces are rinsed in a static rinse tank at room temperature. This tank is only used for gold plating. There is a second rinse in the round tank heated to 80°C. This tank is part of the silver plating cycle. Makeup water for the main bath and the rinse tank is also provided using well water, which introduces a degree of contamination that cannot be controlled; therefore, the use of deionized water at this stage is recommended.

The gold cyanide bath is also kept at an acceptable level of contamination by the "draining" described earlier. It has not been necessary to replace the bath since SADF was founded. The bath is equipped with anti-evaporation balls.

With a view toward possible recovery, the team concluded that the manner in which SADF conducts is rinse operations has one major disadvantage—the same rinse is used for both silver and gold. We could simply recommend separating the rinses after silver plating and after gold plating; however, to take advantage of the fact that the gold plating bath is constantly kept at 100°C, and since makeup water is required in all cases, we recommend eliminating the rinse after gold plating in a static tank and replacing it with a rinse over the bath itself with a spray gun.

D3. Projected Savings

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will fall by 5 m^3 or 17 percent.
- A total of 20 g of gold discharged by this line will be recovered.
- A total of 500 g of the cyanide discharged by this line will be destroyed.

The expected savings for this operation amount to 2,050 Dh per year and are broken down as follows:

- 50 Dh of water based on 10 Dh/m^3
- 2,000 Dh of gold based on 100 Dh/gram of gold.

D4. Operating Expenses

The proportion of the total cost of operating expenses originated by the installed equipment for this line may be estimated at 638 Dh per year on the following basis:

- There is no cost to improve evaporation because the gold bath is already heated to 100° C.
- There is no cost for the electrowinning cell because the rinsing takes place directly above the bath, so there are no individual rinse tanks
- 638 Dh per year for the deionized water supply, or 20 percent of the total cost of operating the ion exchanger.

D5. Investment

The total investment is estimated at 9,300 Dh, broken down as follows:

- 8,800 Dh, or 20 percent of the total investment amount for an ion exchanger.
- 500 Dh for purchasing a spray gun.

D6. Data and Calculations

See the tables in Annexes A, B, C, and D.

E. Project N°5. Minimization of Organic Concentrations of Wastewater Discharged from the Degreasing Process

Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water 84	13,700	12,394	570	-11.824

E1. Recommendations

- Install a deionized water production unit for the makeup water for the rinse tanks, for preparing the degreasing tank, and for makeup water for the same tank.
- Install a counterflowing rinse system comprised of three rinse tanks that includes the degreasing tank (see diagram).
- Install an immersion heater to raise the temperature of the degreasing bath to evaporate the makeup water required for the counterflowing rinses.

E2. Description

The degreasing process is set up in a manner similar to the stages for copper plating, nickel plating, and silver plating. All three rinse tanks are also static but are not used for the other stages of treatment. Well water is also used for makeup water for the degreasing bath and the rinse baths; this in turn generates a degree of contamination that cannot be controlled.

As opposed to the other surface treatment baths, the degreasing bath is not kept at an acceptable level of contamination by its nature. It is, therefore, replaced periodically after every 477 hours of operation. The degreasing agent used is cyanide-free.

In this project, we recommend a counterflow rinse that includes even the degreasing bath. The latter should be kept at a temperature of 45°C to remove the rinse water by evaporation that it takes in (see diagram).

E3. Projected Savings

The above mentioned equipment will help save 57 m^3 of water per year, or 84 percent. The projected savings for the degreasing operations amount to 570 Dh for water based on 10 Dh/m^3. The use of deionized water, combined with drag-out, may substantially increase the service life of the degreasing bath. If this holds true, a 10 percent increase in the service life of the bath would generate savings of 1,650 Dh per year. For the purposes of this study, this assumption will not be evaluated at this point, since this would have to be tested over an extended period of time to be accurately quantified..

E4. Operating Expenses

The proportion of the total operating expenses for the installed equipment for this line may be estimated at 12,394 Dh per year on the following basis:

- 11,756 Dh per year to increase evaporation in the degreasing bath, which is the same as 50 percent of the total cost of the electricity for the three immersion heaters

- No cost for the electrowinning cell, since no suspended metal is generated in the rinse water

- 638 Dh per year for the deionized water supply, or 20 percent of the total operating expenses of the ion exchanger

E5. Investment

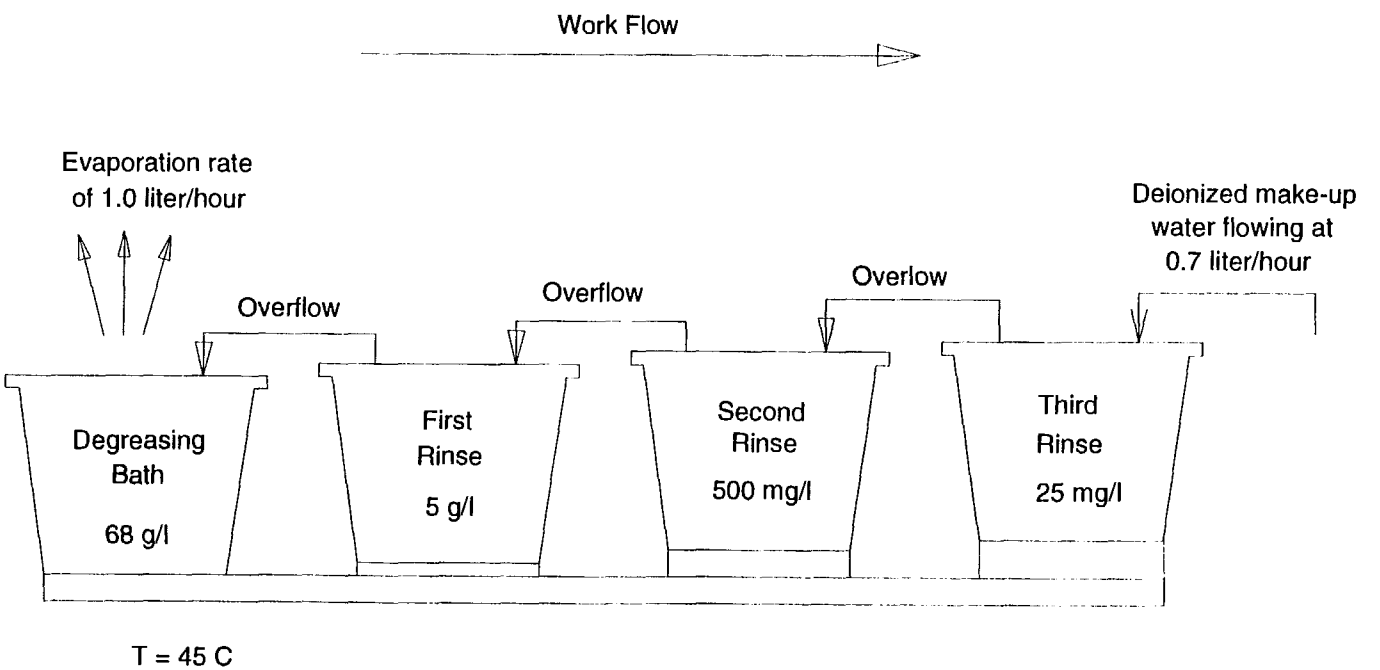
The total investment is estimated at 13,700 Dh, broken down as follows:

- 8,800 Dh, amounting to 20 percent of the total purchase price of an ion exchanger.
- 4,400 Dh for purchasing an immersion heater.
- 500 Dh in costs for rearranging the rinse tanks.

E6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SADF Project No 5: Counterflowing rinse after degreasing



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.

SECTION III

RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

SECTION III
RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

A. Specific Recommendations

- For safety, ensure that safety glasses are worn and that an eyewash station is available to those workers on the plating lines.

- After cleaning the plastic containers in which the different toxic salts are kept, dispose of the containers, by sending them back to the vendor of the chemistry for recycling.

- Minimize compressed air leaks by inspecting the circuit on a daily basis and replacing the defective parts as necessary.

- Clean by scraping the different media and hooks used in the process frequently to reduce the amount of impurities that enter the different baths to lengthen the service life of the baths as much as possible.

- Coat the immersion hooks with plating-resist to prevent product loss through unwanted plating. Such products as plastisols can be used.

- In the different baths, such as nickel and silver, only use truly demineralized, de-ionized or distilled water. Bottled water sold as demineralized water, such as water for batteries, is often if not always heavily laden with mineral salts which are a source of introducing impurities into the tanks.

- Reuse several times the sawdust used to dry the workpieces after natural drying on terraces or vacant land near the facility if available. It appears that the contamination level is low enough to tolerate repeated uses.

- Check and inspect the different parameters, such as exposure time, chemical concentrations in the baths, temperature and current strength. For this purpose, testing equipment should be available, such as thermometers, ammeters and timers with audible alarms. A small space should also be set aside to conduct chemical analyses of the baths.

- Adjust current strength to the type of workpiece to be treated to optimize productivity. The thickness of the deposit on the metal depends on current strength and exposure time. Performing the surface treatment based solely on the time parameter, as is done in the metal finishing facility we audited, may result in excessively high or low production quality. This remark is especially applicable as the surface to be treated is changed.

  For example, when working with current strength of 5 amps/dm^2, the thickness of the nickel deposit increases by 0.001 mm per minute. That means that after 10 minutes, the nickel deposit thickness will be 0.01 mm. Yet, the same deposit quality may be achieved in six minutes with current strength of 8 amps/dm^2.

- Replace the current mold baking system at the foundry with a more efficient system in which propane gas replaces wood as a fuel. Wood has a lower LHV than gas (3,000 versus 11,000 kcal/kg), and its burning efficiency is 40 percent lower. The proposed system would have a hot air generator that uses propane to produce high-temperature fumes that would circulate in a closed space where the terzaks are located.

B. General Recommendations

- Conduct employee awareness training on pollution prevention.
- Develop a pollution prevention strategy in the form of a procedures manual including precise written guidelines defining:
  - An inventory method for all chemicals in use.
  - The restricted handling of chemicals by a limited number of qualified employees.
  - A program of periodical analyses of the baths.
  - Record-keeping method for bath analyses and makeup water.
  - A written procedure for makeup sequences.
  - Methods to optimize the service life of the treatment baths.
  - The frequency of regular inspections of the baths to remove workpieces that accidentally fell into the bath.
  - Preventive maintenance schedule for the tanks.
  - The alarm system used to protect against tank overflow.
  - The installed leak detection systems.
  - Workpiece inspection methods prior to plating.

ANNEX A

TABLES ILLUSTRATING THE STAGES OF THE PROCESS

ANNEX A
TABLES ILLUSTRATING THE STAGES OF THE PROCESS

Stage 1: Degreasing	Data	Units
Replace bath completely every	477	Hours
Tank Dimensions:		
Width	1	m
Length	2	m
Depth	0.8	m
Total solution volume	1600	Liters
Caustic soda	0	Kg
Sodium cyanide	0	Kg
Mineral alkali	0	Kg
KW	108	Kg
Water	1492	Liters
Concentration		Baumé
Degreasing time	5	Minutes

Stage 2: Rinse	Data	Units
Number of rinse tanks for degreasing	3	Tanks
Tank No. 1		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 2		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 3		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters

Stage 3: Copper Plating	Data	Units	Makeup	Units
Number of copper plating tanks	1	Tank		
Tank Dimensions:				
Width	0.9	m		
Length	1.3	m		
Depth	0.8	m		
Total solution volume	530	Liters		
Sodium cyanide	40	Kg	8	Kg/month
Copper cyanide	25	Kg	5	Kg/month
Brightener	5	Liters	1	Kg/week
Caustic soda	35	Liters	7	Kg/month
Copper anodes	8	Anodes		
Wetting agent	2.5	Liters	0.5	L/week
Water	422.5	Liters		
Copper plating time	2	Minutes		
Electric heating	45	°C		
Concentration	14	Baumé		

Stage 4: Rinse	Data	Units
Number of rinse tanks	3	Tanks
Tank No. 1		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total rinse water volume	480	Liters
Tank No. 2		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total rinse water volume	480	Liters
Tank No. 3		
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total rinse water volume	480	Liters

Stage 5: Nickelplating	Data	Units	Makeup	Units
Number of tanks for nickelplating	2	Tanks		
Tank No. 1				
Tank Dimensions:				
Width	2	m		
Length	0.8	m		
Depth	0.9	m		
Total solution volume	1440	Liters		
Nickel sulfate	218.75	Kg	43.75	Kg/month
Nickel chloride	46.25	Kg	9.25	Kg/month
Boric acid	33.5	Kg	6.7	Kg/month
Brightener	5	Liters	1	L/week
Leveler	5	Liters	1	L/week
Wetting agent	5	Liters	1	L/week
Nickel anodes	10	Anodes	5	Kg/year
Water	1126.5	Liters		
Nickelplating time	10	mn		
Electric heating	60	°C		
Concentration	25	Baumé		
Tank No. 2				
Tank Dimensions:				
Width	1	m		
Length	0.7	m		
Depth	0.9	m		
Total solution volume	630	Liters		
Nickel sulfate	70	Kg	14	Kg/month
Nickel chloride	30	Kg	6	Kg/month
Boric acid	15	Kg	3	Kg/month
Brightener	2.5	Liters	0.5	L/week
Leveler	2.5	Liters	0.5	L/week
Wetting agent	2.5	Liters	0.5	L/week
Nickel anodes	6	Anodes	10	Kg/90 days
Water	507.5	Liters		
Nickelplating time	10	mn		
Electric heating	60	°C		
Concentration	25	Baumé		

45

Stage 6: Rinsing	Data	Units
Number of tanks for nickelplating	4	Tanks
Tank No. 1		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 2		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 3		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 4		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters

Stage 7: Silverstrike	Data	Units	Makeup	Units
Number of tanks for silverstrike	1	Tank		
Tank dimensions:				
Width	0.9	m		
Length	1.2	m		
Depth	0.73	m		
Total solution volume	788	Liters		
Silver cyanide	15	Kg	2	Kg/month
Potassium cyanide	140	Kg	24	Kg/month
Brightener	0	Liters	0	L/month
Water	633	Liters		
Strike time	0.166666667	mn		
Concentration	14	Baumé		

Stage 8: Silverplating	Data	Units	Makeup	Units
Number of tanks for silverplating	1	Tank		
Tank dimensions:				
Width	0.9	m		
Length	1.2	m		
Depth	0.73	m		
Total solution volume	788	Liters		
Silver cyanide	20	Kg	2	Kg/month
Potassium cyanide	140	Kg	12	Kg/month
Brightener	0.25	Kg	0.05	Kg/3 day
Silver anodes	8	Anodes	5	Kg/year
Water	628	Liters		
Strike time	2	mn		
Concentration	21	Baumé		

46

Stage 9: Silver Rinse	Data	Units
Number of tanks for silver rinse	3	Tanks
Tank No. 1		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 2		
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume	480	Liters
Tank No. 3		
Tank dimensions:		
Width	1.06	m
Length	0.8	m
Depth	80	C
Total solution volume	706	Liters

Stage 10: Goldplating	Data	Units	Makeup	Units
Number of tanks for goldplating	1	Tank		
Tank dimensions:				
Width	0.6	m		
Length	1	m		
Depth	0.8	m		
Total solution volume	480	Liters		
Gold cyanide	0.5	Kg	0.1	Kg/month
Potassium cyanide	20	Kg	4	Kg/month
Brightener	0.3	Kg	0.06	Kg/week
Anodes (platinum)	4	Anodes		
Water	459.7	Liters		
Electric heating	100	C		
Plating time	0.4166667	mn		
Concentration	19	Baumé		

Stage 11: Rinse	Data	Units
Number of tanks for rinse	1	Tank
Tank dimensions:		
Width	0.8	m
Length	1	m
Depth	0.6	m
Total solution volume		Liters

Stage 12: Drying - Polishing	Data	Units
- Mechanical drying		
Wood waste	50	Kg/Month
Polishing powder		Kg/Day
- Pneumatic drying		
Compressed airjet	ND	ND

ANNEX B

TABLE ILLUSTRATING FEATURES OF THE BATHS

ANNEX B
TABLE ILLUSTRATING CHARACTERISTICS OF THE BATHS

SADF, Fes, Morocco

Annex B: Bath Features

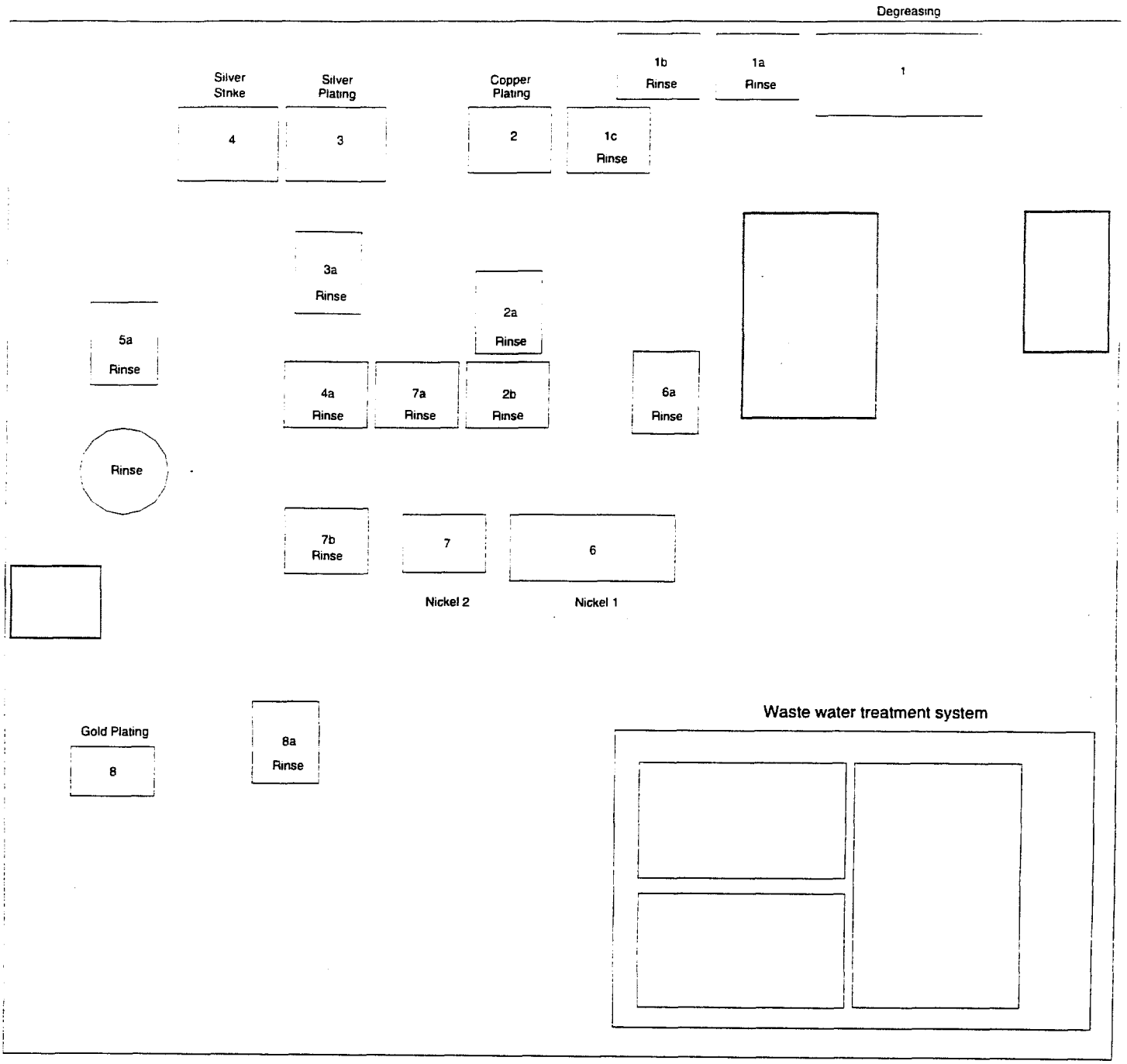
Basin Reference	Basin Description	Features Degrees	TDS in mg/l	pH	Position in cycle	Length of cycle	TDS end of cycle mg/l	Metal as % of cycle	Masses/cycle cations in grams	CN in grams	Annual Weight Kg (metal)	Annual Weight Kg (CN)	Annual Volume Liters	Concentration in cyanide effluent
1	Degreasing	A	68165	12										
1a	Rinse 1		800	8.5	0.14	7	945						19611	
1b	Rinse 2		700	8.7	1.00	7	35						19611	
1c	Rinse 3		770	8.4	1.00	7	105						19611	
	Total						362						58834	
2	Copperplating	45	203495	10.8				16.46%	Cu	CN				
2a	Rinse 1		7160	11.1	0.86	7	7578		598.60	959	24.46	39.20	19611	48.92
2b	Rinse 2		1760	9.4	0.86	7	1278		100.92	162	4.12	6.61	19611	8.25
6a	Rinse 3		1400	7.4	0.43	7	1715		135.48	217	5.54	8.87	19611	11.07
	Total						3523				34.12	54.68	58834	22.75
6	Nickelplating 1	60	218373	4.2				19.15%	Ni					
6a	Rinse 1		1400	7.4	0.43	7	1715		157.61		6.44			
4a	Rinse 2		760	7.1	0.43	7	222		20.37		0.83		19611	
7b	Rinse 3		670	7.1	0.29	7	18		1.61		0.07		19611	
3a	Rinse 4		1000	7.4	0.43	7	782		71.83		2.93		19611	
7	Nickelplating 2	60	195109	4.2				18.73%						
7a	Rinse 1		1910	7.1	0.43	7	2905		261.14		10.67		19611	
4a	Rinse 2		760	7.1	0.43	7	222		19.93		0.81			
7b	Rinse 3		670	7.1	0.29	7	18		1.57		0.06			
3a	Rinse 4		1000	7.4	0.43	7	782				0.00			
	Total						833				21.76		78446	
3	Silverstrike	A	197266	11.3										
4	Silverplating	A	203925	11.6				10.01%	Ag	CN				
3a	Rinse 1		1000	7.4	0.43	7	782		37.57	131	1.54	5.35		
5a	Rinse 2		4220	10	0.43	7	8295		398.72	1389	16.29	56.73	19611	70.80
ND	Round Rinse	80	1050	8	0.86	7	449		21.59	75	0.88	3.07	19611	3.83
	Total						3175				18.71	65.15	39223	
8	Goldplating	80	43333	4.2				2.12%	Au	CN				
8a	Rinse 1		740	6.8	0.67	15	113		1.15	21	0.02	0.40	9152	2.29
	Total						113				0.02	0.40	9152	
	Total											120	244489	492

ANNEX C

DIAGRAM OF METAL FINISHING DEPARTMENT LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS

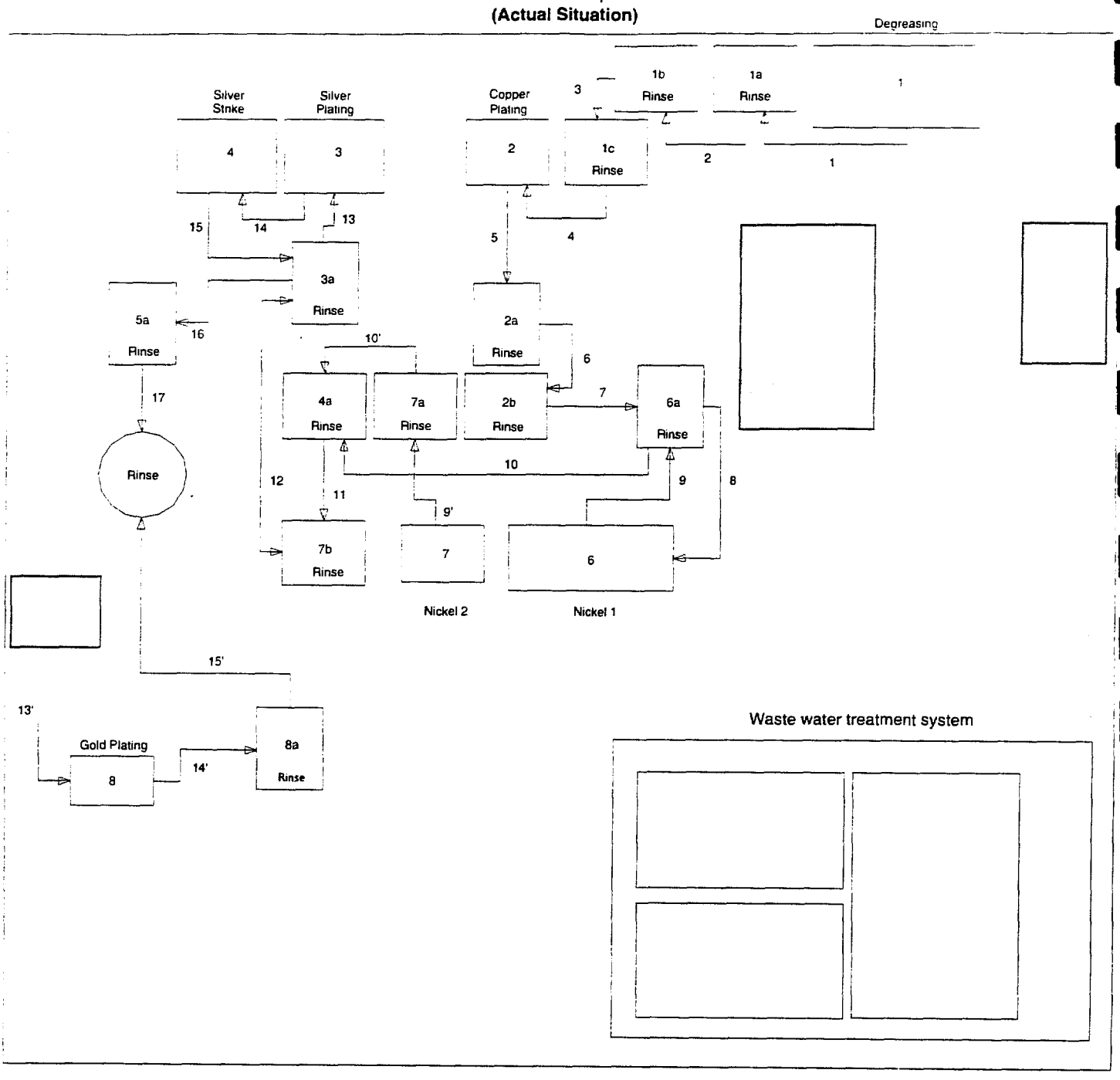
ANNEX C
DIAGRAM OF METAL FINISHING DEPARTMENT LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS

Layout of the metal finishing department at the SADF Corporation



51

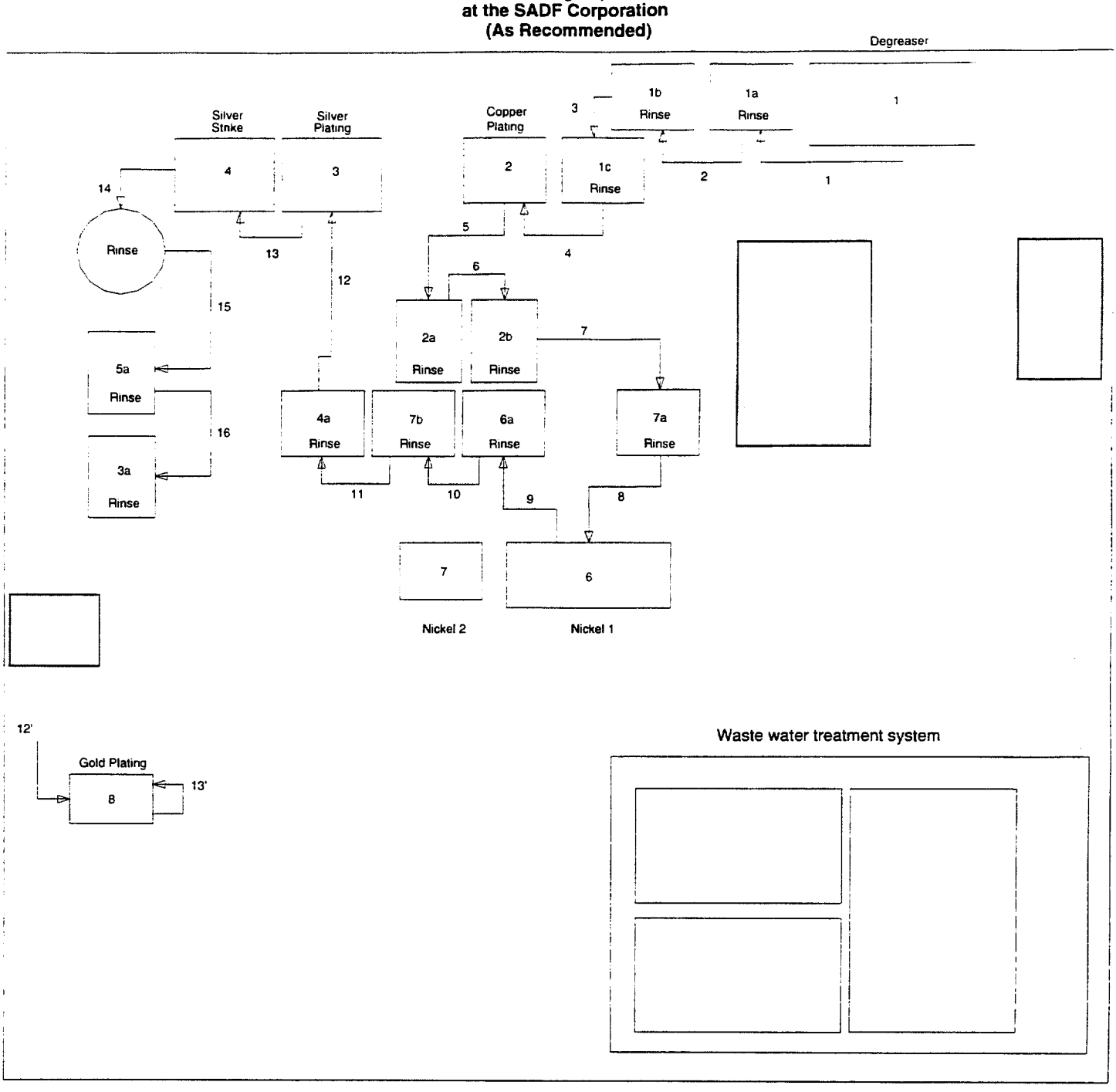
Workflow of the metal finishing department at the SADF Corporation (Actual Situation)



BEST AVAILABLE COPY

52

Workflow of the metal finishing department at the SADF Corporation (As Recommended)



BEST AVAILABLE COPY

53

ANNEX D

OPERATING EXPENSES

ANNEX D
OPERATING EXPENSES

Projected total operating expenses for the electrowinning cell for the five projects:

75.02 kg of heavy metals, 73.725 kg of which will be recovered (98.3 percent) at a total cost of 65.59 Dh/kg[1] for a total of approximately 4,700 Dh per year

Projected total cost of electricity required to operate the immersion heaters:

1.5 Kwh for the copperplating line
1.5 Kwh for the nickelplating line
3.0 Kwh for the degreasing bath

In total, 6 Kwh x 10 hours per day x 286 days per year x 1.37 Dh/Kwh=23,510 Dh per year

Projected total cost of operating the ion exchanger for the five projects:

Rinsewater needed to supply the counterflows:

5 liters per hour x 10 hours per day x 286 days per year=14,300 liters per year

In total, the surface processing department requires 55m^3 per year of water for rinsing and makeup water, including losses through evaporation, at a cost of 58 m^3 [2], for a total of about 3,190 Dh per year.

[1] NCMS and NAMF, "3.5.5.2. Operating Cost of Electrowinning Technology," p. 132 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

[2] NCMS and NAMF, "3.4.5.2. Operating Cost of Ion Exchange Technology," p. 110 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

ANNEX E

BIBLIOGRAPHY

ANNEX E
BIBLIOGRAPHY

ADER, *Etude de faisabilité pour une station de récupération de chrome, d'élimination des métaux lourds et des cyanures et de prétraitement à Ain Nokbi*, ADER, Fès, Morocco, March 1996.

Anderson, Donald F. *Development Document for Effluent Limitations Guidelines and Standards for the Leather Tanning and Finishing Industry*, U.S. Environmental Protection Agency, Effluent Guidelines Division, WH-552, Washington, D.C. November 1982.

GEM Project, *Audit environnemental de la dinanderie argenterie de Fès*, GEM Project, Rabat, Morocco, February 1995.

GEM Project, *Audit environnemental de la tannerie Wad Eddahab*, GEM Project, Rabat, Morocco, February 1995.

Guidebook and directory issue, *Journal of Metal Finishing*, Tarrytown, New York, 1996.

National Center for Manufacturing Sciences and National Association of Metal Finishers, *Pollution Prevention and Control Technology for Plating Operations*, NCMS AND NAMF, Washington, D.C., 1994.

RADDEF, *Plan directeur d'assainissement liquide du grand Fès*, RADDEF, Fès, Morocco, March 1996.

Rinsecalc, special software for optimizing rinse configurations, developed for CAI Engineering, May 1995.

ANNEX F

INVENTORY LISTING

ANNEX F
INVENTORY LISTING

The following inventory listing of chemical products used by SADF is presented in the original French:

Inventory Listing

Article No.	Name (French)	Unit	Quantity	Unit Price	Total
0000000009	CYANURE D'OR +	GRS	1000.000	162.00	162000.00
0000000010	SOUDE CAUSTIQUE	KGS	250.000	7.38	1845.00
0000000011	CYANURE DE SODIUM +	KGS	200.000	39.00	7800.00
0000000012	CARBONATE DE SOUDE	KGS	50.000	6.00	300.00
0000000013	PHOSPHATE TRISODIQUE	KGS	50.000	7.50	375.00
0000000014	SULFATE DE NICKEL	KGS	700.000	33.55	23485.00
0000000015	CHLORURE DE NICKEL	KGS	200.000	35.00	7000.00
0000000016	ACIDE BORIQUE	KGS	100.000	23.00	2300.00
0000000017	CYANURE DE POTASSIUM +	KGS	350.000	51.36	17975.00
0000000018	BRILLANTEUR DE NICKEL	KGS	50.000	75.00	3750.00
0000000019	BASE DE NICKEL	KGS	50.000	66.00	3300.00
0000000020	CYANURE DE CUIVRE +	KGS	50.000	130.00	6500.00
0000000021	ANODE DE NICKEL	KGS	855.900	105.00	90664.88
0000000022	ANODE DE CUIVRE	KGS	28.400	75.00	2130.00
0000000029	AURA MAKE UP	GR	300.000	125.00	37500.00
0000000030	EKASIT - KW	KGS	700.000	23.50	16450.00
0000000033	CUPROBRASE DIAMÈTRE 2	KGS	10.000	204.68	2046.80
0000000034	CYANURE D' ARGENT +	KGS	35.000	2871.43	100500.00
0000000037	LINGOT D'ETAIN	KGS	300.000	90.00	27000.00
0000000038	BRILLANTEUR DE CUIVRE	KGS	25.000	475.00	11875.00
0000000039	MOUILLANT DE CUIVRE	KGS	25.000	250.00	6250.00
0000000042	MOUILLANT DE NICKEL	KGS	25.000	66.00	1650.00
0000000047	PH 1-11		10.000	70.00	700.00
0000000051	AUROCYANURE +	GR	900.000	41.67	37500.00
0000000055	EAU DE JAVEL	KGS	1691.000	2.50	4227.50
0000000056	AGENT ORIMA B	KGS	50.000	300.00	15000.00
0000000057	BRILLANTEUR ORIMA B	KGS	1.000	42840.00	42840.00
0000000058	ACIDE SULFURIQUE	KGS	54.000	3.90	210.60
0000000059	BRILLANTEUR NI - 567	LIT	50.000	65.00	3250.00
0000000060	NIVELANT NI - 567	LIT	50.000	50.00	2500.00
0000000061	ANTIVOILE	LIT	50.000	70.00	3500.00
0000000062	MOUILLANT D	LIT	50.000	40.00	2000.00
0000000063	CHELUX	LIT	25.000	55.00	1375.00
0000000064	MOUILLANT A	LIT	25.000	45.00	1125.00
0000000065	BRILLANTEUR V - 205	LIT	25.000	50.00	1250.00

Inventory Listing

Article No.	Name (French)	Unit	Quantity	Unit Price	Total
0040000001	BANDE LAITON	KGS	30345.200	43.67	1325229.50
0040000002	4 BARRES CORNIÈRES	KGS	8.000	59.50	476.00
0040000003	LAITON	KGS	10.400	76.50	795.60
0040000004	2 TUBES LAITON LISSE EC	KGS	38.160	60.54	2310.30
0040000005	15 BARRES CORNIÈRES	KGS	194.000	87.68	17009.59
0040000006	LAITON	KGS	2341.500	43.82	102600.00
0040000007	40 TUBES LAITONS RAINE	KGS	201.400	35.70	7189.98
0040000008	FIL EN LAITON	KGS	49.900	35.70	1781.43
0040000009	70 BARRE LAITON ROND DI	KGS	50.000	35.70	1785.00
0040000010	23 BARRE 6 PANS DIAMÈTRE	KGS	8.000	35.70	285.60
0040000011	16 BARRES 6 PANS DIAMET	KGS	52.500	35.70	1874.25
0040000012	1 BARRE LAITON ROND DIA	KGS	86.700	35.70	3095.19
0040000013	6 BARRE LAITON ROND DIA	KGS	60.900	62.49	3805.45
0040000020	40 BARRE LAITON SIX PAN	KGS	257.000	60.00	15420.00
0040000024	10 BARRE LAITON MÉPLAT	KGS	40.500	83.30	3373.65
0040000025	FIL MAILLECHORT	KGS	29.000	76.50	2218.50
0040000026	10 TUBE LAITON RAINE 38	KGS	50.000	90.10	4505.00
0040000027	10 TUBE LAITON RAINE 28	KGS	126.500	35.70	4516.05
0040000028	TUBE LAITON TORSADE 16*	KGS	420.000	50.00	21000.00
0040000029	25 BARRE ROND PLEIN LAI	KGS	301.000	35.70	10745.70
0040000030	RANCHE LAITON	KGS	69.500	95.00	6602.50
0040000035	90 BARRE LAITON ROND DI	KGS	43.000	68.00	2924.00
0040000036	5 BARRE LAITON MAIN COU	KGS	165.700	35.70	5915.49
0040000040	21 BARRES MÉPLAT LAITON	KGS	50.000	75.00	3750.00
0040000043	9 BARRES LAITON ROND 18	KGS	198.900	35.70	7100.73
0040000044	MÉTAL D'APPORT LAITON N	KGS	91.600	35.70	3270.12
0040000045	100 BARRES LAITON ROND	KGS	221.900	35.70	7921.83
0040000048	8 BARRES LAITON ROND DI	KGS	26.300	90.10	2369.63
0040000049	24 BARRES LAITON ROND D	KGS	203.800	63.75	12992.25
0040000050	10 TUBE LAITON TORSADE	KGS	3.300	76.50	252.45
0040000052	100 BARRES MÉPLAT LAITON	KGS	21.600	84.80	1831.68
	1 TUBE LAITON LISSE 23*				
	10 TUBE LAITON TORSADE				

ANNEX G

EKASIT - KW

ANNEX G
EKASIT - KW

The following material is presented in the original French:

Dégraissant électrolytique universel pour acier, métaux non ferreux et également zamak en cathodique.

A. Avantages

Exempt de cyanure et de complexants:

- Biodégradable
- Grand pouvoir émulsionnant vis a vis des graisses et huiles

B. Mode opératoire

- Concentration: 40 à 60 g/l
- Température: 35 à 60 °C

Temps d'immersion	Métaux non ferreux	Acier
Dégraissage anodique	10 à 20 secondes	20 à 60 Secondes
Dégraissage cathodique	20 à 40 secondes	30 à 60 secondes
Densité de courant	1 à 4 A/dm2	4 à 8 A/dm2
Voltage	4 à 6 Volts	6 à 8 Volts

C. Équipement

Cuve et système de chauffage en acier doux.

D. Montage d'un bain

Remplir la cuve au 3/4 de l'eau chauffée à 40 - 50° C. Ajouter le dégraissant en agitant jusqu' à dissolution complète. Ajuster au volume final et chauffer à température de travail.

E. Analyse

- Filtrer un échantillon et refroidir à température ambiante.
- Pipetter 10 ml dans un Erlenmeyer et ajouter 2 à 3 gouttes de méthylorange.
- Titrer avec de l'acide sulfurique N ou de l'acide chlorhydrique N (SO_4H_2N ou HCIN); jusqu'à virage du jaune ou rouge.
- Calcul : ml SO_4H_2 ou HCIN X 6,1 = g/l EKASIT KW.

Environmental Audit: Société de Dinanderie, d'Argenterie, et de Quincaillerie (SODAQ)

By:

Abdelkarim Bennani
Serge Astaud
Saïd Bouanani

October 1996

63

ACKNOWLEDGMENTS

The Project in Development and the Environment (PRIDE) and the audit team wish to thank Abdelouahed El-Oudghiri, managing director of Société de Dinanderie d'Argenterie et de Quincaillerie (SODAQ), for his hospitality and assistance while the team was conducting the environmental audit at SODAQ in June 1996.

We also wish to extend our special gratitude to the Moroccan Ministry of the Environment and to the staff at the Laboratoire National D'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement, it would not have been possible to complete these reports without their assistance.

In addition, we wish to thank the SODAQ employees and associates for their willingness to help with the testing and the time they spent with the auditor-engineers collecting data and performing the tests.

The following people conducted the audit of the electroplating facility:

- Abdelkarim Bennani, team leader, Ph.D., chemical industries, consultant in energy and the environment
- Serge Astaud, international consultant and pollution prevention specialist for the surface treatment industry
- Saïd Bouanani, Ph.D. chemical engineering, consulting engineer in energy and the environment

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		i
SECTION I	BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY	I-1
	A. Introduction to SODAQ	I-1
	B. Brief Description of the Process	I-1
	C. Metal Finishing Facility Discharge	I-3
SECTION II	POLLUTION PREVENTION PROJECTS	II-1
	A. Project N°1. Minimization of Copper Cyanide-bearing Waste Stream	II-1
	B. Project N°2. Minimization of Nickel-bearing Waste Stream	II-4
	C. Project N°3. Minimization of Silver Cyanide-bearing Waste Stream	II-7
	D. Project N°4. Minimization of Gold Cyanide-bearing Waste Stream	II-10
	E. Project N°5. Minimization of Organic Content of Waste Water from the Degreasing Process	II-11
	F. Project N°6. Minimization of Wastewater Discharges from the Chrome Plating Process	II-14
SECTION III	RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM	III-1
	A. Specific Recommendations	III-1
	B. General Recommendations	III-2
ANNEX A	TABLES ILLUSTRATING THE STAGES OF THE PROCESS	A-1
ANNEX B	TABLE ILLUSTRATING FEATURES OF THE BATHS	B-1
ANNEX C	DIAGRAM OF LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS	C-1
ANNEX D	OPERATING EXPENSES	D-1
ANNEX E	BIBLIOGRAPHY	E-1

EXECUTIVE SUMMARY

This report presents the findings of the environmental audit of Société de Dinanderie, d'Argenterie et de Quincaillerie (SODAQ), located in the Sidi Brahim Industrial Park in Fès, Morocco. SODAQ was selected along with two other metal finishing/silverplating facilities to receive technical assistance under the USAID-funded Project in Development and the Environment (PRIDE). A team composed of Mr. Abdelkarim Bennani and Mr. Saïd Bouanani, domestic consultants, and Mr. Serge Astaud, an international consultant, conducted the audit. They worked in close cooperation with the company's employees.

The on-site work was carried out in two phases: a pre-audit phase on June 14, 1996, and the testing phase on June 14 and 15, 1996. By conducting the audit, the team identified six projects that would minimize the environmental impacts of the surface treatment department's operations. Implementing these projects would allow the company to reduce:

- Its wastewater volume by 84 percent and its water consumption by the same percentage
- The amount of heavy metals in its effluent by 98 percent
- Its toxic discharges (cyanide) by 98.5 percent

All six projects could be implemented in three stages. The first stage would involve setting up a de-ionized water production unit in the form of an ion exchanger. The unit would provide rinsewater and makeup water for the plating baths. In the second stage, two electrowinning cells would be installed for recovering heavy metals in the three rinse tanks located where the rinse lines begin after copper plating, nickel plating, and silver plating, respectively. One of the electrowinning cells would be used exclusively for recovering nickel metal ions, while the other would be used for both copper and silver. The final stage would be a reorganization of each of the rinse lines, including a conversion to counterflow rinsing. The rinse tank after chromeplating would also be eliminated.

The investment for the six projects combined would amount to 180,000 Moroccan Dirham (Dh) with net savings of 13,434 Dh per year. This investment would allow SODAQ to lower the toxicity of its discharges by 98.5 percent, and it would take 13.5 years to realize the return on the investment.

In the regional context of the City of Fès, however, studies have demonstrated[1] that, for this kind of private-sector investment, the total internal rate of return would be greater than 8 percent for the Kingdom of Morocco. Moroccan authorities, therefore, are considering investment incentives such as direct funding and tax breaks. Such measures would have an

[1]Scandiaconsult International AB, *Etude d'impact des rejets industriels sur la qualité des eaux de l'Oued.*

66

obvious positive impact on the rate of return for investments, as described below. SODAQ also should consider the following intangible benefits:

- Fewer requirements for handling chemicals such as bleach, contaminated rinsewater, and final effluent
- Fewer requirements for storing a wide variety of chemicals
- Improvement in rinsewater quality, which in turn would stabilize product quality
- Fewer impurities in the copperplating bath
- Less liability associated with discharging wastewater
- Protection from future laws that may be enacted to regulate toxic discharges under the water code
- Compliance with European and American environmental production standards, which would guarantee a good position for selling in Moroccan and foreign markets

The following three tables describe the six projects and include several additional comments. The results shown in Table 1 indicate that only Projects 3 and 4 would permit a good return on investments. This fact is explained by the following characteristics:

- Silver and gold are precious metals with a high salvage value
- The electrowinning cell is capable of reducing the silver ions to the metallic state at the rate of 4.024 gr./amp. per hour (as opposed to 1.186 for copper and 1.095 for nickel)
- The recommendations for the goldplating line mainly involve eliminating all the rinse equipment.

Two separate approaches can be used to grasp project sensitivity in terms of a potential partial implementation of the recommendations. Even though both approaches provide a positive cashflow, the economic approach yields a better rate of return, 43 percent higher than the environmental approach.

In addition, it is interesting to note that both approaches include a project called 5a. This variation of Project 5, as described below in the report, simply involves replacing the cyanide-based degreasing chemical with a cyanide-free bath. The other recommendations that involve modifying the rinse line used with this process were not taken into consideration.

Table 1. Overview of Pollution Prevention Projects for SODAQ

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/yr)	Projected gross income (Dh/yr)	Projected cashflow (Dh/yr)
1	Minimization of toxic copper cyanide discharges	Water 99.7 Copper 80 Cyanide 98	54,300	9,682	9,965	283
2	Minimization of toxic nickel discharges	Water 99.7 Nickel 97.4	54,300	8,501	9,900	1,399
3	Minimization of toxic silver cyanide discharges	Water 99.7 Argent 93 Cyanide 96.5	39,600	7,502	12,850	5,348
4	Minimization of toxic gold cyanide discharges	Gold 100 Cyanide 100	9,300	931	6,000	5,069
5	Minimization of organic concentrations of wastewater used in the degreasing process	Water 99.5 Cyanide 100	22,500	13,645	15,000	1,345
6	Minimization of wastewater in the chromeplating process	Water 100 Chrome 100	NA	NA	NA	NA[2]
	Total		180,000	40,261[3]	53,695[4]	13,434

Economic approach. This approach indicates the projects that have the best profitability to environmental impact ratio. See Table 2.

Environmental approach. This approach indicates the projects that provide the best environmental impact to profitability ratio. See Table 3.

Investment figures recommended in the report are based on purchasing equipment from specialized vendors. Because of the relatively low-technology profile of the recommended equipment, SODAQ's engineering department could manufacture some of the equipment, such as the electrowinning cells. This option would make it possible to reduce the total investment figure by about 50,000 Dh and, hence, lower the amount of time it takes to recover the investment to three years.

Moreover, it is important to mention that all the calculations are based on readings and measurements taken on-site, as well as information collected directly from the plant managers.

[2] The chromeplating line is almost never used, so that the economic data do not apply.
[3] Detailed information on how the operating expenses were computed appear in Annex D.
[4] Detailed information on how the earnings were computed appear in the description of each project.

68

Table 2. Economic Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating costs (Dh/yr)	Projected gross income (Dh/yr)	Projected cashflow (Dh/year)
3	Minimization of toxic silver cyanide discharges	Water 99.7 Silver 93 Cyanide 96.5	39,600	7,502	12.850	5.348
4	Minimization of toxic gold cyanide discharges	Gold 100 Cyanide 100	9,300	931	6.000	5.069
5 a	Elimination of cyanide in the degreasing bath	Cyanide 100	NA	NA	5.500	5.500
	Total	Water 24.6 Metals 5.6 Cyanide 80.8	75,300[5]	8,433	24,350	15.917

Note: This approach still requires a supply of deionized water to prevent contaminating the gold bath; and therefore, the purchase of an ion exchanger is strongly recommended. The other equipment is the same as in the individual descriptions for Projects 3, 4, and 5a.

Table 3. Environmental Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating costs (Dh/yr)	Projected gross income (Dh/yr)	Projected cashflow (Dh/yr)
1	Minimization of toxic copper cyanide discharges	Water 99.7 Copper 80 Cyanide 98	54,300	9,682	9,965	283
3	Minimization of toxic silver cyanide discharges	Water 99.7 Silver 93 Cyanide 96.5	39,600	7,502	12,850	5,348
5a	Elimination of cyanides in the degreasing bath	Cyanide 100	NA	NA	5,500	5,500
	Total	Water 49 Metals 68 Cyanide 98.4	120,300	17,184	28,315	11,131

Note: The ion exchanger is also included in this scenario to optimize the amount of time that the metal recovery cycles last before it is necessary to drain the first rinse basin.

[5] This figure includes 26,400 Dh, which amounts to 60 percent of the cost of buying the ion exchanger.

SECTION I

BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY

SECTION I
THE METAL FINISHING FACILITY

A. Introduction to SODAQ

The Société de Dinanderie d'Argenterie et de Quincaillerie (SODAQ) is a corporation founded in 1989. With 40 employees, an installed capacity of 100 KVA and 1,500 m^2 of covered facilities, SODAQ is a company that specializes in manufacturing decorative products using silver plating and gold plating. The company is vertically integrated and comprises all stages of production from cutting to plating and polishing, including all mechanical stages of fabrication. It processes an average of 225 workpieces per day of different shapes and sizes, including teapots, trays, etc. This amounts to an equivalent of 25 m^2 of raw material (brass sheets, bars and tubing) per day. The company is open for business from Monday through Friday. Normal working hours are 8 a.m. to 4 p.m., which amounts to 8 hours per day and 260 days per year.

SODAQ uses around 66,000 kWh of electricity per year at a cost of 108,000 Moroccan Dirham (Dh) including tax. It has a well, and its water tower meets its entire requirement for water. The amount of water used is not metered, but the audit team estimated that SODAQ consumes about 4,500 m^3 per year[1].

B. Brief Description of the Process

B1. Production and Preparation for Workpieces

The production process is comprised of the following phases:

- **Cutting.** The brass sheets vary in thickness according to the item to be produced. They are cut using a template and scissors or a jigsaw.
- **Straightening.** The workpieces become slightly misshapen when cut. To prepare them for stamping, they are straightened in presses.
- **Stamping.** The workpieces are shaped during this phase.
- **Shaping.** This is the stage in which the workpieces take on their final geometric shape.
- **Brazing.** This is done with bronze or brass for assembling some of the items.
- **Lathe work.** The accessories for the items are produced in this facility.
- **Mounting, welding, and assembly.** The item takes on its final shape before it is sold.
- **Cleaning and polishing.** Some items, such as teapots in particular, are descaled on the inside using nitric acid; the others proceed directly to the polishing stage. The items are

[1]Flow rate estimations were made by measuring the time it took to fill a known volume with the water streams.

71

polished using brushes mounted on lathes, and each machine has two brushes. The brushes are dipped in used motor oil from time to time to cool them and are also dipped into polishing grease. Once they are polished, the items are cleaned by hand with kerosene, dried with sawdust[2], and then polished by hand with whiting.

- **Hammering, printing, and decoration.** This work, done entirely by hand, is performed with a remarkable degree of accuracy and craftsmanship.

- **Foundry.** All the metal cut-offs produced during the mechanical phases are melted down and reused to make accessories. The molds are prepared by hand in the shape of a packet (terzak) made with red earth that is baked over a wood fire.

B2. Surface Treatment

Degreasing. When received, the workpieces are hung on hooks and dipped in a basal solution of sodium cyanide (125 g/l) and caustic soda (62.5 g/l) for a given amount of time (5 minutes) to remove all the grease and prepare them for the next stage: nickel plating. Direct voltage passes through the solution which is dumped and replaced every 700 hours of work or every 80 days. There are no ammeters or voltmeters to monitor current or voltage.

Rinsing. The workpieces are removed from the degreasing tank and then rinsed off in a flowing rinse tank that contains 450 liters of water. This rinse is also used as the first rinse tank after copper plating. The water flow rate in the rinse tank is intermittent.

Copper plating. Copper plating is used to promote adhesion and improve deposit quality of the subsequent coating onto the welded areas of the parts. All the items are placed in an alkaline solution (pH 9.7) of copper cyanide (100 g/l) and potassium hydroxide (20 g/l), and a direct current passes through it from four copper anodes. The solution is heated to a temperature of 38°C using an immersion heater placed directly in the bath. The anodes are consumed at the rate of 13.4 kg per year, while 2 kg of potassium hydroxide and 0.5 kg of copper cyanide are added after every 192 hours (24 days) of operation.

Rinsing. The workpieces are removed from the copper plating tank and then rinsed off in a series of 2 flowing rinse tanks, each containing 450 liters of water. The first rinse is also used as a first rinse in the copper plating process, and the second rinse is also serves as the first rinse after nickel plating to promote partial oxidation of the cyanides. These water flow rate of these rinses is intermittent.

Nickel plating. Nickel plating is performed in 2 tanks with a volume of 450 liters each. These acidic solutions (pH 4.2) are made-up of nickel sulfate (300 g/l), nickel chloride (80 g/l) and boric acid (45 g/l). The purpose of boric acid is to produce and maintain an acid pH somewhere between 3.5 and 4.5. Each tank is equipped with 4 nickel anodes which are passivated by $NiCl_2$. The anodes carry the electrical current required for nickel plating. Additives are regularly mixed in the solution makeup, such as brighteners to ensure even deposit thickness and wetting agents to minimize internal stress by reducing solution viscosity.

---

[2]The sawdust is bought from local wood working shops.

72

It takes about 10 minutes for the items to be plated. As a rule, the solution should be heated to 55°C for best results. Different makeup salts are added every 192 hours (24 days) at the rate of 48 kg for nickel sulfate, 12 kg for nickel chloride, and 7.2 kg for boric acid. The nickel anodes are completely replaced for both baths at the rate of 260 kg per year. Nickel plated items are eventually either silver plated or gold plated.

Rinsing. The items removed from the nickel plating tank are then rinsed off in a series of 2 rinse tanks of 450 liters in capacity each. The first and the second rinse tanks are both shared with the copper plating rinse line; the final rinse is also serves as first rinse after silver plating. Partial oxidation of the cyanides occurs as a result of sharing the rinses between these plating lines. The rinse tanks are continuously flowing.

Silver strike. Silver plating occurs in a 450 liters tank that contains silver cyanide (30 g/l) and potassium cyanide (250 g/l). Contact time is approximately 2 minutes. Silver brightener is also used in the solution. Silver cyanide (1.5 kg) and potassium cyanide (7.5 kg) salts are added every 192 hours or 24 days of operation. A current of 25 amps under 3 volts passes through the solution from dimensionally stable anodes to the parts to be plated. SODAQ does not use silver anodes, the metal available for electrodeposition is provided by the silver cyanide salt found in solution in the process tank.

Rinsing. The workpieces are then removed from the silver plating tank and immersed into the rinse tank also used for second rinse after nickel plating.

Gold strike. Gold strike takes place in a 450-liter tank containing gold cyanide (0.6 g/l) and potassium cyanide (44 g/l). Striking usually takes from 20 to 30 seconds. A brightener is also added to the solution which is maintained at a temperature of 90°C. There was no gold plating carried out during the audit.

Rinsing. The workpieces are typically rinsed in the rinse tank used after the silver plating.

Drying. All parts are dried with sawdust. They are then individually inspected, polished using whiting, and dried using compressed air. Used sawdust and whiting amount to 2 kg and 4 kg per day, respectively.

Solution filtering. SODAQ uses a mobile solution filtering system. It is applied successively to each process bath in an effort to remove impurities, thereby extending the bath's service life. Impurities pathways can be classified as follows:

- Metallic structures. These can be minimized by preventing splashes from the tank.
- Anode quality. The nickel anodes should be pure.
- Addition of dirt. This can be curtailed by improving rinsing.
- Makeup water containing high levels of dissolved salts. Use deionized water.
- Airborne particles falling in the tank. Use tank lids when not operating.

C. Metal Finishing Facility Discharges

The use of toxic chemicals in the metal finishing department causes SODAQ's final wastewater effluent to contain a dilute concentration of hazardous chemicals. This wastewater is discharged into the Sidi Brahim neighborhood sewer system, which itself is connected to the river

Oued Mahrez, an affluent of Oued Zitoune, and subsequently Oued Boughrareb. No waste treatment or water reuse method is being applied. Bath preparation is made utilizing simple weight and volume measurement methods, and bath make up needs are based upon pH readings and occasional chemical analyses performed by the vendors. No laboratory equipment or facilities are available in-house. Annual chemical usage figures are not readily available.

C1. Liquid Effluent

Amounts. According to our estimates, SODAQ uses 4,528 m^3 of water per year broken down as follows:

Water Use	**m^3/yr**
Surface treatment	
Rinsing	3,852
Makeup solution	2
Bath evaporation	63
Subtotal	**3,917**
Cleaning	325
Supply water	0
Other	286
Total	**4,528**

The most heavily polluted discharges of water are rinsewater, amounting to 3,852 m^3/yr. This represents about 85 percent of the total volume discharged.

Contaminants. The contaminants are primarily heavy metals such as Cu, Ni, Ag, and Au, along with cyanides. These pollutants are dragged out as salts by the rinse operations. According to our estimates[3], SODAQ would appear to discharge the following quantities:

Contaminants	**kg/yr**
Heavy metals	
Copper	37
Nickel	19
Silver	3.5
Gold	0.06
Subtotal	**59.56**
Cyanides	128
Total	**187.56**

[3]These estimates are derived from TDS measurements; they have been validated or corrected by laboratory analytical results.

74

C2. Solid Waste

Solid waste is comprised of the following materials:

- Cut-offs, including shavings from all mechanical operations. All are recovered at the foundry for molding various accessories.

- Sawdust used for drying the items during polishing and plating. The sawdust is contaminated with oils and hydrocarbons from the polishing process and with the rinse water from the metal finishing operation. Approximately 10 kg of this type of waste is generated per day, and typically disposed of, in local public landfill.

- Whiting powder, used to improve surface finish after polishing and to dry parts after plating, is contaminated with oils and hydrocarbons (from polishing) and with rinse water (from plating). Approximately 12 kg of this waste is generated per day, and disposed of in a local public landfill.

- Towels used for polishing and finishing are contaminated with grease and kerosene, and also disposed of in a local public landfill.

C3. Exhaust

Atmospheric releases are mainly composed of the fumes from the wood fires used to bake earth molds and the cyanide-based emanations are generated by the degreasing process tank when current is applied. A wall fan is used to extract the fumes from the building. For the other process baths containing dissolved metal salts, the hydrogen and oxygen evolving at the cathode and anode respectively, do not entrap a significant mist requiring air emission control equipment.

It should be noted that when and if operating, the chromium plating process tank could generate a toxic chromic acid mist requiring air emission control methods.

SECTION II

POLLUTION PREVENTION PROJECTS

SECTION II
POLLUTION PREVENTION PROJECTS

A. Project N°1. Minimization of Toxic Copper Cyanide Discharges

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/yr)	Projected gross income (Dh/yr)	Projected cash flow (Dh/yr)
Water	99.7	54,300	9,682	9,965	283
Copper	80				
Cyanide	98				

A1. Recommendations

- Install a deionized water production unit for makeup water for the rinse tanks and the copper plating bath.
- Install a counterflowing rinse system comprised of three rinse tanks.
- Install an immersion heater in the first rinse tank after copper plating to evaporate the excess water from the counterflow.
- Install a metal reinforcement structure to maintain the integrity of the first PVC rinse tank which will be heated to a temperature of 50°C.
- Install an electrowinning cell to recover the copper ions in nontoxic metal form and to oxidize and destroy the cyanides.
- Modify the parts rinse system after copper plating by rearranging the tanks.

A2. Description

Currently, the operating method involves using two continuously flowing rinse tanks, overflowing in the sewer, after copper plating. Water is supplied to the tanks from the well. The tanks have a capacity of 450 liters. The second rinse tank after copper plating is also used as the first rinse tank after nickel plating.

The copper plating bath that uses cyanide does not generate a contamination cycle. There has never been any need to replace it since SODAQ was founded. Despite the introduction of impurities from the well water, the air, treated items, etc., it would appear that the bath is sufficiently "purged" by drag-out from the workpieces. The bath is heated to 35°C and is equipped with anti-evaporation balls.

We recommend separating the copper plating rinse and nickel plating rinse systems to optimize the recovery of metal ions through electrowinning.

A3. Projected Gross Income

The above mentioned equipment will make it possible to realize the following savings:

- Annual water consumption for this process will drop by 960 m^3 or 99.7 percent.
- 36.5 kg of copper out of the 37 kg currently generated by the rinse line, or 98.6 percent, will be recovered per year.
- 24.5 kg of cyanide out of the 25 kg generated by this line will be destroyed per year, or 98 percent.

The combined savings for the copper plating operation will be 9,965 Dh per year, broken down as follows:

- 9,600 Dh for water based on 10 Dh/m3
- 365 Dh for recovered copper, based on 10 Dh/kg Cu

A4. Operating Expenses

The proportion of the total operating expenses originated by the equipment installed on this line can be estimated at 9,682 Dh per year, based on the following estimations:

- 6,357 Dh per year to improve evaporation in the first rinse tank, or 20 percent of the total cost of the electricity for the four immersion heaters
- 2,394 Dh per year for the electrowinning cell, or 36.5 kg of copper at 65.59 Dh/kg
- 931 Dh per year for deionized water supply, or 20 percent of the total operating expenses of the ion exchanger

A5. Investment

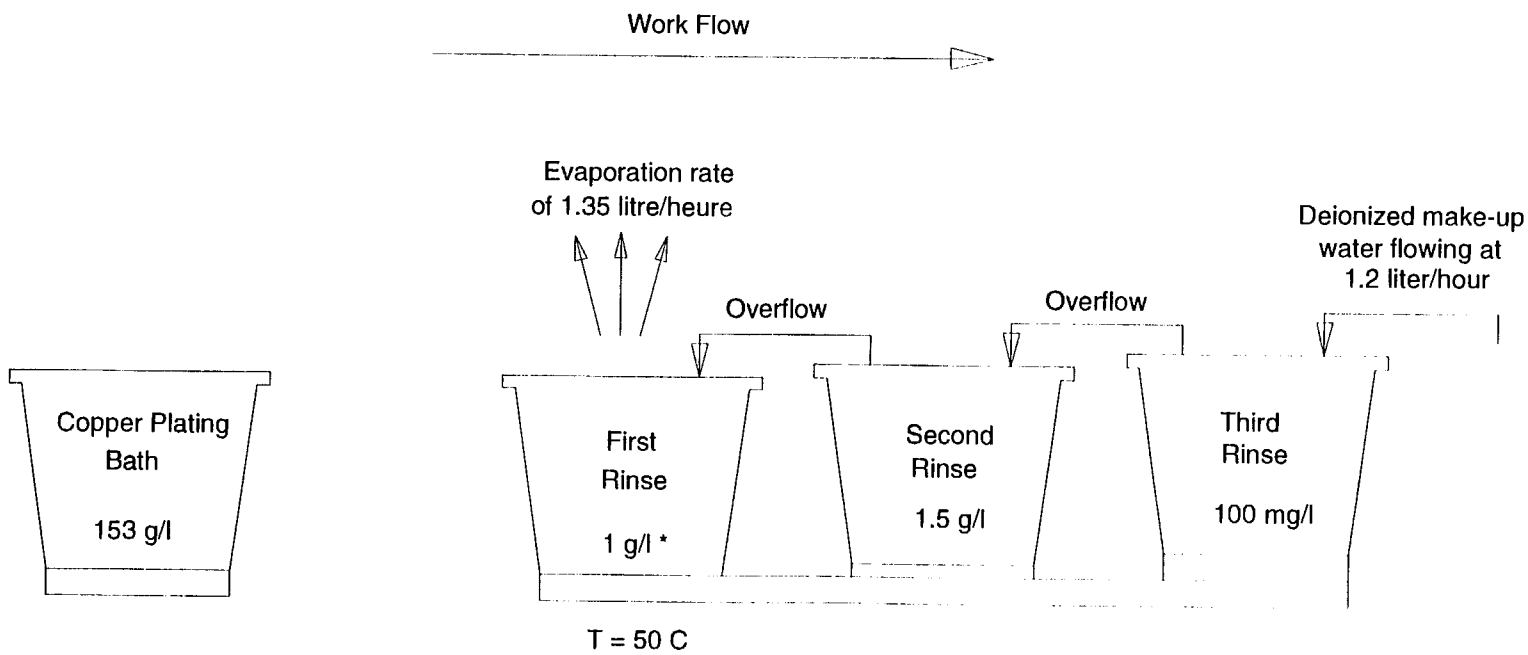
Total investment is estimated to be 54,300 Dh, broken down as follows:

- 26,400 Dh, which is 50 percent of the total purchase price of the electrowinning cell
- 8,800 Dh, which is 20 percent of the total purchase price of the ion exchanger
- 4,400 Dh for the immersion heater
- 1,500 Dh to raise and reinforce the tanks
- 13,200 Dh to add three tanks

A6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SODAQ Project No 1: Counterflowing rinse after copper plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

B. Project N°2. Minimization of Toxic Nickel Discharges

Environmental impact (% of decrease)		Investment (in Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	99.7				
Nickel	97.4	54,300	8,501	9,900	1,399

B1. Recommendations

- Install a de-ionized water production unit for makeup water for the rinse tanks and the nickel bath.
- Install a counterflowing rinse system comprised of three rinse tanks.
- Install an immersion heater in the first rinse tank to evaporate the excess water from the counterflow.
- Install a metal reinforcing structure to maintain the integrity of the first PVC rinse tank that will be heated to a temperature of 50°C.
- Install an electrowinning cell to recover the nickel ions in nontoxic metallic form.
- Modify the rinse circuit for the workpieces after nickelplating by rearranging the tanks.

B2. Description

The nickel plating process is set up in a manner similar to copper plating. Two rinse tanks are used. They have continuous flow as well, and the water is drained by an overflow opening. The first rinse tank after nickel plating is also used as the second rinse for the previous stage or copper plating. The second rinse tank after nickel plating is used as the first rinse tank after silver plating. Makeup water for the bath and the rinse tanks comes from the well, and this introduces a degree of contamination that cannot be controlled.

The nickel bath appears to be kept at an acceptable level of contamination by "drag-out" from the workpieces, as they are taken out of the bath. It has not been necessary to replace the nickel bath since SODAQ was founded. Both nickel baths are heated to 55°C and are equipped with anti-evaporation balls.

The current arrangement for the rinsing operations is not optimal for recovering metal ions using an electrowinning cell. We recommend complete separation of the rinse circuits after copper plating and nickel plating. Moreover, with a view to recovering and using metals, we recommend complete separation of the rinse systems after copper plating and nickel plating.

B3. Projected Gross Income

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 960 m^3 or 99.7 percent.
- On an annual basis, 18.5 kg of nickel will be recovered out of the 19 kg generated by the rinse line, or 97.4 percent.

The combined savings for this nickel plating operation amount to 9,900 Dh per year, broken down as follows:

- 9,600 Dh for water based on 10 Dh per m^3.
- 300 Dh for recovered nickel based on 17 Dh/kg Ni.

B4. Operating Expenses

The proportion of the total operating expenses for the installed equipment for this line may be estimated at 8,501 Dh per year on the following basis:

- 6,357 Dh per year to improve evaporation in the first rinse tank, or 20 percent of the total cost of the electricity for the four immersion heaters.

- 1,213 Dh per year for the electrowinning cell (18.5 kg of nickel at 65.59 Dh per kg).

- 931 Dh per year for the de-ionized water supply, or 20 percent of the total operating expenses for the ion exchanger.

B5. Investment

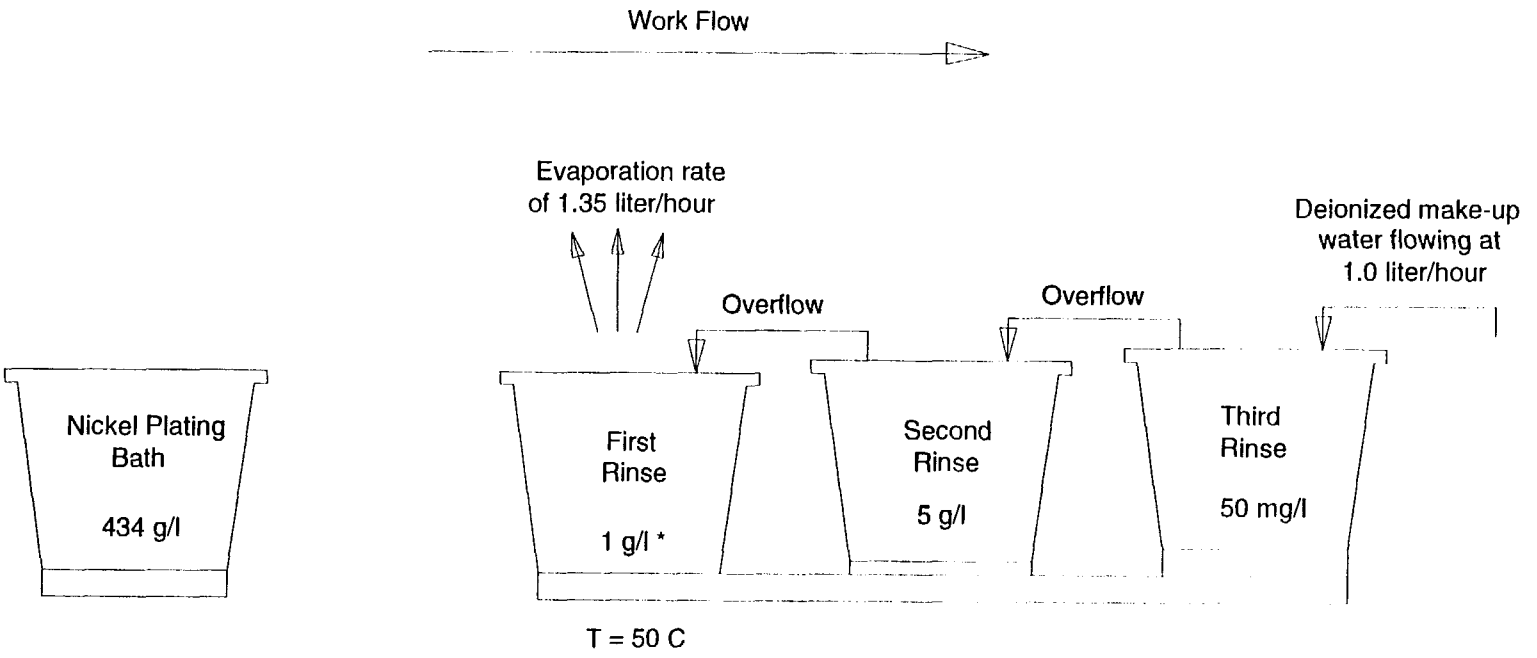
Total investment, estimated at 54,300 Dh, is broken down as follows:

- 26,400 Dh, or 50 percent of the total purchase price of the electrowinning cell
- 8,800 Dh, or 20 percent of the total purchase price of the ion exchanger
- 4,400 Dh for the immersion heater
- 1,500 Dh to raise and reinforce the tanks
- 13,200 Dh for purchasing and usage

B6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SODAQ Project No 2: Counterflowing rinse after nickel plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

C. Project N°3. Minimization of Toxic Silver Cyanide Discharges

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	99.7				
Silver	93	39,600	7,502	12,850	5,348
Cyanide	96.5				

C1. Recommendations

- Install a de-ionized water production unit for makeup water for the rinse tanks and the silver bath.
- Install a counterflowing rinse system comprised of three existing rinse tanks.
- Install an electrowinning cell to recover the silver ions in nontoxic metal form.
- Install an immersion heater in the first rinse tank to evaporate the excess water from the counterflow.
- Install a metal reinforcing structure to maintain the integrity of the first PVC rinse tank which will be heated to a temperature of 50° C.
- Modify the parts rinse system after silver plating by rearranging the tanks.

C2. Description

The silver plating process is set up in a manner similar to copper plating and nickel plating. However, a single rinse tank is used with continuously flowing water and an overflow opening toward the sewer. This rinse tank is used after silver plating and for the second rinse for the previous nickel plating stage, as well as the one rinse tank after the workpieces have been gold plated. Makeup water for the bath and the rinse tanks comes from the well, which in turn introduces a degree of contamination that cannot be controlled.

The silver bath is also kept at an acceptable level of contamination by "drag-out," as described above. It has not been necessary to replace it since SODAQ was founded. The current rinse arrangement is not optimal for recovering metal ions using an electrowinning cell. We recommend complete separation of the rinse circuits after silver plating, nickel plating, and gold plating.

C3. Projected Gross Income

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 958 m^3 or 99.7 percent.
- 3.26 kg out of the 3.5 kg of silver or 93 percent generated by this line will be recovered.
- 13.5 kg out of the 14 kg of cyanide or 96.5 percent generated by this line will be destroyed.

All the savings combined for the silverplating operation amount to 12,850 Dh per year and are broken down as follows:

- 9,600 Dh for water, based on 10 Dh/m^3
- 3,250 Dh of silver recovered based on 1,000 Dh/kg of Ag

C4. Operating Expenses

The proportion of the total operating expenses originated by the installed equipment for this line may be estimated at 7,502 Dh per year on the following basis:

- 6,357 Dh per year for increasing evaporation in the first rinse tank, or 20 percent of the total cost of electricity for the four immersion heaters

- 214 Dh per year for the electrowinning cell (3.26 kg of silver at 65.59 Dh/kg)

- 931 Dh per year for the de-ionized water supply, or 20 percent of the total cost of operating the ion exchanger

C5. Investment

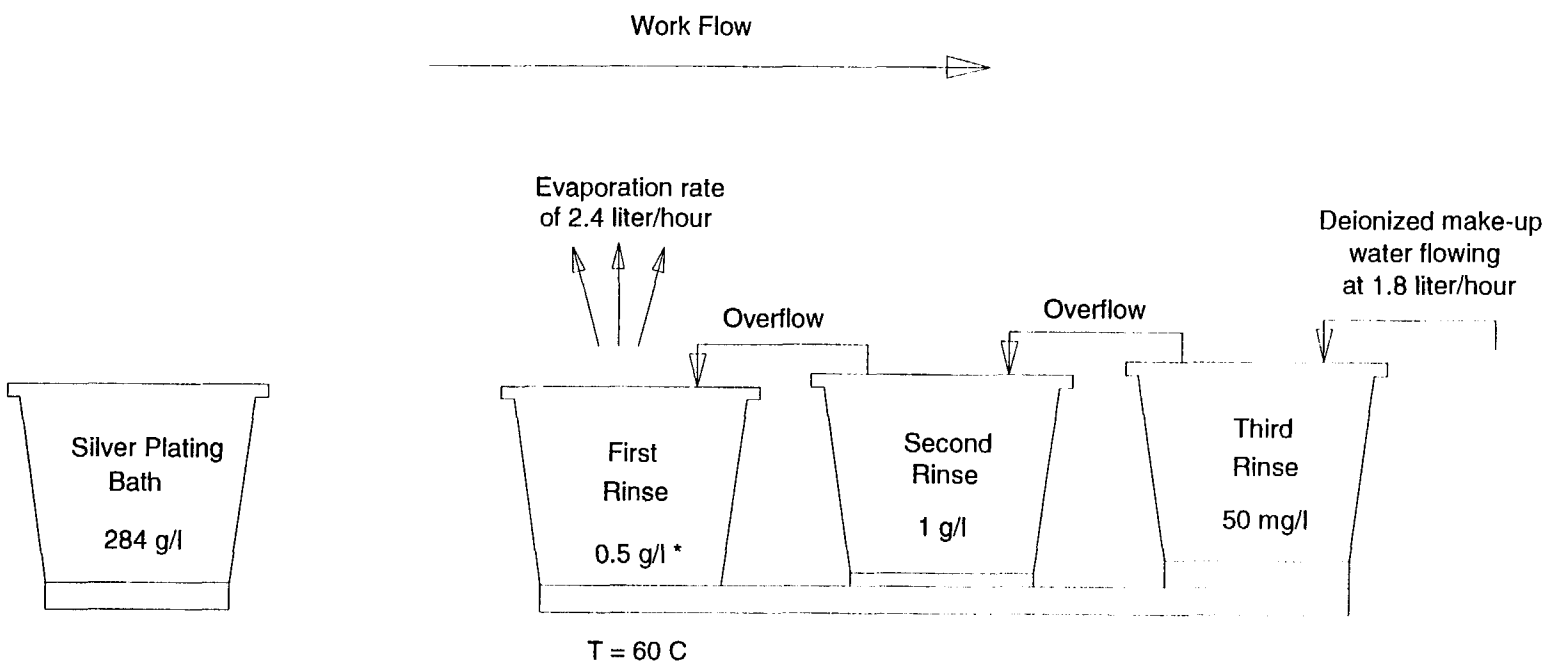
The total investment is estimated at 39,600 Dh, broken down as follows:

- 26,400 Dh for purchasing an electrowinning cell
- 8,800 Dh which amounts to 20 percent of the total cost of purchasing the ion exchanger
- 4,400 Dh for the immersion heater

C6. Data and Calculations

See the tables in Annexes A, B, C, and D.

SODAQ Project No 3: Counterflowing rinse after silver plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

D. Project N°4. Minimization of Toxic Gold Cyanide Discharges

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Gold	100				
Cyanide	100	9,300	931	6,000	5,069

D1. Recommendations

- Install a deionized water production unit for makeup water for the gold bath.
- Eliminate all the rinse tanks.
- Rinse the workpieces above the gold bath.
- Raise the bath temperature to 100°C.

D2. Description

The gold plating process is used only occasionally. After the gold cyanide bath, the workpieces are placed in the first continuously flowing rinse tank. This tank is also used as the first rinse tank after silver plating. Makeup water for the bath and the dedicated rinse tank is also provided using well water; as this introduces a degree of contamination that cannot be controlled, de-ionized water must be used.

The gold cyanide bath is also kept at an acceptable level of contamination by the "drag-out" described earlier. It has not been necessary to replace the bath in the years since SODAQ was founded. The bath is equipped with anti-evaporation balls.

With a view toward possible recovery, the team found the manner in which SODAQ conducts rinse operations to have one major disadvantage in that the same rinse is used for both silver and gold. We could simply recommend separating the rinses after silver plating and after gold plating. To improve the operation even more, however, we recommend eliminating the rinse after gold plating in a static tank and replacing it with a rinse over the bath itself with a spray gun while keeping the bath at a temperature of 100°C.

D3. Projected Gross Income

The above mentioned equipment will help generate the following savings:

- A total of 60 g of gold discharged by this surface treatment line (100 percent) will be recovered.
- 1.89 kg of the cyanide discharged by this surface treatment line (100 percent) will be destroyed.

The expected savings for this goldplating operation amount to 6,000 Dh per year based on 100 Dh/g of gold.

86

D4. Operating Expenses

These include 931 Dh per year for the deionized water supply, or 20 percent of the total cost of operating the ion exchanger.

D5. Investment

The total investment is estimated at 9,300 Dh, broken down as follows:

- 8,800 Dh, or 20 percent of the total investment cost of an ion exchanger
- 500 Dh for purchasing a spray gun

D6. Data and Calculations

See the tables in Annexes A, B, C, and D.

E. Project N°5. Minimization of Organic Concentrations of Wastewater Discharged from the Degreasing Process

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (in Dh/year)	Projected cash flow (Dh/year)
Water	99.5				
Cyanide	100	22,500	13,645	15,000	1,345

E1. Recommendations

- Install a deionized water production unit for makeup water in the rinse tanks, for preparing the degreasing tank and for makeup water in the degreasing tank.
- Install a counterflowing rinse system comprised of two additional rinse tanks that includes the degreasing tank.
- Install an immersion heater to raise the temperature of the degreasing bath to 60°C to evaporate the makeup water required for the counterflow rinse.
- Eliminate the chemistry currently in use and instead use a cyanide-free solution.

E2. Description

The degreasing process is set up in a manner similar to the stages for copper, nickel, and silver plating. The single rinse tank receives a continuous supply of water and is constantly being emptied via an overflow opening. The rinse tank is also used as the first rinse after copper plating. Well water is used for makeup water for the degreasing bath and the rinse baths; which in turn generates a degree of contamination that cannot be controlled.

As opposed to the other plating baths, the degreasing solution is not kept at an acceptable level of contamination by its nature and, therefore, is replaced periodically after every 700 hours of operation. For this project, we recommend using a cyanide-free degreasing agent as well as a counterflow rinse that includes even the degreasing bath. The latter should be kept at a temperature of 60°C to drain the rinsewater by evaporating water that flows into it.

E3. Projected Gross Income

The above mentioned equipment will help save 957 m^3 of water per year, or 99.3 percent. In addition, replacing the current degreasing agent with a cyanide-free product would generate annual savings of about 5,500 Dh per year and would totally eliminate all the 88 kg per year of cyanide in the water or air discharges. The total estimated savings for the degreasing operation is 15,000 Dh per year, broken down as follows:

- 9,570 Dh per year based on 10 Dh per m^3
- 5,500 Dh per year, which is the difference between the current and the recommended degreasing cost

It is possible that using de-ionized water for make-up combined with counterflowing rinse system, would significantly increase the service life of the degreasing bath. If that is so, then a 10 percent increase in the service life of the bath would generate annual savings of 1,650 Dh. For the purposes of this study, this assumption will not be evaluated, since this would have to be tested over an extended period of time to be accurately quantified..

E4. Operating Expenses

The proportion of the total operating expenses originating from the installed equipment that is attributable to this line may be estimated at 13,645 Dh per year as follows:

- 12,714 Dh per year to increase evaporation in the degreasing bath, which is the same as 40 percent of the total cost of the electricity for the four immersion heaters
- No cost for the electrowinning cell, since no suspended metal is generated in the rinsewater
- 931 Dh per year for the deionized water supply, or 20 percent of the total cost of operating the ion exchanger

E5. Investment

The total investment is estimated at 22,500 Dh, broken down as follows:

- 8,800 Dh, amounting to 20 percent of the total amount, for purchasing an ion exchanger
- 4,400 Dh for purchasing an immersion heater
- 500 Dh in costs for rearranging the rinse tanks
- 8,800 Dh for the additional rinse tanks

E6. Data and Calculations

See the tables in Annexes A, B, C, and D.

F. Project N°6. Minimization of Wastewater Discharge from the Chromeplating Process

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh per year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	100				
Chrome	100	NA	NA	NA	NA[1]

F1. Recommendations

- Install a de-ionized water production unit for makeup water for the rinse and the chrome bath.
- Eliminate all the rinse tanks and rinse directly over the bath for direct recovery.
- Eliminate and replace the anti-evaporation balls, by a chemical fume suppressant

F2. Description

The chrome plating process is not used frequently. It is set-up with a static rinse tank after chrome plating. This single rinse tank is not shared with any other plating process. Well water is used for makeup water for the bath and the rinse tank; this in turn introduces a degree of contamination that cannot be controlled.

The chrome plating bath is also kept at an acceptable contamination level by "drag-out," and the fact that it is rarely used, as described earlier. It has not been necessary to replace the bath in the years since SODAQ was founded. When used, the bath is heated to 60°C, so it is equipped with anti-evaporation balls. However, even though the anti-evaporation balls are relatively efficient at reducing fumes (50% to 75%), the chemical fume suppressant would be allow regular operation of the chrome plating tank, at 60°C, while meeting the OSHA requirements for chromic acid mist control in the workplace

F3. Projected Gross Income

The above recommendations will not generate any savings. They do provide the following non-quantifiable benefits:

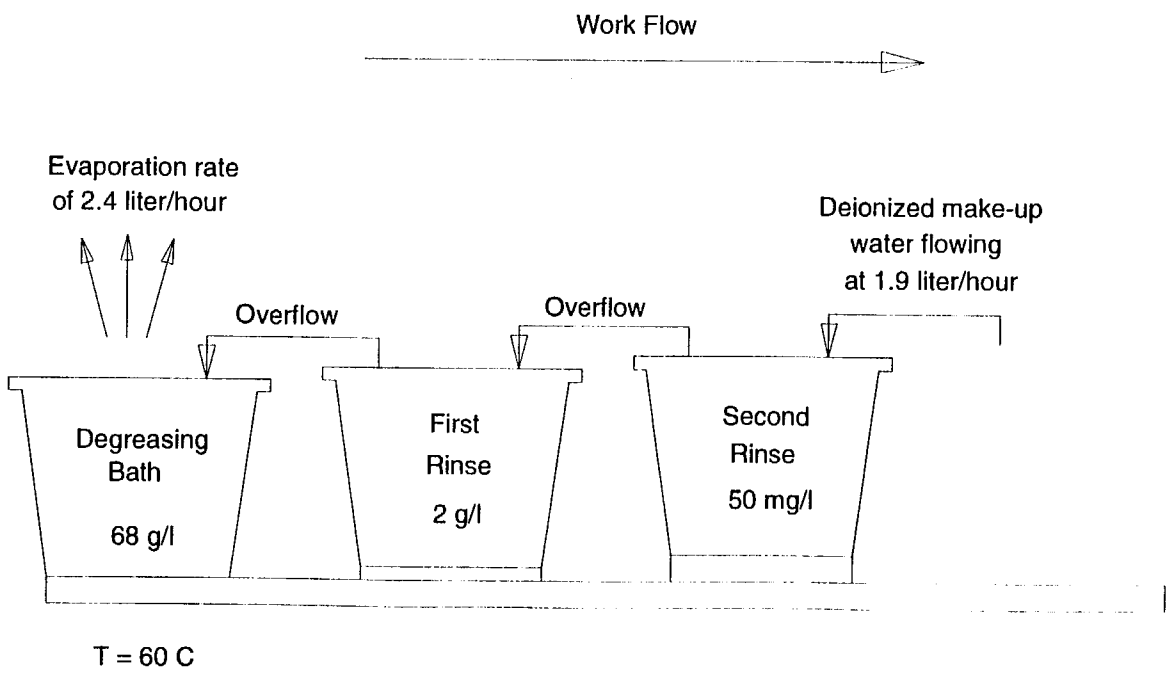
- Elimination of all drainage of hexavalent chrome in the discharged wastewater and the atmosphere.
- Freeing up enough space to install the second rinse tank after degreasing

F4. Investment

No investments are directly linked to implementing the recommendations for this project. The implementation of the preceding projects will result in implementing systems that infrequently use the chrome plating tank. Consequently, in this project we will not present the operating expenses or include data or calculations.

[1] The chromeplating line is almost never used, so that no economic data apply

SODAQ Project No 5: Counterflowing rinse after degreasing



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.

SECTION III

RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

SECTION III
RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

A. Specific Recommendations

- For safety, ensure that safety glasses are worn and that an eyewash station is available to those workers on the plating lines.

- After cleaning the plastic containers in which the different toxic salts are kept, dispose of the containers, by sending them back to the vendor of the chemistry for recycling.

- Minimize compressed air leaks by inspecting the circuit on a daily basis and replacing the defective parts as necessary.

- Clean by scraping the different media and hooks used in the process frequently to reduce the amount of impurities that enter the different baths to lengthen the service life of the baths as much as possible.

- Coat the immersion hooks with plating-resist to prevent product loss through unwanted plating. Such products as plastisols can be used.

- In the different baths, such as nickel and silver, only use truly demineralized, de-ionized or distilled water. Bottled water sold as demineralized water, such as water for batteries, is often if not always heavily laden with mineral salts which are a source of introducing impurities into the tanks.

- Reuse several times the sawdust used to dry the workpieces after natural drying on terraces or vacant land near the facility if available. It appears that the contamination level is low enough to tolerate repeated uses.

- Check and inspect the different parameters, such as exposure time, chemical concentrations in the baths, temperature and current strength. For this purpose, testing equipment should be available, such as thermometers, ammeters and timers with audible alarms. A small space should also be set aside to conduct chemical analyses of the baths.

- Adjust current strength to the type of workpiece to be treated to optimize productivity. The thickness of the deposit on the metal depends on current strength and exposure time. Performing the surface treatment based solely on the time parameter, as is done in the metal finishing facility we audited, may result in excessively high or low production quality. This remark is especially applicable as the surface to be treated is changed.

  For example, when working with current strength of 5 amps/dm^2, the thickness of the nickel deposit increases by 0.001 mm per minute. That means that after 10 minutes, the nickel deposit thickness will be 0.01 mm. Yet, the same deposit quality may be achieved in six minutes with current strength of 8 amps/dm^2.

- Replace the current mold baking system at the foundry with a more efficient system in which propane gas would replace wood as a fuel. Wood has a lower LHV than gas: 3,000 versus 11,000 kcal/kg, and its burning efficiency is 40 percent lower. The proposed system would be as follows: a hot air generator using propane would produce high-temperature fumes that would circulate in a closed space where the terzaks are located.

B. General Recommendations

- Conduct employee awareness training on pollution prevention.
- Develop a pollution prevention strategy in the form of a procedures manual including precise written guidelines defining:
  - An inventory method for all chemicals in use.
  - The restricted handling of chemicals by a limited number of qualified employees.
  - A program of periodical analyses of the baths.
  - Record-keeping method for bath analyses and makeup water.
  - A written procedure for makeup sequences.
  - Methods to optimize the service life of the treatment baths.
  - The frequency of regular inspections of the baths to remove workpieces that accidentally fell into the bath.
  - Preventive maintenance schedule for the tanks.
  - The alarm system used to protect against tank overflow.
  - The installed leak detection systems.
  - Workpiece inspection methods prior to plating.

ANNEX A

TABLES ILLUSTRATING THE STAGES OF THE PROCESS

SODAQ

Annex A: Process Stages

Stage 1: Degreasing	Data	Units
Replace bath completely every	700	Hours
Tank Dimensions:		
Width	0.8	m
Length	1	m
Depth	0.7	m
Total solution volume	560	Liters
Caustic soda	35	Kg
Sodium cyanide	70	Kg
Mineral alkali	0	Kg
KW	0	Kg
Water	455	Liters
Concentration	ND	Baumé
Degreasing time	5	mn

Stage 2: Rinse	Data	Units
Number of rinse tanks for degreasing	1	Tank
Tank No. 1		
Tank Dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters

Stage 3: Cuivrage	Data	Units	Makeup	Units
Number of Copper Plating Tanks	1	Tank		
Tank Dimensions:				
Width	0.5	m		
Length	1	m		
Depth	0.8	m		
Total solution volume	400	Liters		
Potassium hydroxide	8	Kg	2	Kg/month
Copper cyanide	40	Kg	0.5	Kg/month
Mira C-1	12	Liters	ND	Kg/week
Mira C-2	1.2	Liters	ND	Kg/month
Copper anodes	4	Anodes	1.33	Anode/year
Wetting agent	0	Liters	0	L/week
Water	358.8	Liters		
Copperplating tank	0.5	mn		
Electric Heating	35	°C		
Concentration	ND	Baumé		

96

Stage 4: Rinse	Data	Units
Number of copperplating rinse tanks	3	Tanks
Tank No. 1		
Tank Dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters
Tank No. 2		
Tank Dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters

Stage 5: Nickelplating	Data	Units	Makeup	Units
Number of tanks for nickelplating	2	Tanks		
Tank No. 1				
Tank Dimensions:				
Width	0.75	m		
Length	1	m		
Depth	0.6	m		
Total solution volume	450	Liters		
Nickel sulfate	135	Kg	2	Kg/day
Nickel chloride	36	Kg	0.5	Kg/day
Boric acid	20.25	Kg	0.3	Kg/day
Brightener	1	Kg	0.01	Kg/week
Leveler	1	Liters	0.01	L/week
Wetting agent	2	Liters	0.02	L/week
Nickel anodes	4	Anodes	ND	ND
Water	254.75	Liters		
Nickelplating time	10	mn		
Electric heating	55	°C		
Concentration	25	Baumé		
Tank No. 2				
Tank Dimensions:				
Width	0.75	m		
Length	1	m		
Depth	0.6	m		
Total solution volume	450	Liters		
Nickel sulfate	135	Kg	2	Kg/day
Nickel chloride	36	Kg	0.5	Kg/day
Boric acid	20.25	Kg	0.3	Kg/day
Brightener	1	Kg	0.01	Kg/week
Leveler	1	Liters	0.01	L/week
Wetting agent	2	Liters	0.02	L/week
Nickel anodes	4	Anodes	ND	ND
Water	254.75	Liters		
Nickelplating time	10	mn		
Electric heating	55	°C		
Concentration	25	Baumé		

Stage 6: Rinsing	Data	Units
Number of tanks for nickelplating	2	Tanks
Tank No. 1		
Tank dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters
Tank No. 2		
Tank dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters

Stage 7: Silverstrike	Data	Units	Makeup	Units
Number of tanks for silverstrike	1	Tank		
Tank dimensions:				
Width	0.75	m		
Length	1	m		
Depth	0.6	m		
Total solution volume	450	Liters		
Silver cyanide	0.9	Kg	0.5	Kg/month
Potassium cyanide	45	Kg	5	Kg/month
Brightener	0	Liters	0	L/month
Water	404	Liters		
Strike time	0.5	mn		
Concentration		Baumé		

Stage 8: Silverplating	Data	Units	Makeup	Units
Number of tanks for silverplating	1	Tank		
Tank dimensions				
Width	0.75	m		
Length	1	m		
Depth	0.6	m		
Total solution volume	450	Liters		
Silver cyanide	13.5	Kg	1.5	Kg/month
Potassium cyanide	112.5	Kg	7.5	Kg/month
Brightener	2	Liters	ND	ND
Silver anodes	ND	Anodes	ND	ND
Water	322	Liters		
Strike time	ND	mn		
Concentration	ND	Baumé		

Stage 9: Silver Rinse	Data	Units
Number of tanks for silver rinse	1	Tank
Tank No. 1		
Tank dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters

Stage 10: Goldplating	Data	Units	Makeup	Units
Number of tanks for goldplating	1	Tank		
Tank dimensions:				
Width	0.75	m		
Length	1	m		
Depth	0.6	m		
Total solution volume	450	Liters		
Gold cyanide	0.3	Kg	ND	ND
Potassium cyanide	20	Kg	ND	ND
Brightener	0	Kg	0	Kg/week
Anodes (platinum)	ND	Anodes		
Water	430	Liters		
Electric heating	40	C		
Plating time	0.5	mn		
Concentration	ND	Baumé		

Stage 11: Rinse	Data	Units
Number of tanks for rinse	1	Tank
Tank No. 1		
Tank dimensions:		
Width	0.75	m
Length	1	m
Depth	0.6	m
Total solution volume	450	Liters

Stage 12: Drying - Polishing	Data	Units
- Mechanical drying		
Wood waste	50	Kg/week
Polishing powder	5	Kg/day
- Pneumatic drying		
Compressed airjet	ND	ND

99

ANNEX B

TABLE ILLUSTRATING FEATURES OF THE BATHS

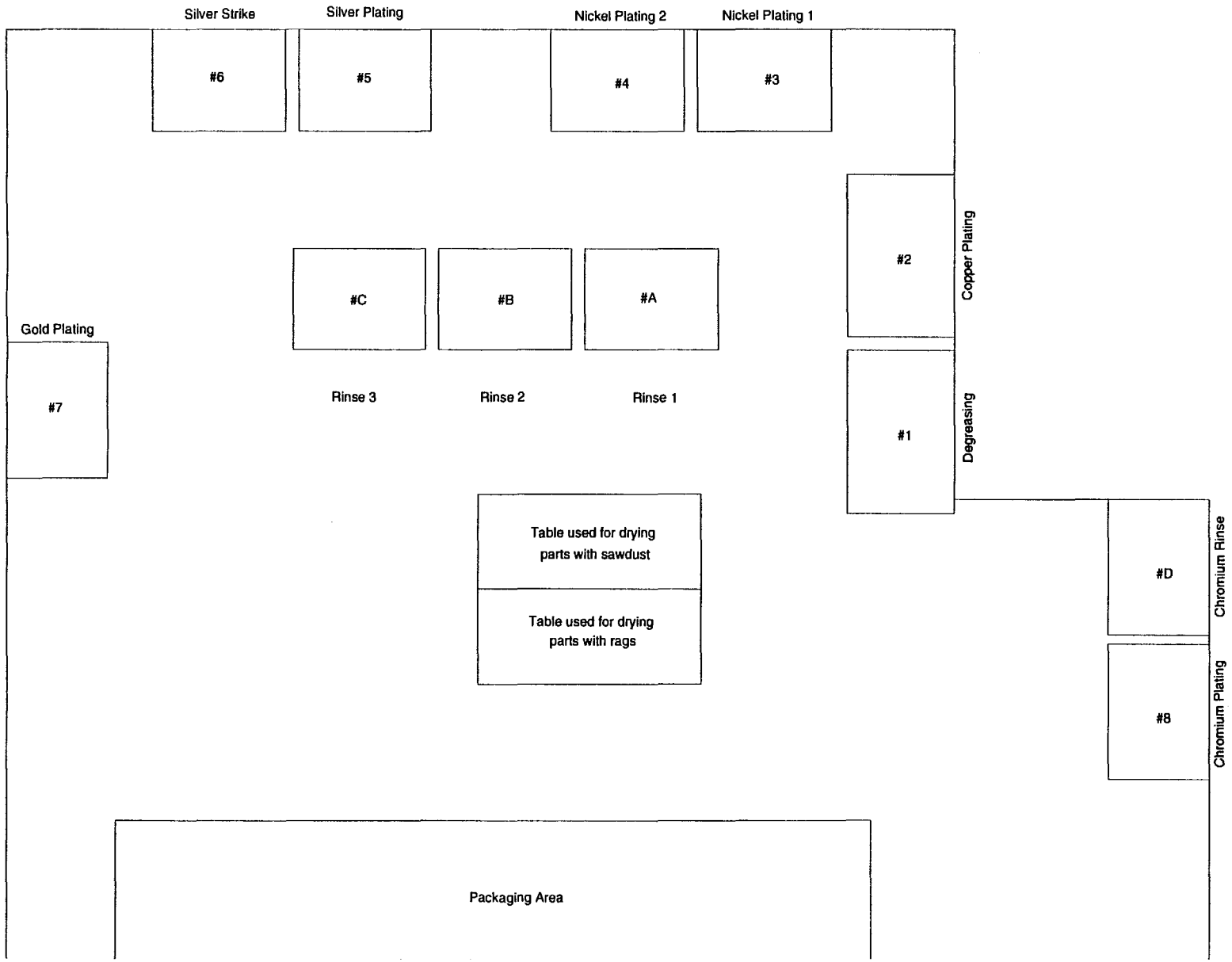
SODAQ, Fes, Morocco
Annex B: Bath Features

Basin reference	Basin Description	Features Temp	TDS in mg/l	pH	Position in cycle	Length of cycle	TDS end of cycle mg/l	Metal as % of cycle	Masses/Cycle Cations in grams	CN in grams	Annual Weight Kg (metal)	Annual Weight Kg (CN)	Annual Volume Liters	Concentration in cyanide effluent mg/l
1	Degreasing	A	187920	11						37100		62.70	1690	21952.66
A	Rinse 1		570	9.1	1.00	1	75			11.90		25.45	962593	0.01
	Total						75					88.15	964283	
2	Copperplating	38	153420	9.7				46.28%	Cu	CN				
A	Rinse 1		570	9.1	1.00	1	75		15.62	10.46	33.41	22.38		
B	Rinse 2		520	7.6	1.00	1	8		1.56	1.05	3.34	2.24	962593	0.00
	Total						41			11.51	36.75	24.62	962593	
6	Nickelplating 1	49	434309	4.9				19.95%	Ni					
B	Rinse 1		520	7.6	1.00	1	46		4.15		8.88			
C	Rinse 2		470	8.8	1.00	1	3		0.22		0.48		962593	
7	Nickelplating 2	52	434309	4.2				19.95%	Ni					
B	Rinse 1		520	7.6	1.00	1	46		4.15		8.88			
C	Rinse 2		470	8.8	1.00	1	3		0.22		0.48			
	Total						24				18.73		962593	
3	Silverstrike	A	102420	11.3										
4	Silverplate	A	284864	11.5				8.48%	Ag	CN				
C	Rinse 1		470	8.8	1.00	1	40		1.53	6.69	3.26	14.30	962593	0.01
	Total						40			6.69	3.26	14.30	962593	
8	Goldplate	49	45531	10.6				1.29%	Au	CN				
C	Rinse 1		470	8.8	1.00	1	5		0.03	0.88	0.06	1.89		0.00
	Total						5			0.88	0.06	1.89	0	
	Total											128.96	3852060	0.00

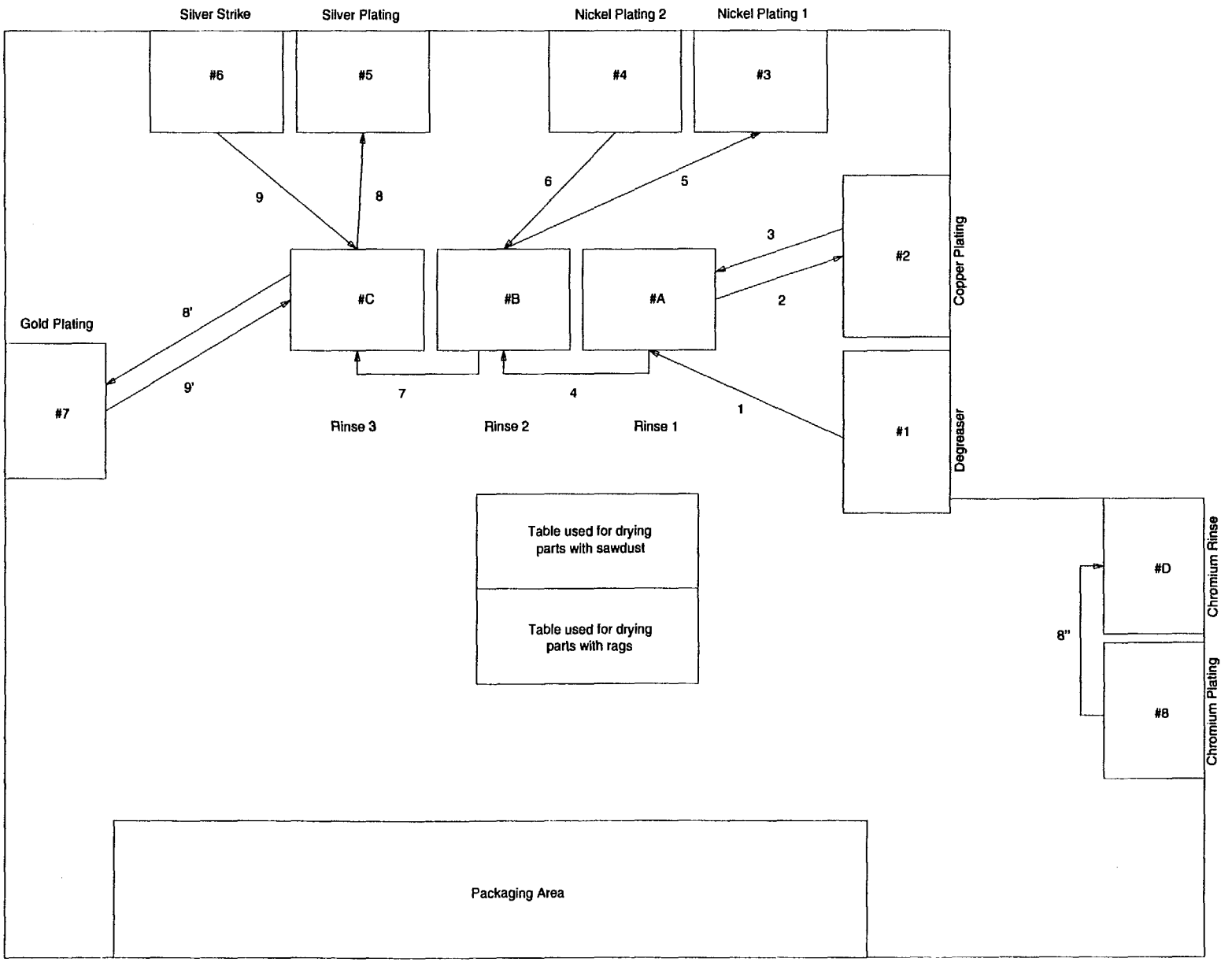
ANNEX C

DIAGRAM OF METAL FINISHING DEPARTMENT LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS

Layout of the metal finishing department at the SODAQ Corporation

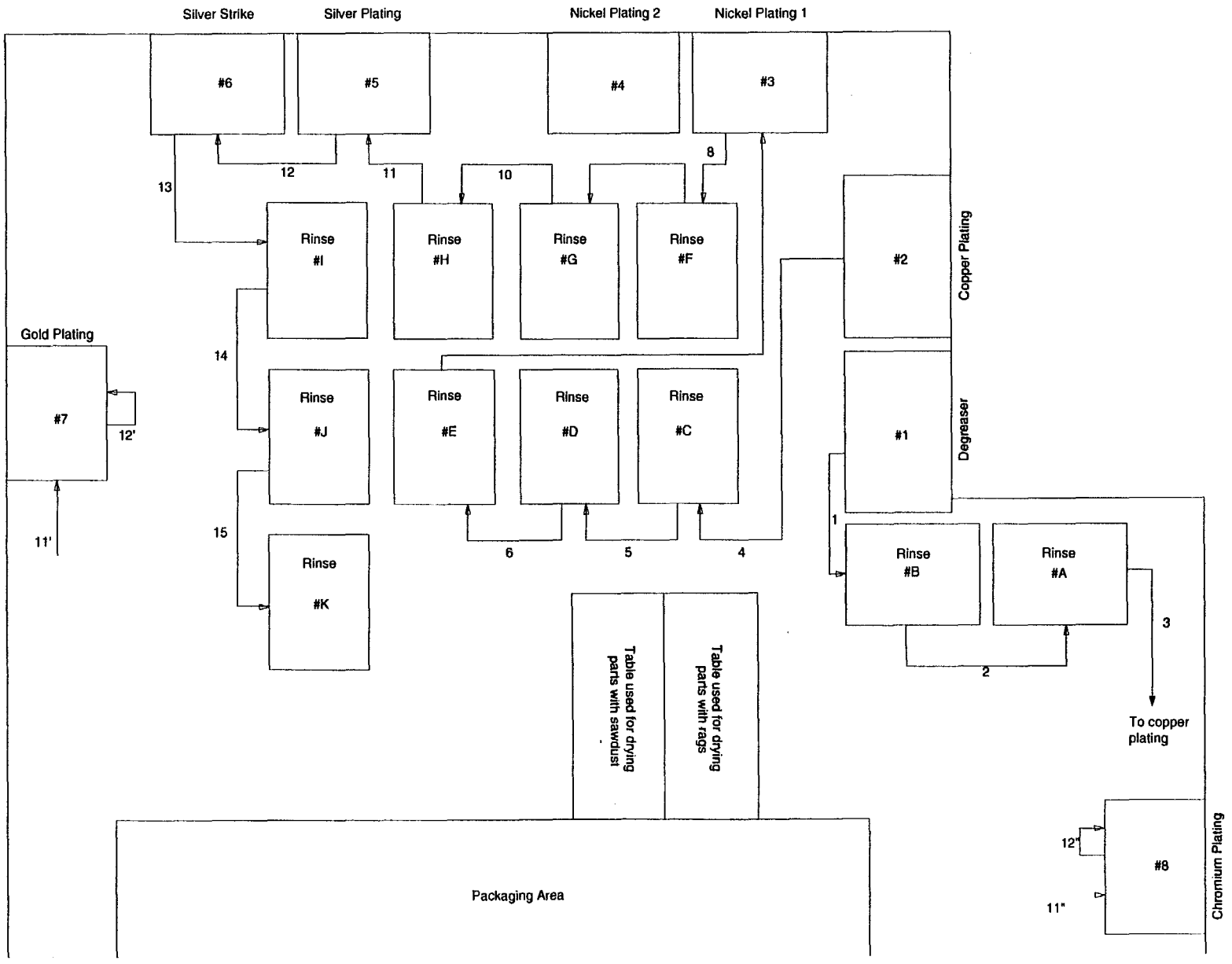


Layout of the metal finishing department at the SODAQ Corporation (Actual Situation)



164

Layout of the metal finishing department at the SODAQ Corporation (As Recommended)



195

ANNEX D

OPERATING EXPENSES

ANNEX D
OPERATING EXPENSES

A. Estimated Total Operating Expenses for the Electrowinning Cell for the Six Projects

59.56 kg of heavy metals, 58.37 kg of which will be recovered (98 percent) at a cost of 65.59 Dh/Kg[1] for a total of approximately 3,830 Dh per year

B. Estimated Total Cost of Electricity Required to Operate the Four Immersion Heaters

- 1.5 Kwh for the copperplating line, or 20 percent of the total
- 1.5 Kwh for the nickelplating line, or 20 percent of the total
- 1.5 Kwh for the silverplating line, or 20 percent of the total
- 3 Kwh for the degreasing bath, or 40 percent of the total

In total, 7.5 Kwh x 10 hours per day x 260 days per year x 1.63 Dh/Kwh = 31,785 Dh per year

C. Estimated Total Cost of Operating the Ion Exchanger for the Six Projects

Rinsewater needed to supply the counterflows:

5.9 liters per hour x 10 hours per day x 260 days per year = 15,340 liters per year

In total, the surface processing department requires 80.3m^3 per year of water for rinsing and makeup water, including losses through evaporation, at a cost of 58m^3,[2] for a total of about 4,657 Dh per year.

---

[1] NCMS and NAMF, "3.5.5.2. Operating Cost of Electrowinning Technology," p. 132 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

[2] NCMS and NAMF, "3.4.5.2. Operating Cost of Ion Exchange Technology," p. 110 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

ANNEX E

BIBLIOGRAPHY

ANNEX E
BIBLIOGRAPHY

ADER, *Etude de faisabilité pour une station de récupération de chrome, d'élimination des métaux lourds et des cyanures et de prétraitement à Ain Nokbi*, ADER, Fès, Morocco, March 1996.

Anderson, Donald F. *Development Document for Effluent Limitations Guidelines and Standards for the Leather Tanning and Finishing Industry*, U.S. Environmental Protection Agency, Effluent Guidelines Division, WH-552, Washington, D.C. November 1982.

GEM Project, *Audit environnemental de la dinanderie argenterie de Fès*, GEM Project, Rabat, Morocco, February 1995.

GEM Project, *Audit environnemental de la tannerie Wad Eddahab*, GEM Project, Rabat, Morocco, February 1995.

Guidebook and directory issue, *Journal of Metal Finishing*, Tarrytown, New York, 1996.

National Center for Manufacturing Sciences and National Association of Metal Finishers, *Pollution Prevention and Control Technology for Plating Operations*, NCMS AND NAMF, Washington, D.C., 1994.

RADDEF, *Plan directeur d'assainissement liquide du grand Fès*, RADDEF, Fès, Morocco, March 1996.

Rinsecalc, special software for optimizing rinse configurations, developed for CAI Engineering, May 1995.

Environmental Audit:
Société de Dinanderie et d'Argenterie
Lala Idouna

By:

Abdelkarim Bennani
Serge Astaud
Saïd Bouanani

October 1996

110

ACKNOWLEDGMENTS

PRIDE and the audit team wish to thank Haj Mokhtar El-Fasiki, managing director of Lala Idouna, and one of the leading metal finishers in Fès, for his support to the PRIDE mission and the hospitality he extended to the team while the environmental audit was being conducted.

In addition, we wish to thank the Ministère de l'Environnement du Maroc, as well as the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement, for their invaluable contribution.

Our special thanks also go to the Lala Idouna employees and associates for their willingness to help with the testing and for the time they spent with the auditor-engineers collecting data and performing the tests.

The following people conducted the audit of the metal finishing facility:

- Abdelkarim Bennani, team leader, Ph.D. in chemical industries and consultant in energy and the environment
- Serge Astaud, international consultant and pollution prevention specialist for the surface treatment industry
- Saïd Bouanani, Ph.D. in chemical engineering and consulting engineer in energy and the environment.

TABLE OF CONTENTS

			Page
EXECUTIVE SUMMARY			i
SECTION I	BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY		
	A.	Introduction to Lala Idouna	I-1
	B.	Brief Description of the Surface Treatment Process	1-1
	C.	Metal Finishing Facility Discharges	I-2
SECTION II	POLLUTION PREVENTION PROJECTS		II-1
	A.	Project N°1. Minimization Nickel-bearing Waste Streams	II-1
	B.	Project N°2. Minimization Silver Cyanide-bearing Waste Streams	II-4
	C.	Project N°3. Minimization of Organic Content of Waste Waters from the Degreasing Process	II-7
SECTION III	RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM		III-1
	A.	Specific Recommendations	III-1
	B.	General Recommendations	III-2
ANNEX A	TABLES ILLUSTRATING THE STAGES OF THE PROCESS		A-1
ANNEX B	TABLE ILLUSTRATING CHARACTERISTICS OF THE BATHS		B-1
ANNEX C	DIAGRAM OF LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS		C-1
ANNEX D	OPERATING EXPENSES		D-1
ANNEX E	BIBLIOGRAPHY		E-1

EXECUTIVE SUMMARY

This report presents the findings of the environmental audit of Société de dinanderie, d'argenterie Lala Idouna, located in the Bin Lemdoun Fès Medina district. Lala Idouna, along with two other metal finishing/silver plating facilities in Fès, was selected to receive technical assistance under PRIDE.

A team composed of Mr. Abdelkarim Bennani and Mr. Saïd Bouanani, domestic consultants, and Mr. Serge Astaud, an international consultant, conducted the audit. They worked in close cooperation with the company's own employees. The on-site work was carried out in two phases: a pre-audit phase on June 17, 1996, and a testing phase on June 18, 1996. The audit helped identify three projects that would minimize the environmental impact of the surface finishing operations. Implementing these projects would allow the company to reduce:

- Its wastewater volume by 50 percent and its water consumption by the same percentage
- The amount of heavy metals in its effluent by 95 percent
- Its toxic discharges (cyanides) by 97 percent

All three projects could be implemented in three stages. The first stage would involve setting up a deionized water production unit in the form of an ion exchanger. The unit would provide rinsewater and makeup water for the plating baths. In the second stage, two electrowinning cells would be installed for recovering heavy metals in the three rinse tanks located where the rinse lines begin after copper plating, nickel plating, and silver plating respectively. One of the electrowinning cells would be used exclusively for recovering nickel ions, while the other would be used for both copper and silver. The final stage would be a reorganization of each of the rinse lines, including a conversion to counterflow rinsing.

The investment for all three projects combined would amount to 138,500 Moroccan Dirham (Dh), with annual operating expenses of 4,668 Dh per year. This investment would allow Lala Idouna to lower the toxicity of its discharges by 97 percent, and it would take 30 years to realize a return on the investment.

In the regional context of the City of Fès, however,it has been demonstrated[1] that, for this kind of private-sector investment, the total internal rate of return would be greater than 8 percent for the Kingdom of Morocco. Moroccan authorities thus are considering investment incentives such as direct funding and tax breaks. Such measures would have an obvious positive impact on the rate of return.

In addition, the management of Lala Idouna should also take the following intangible benefits into consideration:

- Fewer requirements for handling chemicals such as bleach, contaminated rinsewater, and final effluent

[1] Scandiaconsult International AB, *Etude d'impact des rejets industriels sur la qualité des eaux de l'Oued.*

113

- Fewer requirements for storing a variety of chemicals
- Improvement in rinsewater quality, which in turn would stabilize product quality
- Fewer impurities in the copper plating bath
- Less liability associated with discharging wastewater
- Protection from future laws that may be enacted to regulate toxic discharges under the water code
- Compliance with European and American environmental production standards (such as ISO-14000 and ISO-9000), which would guarantee a good position for selling in these markets

The following three tables describe the overall projects and include several additional comments.

Table 1. Overview of Pollution Prevention Projects for Lala Idouna

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
1	Minimization of toxic nickel discharges	Water 98.7 Nickel 96	60,200	4,438	4,600	162
2	Minimization of toxic silver cyanide discharges	Water 99.2 Silver 85 Cyanide 95	54,300	3,651	4,000	349
3	Minimization of organic concentrations of wastewater in the degreasing process	Water 93.4 Cyanide 100	24,000	6,643	10,800	4,157
	Total		138,500	14,732[2]	19,400[3]	4,668

Note: The results illustrated in Table 1. demonstrate that implementing all the projects would generate net annual income of 4,668 Dh; however, the shortest return time on the investment will be realized if only Project 3 is implemented.

Two separate approaches can be used to grasp the sensitivity of the project if the recommendations are only partially implemented. Although the following two approaches generate positive annual cashflow, the return on the investment will be realized 10 times faster with the economic approach than with the environmental approach.

Economic approach. This approach indicates those projects with the best profitability to environmental impact ratio. See Table 2.

---

[2] Detailed information on how the operating expenses were computed appear in Annex D.

[3] Detailed information on how the income was computed appear in each project description.

114

Environmental approach. This approach indicates the projects that provide the best environmental impact to profitability ratio. See Table 3.

It is interesting to note also that a project called 3a could be designed. It would simply entail replacing the cyanide-based degreasing chemical with a cyanide-free bath. This variation of Project 3 would not require any investment and would generate an annual cashflow of 9,300 Dh per year.

It should be noted that the investment figures recommended in the report are based on purchasing the equipment from specialized vendors. Because of the relatively low-technology profile of the recommended equipment, Lala Idouna's engineering department could manufacture some of the equipment, such as the electrowinning cells. This would reduce the total investment figure by about 50,000 Dh and shorten the time it takes to realize a return on the investment of seven years.

It should be mentioned that, as part of the program to move leather tanning firms and metal finishing facilities out of the central medina and into the crafts district of Ain Nokbi under the ADER program, Lala Idouna could benefit from this project's recommendations for designing and building its new production facility. With this in mind, an improvement in the firm's productivity should be part of the profitability of the recommended projects. Moreover, it is important to mention that all the calculations are based on readings and measurements taken on-site, as well as information collected directly from the plant managers.

Table 2. Economic Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
3	Minimization of organic content in the waste water from the degreasing process	Water 93.4 Cyanide 100	9,300	6,643	10,800	4,157
	Total	Water 25.4 Cyanide 97.4	9,300[4]	6,643	10,800	4,157

Note: This approach does not require a supply of de-ionized water.

[4] This figure was decreased by 14,700 Dh to take into account the fact that the ion exchanger has been eliminated from this scenario.

115

Table 3. Environmental Approach

No	Name of project	Environmental impact (% of decrease)	Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cashflow (Dh/year)
2	Minimization of silver cyanide discharge	Water 99.2 Silver 85 Cyanide 95	41,100	3,651	4,000	349
3	Minimization of organic concentrations of wastewater for the degreasing process	Water 93.4 Cyanide 100	36,200	6,643	10,800	4,157
	Total	Water 69.6 Metals 9.7 Cyanide 99.7	107,700	10,294	14,800	4,506

Note: The ion exchanger is included in this scenario as well in order to optimize the amount of time that the metal recovery cycles last before it is necessary to drain the first rinse basin after silverplating.

116

SECTION I

BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY

SECTION I
BRIEF DESCRIPTION OF THE METAL FINISHING FACILITY

A. Introduction to Lala Idouna

Lala Idouna is a corporation founded in 1987. The company is a low-voltage power customer with 11 employees and covered facilities with an area of 100 m^2. It specializes in making household items and decorative products using silver plating and gold plating. Initially, the company handled all stages of production. However, for some time and due to market-related difficulties, Lala Idouna has restricted its work to subcontracting surface treatment operations. Lala Idouna subcontracts an average of more than 750 workpieces per day of different shapes and sizes such as teapots, trays, etc. This amounts to an equivalent of 60 m^2 of raw material (brass sheets, bars and tubing) per day. The company is open for business from Saturday through Thursday. Normal working hours are from 8 a.m. to 1 p.m. and from 3 p.m. to 6 p.m., which amounts to 8 hours per day and 200 days per year.

Lala Idouna obtains its power and water from the RADEEF system. The company consumes about 29,000 kWh of electricity per year, at a cost of 30,000 Dh including tax, and 1,291 m^3 of water per year, at a cost of 12,000 Moroccan Dirham (Dh).

B. Brief Description of the Surface Treatment Process

Degreasing. When received, the workpieces are hung on hooks and dipped in a basal electrolytic solution of sodium cyanide (71.5 g/l), mineral alkali (28.6 g/l) and caustic soda (71.5 g/l). The workpieces are dipped for a given amount of time (10 minutes) to remove all the grease and prepare them for the next stage: nickel plating. Direct voltage with 200 amps and 5.5 volts passes through the solution which is completely replaced every 192 hours of work, or every 24 days.

Rinsing. The workpieces are removed from the degreasing tank and then rinsed in a series of two flowing rinse tanks of 500 liters each, in capacity. The rinsewater flow rate is intermittent.

Nickel plating. Nickel plating is done in either of three tanks with a volume of 700 liters of solution each. These acidic solutions (pH=5.2, which is considered high compared to common industry practices), are comprised of nickel sulfate (400 g/l), nickel chloride (86 g/l), and boric acid (17 g/l). The purpose of boric acid is to produce and maintain acid pH somewhere between 3.5 and 4.5. Four nickel anodes in each tank, in which the $NiCl_2$ provides passivity, carry the electrical current required for nickel plating. Additives are regularly used in the solution makeup, such as brighteners to enhance finish, leveling agents to ensure even deposit thickness, and wetting agents to minimize internal stress by reducing solution viscosity.

It takes about 10 minutes for the items to be treated. The solution is heated to 80°C. This seems high compared to the industry standard of 44-66°C. Different makeup salts are added every 82 hours (12 days) at the rate of 25 kg for nickel sulfate, 3 kg for nickel chloride (6 for the small tank), and 3 kg for boric acid. All the nickel anodes are replaced for both baths at the rate of 1,100 kg per year. A 105 amp current with 4 volts passes between the solution and the items to be treated.

Rinsing. The items are removed from the nickel plating tank and then rinsed off in a series of two flowing rinse tanks of 500 liters each, in capacity. The second rinse also serves as silver rinse tank, which causes partial oxidation of the cyanides. The baths are replaced using continuous makeup water on a relatively constant basis.

Silver strike. Silver plating takes place in a 700 liter bath that contains a solution of silver cyanide (21.4 g/l) and potassium cyanide (457 g/l). The process takes roughly one minute. Silver brightener is also added to the solution. Two kg of silver cyanide and 24 kg of potassium cyanide are added after every 192 hours or 24 days. A 50-amp, 6-volt current circulates between the solution and the workpieces to be treated. Lala Idouna does not use silver anodes; the metal available for electrodeposition is provided by the silver cyanide salt found in solution in the process tank .

Rinsing. The workpieces are removed from the silver plating tank. They are then rinsed off in the rinse tank also used for the second nickel plating rinse.

Drying. All workpieces are dried with sawdust[1]. They are then inspected again and polished with whiting and then dried by compressed air. The amount of sawdust and whiting used is 4 kg and 8 kg per day respectively.

Solution filtering. Lala Idouna uses a mobile solution filtering system. It is applied successively to each process bath in an effort to remove impurities, thereby extending the bath's service life. Impurities pathways can be classified as follows:

- Metallic structures. These can be minimized by preventing splashes from the tank.
- Anode quality. The nickel anodes should be pure.
- Addition of dirt. This can be curtailed by improving rinsing.
- Makeup water containing high levels of dissolved salts. Use deionized water.
- Airborne particles falling in the tank. Use tank lids when not operating.

C. Metal Finishing Facility Discharges

The use of toxic chemicals in the metal finishing department, causes Lala Idouna's final wastewater effluent to contain a dilute concentration of hazardous chemicals. Wastewaters are discharged in the Oued Boughrareb which itself discharges in the Wed Sebou. The Oued Boughrareb is a medium-size river that flows through the Medina. No waste treatment or water reuse method is being used. Bath preparation is made utilizing simple weight and volume measurement methods, and bath make up needs are based upon pH readings and occasional chemical analyses performed by the vendors. No laboratory equipment or facilities are available in-house. Annual chemical usage figures are not readily available.

[1]The sawdust is bought from local wood working shops.

119

C1. Liquid Effluent

Amounts. According to our estimates[2], Lala Idouna uses 1,122 m^3 of water per year broken down as follows:

Uses		m^3/year
Surface treatment		
Rinsing		591
Makeup solution		8
Bath evaporation		10
	Subtotal	**610**
Cleaning		227
Supply water		0
Other		286
	Total	**1,122**

The most heavily polluted discharges of water are rinsewater, amounting to 591 m^3 per year. This represents about 53 percent of the total volume discharged.

Contaminants. The contaminants are primarily heavy metals such as Cu, Ni, Ag and Au, and cyanides. These contaminants are dragged out as salts by the rinse operations. According to our estimates[3], Lala Idouna would appear to discharge the following quantities in kg per year:

Contaminants		kg/year
Heavy metals		
Nickel		14
Silver		1.5
	Total	**15.5**
Cyanides		385

C2. Solid Waste

Solid waste is comprised of the following materials:

- Sawdust used for drying the items during polishing and surface treatment. The sawdust is contaminated with oils and hydrocarbons from the polishing process and the rinse waters from the metal finishing operation. Approximately 4 kg of this type of waste is generated per day. The sawdust waste is subsequently disposed off in a public landfill.

---

[2]Flow rate estimations were made by measuring the time it took to fill a known volume with the water stream.

[3]These estimates are derived from TDS measurements that have been validated or corrected by laboratory analytical results.

- Whiting powder, used to improve surface finish after polishing and to dry parts after plating, is contaminated with oils and hydrocarbons (from polishing) and with rinse water (from plating). Approximately 8 kg of this waste is generated per day. The resulting waste is subsequently disposed off in a public landfill.

- Towels used for polishing and finishing the items are also disposed off in a public landfill.

C3. Exhaust

Atmospheric releases containing cyanide-based emanations are generated by the degreasing process tank when current is applied. An wall fan is used to extract the fumes outside the building. For the other process baths containing dissolved metal salts, the hydrogen and oxygen evolving at the cathode and anode respectively, do not entrap a significant mist requiring air emission control equipment.

121

SECTION II

POLLUTION PREVENTION PROJECTS

SECTION II
POLLUTION PREVENTION PROJECTS

A. Project N°1. Minimization of Toxic Nickel Discharges

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	98.7	60,200	4,438	4,600	162
Nickel	96				

A1. Recommendations

- Install a de-ionized water production unit for makeup water for the rinse tanks and the nickel bath.
- Install a counterflow rinse system comprised of four rinse tanks, one of which already exists.
- Install an immersion heater in the first rinse tank to evaporate the excess water from the counterflow.
- Install a metal reinforcing structure to maintain the integrity of the first PVC rinse tank that will be heated to a temperature of 50°C.
- Install an electrowinning cell to recover the nickel ions in nontoxic metallic form.

A2. Description

The nickel plating process is comprised of two tanks filled with a continuous supply of water and the water is drained by an overflow opening. The second rinse tank after nickel plating is also used for the first rinse tank after silver plating. City water is used to provide makeup water for the bath and the rinse tanks; this in turn generates a degree of contamination that cannot be controlled.

The nickel bath appears to be kept at an acceptable level of contamination by "drag-out" since the nickel solution is removed with the workpieces as they are taken out of the bath. It has never been necessary to replace the nickel bath since Lala Idouna was founded. Both nickel baths are heated to 80°C and are equipped with anti-evaporation balls.

The current arrangement for the rinsing operations is not optimal for recovering metal ions using an electrowinning cell. In addition, and in an attempt to recover and use the metals, we recommend complete separation of the rinse circuits after silver plating and nickel plating.

A3. Projected Income

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 150 m^3 or 98.7 percent.
- On an annual basis, 13.5 kg of nickel will be recovered out of the 15 kg generated by the rinse line, or 96 percent.

The combined income for this nickel plating operation amounts to 4,600 Dh per year, broken down as follows:

- 1,500 Dh for water based on 10 Dh per m^3
- 3,100 Dh for recovered copper based on 17 Dh per kg Ni

A4. Operating Expenses

The proportion of the total operating expenses originating from the installed equipment for this line may be estimated at 4,438 Dh per year on the following basis:

- 3,090 Dh per year to improve evaporation in the first rinse tank, or 25 percent of the total cost of the electricity for the three immersion heaters
- 885 Dh per year for an electrowinning cell (13.5 kg of nickel at 65.59 Dh per kg)
- 463 Dh per year for the de-ionized water supply, or 33 percent of the total operating expenses for the ion exchanger

A5. Investment

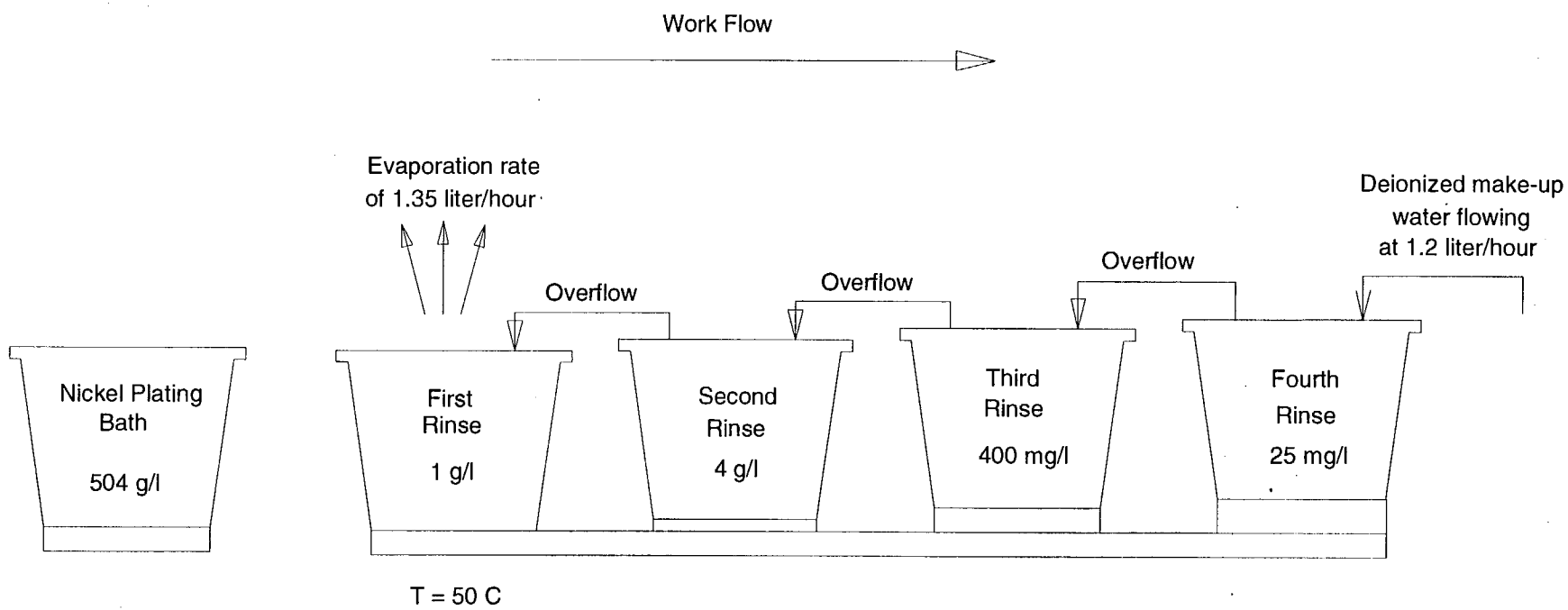
Total investment, estimated at 67,500 Dh, is broken down as follows:

- 26,400 Dh, or 50 percent of the total purchase price of the electrowinning cell
- 22,000 Dh, or 50 percent of the total purchase price of the ion exchanger
- 4,400 Dh for the immersion heater
- 1,500 Dh to raise and reinforce the tanks
- 13,200 Dh to purchase and use the additional tanks

A6. Data and Calculations

See the tables in Annexes A, B, C, and D.

LALA IDOUNA Project No 1: Counterflowing rinse after nickel plating



Note: The above-mentioned values were generated using a mathematic model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

B. Project N°2. Minimization of Toxic Silver Cyanide Discharges

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	99.2				
Silver	85	54,300	3,651	4,000	349
Cyanide	95				

B1. Recommendations

- Install a de-ionized water production unit for makeup water for the rinse tanks and the silver plating bath.
- Install a counterflowing rinse system comprised of four rinse tanks, two of which already exist.
- Install an electrowinning cell to recover the silver ions in nontoxic metal form.
- Install an immersion heater in the first rinse tank to evaporate the excess water from the counterflow.
- Install a metal reinforcement structure to maintain the integrity of the first PVC rinse tank which will be heated to a temperature of 50°C.

B2. Description

The silver plating process is set up in a manner similar to nickel plating. However, a single rinse tank is used with continuous flow and an overflow opening. After silver plating, this rinse tank is also used for the second rinse for the stage prior to nickel plating. City water provides the makeup water for the bath and the rinse tanks; this in turn generates a degree of contamination that cannot be controlled.

The silver bath is also kept at an acceptable level of contamination by "drag-out" as described above. It has not been necessary to replace it since Lala Idouna was founded. The current rinse arrangement is not optimal for recovering metal ions using an electrowinning cell. Moreover, we recommend complete separation of the rinse circuits after silver plating and after nickel plating.

B3. Projected Income

The above mentioned equipment will help generate the following savings:

- Annual water consumption for this process will be reduced by 270 m^3 or 99.2 percent.
- 1.36 kg out of the 1.6 kg of silver or 85 percent generated by this line will be recovered.

- 9.5 kg out of the 10 kg of cyanide or 95 percent generated by this line will be recovered.

All the income combined for the copper plating operation amounts to 21,180 Dh per year and is broken down as follows:

- 2,700 Dh of water based on 10 Dh per m^3
- 1,300 Dh of silver recovered based on 1,000 Dh per kg Ag

B4. Operating Expenses

The proportion of the total operating expenses originating from the installed equipment for this line may be estimated at 3,651 Dh per year on the following basis:

- 3,090 Dh per year to improve evaporation in the first rinse tank, or 25 percent of the total cost of the electricity for the three immersion heaters
- 98 Dh per year for the electrowinning cell, or 1.5 kg of silver at 65.59 Dh per kg
- 463 Dh per year for the de-ionized water supply, or 33 percent of the total cost of operating the ion exchanger

B5. Investment

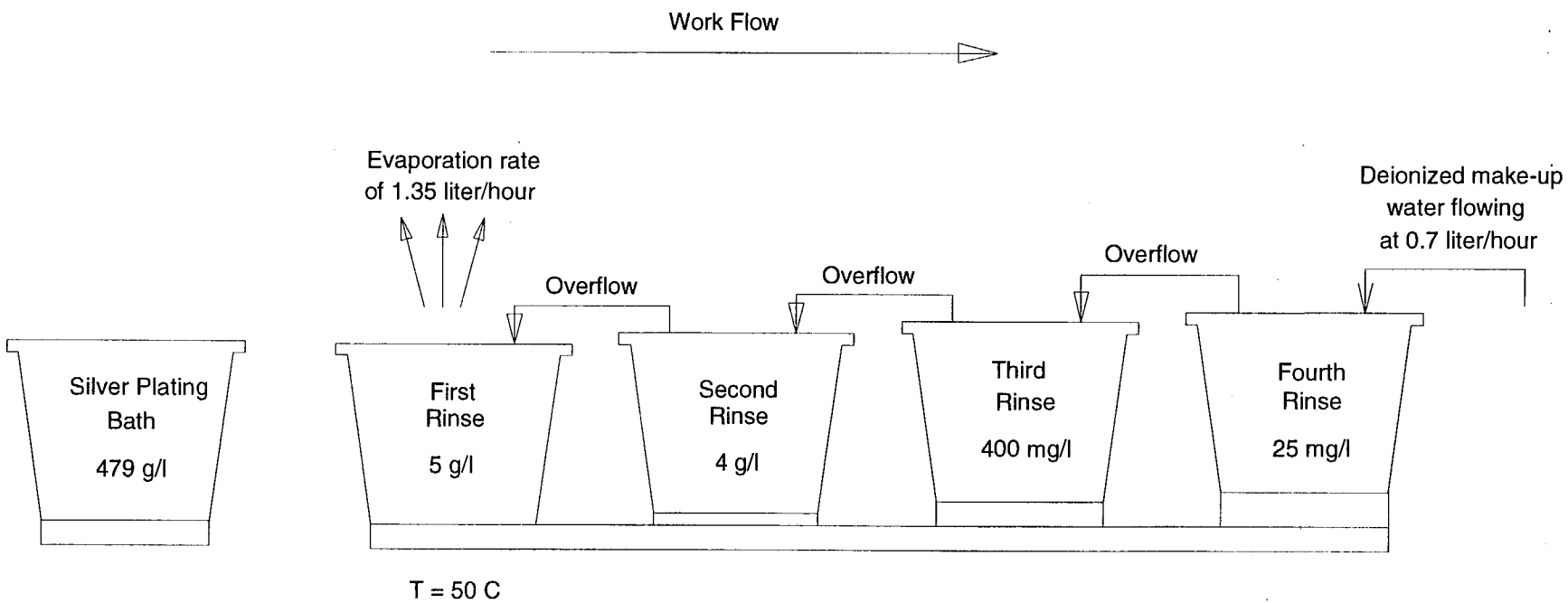
The total investment is estimated at 57,200 Dh

- 26,400 Dh for purchasing an electrowinning cell
- 22,000 Dh which amounts to 50 percent of the total cost of purchasing the ion exchanger
- 8,800 Dh to purchase two additional rinse tanks
- 4,400 Dh for the immersion heater

B6. Data and Calculations

See the tables in Annexes A, B, C, and D.

LALA IDOUNA Project No 2: Counterflowing rinse after silver plating



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This concentration is reached when the electrowinning cell operates continuously.

C. Project N°4. Minimization of Organic Concentrations of Wastewater Discharged from the Degreasing Process

Environmental impact (% of decrease)		Investment (Dh)	Operating expenses (Dh/year)	Projected gross income (Dh/year)	Projected cash flow (Dh/year)
Water	93.4				
Cyanide	100	24,000	6,643	10,800	4,157

C1. Recommendations

- Install a de-ionized water production unit for the makeup water for the rinse tanks, for preparing the degreasing tank and for makeup water for the same tank.
- Install a counterflow rinse system comprised of three additional rinse tanks that includes the degreasing tank (two of the tanks already exist).
- Install an immersion heater to raise the temperature of the degreasing bath to 45°C to evaporate the makeup water required for the counterflow rinse.
- Eliminate the chemicals currently used and instead use a cyanide-free solution.

C2. Description

The degreasing process is set up in a manner similar to the stages for nickel plating and silver plating. The process is comprised of two rinse tanks. Water is supplied continuously and it is constantly drained by an overflow opening. City water is used to provide makeup water; this in turn generates a degree of contamination that cannot be controlled.

As opposed to the other surface treatment baths, the degreasing bath is not kept at an acceptable level of contamination due to its nature. Therefore, it is replaced periodically after every 120 hours of operation.

For this project we recommend using a cyanide-free degreasing agent and a counterflow rinse that even includes the degreasing bath. This bath should be kept at a temperature of 45°C to remove the rinse water that it takes in by evaporation (see the counterflow rinse diagram). Furthermore, the cyanide-free solution will rid the degreasing operation from the potential risk of cyaniric gas emanations in the workplace.

C3. Projected Income

The above mentioned equipment will help save 155 m^3 of water per year, or 93.4 percent. In addition, replacing the current degreasing agent with a cyanide-free product would generate income of about 9,300 Dh per year and would eliminate all of the 357 kg of cyanide released every year in the final effluent, plus the cyanide released in the atmosphere. The total estimated savings for the degreasing operation would be 10,800 Dh per year broken down as follows:

- 1,500 Dh per year of water based on 10 Dh per m^3
- 9,300 Dh per year, which is the difference between the current and recommended degreasing cost.

The use of de-ionized water for make-up, combined with a counterflowing rinse system, may substantially increase the service life of the degreasing bath. If this holds true, a 10 percent increase in the service life of the bath would generate savings of 1,650 Dh per year. For the purposes of this study, this assumption will not be evaluated at this point, since this would have to be tested over an extended period of time to be accurately quantified.

C4. Operating Expenses

The proportion of the total operating expenses originating from the installed equipment for this line may be estimated at 6,643 Dh per year on the following basis:

- 6,180 Dh per year to increase evaporation in the degreasing bath, which is the same as 50 percent of the total cost of the electricity for the three immersion heaters
- No cost for the electrowinning cell since no suspended metal is generated in the rinse water
- 463 Dh per year for the de-ionized water supply, or 33 percent of the total operating expenses of the ion exchanger

C5. Investment

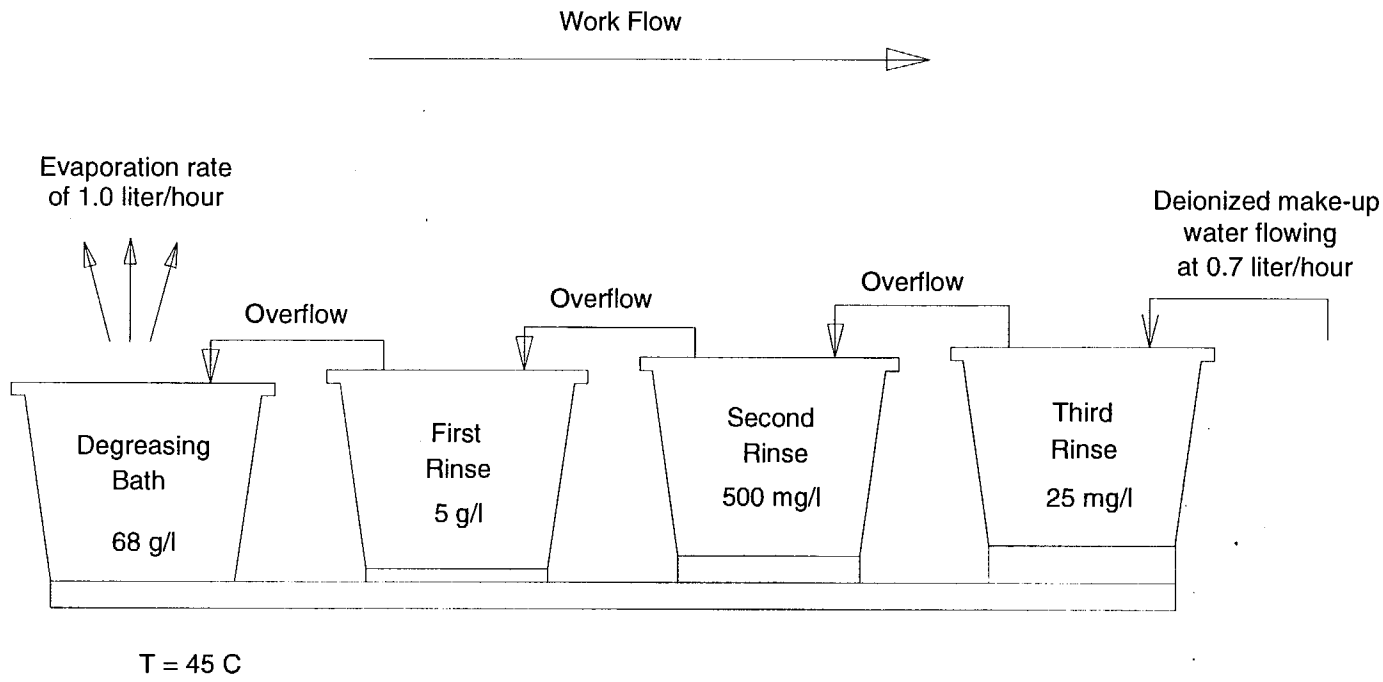
The total investment is estimated at 24,000 Dh, broken down as follows:

- 14,700 Dh, amounting to one-third of the total purchase price of an ion exchanger
- 4,400 Dh for purchasing an immersion heater
- 500 Dh in costs for rearranging the rinse tanks
- 4,400 for the additional rinse tanks.

C6. Data and Calculations

See the tables in Annexes A, B, C, and D.

LALA IDOUNA Project No 3: Counterflowing rinse after degreasing



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.

SECTION III

RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

SECTION III
RECOMMENDATIONS FOR A SUCCESSFUL POLLUTION PREVENTION PROGRAM

A. Specific Recommendations

- For safety, ensure that safety glasses are worn and that an eyewash station is available to those workers on the plating lines.

- After cleaning the plastic containers in which the different toxic salts are kept, dispose of the containers, by sending them back to the vendor of the chemistry for recycling.

- Minimize compressed air leaks by inspecting the circuit on a daily basis and replacing the defective parts as necessary.

- Clean by scraping the different media and hooks used in the process frequently to reduce the amount of impurities that enter the different baths to lengthen the service life of the baths as much as possible.

- Coat the immersion hooks with plating-resist to prevent product loss through unwanted plating. Such products as plastisols can be used.

- In the different baths, such as nickel and silver, only use truly demineralized, de-ionized or distilled water. Bottled water sold as demineralized water, such as water for batteries, is often if not always heavily laden with mineral salts which are a source of introducing impurities into the tanks.

- Reuse several times the sawdust used to dry the workpieces after natural drying on terraces or vacant land near the facility if available. It appears that the contamination level is low enough to tolerate repeated uses.

- Check and inspect the different parameters, such as exposure time, chemical concentrations in the baths, temperature and current strength. For this purpose, testing equipment should be available, such as thermometers, ammeters and timers with audible alarms. A small space should also be set aside to conduct chemical analyses of the baths.

- Adjust current strength to the type of workpiece to be treated to optimize productivity. The thickness of the deposit on the metal depends on current strength and exposure time. Performing the surface treatment based solely on the time parameter, as is done in the metal finishing facility we audited, may result in excessively high or low production quality. This remark is especially applicable as the surface to be treated is changed.

  For example, when working with current strength of 5 amps/dm^2, the thickness of the nickel deposit increases by 0.001 mm per minute. That means that after 10 minutes, the nickel deposit thickness will be 0.01 mm. Yet, the same deposit quality may be achieved in six minutes with current strength of 8 amps/dm^2.

133

B. General Recommendations

- Conduct employee awareness training on pollution prevention.
- Develop a pollution prevention strategy in the form of a procedures manual including precise written guidelines defining:
  - An inventory method for all chemicals in use.
  - The restricted handling of chemicals by a limited number of qualified employees.
  - A program of periodical analyses of the baths.
  - Record-keeping method for bath analyses and makeup water.
  - A written procedure for makeup sequences.
  - Methods to optimize the service life of the treatment baths.
  - The frequency of regular inspections of the baths to remove workpieces that accidentally fell into the bath.
  - Preventive maintenance schedule for the tanks.
  - The alarm system used to protect against tank overflow.
  - The installed leak detection systems.
  - Workpiece inspection methods prior to plating.

ANNEX A

TABLES ILLUSTRATING THE STAGES OF THE PROCESS

La Dinanderie et Argenterie Lala Idouna
Annex A: Process Stages

	Data	Units	Makeup	Units
Stage 1: Degreasing				
Replace bath completely every	120	Hours		
Tank Dimensions:				
Width	0.71	m		
Length	1.4	m		
Depth	0.7	m		
Total solution volume	700	l		
Caustic soda	50	kg		
Sodium cyanide	50	kg		
Mineral alkali	20	kg		
KW	0	kg		
Water	580	l		
Concentration	17	Baumé		
Degreasing time	2	mn		
Stage 2: Rinse				
Number of rinse tanks for degreasing	2	Tanks		
Tank No. 1 Dimensions				
Width	0.76	m		
Length	1	m		
Depth	0.66	m		
Total solution volume	500	l		
Tank No. 2 Dimensions				
Width	0.76	m		
Length	1	m		
Depth	0.66	m		
Total solution volume	500	l		

136

	Data	Units	Makeup	Units
Stage 3: Nickel Plating				
Number of tanks for nickel plating	3	Tanks		
Tank No. 1 dimensions				
Width	0.73	m		
Length	1.2	m		
Depth	0.8	m		
Total solution volume	700	l		
Nickel sulfate	280	kg	1.67	kg/day
Nickel chloride	60	kg	0.53	kg/day
Boric acid	12	kg	0.27	kg/day
Brightener	ND	l	0.50	l/week
Leveler	ND	l	0.50	l/week
Wetting agent	ND	l	0.50	l/week
Nickel anodes	4	Anodes	ND	ND
Water	348	l		
Nickel plating time	4	mn		
Electric heating	80	°C		
Concentration	27	Baumé		
Tank No. 2 dimensions				
Width	0.73	m		
Length	1.2	m		
Depth	0.8	m		
Total solution volume	700	l		
Nickel sulfate	280	kg	1.7	kg/day
Nickel chloride	60	kg	0.53	kg/day
Boric acid	12	kg	0.27	kg/day
Brightener	ND	l	0.5	l/week
Leveler	ND	l	0.5	l/week
Wetting agent	ND	l	0.5	l/week
Nickel anodes	4	Anodes	ND	ND
Water	348	l		
Nickel plating time	4	mn		
Electric heating	80	°C		
Concentration	27	Baumé		

	Data	Units	Makeup	Units
Tank No. 3 dimension				
Width	0.73	m		
Length	1.2	m		
Depth	0.8	m		
Total solution volume	700	l		
Nickel sulfate	280	kg	2	kg/day
Nickel chloride	60	kg	0.5	kg/day
Boric acid	12	kg	0.3	kg/day
Brightener (DE 3)	ND	kg	0.01	kg/week
Leveler	ND	l	0.01	l/week
Wetting agent	ND	l	0.02	l/week
Nickel anodes	4	Anodes	ND	ND
Water	348	l		
Nickel plating time	4	mn		
Electric heating	80	°C		
Concentration	27	Baumé		
Stage 4: Rinse				
Number of tanks for nickelplating	2	Tanks		
Tank No. 1 dimensions				
Width	0.76	m		
Length	1	m		
Depth	0.66	m		
Total solution volume	500	l		
Tank No. 2 dimensions				
Width	0.76	m		
Length	1	m		
Depth	0.66	m		
Total solution volume	500	l		

	Data	Units	Makeup	Units
Stage 5: Silverstrike				
Number of tanks for silverstrike	1	Tank		
Tank dimensions				
Width	0.75	m		
Length	1.3	m		
Depth	0.72	m		
Total solution volume	700	l		
Silver cyanide	15	kg	2	kg/month
Potassium cyanide	320	kg	24	kg/month
Brightener	0	l	ND	ND
Silver anodes	ND	Anodes	ND	ND
Water	365	l		
Strike time	1	mn		
Concentration	18	Baumé		
Stage 6: Rinse				
Number of tanks for rinse	1	Tank		
Tank No. 1 dimensions				
Width	0.76	m		
Length	1	m		
Depth	0.66	m		
Total solution volume	500	l		
Stage 7: Drying - Polishing				
Mechanical drying				
Wood waste	30	kg/day		
Polishing powder	20	kg/day		
Pneumatic drying				
Compressed airjet	ND	ND		

139

ANNEX B

TABLE ILLUSTRATING CHARACTERISTICS OF THE BATHS

LALA IDOUNA, Fes, Morocccco

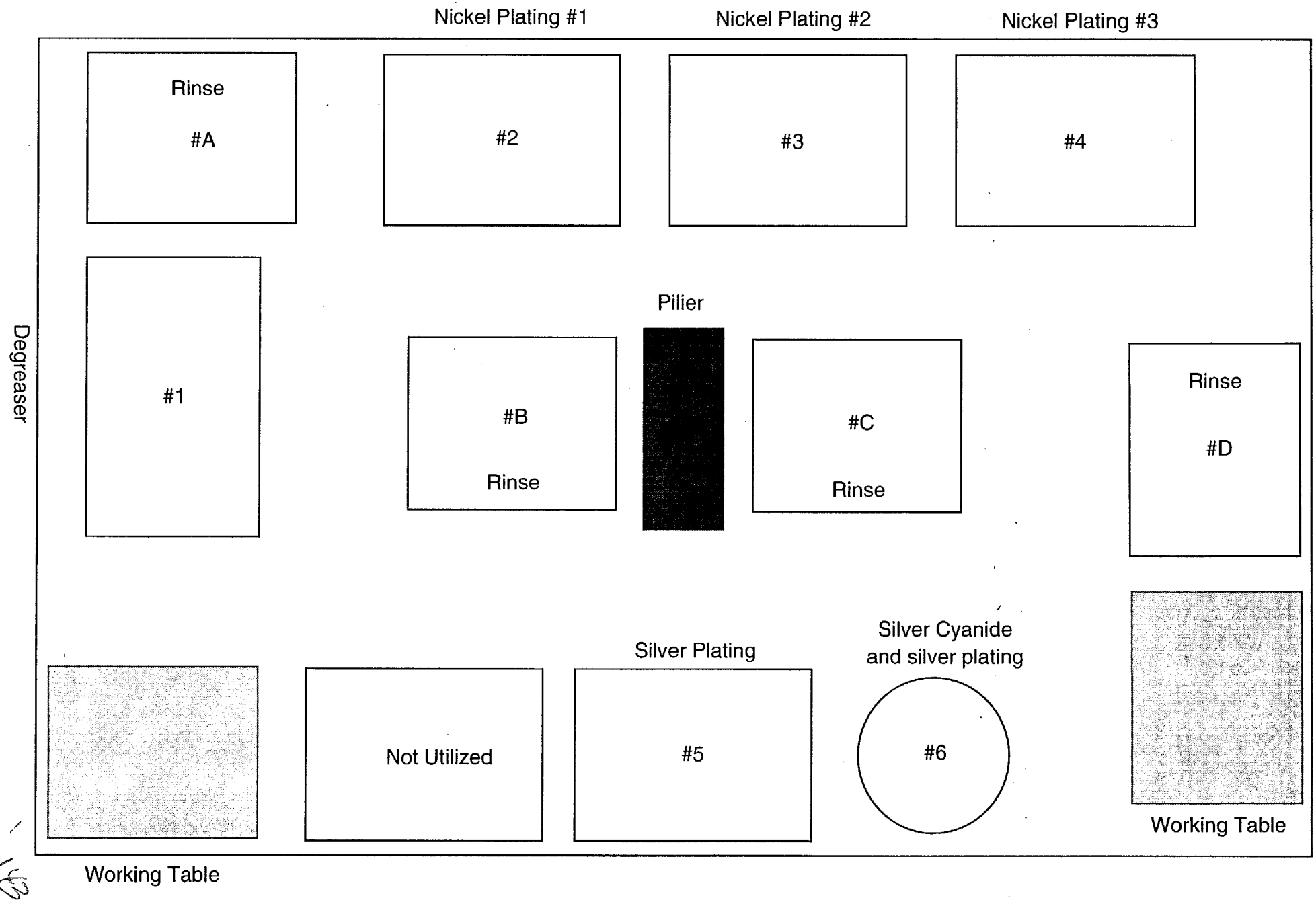
Annex B: Bath Features

Tank reference	Bath description	Features Temperature	TDS in mg/l	pH	Position in cycle	Length of cycle	TDH end of cycle mg/l	Metal as % of cycle	Mass/Cycle Cations in grams	CN in grams	Annual Weight Kg (metal)	Annual Weight Kg (CNI)	Annual Volume Litres	Solution Drag-out in l/cycle
1	Degreasing	A	171917	11						26499.90		353.33	9333	
A	Rinse 1		1160	10.7	1.00	6	740			81.48		20.72	127170	0.64
B	Rinse 2		520	8.4	1.00	20	100			11.01		0.87	39331	0.28
	Total						740			26592.39		374.92	166501	
2	Nickelplating 1	80	503392	5.1				21.93%	Ni					
C	Rinse 1		830	7.7	1.00	5	410		44.96		13.72		152604	
D	Rinse 2		590	8.9	1.00	3	9		0.93		0.51		272507	
3	Nickelplating 2	80	503392	5.4				21.93%	Ni					
C	Rinse 1		830	7.7	1.00	5	410				0.00			
D	Rinse 2		590	8.9	1.00	3	9				0.00			
3	Nickelplating 2	80	503392	5				21.93%	Ni					
C	Rinse 1		830	7.7	1.00	5	410				0.00			
D	Rinse 2		590	8.9	1.00	3	9				0.00			
	Total						209				14.23		425111	
4	Silverplating	A	478957	11.5				3.60%	Ag	CN				
D	Rinse 1		590	8.9	1.00	3	162		2.91	31.53	1.58	9.69		0.07
	Total						162			31.53	1.58	9.69	0	
	Total											385	591612	650.11

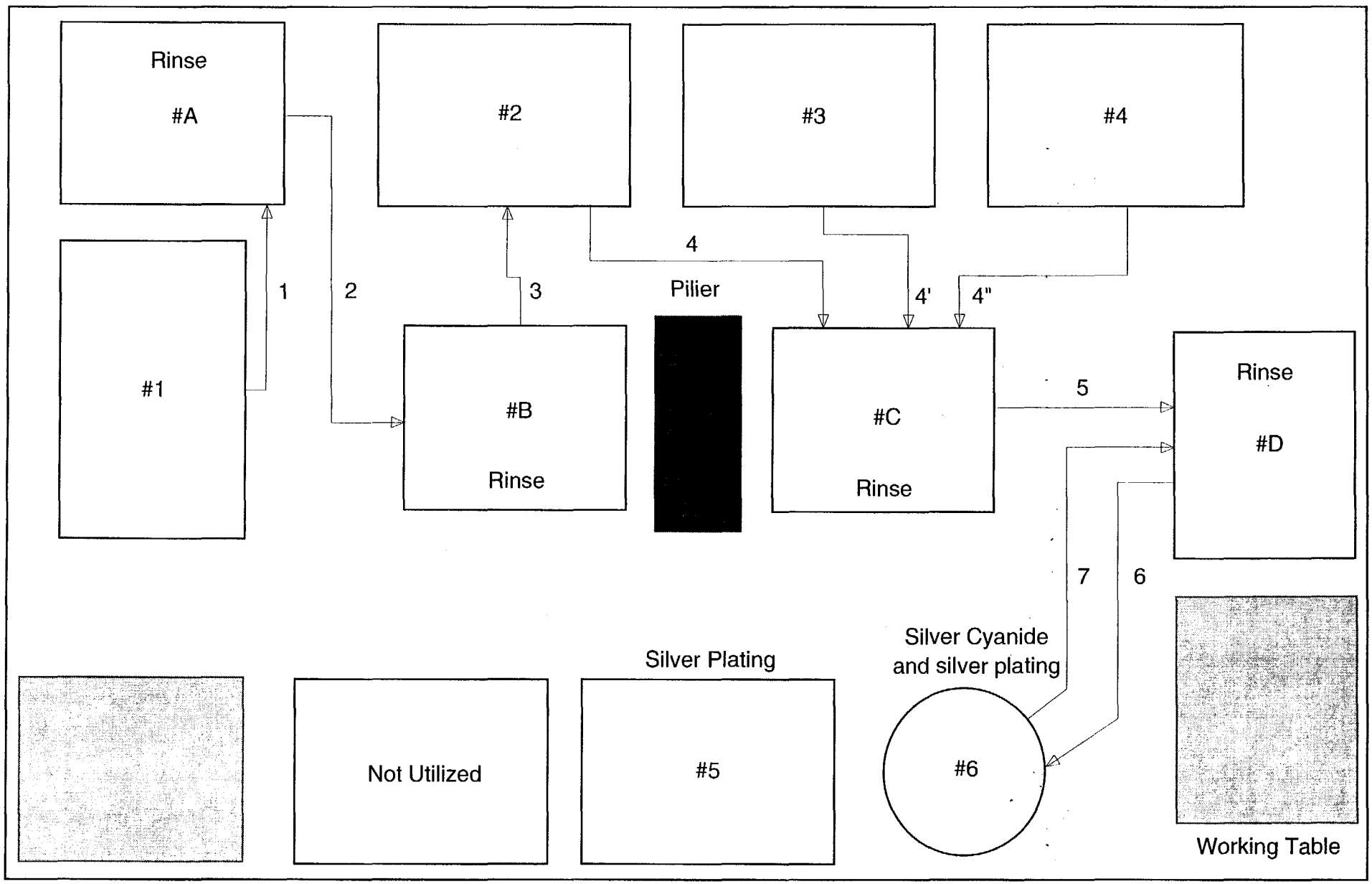
ANNEX C

DIAGRAM OF LAYOUT PLUS ACTUAL AND RECOMMENDED WORKFLOWS FOR TANKS AND CIRCUITS

Layout of the metal finishing department at the LALA IDOUNA Corporation



Layout of the metal finishing department at the LALA IDOUNA Corporation (Actual Situation)

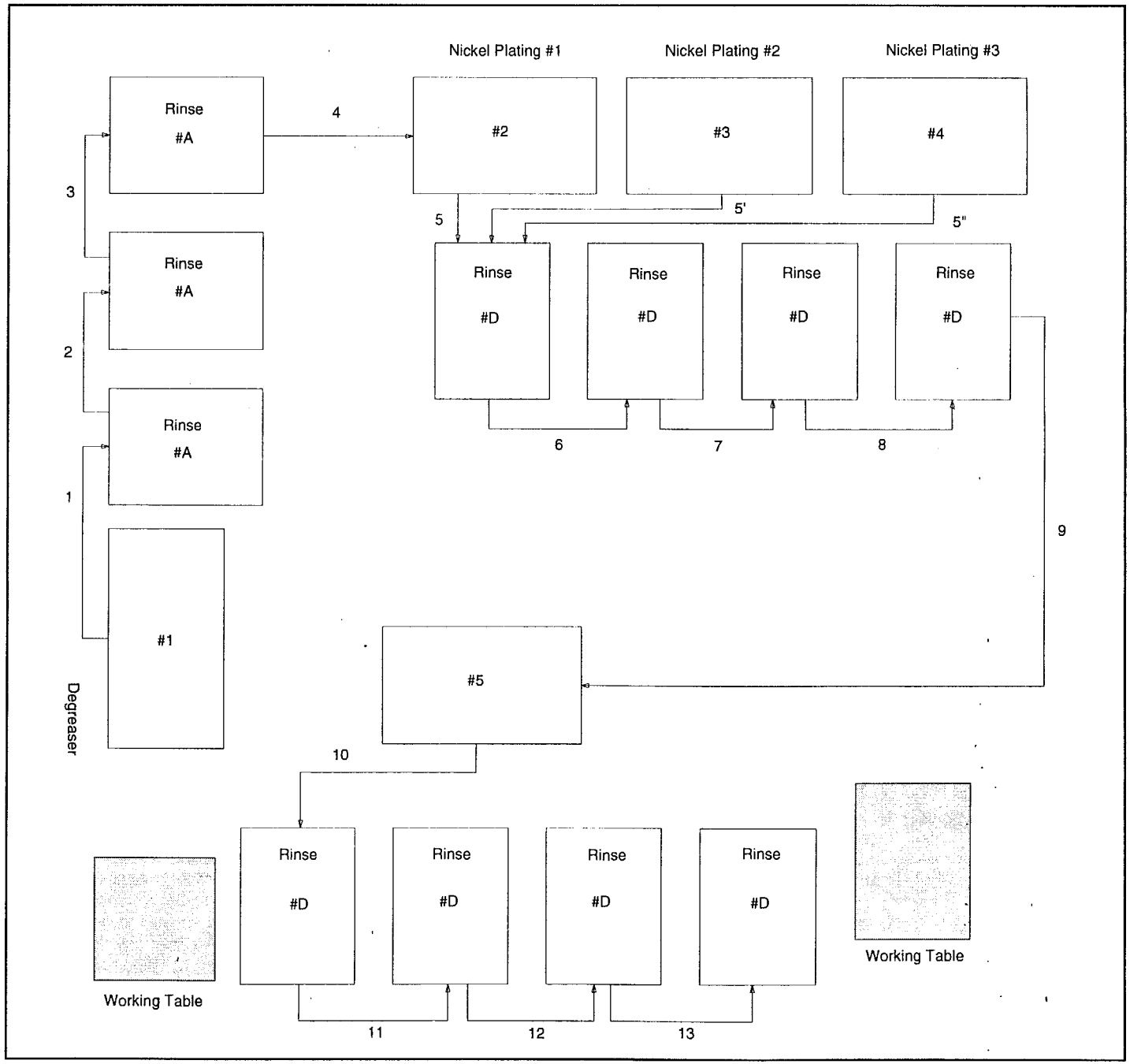


Degreaser

C-2

Working Table

Workflow of the metal finishing department at the LALA IDOUNA Corporation (As Recommended)



145

ANNEX D

OPERATING EXPENSES

ANNEX D
OPERATING EXPENSES

A. Estimated Total Operating Expenses for the Electrowinning Cell for the Six Pollution Prevention Projects

15.5 kg of heavy metals, 14.725 kg of which will be recovered (95 percent) at a total cost of 65.59 Dh/Kg[1] for a total of approximately 966 Dh per year

B. Estimated Total Cost of Electricity Required to Operate the Four Immersion Heaters

- 1.5 Kwh for the copperplating line, or 25 percent of the total
- 1.5 Kwh for the nickelplating line, or 25 percent of the total
- 3 Kwh for the degreasing bath, or 50 percent of the total

In total, 6 Kwh x 10 hours per day x 200 days per year x 1.03 Dh/Kwh = 12,360 Dh per year

C. Estimated Total Cost of Operating the Ion Exchanger for the 6 Projects

Rinsewater needed to supply the counterflows:

3.1 liters per hour x 10 hours per day x 200 days per year = 6,200 liters per year

In total, the surface processing department requires 24.2 m^3 per year of water for rinsing and makeup water, including losses through evaporation, at a cost of 58 m^3 [2], for a total of about 1,404 Dh per year.

---

[1] NCMS and NAMF, "3.5.5.2. Operating Cost of Electrowinning Technology," p. 132 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

[2] NCMS and NAMF, "3.4.5.2. Operating Cost of Ion Exchange Technology," p. 110 in *Pollution Prevention and Control Technology for Plating Operations*, 1994.

147

ANNEX E

BIBLIOGRAPHY

ANNEX E
BIBLIOGRAPHY

ADER, *Etude de faisabilité pour une station de récupération de chrome, d'élimination des métaux lourds et des cyanures et de prétraitement à Ain Nokbi*, ADER, Fès, Morocco, March 1996.

Anderson, Donald F. *Development Document for Effluent Limitations Guidelines and Standards for the Leather Tanning and Finishing Industry*, U.S. Environmental Protection Agency, Effluent Guidelines Division, WH-552, Washington, D.C. November 1982.

GEM Project, *Audit environnemental de la dinanderie argenterie de Fès*, GEM Project, Rabat, Morocco, February 1995.

GEM Project, *Audit environnemental de la tannerie Wad Eddahab*, GEM Project, Rabat, Morocco, February 1995.

Guidebook and directory issue, *Journal of Metal Finishing*, Tarrytown, New York, 1996.

National Center for Manufacturing Sciences and National Association of Metal Finishers, *Pollution Prevention and Control Technology for Plating Operations*, NCMS AND NAMF, Washington, D.C., 1994.

RADDEF, *Plan directeur d'assainissement liquide du grand Fès*, RADDEF, Fès, Morocco, March 1996.

Rinsecalc, special software for optimizing rinse configurations, developed for CAI Engineering, May 1995.

Environmental Audit: Tannerie Saïs

By:

Abdelkarim Bennani
Serge Astaud
Saïd Bouanani

October 1996

150

ACKNOWLEDGMENTS

PRIDE and the audit team wish to thank Mr. Berrada, managing director of Tannerie Saïs, for the hospitality he extended to the team and the assistance he provided during the environmental audit.

In addition, we would like to express our special gratitude to the Moroccan Ministry of the Environment and to the team at the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement, without whom, it would not have been possible to complete this report.

We also wish to thank all the employees and associates for their willingness to help with the testing and for the time they spent with the auditor-engineers collecting data and performing the tests.

The audit of the tanning facility was conducted by:

- Abdelkarim Bennani, team leader, a Ph.D. in chemical industries and consultant in energy and the environment.
- Serge Astaud, international consultant and pollution prevention specialist for the surface treatment industry.
- Saïd Bouanani, a Ph.D. in chemical engineering and consulting engineer in energy and the environment.

TABLE OF CONTENTS

		Pages
EXECUTIVE SUMMARY		i
SECTION I	BRIEF DESCRIPTION OF THE TANNING FACILITY	I-1
	A. Introduction to Tannerie Saïs	I-1
	B. Brief Description of the Leather Production Process	I-1
SECTION II	POLLUTION PREVENTION PROJECTS	II-1
	A. Project N°1. Minimization of Water Use during Soaking	II-1
	B. Project N°2. Sodium Sulfide Recovery from the Liming/ Re-liming Operation	II-2
	C. Project N°3. Optimization of Chromium Fixation	II-3
	D. Project N°4. Chromium Recovery via Direct Recycling	II-4
	E. Project N°5. Separation of Acid and Alkaline Effluent	II-5
SECTION III	ENVIRONMENTAL ASSESSMENT AND RECOMMENDATIONS	III-1
	A. Water Consumption Evaluation and Recommendations	III-1
	B. Wastewater Pollutant Evaluation	III-2
	C. Other Recommendations	III-2
ANNEX A	TANNERIE SAÏS PROJECTS	A-1
ANNEX B	WATER CONSUMPTION FOR THE STAGES OF THE TANNERIE SAÏS PROCESS	B-1
ANNEX C	RESULTS OF EFFLUENT ANALYSES	C-1
ANNEX D	DIAGRAM FOR CHROMIUM RECOVERY VIA PRECIPITATION	D-1
ANNEX E	TANNERIE SAÏS INVENTORY LISTING	E-1

152

EXECUTIVE SUMMARY

This report presents the findings of the environmental audit of Tannerie Saïs, which was selected to receive technical assistance under PRIDE. A team composed of Mr. Abdelkarim Bennani and Mr. Saïd Bouanani, domestic consultants, and Mr. Serge Astaud, an international consultant, conducted the audit. They worked in close cooperation with the company's employees. On-site work was carried out in two phases: a pre-audit phase on June 19, 1996, and a testing phase on June 20 and 21, 1996.

The audit identified five projects to reduce losses of chemicals. Income realized from these projects would amount to 528,000 Dh (Moroccan Dirham) per year, from an investment of 81,000 Dh. It would take two months to realize a return on the investment (see the following table).

In addition, implementing these projects would enable the tanning facility to reduce:

- Chromium discharges by 86 percent
- Sulfide and lime discharges by 33 percent
- Wastewater volume by 26 percent and water consumption by the same amount, which could be lowered from 60 l/kg of rawhide to 43 l/kg.

Tannerie Saïs uses water from a well located on plant premises, and thus the operators are not as sensitive to the need for conserving water as they might be without this convenient water source. During the course of the audit, the Moroccan government enacted a Water Act[1], which stipulates that a parafiscal tax will be levied on water use and discharge. Consequently, the cost has been estimated at 10 Dh/m^3.

This audit report of Tannerie Saïs was conducted in the unusual economic context of 1996, at a time when the leather tanning industry in Morocco was being temporarily affected by the following conditions:

- In terms of precipitation, 1996 has been an unusual year. As a result, pasture grasses have tended to develop more thorns, which in turn has hurt the average quality of animal hides for this year.

- The precipitation has improved farm yields, thereby giving animal breeders an incentive to hold on to their herds instead of sending them to slaughter.

- Customs inspection programs have resulted in fewer hides being imported.

Under these unusual circumstances, the entire tanning industry has scaled back considerably its hide production programs for 1996. In light of these factors and for the purposes of this study, the team considered that Tannerie Saïs operates 300 days a year.

[1]Dahir #1-95-154 du 16 Août 1995.

153

Calculations made to determine income were based on the readings and tests performed on-site, as well as information collected from the plant managers.

Table 1. List of Tannerie Saïs Projects

No.	Name of project	Type of savings	Value in income Dh/year	Invest-ment Dh	Return time (months)	Environmental impact		
						Chrome %	Sulfur %	Volume %
1	Minimization of water use during soaking	Water	314,000	7,000	Immediate			26
2	Sodium sulfide recovery	Sulfur+lime	156,000	20,000	1.5	36	33	
3	Optimization of chromium fixation	Cr sulfate	24,000	12,000	6	50		
4	Direct chromium recycling	Cr sulfate	34,000	12,100	5			
5	Separation of effluent	Prevention		30,000				
TOTAL			528,000	81,100	12.5	86	33	26

154

SECTION I

BRIEF DESCRIPTION OF THE TANNING FACILITY

SECTION I
BRIEF DESCRIPTION OF THE TANNING FACILITY

A. Introduction to Tannerie Saïs

Founded in 1990, Tannerie Saïs is located in the Dokkarat industrial park in Fès. The facility occupies 1,100 m^2 with covered premises of 1,600 m^2. The installed capacity is 160 kVA, and the facility has from 20 to 60 employees depending on the season. In terms of treatment, installed capacity for this tanning facility is 2,700 hides per day; however, on the average it only treats 1,500 hides per day during a 300-day year. Hides are bought from domestic slaughter houses and a portion of them will be exported in Italy. It still remains one of the largest tanneries in the area and uses 130,000 kWh of power per year at a cost of 173,000 Dh (Moroccan Dirham), including tax. Tannerie Saïs has a well and a water tower that meet all of the facility's water requirements. Water consumption is not metered, but the audit team estimated that the facility consumes roughly 126,000 m^3 of water per year[1]. The portion of the hide-related solid waste generated by Tannery Saïs was estimated to be approximately 1.5 Kg per hide, on average. This amounts to 675,000 Kg annually, and represents 25 percent of the initial weight of the hides purchased. The facility also uses 15 tons of wood per year for heating the process water.

B. Brief Description of the Leather Production Process

B1. Soaking and Unhairing

Tannerie Saïs treats around 1,500 sheepskins a day. When they arrive, the skins are soaked in water for 24 hours to eliminate mud, blood, preservative salts, and water-soluble proteins. The skins are initially washed in running water for three hours with a flow of 10 m^3 per hour. Then they are washed again individually for four hours with a flow rate of 25 m^3 per hour. Next, they are split and trimmed down before the lime paste is applied on the flesh side (the lime paste is a mixture of lime and sodium sulfide.) The paste is made up in 120-liter drums using the following proportions: sodium sulfide 5 kg and lime 50 kg. One drum contains enough paste to apply to 100 hides.

The alkaline paste is applied to the skins to open up the fiber structure, which in turn makes it easier to pull out the wool. The process, called alkaline swelling, also swells the skin and makes it more flexible. During this process, the skins, at times, may become twice as thick as they were originally. The process takes four hours and then the wool is pulled out.

The wool is recovered after washing and then sold for various uses, in particular by small-scale industries that make mattresses and rugs. Washing the wool consumes around 80 m^3 per day of water for an initial batch of 1,000 skins.

Once the wool has been pulled out, the skins are then placed in an agitated rinse tank that contain 40 kg of lime for every 500 hides to be treated. This process occurs overnight and takes about 10 hours; the purpose is to ensure that the skins swell evenly.

---

[1]Flow rate estimations have been made by measuring the time it took to fill a known volume with the water stream.

156

B2. Fleshing

This operation is mechanical and is done on fleshing machines. The process consists of scraping the flesh side of the skins by removing the tissue and fat that still adhere to them.

B3. Deliming

Deliming is the first stage of preparation for tanning. First the skins are weighed, then they are placed in the drum to wash off the lime. After washing, the residual lime is dissolved again and neutralized. This eliminates any possible interference with the subsequent tanning stages. The operation takes 30 minutes. Ammonium sulfate is applied using the proportion of 3 kg for every 100 kg of hide (hereinafter referred to as 3 percent). Following neutralization, the skins revert back to their initial thickness.

B4. Bating

Enzymes are added to the previous bath (0.7 percent bate and 1 percent degreasing agent). These products eliminate all remaining hair and damaged proteins using a catalytic mechanism that destroys the links formed by the double chemical bonds characteristic of amino acid chains. The solution is drained away after 30 minutes of treatment and the skins are washed under running water until the bath runs clear. This washing process takes about two hours.

B5. Pickling

Pickling takes place using the following solutions: sodium salt (10 percent), formic acid (0.8 percent, diluted to 10 percent) and sulfuric acid (0.8 percent diluted to 10 percent). Pickling gives the skin the acidity needed (pH=2.8) to prevent subsequent precipitation of the chromium salts on the skin fibers. Pickling, the final operation in preparation for tanning, also sterilizes the skins.

B6. Tanning

Tanning stabilizes the skin's collagen structure by adding chromium sulfate (8 percent). This operation takes place in the same bath and usually lasts five hours. The next step is the basification of the bath by adding sodium bicarbonate and carbonate (1.2 percent). Three hours later, the drums are drained. Then the skins are placed in piles and left to sit for 48 hours. Tannerie Saïs, does not utilize a chrome recovery process, but manages to obtain a rate of 85 percent of chromium fixation.

B7. Wringing

After tanning, mechanical operations are performed on the skins that even out the uneven surface of the material. This operation also removes excess moisture.

B8. Retanning

The skins are then returned to the drum where they are washed under running water before retanning. Several chemicals are added in succession to the same bath: 0.3 percent formic acid diluted to 10 percent, 0.3 percent degreasing agent, and tannin comprised of

157

3 percent chromium sulfate, 2 percent acrylic resin, 1 percent bicarbonate, and 0.5 percent sodium formate for masking. This operation is carried out at a temperature of 35°C. Retanning makes the skin "full" and gives it the appearance of leather.

B9. Dying and Finishing

After tanning, the skins are washed under running water and then with hot water (50°C). Next, synthetic or vegetable oils and dyes are added. This stage is followed by lubrication to correct the dye and retanning using resins if any special features are required. Finally, the skins are washed, rinsed, and arranged in piles. Then they are dried outside before a number of mechanical operations that give the leather as much flat surface and flexibility as possible. These stages are staking, stretching, and blocking. Surface treatments entail applying pigments by spraying them on the leather. The final coating uses cellulose nitrate lacquer.

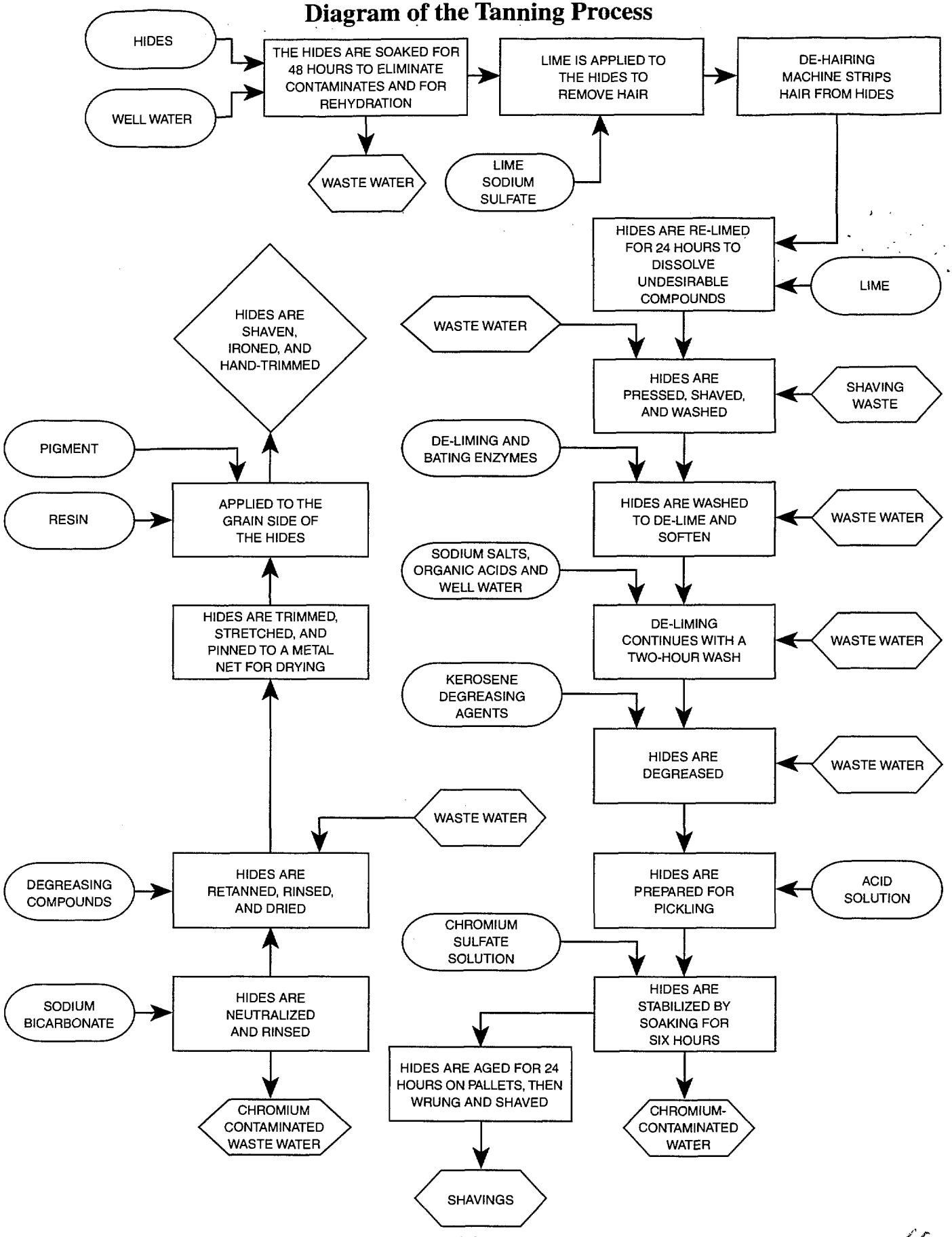
B10. Quality Control, Surface Measurement, and Shipping

In this stage, the different skins are sorted based on shades of color, feel, appearance, and other parameters. A mechanical device measures the surface area, and that figure is written on the skin.

Operations typical of the tanning procedure are presented in a diagram of tanning operations.

158

Diagram of the Tanning Process



159

SECTION II

POLLUTION PREVENTION PROJECTS

SECTION II
POLLUTION PREVENTION PROJECTS

A. Project N°1. Minimization of Water Use during Soaking

Project Summary	
Water Savings	314,000 Dh per year
Installation cost	7,000 Dh
Return time	Immediate

A1. Recommendations

- Use pressurized water for filling the soaking baths.
- For washing, use a high-pressure low-flow jet system.
- Replace continuous washing with 15-minute batches.

A2. Description

Hide washing alone accounts for over 50 percent of the tannery's total water consumption. Rawhides are very dirty and, to a very great extent, the quality of the leather depends on how well the skins are cleaned. At Tannerie Saïs, the skins are washed individually under a water jet flowing at 25 m^3 per hour. At this flow rate, the water is used as a mechanical method of stripping as opposed to washing. This explains why we are recommending the use of taps equipped with flow restrictors. A pressure booster should be installed on the taps to provide a high-pressure jet.

A3. Projected Income

Projected income for this project is estimated at 31,400 m^3 per year, which represents a 314,000 Dh per year, income, based on a unit cost of 10 Dh per m^3 of water.

A4. Investment

The investment, estimated at 7,000 Dh, is for purchasing and installing a water pressure booster and a set of spigots.

A5. Return Information

Return time is immediate.

A6. Data and Calculations

Calculations were made based on readings taken during the audit. A summary of the results of the calculations appears in Annex A.

Project No. 1
Minimization of Water Use During Soaking

Amount of water per 100 hides	m3	139.89
Amount of water used for washing wool per 1,000 hides	m3	76.30
Percentage of reduction due to soaking	%	0.50
Number of hides treated per year	peaux	450000.00
Water saved per year	**m3/year**	**31475**
	Dh/year	**314746**
New tannery water use ratio	**L/Kg**	**42.78**
Investment (booster and restrictors)	**Dh**	**7000.00**
Return time	**Month**	**Immediate**

162

B. Project N°2. Sodium Sulfide Recovery from the Liming/reliming Operation

Project Summary	
Sodium Sulfide savings	156,500 Dh per year
Installation cost	20,000 Dh
Return time	1.5 months

B1. Recommendation

Recover a portion of the liming liquors, process them, and re-use them for preparing the lime paste.

B2. Description

After the hair has been pulled out by hand, a sodium sulfide paste is applied to the hides, and the lime is placed in tanks filled with water. The hides stay in the tanks overnight. They are then removed, and the liquor is drained into the sewer. According to our estimates, the liquor content, after filtering, is as follows: 14 g/l of sodium sulfide and 134 g/l of lime. This explains why it is worthwhile to use it again for preparing the lime paste. The amounts that can be recovered (3.2 m^3 per cycle) are greater than the volume required for preparing the paste (1.2 m^3). This means that not all of the effluent is used. According our calculations, 33 percent of the sodium sulfide and lime are recovered. This operation takes place in an intermediate storage tank with a 1-mm mesh filter and a transfer pump (see the diagram of tanning operations in Section I). The system described in Project N°5 may also be used for this project.

B3. Projected Income

The savings from this project amount to approximately 7,636 tons of sodium sulfide per year, 72,447 tons of lime per year, and 540 m^3 of water per year, amounting to a 156,500 Dh per year income.

B4. Investment

The investment, estimated at 20,000 Dh, is primarily comprised of an intermediate storage tank, a filter, a transfer pump, and their installation.

B5. Return Information

Gross return time is 1.5 months.

B6. Risk

Reusing the sulfide liquor may have an effect on the swelling ability of the leather. It is possible that a swelling loss of up to 4-5 percent may occur from using this process.

B7. Data and Calculations

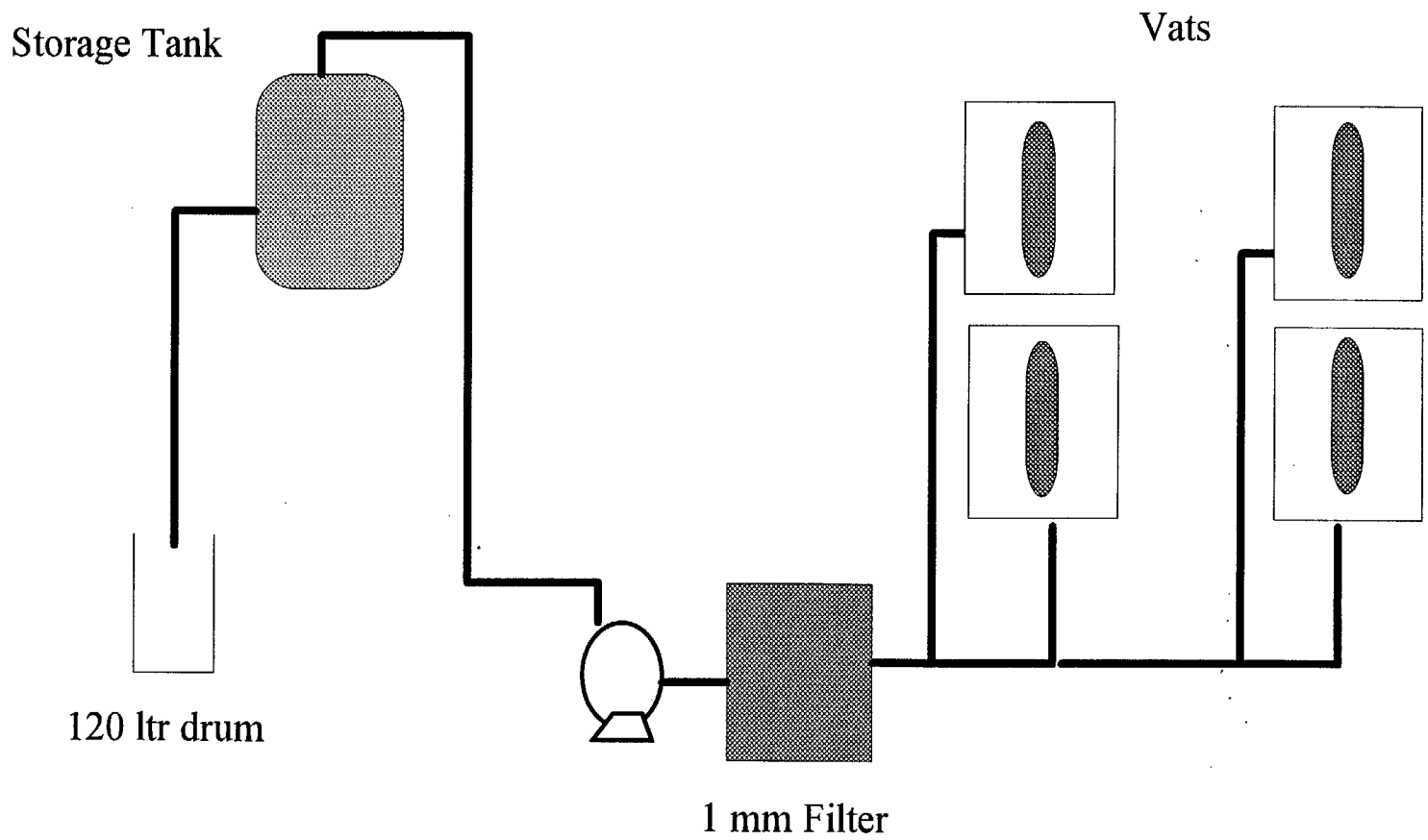
Calculations based on readings from the audit appear in summary form in Annex A.

163

Project No. 2 **Sodium Sulfide Recovery**		
Amount of sodium sulfide per 1,000 hides	Kg	50
Sodium sulfide concentration in the paste	g/l	41.6667
Amount of lime per 1,000 hides	Kg	480
Lime concentration in the base	g/l	400
Volume of wastewater from the liming bath per 1,000 hides	m3	6.44
Solution recovery rate		0.5
Volume of solution that may be recovered	m3/cycle	3.22
Total sulfur recovery rate		0.9
Total lime recovery rate		0.9
Amount of sulfur that may be recovered per 1,000 hides	kg	45
Amount of lime that may be recovered per 1,000 hides	kg	432
Sulfur concentration in the liming bath	g/l	7.76398
Lime concentration in the liming bath	g/l	74.5342
Sulfur concentration in the filtration	g/l	13.9752
Lime concentration in the filtration	g/l	134.161
Amount reused	m3	1.2
Amount of sulfur reused	Kg	16.7702
Amount of lime reused	Kg	160.994
Net sulfur recovery rate	%	0.3354
Net lime recovery rate	%	0.3354
Annual sulfur consumed	Tons	22.5
Annual lime consumed	Tons	216
Annual savings in sulfur	Dh/year	64146
Annual savings in lime	Dh/year	86937
Water saved	Dh/year	5400
Total saved	Dh/year	**156483**
Investment	**Dh**	**20000**
Return time	**Month**	**1.5**

164

Sodium Sulfate Recovery
Tannerie Saïs



165

C. Project N°3. Optimization of Chromium Fixation

Project Summary	
Chromium savings	24,000 Dh/year
Installation cost	12,000 Dh
Return time	6 months
Reduction of chromium in discharges	36 percent

C1. Recommendations

Improve chromium fixation by implementing the following:

- Fill the drums to the maximum level.
- Heat the water in the drums and keep the bath at a temperature of about 35°C.
- Lengthen tanning time as much as possible.
- Use a more accurate instrument to test pH.

C2. Description

The measurements taken on a sample of the tanning liquor removed during the audit, analyzed by the Laboratoire National d'Etudes et de Surveillance de la Pollution et des Nuisances du Ministère de l'Environnement du Maroc, showed Cr concentration of 4,660 ppm. According to our calculations (see table on page II-8), this concentration yields an 82 percent chromium fixation rate. Although this yield is satisfactory compared to what we generally observed in other tanneries in Fès, an 88 percent fixation rate can be achieved using the above mentioned recommendations. By exercising rigorous control over the process, a number of tanneries throughout the world reach chromium fixation rates of about 90 percent for hides.

Currently, at Tannerie Saïs, tanning is performed using a self-basifying chromium sulfide. This explains the acceptable fixation rate value. We did note, however, that tanning is performed at a temperature of about 25°C (measured during the audit), that the amounts of water used are not measured, and that pH is measured using a color indicator.

To implement our recommendations, Tannerie Saïs will need to equip the drums with temperature- and pH-measuring devices and with a water meter, in particular.

C3. Projected Income

Income from this project stands at 24,000 Dh per year, resulting in savings of 2.280 tons of chromium sulfide. Process testing will also generate savings in the other salts and chemicals used, but these figures are difficult to project. The environmental impact of this project is significant because the chromium discharged from the facility will be reduced by 36 percent.

C4. Investment

The total investment, estimated at 12,000 Dh, will be used for purchasing measuring devices.

166

C5. Return Information

Gross return time is 6 months.

C6. Data and Calculations

Calculations based on readings from the audit appear in summary form in Annex A.

Project No. 3
Optimization of Chromium Fixation

Chromium Fixation		
Chromium charge per cycle (1,000 hides)		
Tanning compound charge	120	kg Cr2(SO4)3
Charge of hides per cycle	1,500	kg hide
Charge of compound per 100 kg of hide	8	kg Cr2(SO4)3/100 kg hide
Molecular weight of compound	392	g/mole
Molecular weight of chromium	104	g/mole
Percentage of chromium in weight	26.5%	
Chromium charge per cycle	**31.8**	**kg Cr/cycle**
Chromium discharged in tanning water		
Chromium - laboratory concentration	4,660	mg Cr/L
Amount of wastewater per cycle	1,200	Liiters
Total chromium discharged per cycle	5,592,000	mg
Total chromium discharged per cycle	5.59	kg

Fixated Chromium	**26.23**	**kg/cycle**
	82%	

SAVINGS		
Chromium savings		
New percentage of chromium fixation	88%	
New amount of chromium	29.8	kg Cr/cycle
New amout of tannning compound	112.4	kg/cycle
Tanning compound saved	7.6	kg/cycle
Compound cost	10.5	Dh/kg
Savings per cycle	80	Dh/cycle
Number of cycles per year	300	
Annual Savings	**23,934**	***Dh/year***

INVESTMENTS		
Projects:		
Heat to a temperature of 35 C		
Fill the foulon to its maximum level		
Lengthen tanning time		
Use a more accurate instrument to test for pH		
Investment	***12,000***	***Dh/year***

Return Time	***6***	***Months***

D. Project N°4. Chromium Recovery via Direct Recycling

Project Summary	
Chromium savings	34,000 Dh per year
Installation cost	12,000 Dh
Return time	5 months
Reduction of chromium in discharges	50 percent

D1. Recommendation

Recover the chromium liquors after tanning, process them, and re-use them for tanning.

D2. Description

Once the recommendations for the previous project are implemented, 1,200 liters of solution will be obtained containing 11.24 g/l of chromium sulfate. We recommend reusing this liquor after adjusting the Cr salt concentration to 63 g/l for retanning. This operation will be performed with an intermediate storage tank and a transfer pump (see the diagram of tanning operations in Section I).

D3. Projected Income

Projected savings under this project amount to around 3.237 tons of chromium sulfide per year, which in turn amounts to 34,000 Dh per year.

The overall impact on the environment of this and the preceding projects, are quite significant, since they lower the facility's chromium sulfate discharge by 86 percent. Such a reduction would translate in a total annual discharge of chromium metal of 858 Kg. This improvement would be a first step toward meeting the requirements set forth through the environmental objectives prescribed by the Stratégie Nationale pour la Protection de l'Environnement et le Développement Durable[2]. The Stratégie recommends stabilizing the amount of chromium discharged by the leather tanning industry at its 1992 national average of 300Kg/year per tanning facility. Such objective is to be met by 2005. A second effort can then take place, aiming at reducing by 43% the chromium content of the industry's wastewaters, in any single facility, by year 2020.

D4. Investment

The investment is estimated at 12,100 Dh. This figure basically includes one intermediate storage tank, one transfer pump, and the installation of both pieces of equipment.

D5. Return Information

Gross return time is 5 months.

---

[2]Projet PNUD/UNESCO: Mor./90/001

D6. Risk

The risk for this project is based on the proportion of the different components of the tanning solutions which may vary; and therefore, we recommend conducting tests and adjusting the concentration of chemicals as the recovered effluent is used.

D7. Data and Calculations

Calculations based on readings from the audit appear in summary form in Annex A.

Project No. 4
Direct Chromium Recycling

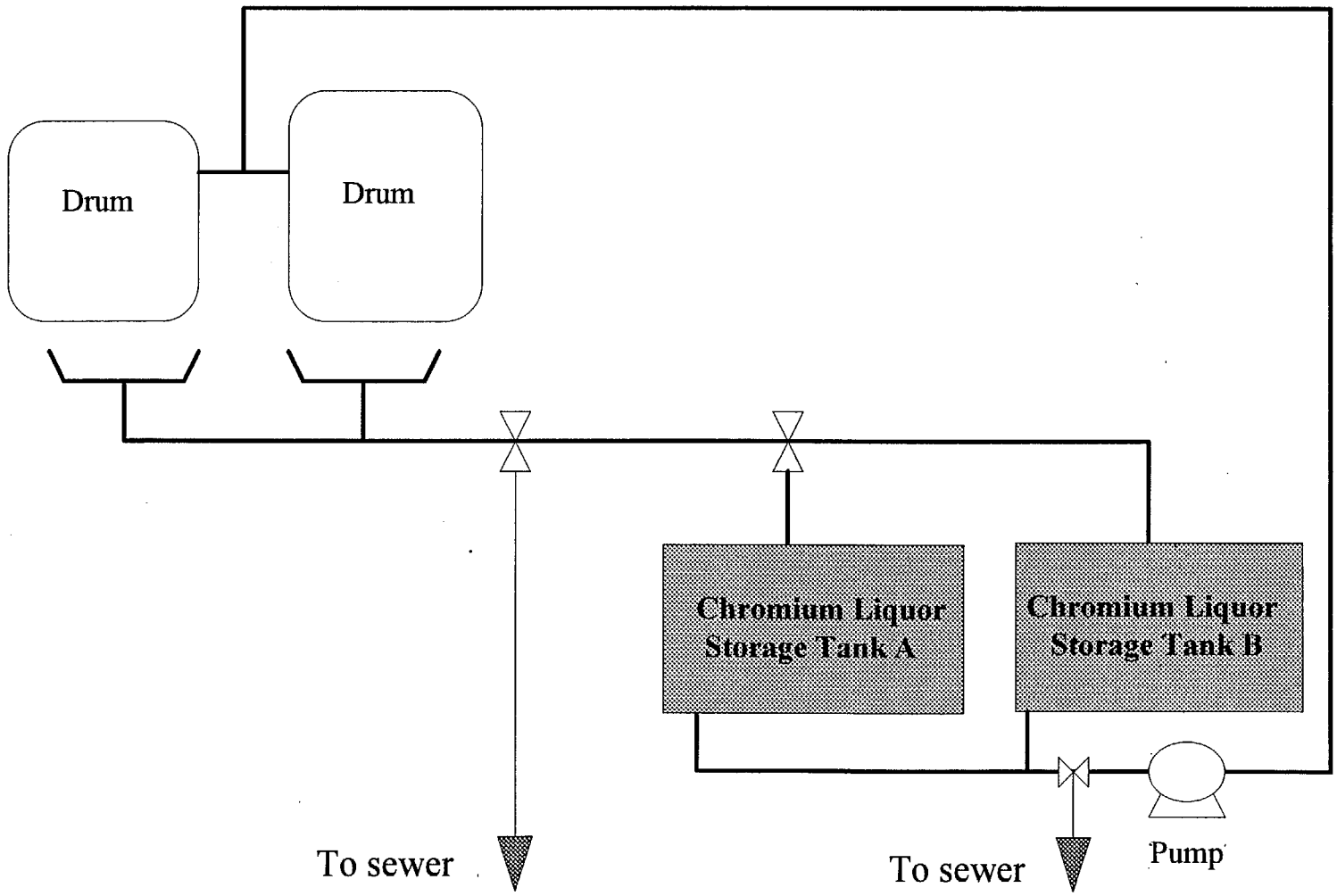
SAVINGS		
Chromium Saved		
Amount of chromium compound discharged	3.58	kg Cr/day
Equivalent amount of chromium compound	13.49	kg Cr2(SO4)3/day
Portion of recyclable chromium	80%	
Equivalent amount of recycled chromium compound	10.79	kg Cr2(SO4)3/day
Cost of chromium compound	10.5	Dh/kg
Equivalent savings of recyclable chromium compound	113.3	Dh/day
Annual Savings	**33,990**	***Dh/year***

INVESTMENTS	Qty	Unit Cost, Dh	Total
Storage tank: chromium liquor	2	3,000	6,000
Transfer pump	1	2,000	2,000
Plumbing and electricity			3,000
Contigencies	10%		1,100
Total Investment		***Dh***	**12,100**

Return Time	***5***	***Months***

170

Schematic Principle of Chromium Recovery



E. Project N°5. Separation of Acid and Alkaline Effluent

Project Summary	
Savings of materials	0 Dh per year
Installation cost	30,000 Dh
Return time	Not determined

E1. Recommendations

- Build sewers for draining the liming and reliming wastewater.
- Connect these sewers to those used for the soaking water.
- Isolate the water drained that has been used for deliming, bating, pickling, tanning, retanning, and for rinsing and channel it separately over the existing system.
- Build two trenches into which the alkaline water will flow. One trench will carry, water from soaking, wool washing, liming, and reliming will flow, and the other, the acidic wastewater from the pre-tanning, tanning, and retanning operations.

E2. Description

Figure A, illustrates the tannery's wastewater drainage system, and shows that the two separate systems come together in the last trench. One system is for the soaking and the wool washing operations, the other for the remaining operations. We recommend segregating the alkaline wastewater, used for the liming/reliming operations, from the acidic wastewater, used for pretanning, tanning, and retanning, as shown in Figure B. This recommendation serves two purposes:

- Gain better control of pH and, hence, final effluent treatment
- Eliminate the risk, inside the facility, to generate hydrogen sulfide, a highly toxic gas.

The wastewater from the liming/reliming tanks is frequently loaded with sulfur which may convert to H_2S (hydrogen sulfide) in an acidic medium.

E3. Projected Income

There is no financial income for this project, but it should be considered as one that supplements Project N°2.

E4. Investment

The investment, estimated at 30,000 Dh, is for building approximately 100 m of trenches, covering them, fencing and purchasing the required piping, and for building two additional trenches. The same transfer pump that is used for Project N°2 may also be used for this project.

172

Project No. 5

Pollutant Concentrations

Pollutant	Final effluent SAIS mg/L	UNEP Average mg/L	USA Average mg/L
BOD	2,200	900	1364
COD	nd	2500	3357
Chromium	286	70	79
Sulfur	28	160	36
Ammonium	157	70	90
Total Nitrogen	265	120	274
Suspended Matter	3483	2500	3793

Pollutant Volume

Pollutant	Final Effluent				Reference - UNEP		Reference - USA		EPA Limits	
	Analysis mg/L	Total rate m3/day	Total charge kg/day	Total charge kg/T produced	Average kg/T produced	Scale kg/T produce	Average kg/T produced	Average kg/T produce	Daily maximum kg/T produced	Monthly Average kg/T produced
BOD	2,200	268.811	591	**131**	**60**	40 -100	**67.31**	14-224	8.2	3.7
COD	nd	268.811	0	**nd**	**10**	-	**161**	62-252		
Chrome (Cr)	286	268.811	77	**17**	**4.5**	-	**4.76**	.038-43.7	0.21	0.08
Sulfures (S)	28	268.811	8	**2**	**7**	-	**1.94**	1.47-4.71		
Ammonium (NH4)	157	268.811	42	**9**	**3**	-	**4.07**	3-4.21		
Nitrogen	265	268.811	71	**16**	**10**	-	**12.76**	7.90-24.81		
Suspended Matter	3483	268.811	936	**208**			**199**	24-656	11.8	5.4

74

Figure A

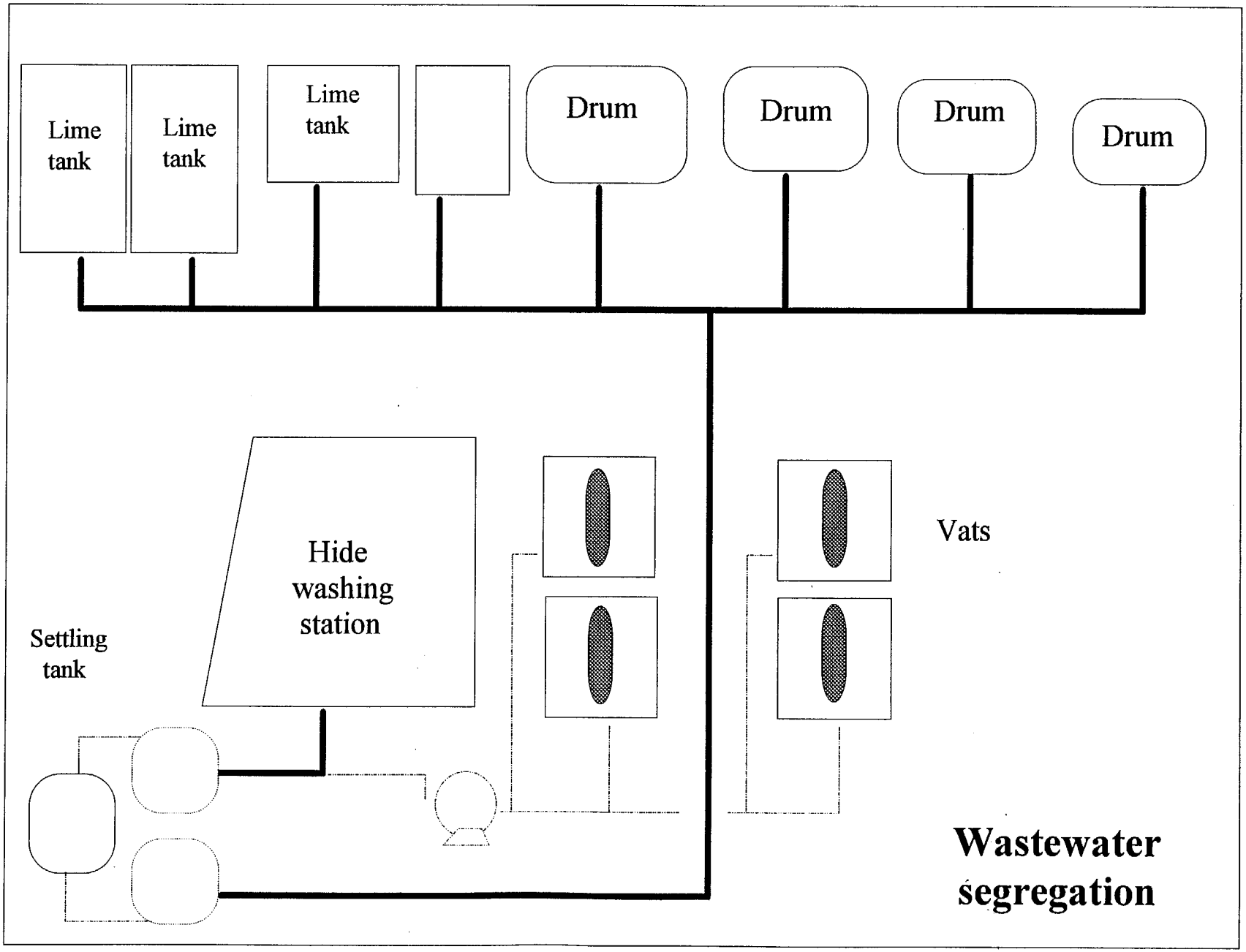
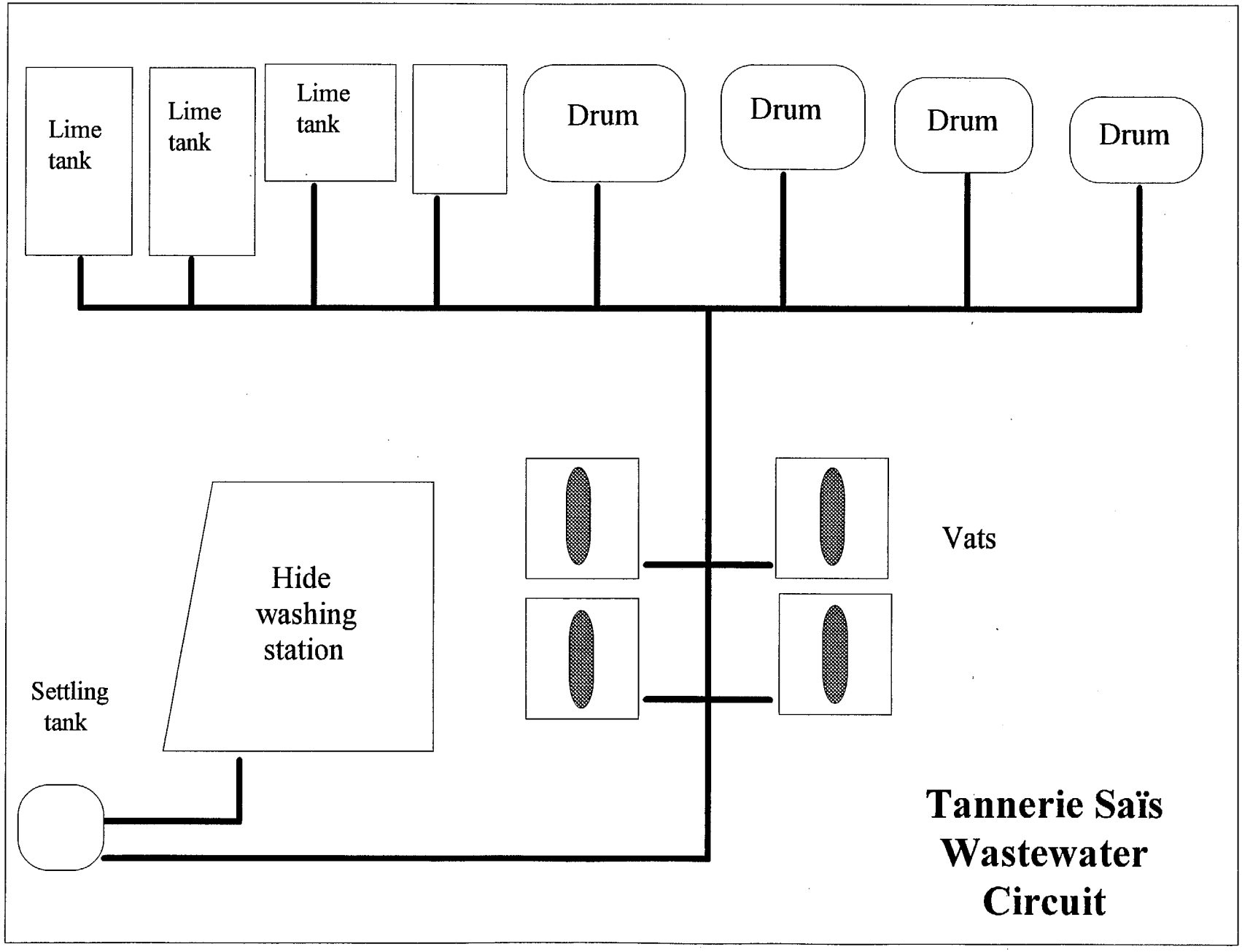

Lime tank
Lime tank
Lime tank
Drum
Drum
Drum
Drum
Hide washing station
Settling tank
Vats
Wastewater segregation

Figure B


Lime tank
Lime tank
Lime tank
Drum
Drum
Drum
Drum
Hide washing station
Vats
Settling tank
Tannerie Saïs Wastewater Circuit

SECTION III

ENVIRONMENTAL ASSESSMENT AND RECOMMENDATIONS

SECTION III
ENVIRONMENTAL ASSESSMENT AND RECOMMENDATIONS

A. Water Consumption Evaluation and Recommendations

Tannerie Saïs uses considerable amounts of water. According to UNEP, a typical tannery consumes from 25 to 80 l/kg (liters per kilogram of rawhide). The average in the United States for tanneries such as Saïs is 48.4 l/kg. The audit team estimated this ratio to be more than 60 l/kg for Tannerie Saïs (see Annex B).

A review of the different consumption operations showed that, except for the soaking operation which alone accounts for over 50 percent of consumption, the other operations use much less water than American tanneries (see the tables and figures that follow).

Project N°1, presented in the preceding chapter, would allow Tannerie Saïs to lower its water consumption for soaking by 50 percent, thereby decreasing its total water consumption ratio to 43 l/kg.

Regardless, the ratio is still above values found in other tanneries in Fès, and we believe that it is possible to bring it down even more, if the following recommendations are implemented:

A1. Replacing Drum Loading Gates

The employees who use the gates that are now on the drums find them difficult to operate. Loading gates with a quick-release mechanism would help improve employee efficiency and would make batch rinsing easier.

A2. Using Batch Rinsing in the Drums

The new loading gates would make batch rinsing possible. During rinsing, the drums would be closed. At the end of each rinse, the gate would open to drain out the rinsewater. This procedure would lower water usage by 50 percent. A typical cycle could be described as follows:

- First cleaning for 20 minutes followed by draining.
- Second cleaning for 20 minutes followed by draining.

A3. Using Less Water for Each Drum Cycle

Water meters should be installed on the drums to check and minimize water volumes added during treatment operations. This would make it possible to indirectly lower the quantity of chemicals without any effect on leather quality.

A4. Conducting a Consciousness-raising Session

We recommend conducting a session to raise the consciousness of the employees as to the value of conserving water. Workers should be informed of the real cost of water, even though the water comes from a well.

A5. Using Floater Valves in the Water Tanks

Whenever possible, we recommend using floater valves in the water tanks. These valves undeniably make it possible to prevent unnecessary water waste, especially if filled manually and if employees are responsible for doing this.

B. Wastewater Pollutant Evaluation

The audit team took several composite samples of wastewater at different stages of the tanning process. The results of the analyses appear in Annex B.

The results of the final effluent analyses (the composite sample taken over 24 hours of operation) are useful in assessing pollution from the tannery that was audited relative to pollution from tanneries located elsewhere in the world. The tables and graphs on the following pages are used to develop the comparison.

C. Other Recommendations

C1. Setting Up a Chemical Dosage Station

We recommend setting up a chemical dosage station at the drum level to better comply with the dosage instructions and to make it easier for employees to do their work.

C2. Installing Mechanical Rinse/agitation Devices

We further recommend equipping the lime tanks with mechanical rinse/agitation devices to save time during treatment.

C3. Increasing Effectiveness of Pigmentation

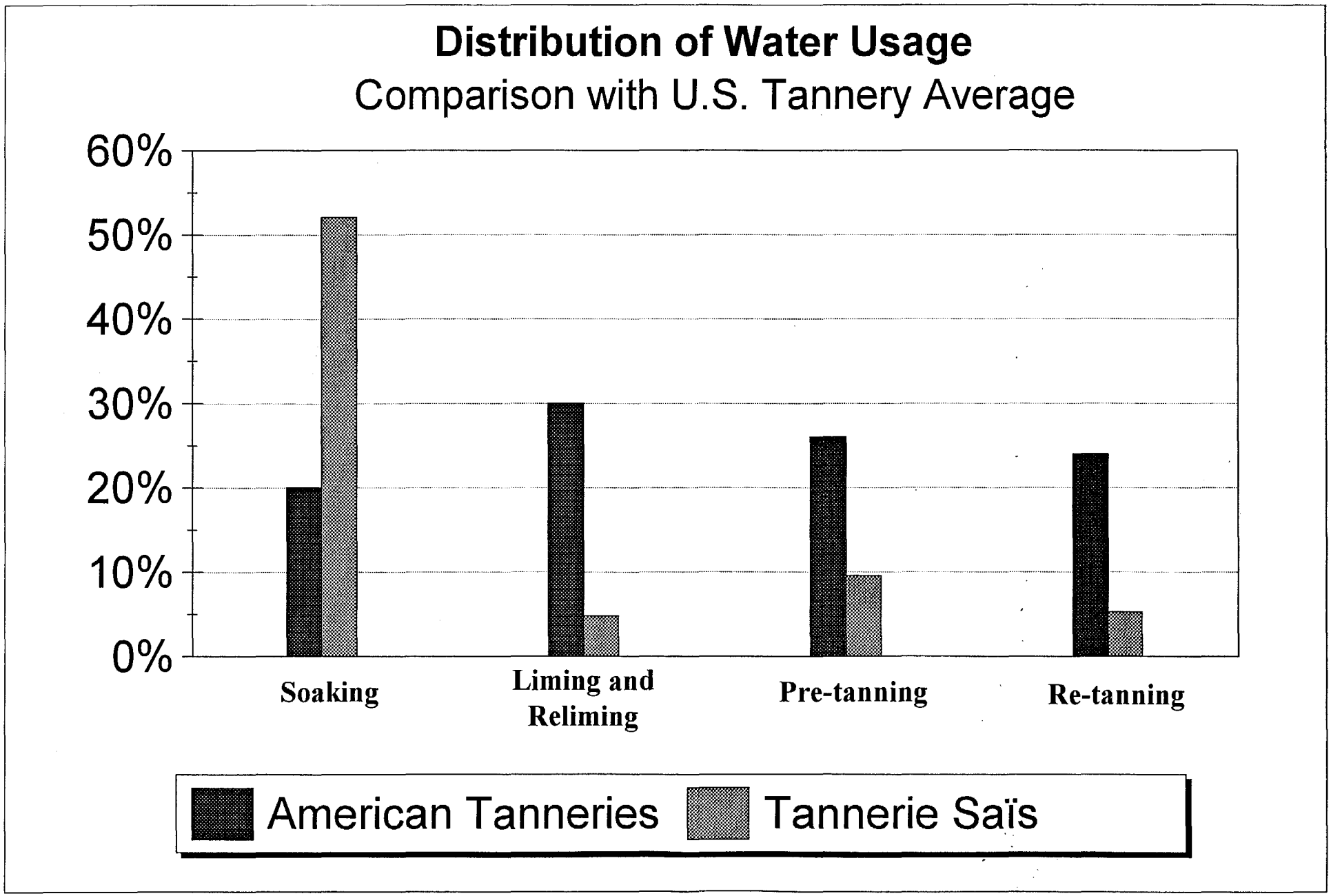
The following factors have a considerable influence on the effectiveness of pigmentation:

- Type of equipment
- Distance between the gun and the hide
- Hide size
- Hide geometry
- Air velocity in the pigmentation booth
- Air spray pressure
- Pigment flow rate through the gun
- Size of pass with the gun over the hide

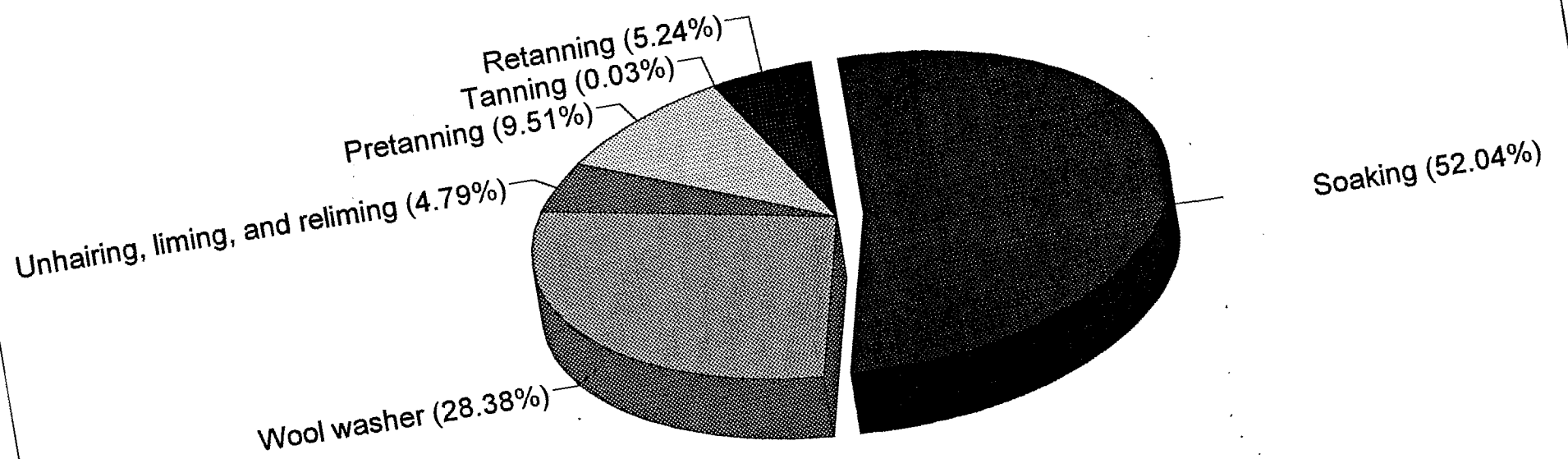
Also see Annex C.

C4. Sharing a Chromium Recovery System

A chromium recovery system that works through precipitation, filtration, and dissolution is in use in a number of countries. The greater the amount of chromium, the more cost-effective the system becomes. Consequently, a group of several tanning facilities may use one (see Annex D).


Distribution of Water Usage
Comparison with U.S. Tannery Average
60%
50%
40%
30%
20%
10%
0%
Soaking
Liming and Reliming
Pre-tanning
Re-tanning
American Tanneries
Tannerie Saïs

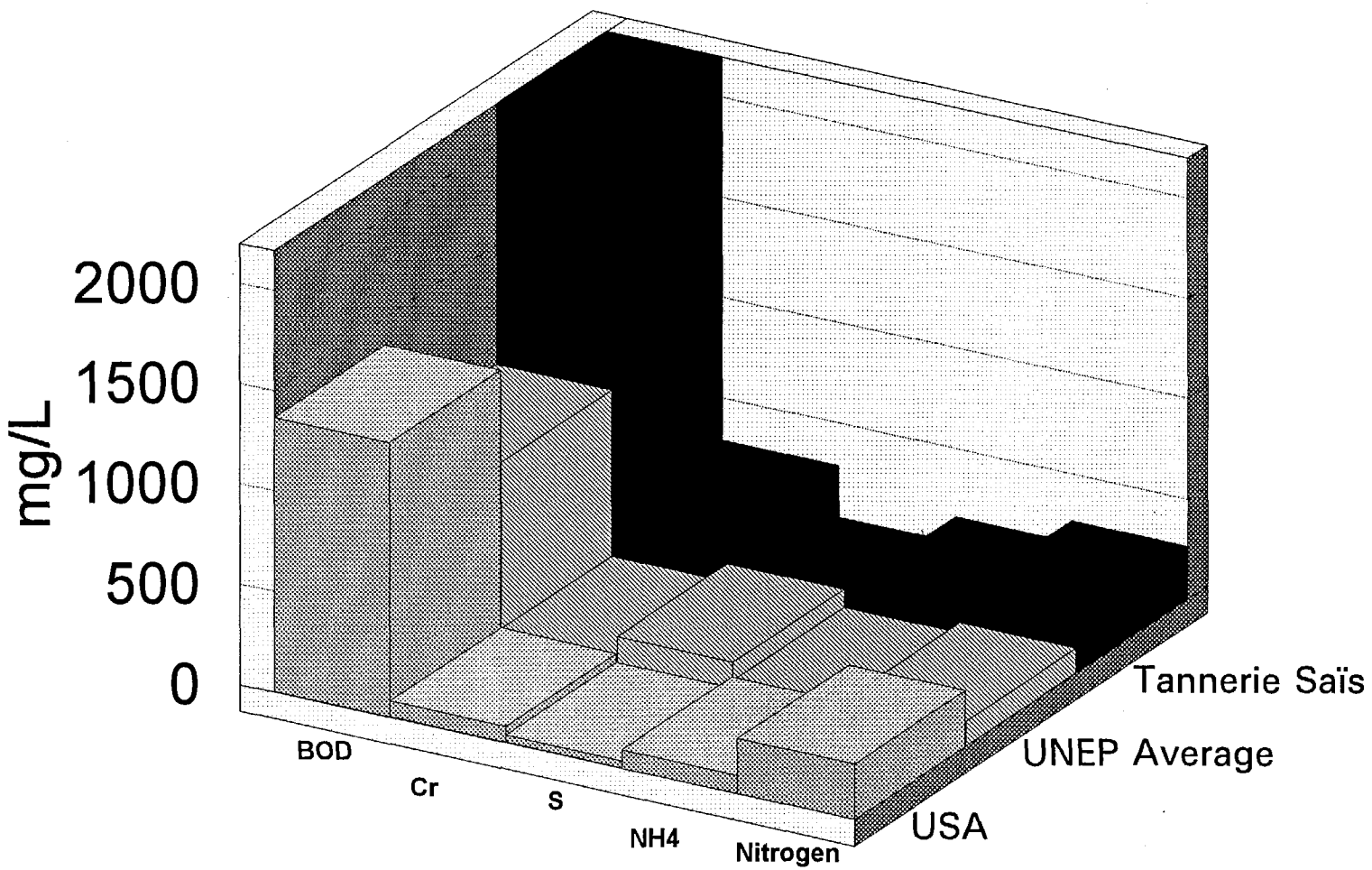
Breakdown of Water Usage by Process
Tannery Saïs



180

Pollutant Concentrations

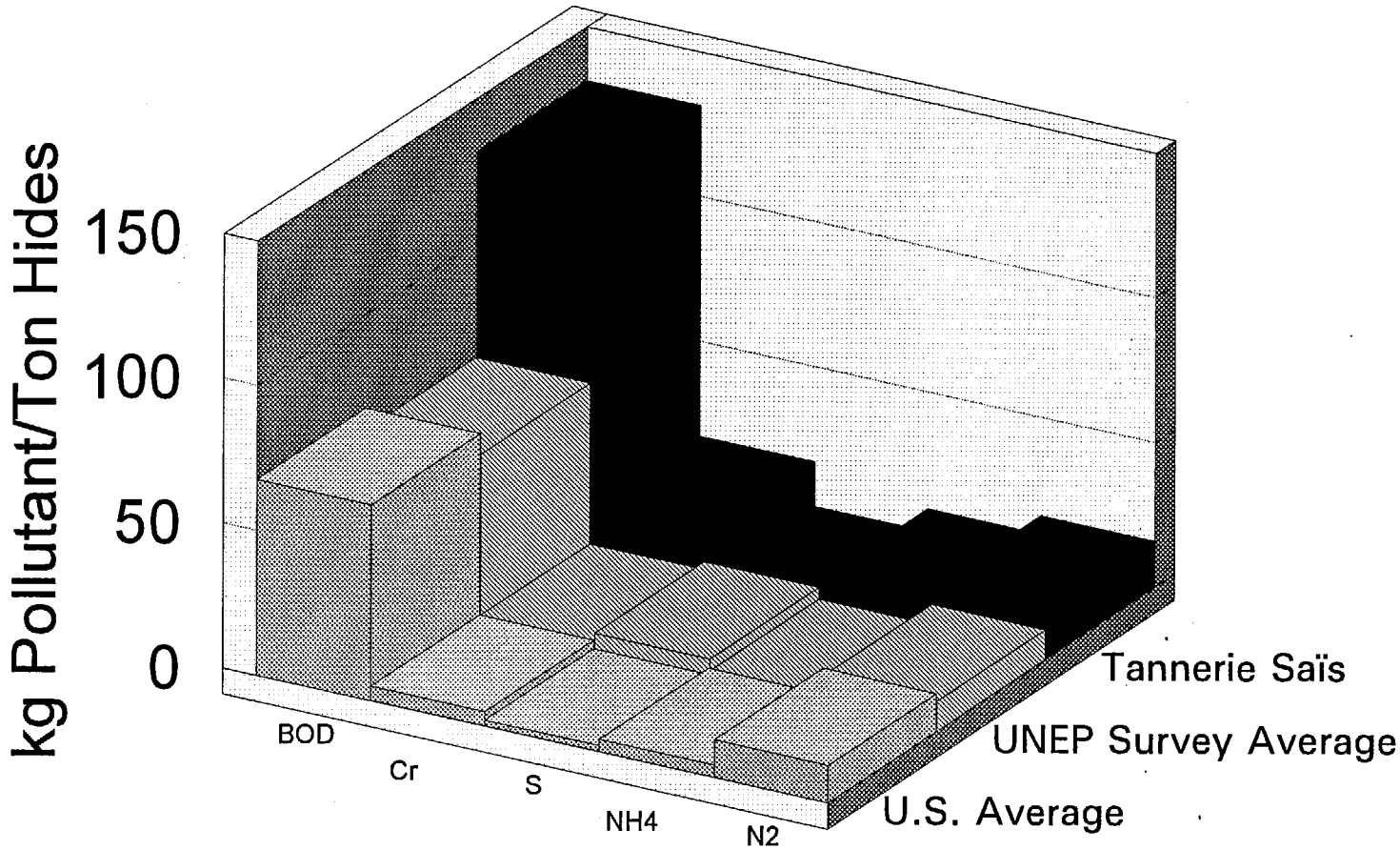
Tannerie Saïs vs UNEP Survey Average



181

Pollutant Volume

Tannerie Saïs vs UNEP Survey Average



182

ANNEX A

WATER CONSUMPTION FOR THE STAGES OF THE TANNERIE SAÏS PROCESS

Water Consumption
SAIS Tannery, Fes, Morocco

Tank Water Flow

Tank Water Flow, m3/hr		6.36
Stage	Time Spigot Open, hr	Quantity of water m3/1000 hides
Initial Rinse	2.0	12.72
(Deliming)		
Enzyme	0.0	0.00
Enzyme rinse	0.1	0.53
Degreasing agent	0.0	0.00
Rinse	1.8	11.13
Pickling	-	1.20
Tanning	-	0.08
Aging	-	0.00
Washing	-	1.20
Retanning	-	1.05
Retanning rinse	0.5	3.18
Dying	-	1.25
Retannage	-	1.05
Retanning rinse	1.0	6.36
Total water for one tank	5.33	39.74
Number of tanks		1
Total tank		**39.74**

Others		
Soaking	4	139.89
Wool washing	8	76.30
Liming		6.44
Pelenage		6.44
Total others		**229.07**
Total water/1,000 hides		**268.8**

Daily production	**1000**	**hide/day**
Estimated kg/raw water	**4.5**	**kg/hide**
Daily production	**4500**	**kg/day**
Water flow, L/kg hide	**60**	**L/kg**

Breakdown of water use	m3/day	SAIS
Soaking	139.887	52.04%
Wool washer	76.302	28.38%
Unhairing, liming, and reliming	12.88	4.79%
Pretanning	25.57425	9.51%
Tanning	0.08	0.03%
Retanning	14.08775	5.24%
	268.811	100.00%

184

ANNEX B

RESULTS OF EFFLUENT ANALYSES

Analysis Results							
Parameter mg/l	Final Effluent	Soaking Effluent	Liming Effluent	Reliming Effluent	Deliming Effluent	Tanning Effluent	Retanning Effluent
BOD	2200			2500	1550		
COD							
Cr	286					4660	158
S	28		367	63			700
NH4	157				6482		
Nitrogen	265				6989		
Suspended matter	3483	962	12687	8553	1171		
Oil and fat	nd		4483	2380	5881		

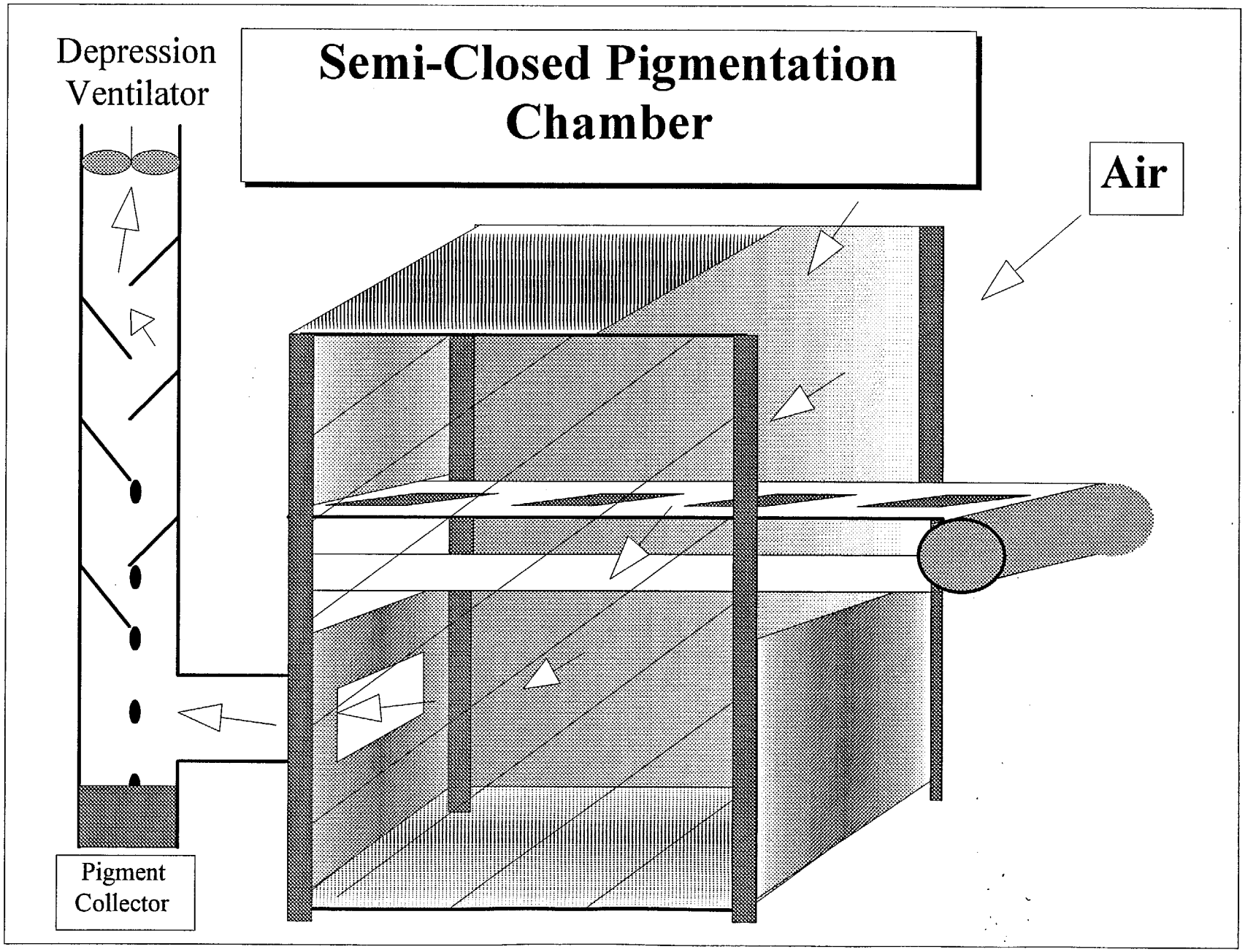
Notes:

1. The amount of sulfur in the sample seemed too low to us.

186

ANNEX C

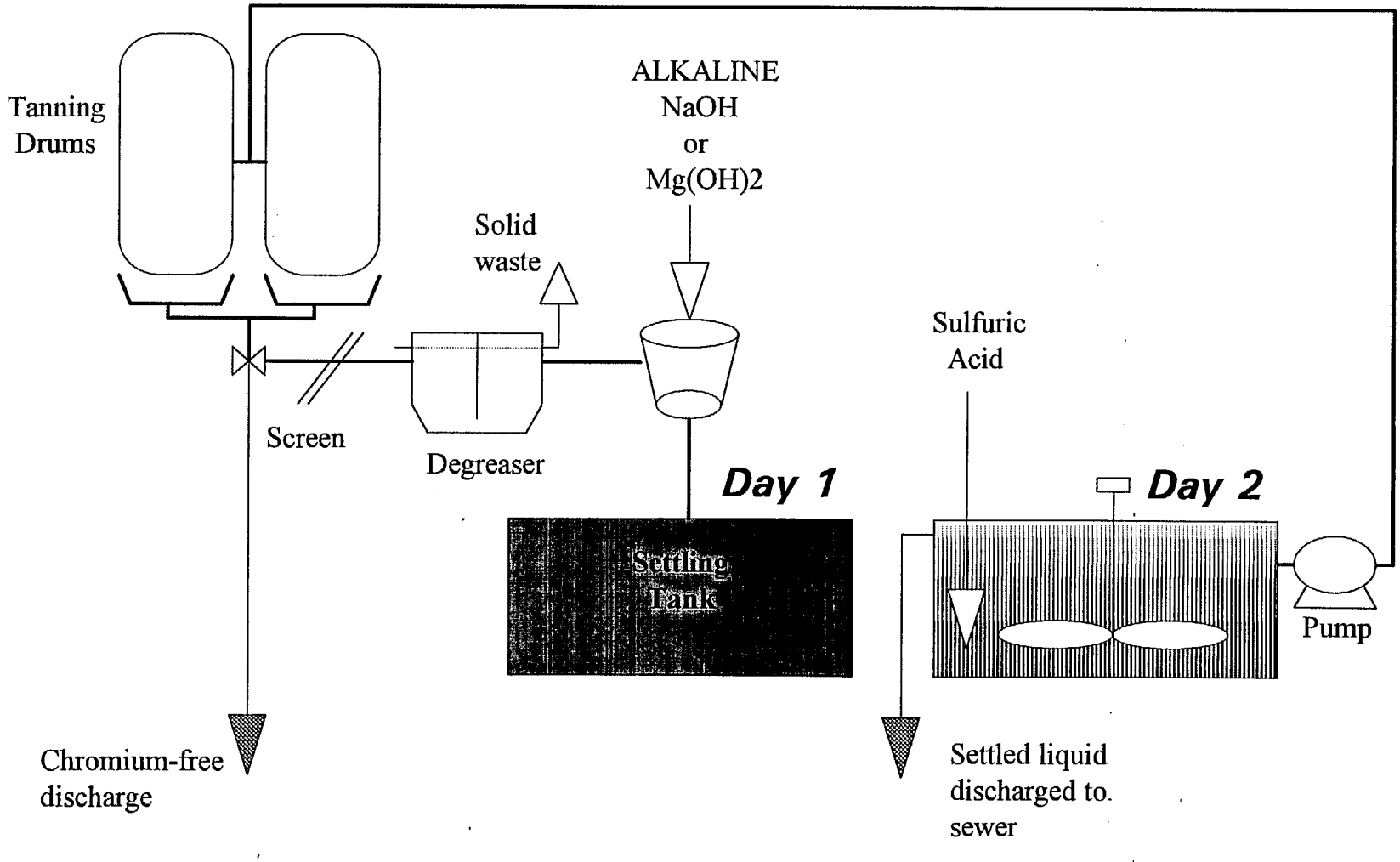
DIAGRAM OF THE PIGMENTATION PROCESS


Semi-Closed Pigmentation Chamber
Depression Ventilator
Air
Pigment Collector

ANNEX D

DIAGRAM FOR CHROMIUM RECOVERY VIA PRECIPITATION

Chromium Recycling by the Chemical Precipitation Process



ANNEX E

TANNERIE SAÏS INVENTORY LISTING

ANNEX E
TANNERIE SAÏS INVENTORY LISTING

The following inventory listing of chemical products used by the Tannerie Saïs is presented in the original French:

Inventory Listing of Chemical Products

Manufacturer	Name (French)	Quantity	Unit Price	Total
Sandoz Maroc	Relcafinish HG Pate	519.4	47.7	24 775,19
	Melio WF 5230	86.57	149.9	12 976,24
	Brun Derma DR 100%	865.66	213.8	185 078,11
	Tergotane FG	216.42	40.8	8 829,73
	Blac Discover Conc. V	519.4	48.9	25 398,46
	Noir Supronil HK	519.4	129	67 002,08
	Rubis Discover	519.4	95.2	49 446,50
	Bleu Discover N	519.4	90.8	47 161,16
A.T.C.M.	Actan PAC	216.42	29	6 276,04
	PC 9125	519.4	32	16 620,67
	Biocide B7	17.31	91.2	1 578,96
	Biocide C3	17.31	221.8	3 840,07
	Actan AC	432.83	29.5	12 768,49

Manufacturer	Name (French)	Quantity	Unit Price	Total
Alpha Chemicals	Synektan TBM Poudre	865.66	39	33 760,74
	Bicarbonate De Soude	1 471,62	5	7 358,11
	Coriacide Brun 3J	1 082,08	162	175 296,15
	Violet S	1 082,08	360	389 547,00
BASF	Fond Corial IF	1 038,79	32.2	33 449,10
	Lepton Noir	519.4	36	18 698,26
	Relugan GT 50	216.42	63.5	13 742,35
	Lepton Brun	519.4	58	30 124,97
	Lepton Filler H	519.4	51.09	26 535,94
	Luganil Noir NT	1 082,08	190	205 594,25
	Lurazol Brun PM	1 082,08	127.95	138 451,50
	Relugan GT SU	649.25	63.5	41 227,06
	Lipodermlicker IC	649.25	63.5	41 227,06
Bayer	Chromosal B	14 636,00	10.5	15367800
	Provol BA	2 272,36	30	68 170,73
	Novalton MAP	432.83	31.4	13 590,86
	Supralan 80	1 829,50	37.6	68 789,20
Consortium	Lipsol BSF - R	2 272,36	35.75	81 236,78
	Neosyn DFS - 3	865.66	23.2	20 083,31
	Pancreol EG 98	1 280,65	11.2	14 343,28
	Quimifeller 60	259.7	37.7	9 790,61
	Idrosol Maron	519.4	49	25 450,40
	Syntan ZN	519.4	16	8 310,34
	Dermap Blanc SE	519.4	43.7	22 697,61
	Dermap Bordeaux	519.4	73.8	38 331,42
	Dermap Caramel D	519.4	28.4	14 750,85
	Dermap maron	519.4	29.2	15 166,36
	Dermap Rouge B	519.4	58.2	30 228,85

Manufacturer	Name (French)	Quantity	Unit Price	Total
Abdellaoui	Chaux	7 318,00	1.2	8 781,60
	Acide Formique	3 293,10	12.5	41 163,75
	Acide Sulfurique	1 463,60	2.3	3 366,28
Bennani	Formate	216.42	8.5	1 839,53
	Sulfure	3 659,00	8.5	31 101,50
	Sel	18 295,00	0.6	10 977,00
	Sulfate	5 488,50	1.3	7 135,05
Total H.T.:				2 280 669,32
T.V.A.:				433 327,17
Total T.T.C.:				2 713 996,49

GENERAL ANNEXES

GENERAL ANNEX I
PROGRAM OF THE WORKSHOP HELD ON JULY 16, 1996

A. General Context of the Study

- Environmental problems in the Fès area
- Characterization of industrial water discharge in Fès
- Projects scheduled as part of the general guidelines for the local sewage system (RADEEF)

B. PRIDE Project Contribution

- Previous USAID Work in Fès
- The Coming WRS Project (USAID/MOE)
- Present project contributions: environmental audits of three metal finishing facilities and one leather tannery

C. Summary of the Auditing Activity and the Proposed Recommendations

- SADF (metal finishing company)
- SODAQ (metal finishing company)
- Lala Idouna (metal finishing company)
- Saïs Tannery

D. General and Specific Recommendations

- Metal finishing industry
- Leather tanning industry

E. Conclusions

GENERAL ANNEX II
AUDITING FORM

- Company:

.....

Address:.....

Telephone and fax:.....

General manager:.....

Technical director:.....

- Date:

.....

- Employees:

.....
.....
.....
.....
.....
.....
.....
.....
.....

- Industry classification:

.....

- Person contacted:

Name	Title	Motivation[1]

[1]Grade from 1 to 10.

197

- Number of employees:

Total	Permanent		Temporary	
	Males	Females	Males	Females

- Number of managers:

.....

- Electricity consumption:

K Wh/year	
Maximum power	
Average cost	

- Energy consumption:

Fuel (tons/year)	
Gas and oil (m^3/year)	
Propane (T/year)	
Water (m^3/year)	

- Invoices (Dh/year):

Electricity	
Fuel	
Gas and oil	
Propane	
Water	

198

- Water process:

Quantity		
Source		
Contaminants	Heavy metals	
	Organics	
Treatment	Rinse water	
	Baths dumps	

- Water heating system:

Quantity	
Source	
Treatment	

- Counters:

Electricity	
Water	
Fuel	

- Accounting system

Manual	
Computerized	

199

- Raw materials:

Description	Quantity

- Products manufactured:

Products	Quantity

- Final effluent:

Effluent	Quantity	Aspect	Composition

200

- Condition of equipment per process:

	Characteristics	Very good	Good	Poor	Very poor
Tanks					
Rectifiers					
Instrumentation					
Other					

- Effluent per process:

Effluent (source)	Quantity	Aspect	Composition

- Probable projects:

Project	Potential savings

202

GENERAL ANNEX III
HEALTH AND SAFETY RECOMMENDATIONS

This addendum is provided as a general guideline for understanding the safety and health concerns associated with handling toxic substances in a work environment. The information contained in the following paragraphs is based on research and tests developed by the U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) and is applicable to the metal finishing as well as the tanning industry. The recommendations are generic in nature and do not replace specific guidelines for proper handling of proprietary chemicals as supplied by chemical manufacturers. Material Safety Data Sheets (MSDSs) may contain specific recommendations, not included herein, and therefore should be systematically supplied with every chemical purchased, carefully studied, made available to employees, and kept in file in each facility.

Additionally, the information contained in the following pages will provide the reader with a basis for understanding the importance of pollution prevention efforts and, in particular, the need for minimizing uncontrolled release of toxic chemicals in sewer systems or the aquifer.

The chemical solutions studied in the course of the four audits mainly owed their toxicity to five heavy metals: copper, nickel, silver, gold, and chromium (both trivalent and hexavalent); and cyanide was used as an electrolyte component in several chemical processes. Consequently, this appendix reviews some characteristics of each of these components when placed in the near environment of human beings.

A. Copper Cyanide

A1. Identification

Copper cyanide is a green powder used in electroplating copper on iron and as an insecticide and catalyst.

A2. Hazard Summary

- Copper cyanide can affect those who inhale it.
- Eye contact can cause severe burns with loss of vision.
- Skin contact can cause irritation or burns.
- Breathing copper cyanide causes irritation of the nose and may cause nose bleeds or sores in the nose. Irritation of the air passages also occurs.
- Heating copper cyanide releases deadly CYANIDE gas.

A3. Workplace Exposure Limits in the United States

These exposure limits are recommended for copper dust and mist:

- OSHA: The legal airborne permissible exposure limit (PEL) is 1 mg/m^3 averaged over an 8-hour workshift.

- The American Conference of Governmental Industrial Hygienists (ACGIH): The recommended airborne exposure limit is 1 mg/m^3 averaged over an 8-hour workshift.

A4. Additional Workplace Exposure Limits (Recommended for Cyanides)

- OSHA: The legal airborne permissible exposure limit (PEL) is 5 mg/m^3 averaged over an 8-hour workshift.

- The National Institute for Occupational Safety and Health (NIOSH): The recommended airborne exposure limit is 5 mg/m^3, which should not be exceeded during any 10-minute work period.

- ACGIH: The recommended airborne exposure limit is 5 mg/m^3 averaged over an 8-hour workshift.

A5. Ways of Reducing Exposure

- Where possible, managers should enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, potentially exposed workers should wear respirators.

- Managers should post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, they should communicate all information on the health and safety hazards of copper cyanide to potentially exposed workers.

A6. Health Hazard Information

A6a. Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to copper cyanide:

- Contact can burn the eyes, with severe damage, and cause skin irritation or burns.

- Breathing copper cyanide irritates the nose. Nose bleeds or nose ulcers may result. Irritation of air passages also occurs with cough.

A6b. Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to copper cyanide and can last for months or years:

- Cancer Hazard: According to the information presently available to the New Jersey Department of Health, copper cyanide has not been tested for its ability to cause cancer in animals.

- Reproductive Hazard: According to the information presently available to the New Jersey Department of Health, copper cyanide has not been tested for its ability to adversely affect reproduction.

- Other Long-Term Effects:

  - Repeated exposure can cause copper to deposit in the liver and other body organs, causing damage.

  - Copper deposits in the skin and hair also occur, leaving a green color.

  - Repeated exposure can also cause shrinking (atrophy) of the inner lining of the nose, with a watery discharge.

  - Metallic taste may also occur.

  - Exposure may cause skin allergy, with dash dnd itching.

  - If allergy develops, even low future exposures may trigger rash.

  - Very irritating substances may affect the lungs, but it is not known whether copper cyanide causes lung damage.

A7. Ecological Information

Copper is a commonly occurring element in natural waters. At low concentrations, it is an essential element for both plants and animals. At slightly higher concentrations it is toxic to aquatic life. The toxicity of copper and its compounds to aquatic life varies with the physical and chemical conditions of the water. Factors such as water hardness, alkalinity, and pH influence copper toxicity.

A8. Bioaccumulation in Aquatic Organisms

Some substances increase in concentration, or bioaccumulate, in living organisms as they breathe contaminated air, drink contaminated water, or eat contaminated food. These chemicals can become concentrated in the tissues and internal organs of animals and humans. The concentration of copper found in fish tissues is expected to be considerably higher than the average concentration of copper in the water from which the fish was taken.

B. Nickel Sulfate-Based Solutions

B1. Identification

Nickel sulfate, in the form of blue to blue-green crystals, has a sweet taste. It is used to make other nickel compounds and as a mordant in dyeing and printing textiles, coatings, and ceramics.

B2. Hazard Summary

- Nickel sulfate can those who inhale it.
- Nickel sulfate may cause mutations. Handle with extreme caution.
- It may also cause infertility in males.
- Skin contact may cause skin allergy, with itching, redness, and later rash.
- High or repeated exposures can scar the lungs.
- High exposure can cause cough, shortness of breath, and fluid in the lungs (pulmonary edema), which can lead to death.
- Nickel sulfate can cause an asthma-like lung allergy.

B3. Workplace Exposure Limits

- OSHA: The legal airborne permissible exposure limit (PEL) is 1 mg/m^3 averaged over an 8-hour workshift.
- NIOSH: The recommended airborne exposure limit is 0.015 mg/m^3 averaged over a 10-hour workshift.
- ACGIH: The recommended airborne exposure limit is 0.1 mg/m^3 averaged over an 8-hour workshift.
- These exposure limits are recommended for soluble nickel compounds and are measured as nickel (Ni).
- Since nickel sulfate may cause mutations, all contact with this chemical should be reduced to the lowest possible level.

B4. Ways of Reducing Exposure

- Where possible, managers should enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, potentially exposed workers should wear respirators.
- Potentially exposed workers should wear protective work clothing.

- Workers should wash thoroughly immediately after exposure to nickel sulfate.

- Managers should post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, they should communicate all information on the health and safety hazards of nickel sulfate to potentially exposed workers.

B5. Health Hazard Information

B5a. Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to nickel sulfate:

- Eye or skin contact can cause irritation.

- Exposure can irritate the lungs, causing coughing and shortness of breath. Higher levels can cause a build-up of fluid (pulmonary edema),which can lead to death.

B5b. Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to nickel sulfate and can last for months or years:

- Cancer Hazard: Nickel sulfate may cause mutations (genetic changes) in living cells. Whether or not it poses a cancer hazard needs further study.

- Reproductive Hazard: Nickel sulfate may cause infertility in males; this effect is usually reversible with removal from exposure.

- Other Long-Term Effects:

  - Contact can cause skin allergy to develop. Symptoms include burning, itching, redness, and bumps or other rash. Rash may spread to other areas and last for weeks after the end of exposure but usually improves in about a week.

  - Lung allergy (asthma) occasionally occurs with wheezing and/or tightness in the chest.

  - Single high or repeated lower exposures may damage lungs, with scarring of lung tissues, and may cause damage to heart muscle, liver, and/or kidneys.

B6. Ecological Information

Nickel is one of the most common metals occurring in surface waters. It occurs naturally in surface waters from the weathering of rocks. Other sources of nickel and compounds to the environment include the burning of coal and other fossil fuels and discharges from such industries as electroplating and smelting.

B7. Bioaccumulation in Aquatic Organisms

Some substances increase in concentration, or bioaccumulate, in living organisms as they breathe contaminated air, drink contaminated water, or eat contaminated food. These chemicals can become concentrated in the tissues and internal organs of animals and humans.

The concentration of nickel and its compounds found in fish tissues is expected to be somewhat higher than the average concentration of nickel and its compounds in the water from which the fish was taken.

C. Silver-Based Solutions

C1. Identification

Silver is a brilliant, soft, white metal. It is used in making jewelry, silverware and mirrors. It is also used in photography and in solders and electroplating.

C2. Hazard Summary

- Silver can affect those who inhale it.
- Repeated exposure to fine silver dust or fumes can cause blue-grey staining of the eyes, mouth, throat, internal organs and skin. This occurs slowly and may take years to develop. Once present, it does not go away. It can be very disfiguring.
- Skin contact can cause silver to become imbedded in small cuts in the skin, forming a permanent tattoo.

C3. Workplace Exposure Limits

- OSHA: The legal airborne permissible exposure limit (PEL) is 0.01 mg/m^3 averaged over an 8-hour workshift.
- ACGIH: The recommended airborne exposure limit is 0.1 mg/m^3 averaged over an 8-hour workshift.
- Silver may form metal fumes which present different hazards than the substance itself.

C4. Ways of Reducing Exposure

- Where possible, managers should enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, potentially exposed workers should wear respirators.
- Potentially exposed workers should wear protective work clothing.

- Potentially exposed workers should wash thoroughly at the end of the work-shift.

- Managers should post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, they should communicate all information on the health and safety hazards of silver to potentially exposed workers.

C5. Health Hazard Information

C5a. Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to silver:

- With eye contact, fragments of silver metal or metal dust can scratch the surface of the eye and become imbedded there, forming permanent blue-grey stains in the eye.

- Metal fragments can also enter small cuts in the skin, forming a permanent tattoo.

C5b. Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to silver and can last for months or years:

- Cancer Hazard: According to the information presently available to the New Jersey Department of Health, silver has not been tested for its ability to cause cancer in animals.

- Reproductive Hazard: According to the information presently available to the New Jersey Department of Health, silver has not been tested for its ability to affect reproduction.

- Other Long-Term Effects:

  - Breathing fine silver dust or fumes can gradually cause the eyes, nails, inner nose, mouth, throat, internal organs and skin to turn a blue-grey color. This usually takes 2-20 years but is permanent, and can be very disfiguring. This condition is called "argyria."

  - Repeated exposure can cause clouding in the cornea of the eye. This can cause problems with vision, especially at night.

  - High, repeated exposure to silver may cause kidney damage.

C6. Ecological Information

Silver is a naturally occurring metal in the earth's crust. It is used to make coins, tableware, mirrors, jewelry, electroplating and in electrical conductors. Silver-containing compounds are used in photography, as an anti-infective, as a reagent, and to seed clouds to

cause precipitation. Because of its wide use, silver enters the environment in nonpoint as well as specific discharges such as industrial and municipal effluents.

C7. Bioaccumulation in Aquatic Organisms

Some substances increase in concentration, or bioaccumulate, in living organisms as they breathe contaminated air, drink contaminated water, or eat contaminated food. These chemicals can become concentrated in the tissues and internal organs of animals and humans.

The concentration of silver found in fish tissues is expected to be much higher than the average concentration of silver in the water from which the fish was taken.

D. Gold-Based Solutions

No specific information on gold-based solutions is available on the U.S. EPA online database of toxic substances. See the previous presentation on silver-based solutions.

E. Hexavalent Chromium-Based Solutions

E1. Identification

Chromic acid is a dark, purplish red, odorless, crystalline solid. It is used in chromium plating, medicine, ceramic glazers, and paints.

E2. Hazard Summary

- Chromic acid can affect those who inhale it. It can also pass into inner layers of the skin.
- Chromic acid should be handled as a CARCINOGEN//WITH EXTREME CAUTION.
- Eye contact can cause severe damage with loss of vision.
- Breathing chromic acid can cause a sore or hole through the inner nose, sometimes with bleeding, discharge, or crusting. Irritation of the nose, throat, and bronchial tubes can also occur with cough and/or wheezing.
- It is a CORROSIVE CHEMICAL, and skin contact can cause severe irritation, deep ulcers or an allergic skin rash.

E3. Workplace Exposure Limits

- OSHA: The legal airborne permissible exposure limit (PEL) is 0.1 mg/m^3, not to be exceeded at any time.

- NIOSH: The recommended airborne exposure limit is 0.025 mg/m^3 averaged over an 10-hour workshift and 0.05 mg/m^3, not to be exceeded during any 15-minute work period.

- ACGIH: The recommended airborne exposure limit is 0.05 mg/m^3 averaged over an 8-hour workshift.

E4. Ways of Reducing Exposure

- Where possible, managers should enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, potentially exposed workers should wear respirators.

- Potentially exposed workers should wear protective work clothing.

- Workers should wash thoroughly immediately after exposure to chromic acid and at the end of the workshift.

- Managers should post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, they should communicate all information on the health and safety hazards of chromic acid to potentially exposed workers.

E5. Health Hazard Information

E5a. Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to chromic acid:

- Eye contact can cause severe damage with loss of vision.

- Skin contact can cause irritation. Concentrated solutions can cause skin burns. Unless skin contact is quickly stopped, chromic acid can enter the body through the affected skin areas.

E5b. Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to chromic acid and can last for months or years:

- Cancer Hazard: While chromic acid has not been identified as a carcinogen, certain kinds of chromium compounds, known as hexavalent chromium or chromium VI compounds, have been determined to be human carcinogens. Chromic acid is such a compound and should therefore be handled with extreme caution.

- Reproductive Hazard: According to the information presently available to the New Jersey Department of Health, chromic acid has not been tested for its ability to affect reproduction.

- Other Long-Term Effects:
  - Chromic acid can cause a hole in the "bone" dividing the inner nose.
  - Irritation, discharge, bleeding, and/or formation of a crust in the inner nose may occur.
  - Exposed persons may develop a skin allergy with a rash-like eczema. If this happens, any even small future skin contact can trigger a severe rash.
  - When chromic acid enters skin cuts or sores, slow healing ulcers can result.
  - Exposure can erode and discolor the teeth and cause growths (polyps) on the voice box.
  - Chromic acid may cause irritation of the bronchial tubes (bronchitis) with cough and phlegm.
  - Lung allergy, with wheezing or shortness of breath, sometimes occurs. In such cases, even small future exposure can cause symptoms.
  - Repeated or severe exposure may cause kidney or liver damage.

E6. Ecological Information

Chromium is a steel-gray lustrous metal used to make chrome-steel or stainless steel, and for chrome-plating of other metals. Chromium exists mainly in the 3+ (III) or 6+ (VI) oxidation states in natural bodies of water, and each form can be converted to the other form under appropriate environmental conditions. Chromium may enter the environment in effluents from metal plating industries or in municipal waste treatment plant discharges. Chromium is highly persistent in water, with a half-life of greater than 200 days. The half-life of a pollutant is the amount of time it takes for one-half of the chemical to be degraded.

E7. Bioaccumulation in Aquatic Organisms

Some substances increase in concentration, or bioaccumulate, in living organisms as they breathe contaminated air, drink contaminated water, or eat contaminated food. These chemicals can become concentrated in the tissues and internal organs of animals and humans.

The concentration of chromium found in fish tissues is expected to be somewhat higher than the average concentration of chromium in the water from which the fish was taken.

F. Trivalent Chromium-Based Solutions

F1. Identification

Chromium (III) oxide is a bright green, odorless powder used as a paint pigment, a fixative for certain textile dyes, and a catalyst.

F2. Hazard Summary

- Chromium (III) oxide can affect those who inhale it.
- Chromium (III) oxide is a CARCINOGEN and may be a TERATOGEN//HANDLE WITH EXTREME CAUTION.
- Skin contact may cause irritation, especially if repeated or prolonged.
- Skin allergy sometimes occurs with itching, redness, and/or an eczema-like rash. If this happens, future contact can trigger symptoms.
- Eye contact may cause irritation.

F3. Workplace Exposure Limits

- OSHA: The legal airborne permissible exposure limit (PEL) is 1 mg/m^3 as Chromium averaged over an 8-hour workshift.
- ACGIH: The recommended airborne exposure limit is 0.5 mg/m^3 as chromium averaged over an 8-hour workshift.
- Chromium (III) oxide is a CARCINOGEN in humans. Since there may be no safe level of exposure to a carcinogen, all contact should be reduced to the lowest possible level.

F4. Ways of Reducing Exposure

- Where possible, managers should enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, potentially exposed workers should wear respirators.
- Managers should establish a regulated, marked area where chromium (III) oxide is handled, used, or stored.
- Potentially exposed workers should wear protective work clothing.
- Workers should wash thoroughly immediately after exposure to chromium (III) oxide.

- Managers should post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, they should communicate all information on the health and safety hazards of chromium (III) oxide to potentially exposed workers.

F5. Health Hazard Information

F5a. Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to chromium (III) oxide: Skin or eye irritation may occur with contact especially if repeated or prolonged.

F5b. Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to chromium (III) oxide and can last for months or years:

- Cancer Hazard: Chromium (III) oxide is a CARCINOGEN in humans. It has been shown to cause lung and throat cancer. Many scientists believe there is no safe level of exposure to a carcinogen. Such substances also may have the potential for causing reproductive damage in humans.

- Reproductive Hazard: Chromium (III) oxide may be a teratogen in humans; it has been shown to be a teratogen in animals.

- Other Long-Term Effects: Skin allergy can develop, with a red, itching rash resembling eczema. When this occurs, even small future exposure can trigger symptoms.

F6. Ecological Information

Chromium is a steel-gray lustrous metal used to make chrome-steel or stainless steel, and for chrome-plating of other metals. Chromium exists mainly in the 3+ (III) or 6+ (VI) oxidation states in natural bodies of water, and each form can be converted to the other form under appropriate environmental conditions. Chromium may enter the environment in effluents from metal plating industries or in municipal waste treatment plant discharges. Chromium is highly persistent in water, with a half-life of greater than 200 days. The half-life of a pollutant is the amount of time it takes for one-half of the chemical to be degraded.

F7. Bioaccumulation in Aquatic Organisms

Some substances increase in concentration, or bioaccumulate, in living organisms as they breathe contaminated air, drink contaminated water, or eat contaminated food. These chemicals can become concentrated in the tissues and internal organs of animals and humans. The concentration of chromium found in fish tissues is expected to be somewhat higher than the average concentration of chromium in the water from which the fish was taken.

ADDENDUM

ENVIRONMENTAL AUDITS PERFORMED IN THE METAL FINISHING FACILITIES

ADDENDUM
ENVIRONMENTAL AUDITS PERFORMED IN THE METAL FINISHING FACILITIES

A. Introduction

As part of the Fès environmental auditing project, the managers of the companies that were audited were invited to come to the United States to visit factories. The technical discussions and concrete technological examples presented during the study trip enabled the Moroccan business leaders to better visualize the opportunities described in the audit reports.

For the metal finishing industry, the study trip included plant visits, making it possible to point out many alternative technologies that can be used to treat and/or recycle rinsewater.

Moreover, a detailed technical presentation of the silver plating line of one of the American companies visited identified an additional stage in the recovery process that helps products better withstand silver deposit oxidation. This information could solve a problem that all three of the metal finishing facilities audited have experienced.

This addendum summarizes the technological combinations that appealed most to the Moroccan business leaders.

B. Rinse Treatment/Recovery Project

This project provides an alternative to the separate rinse system recommended in the audit reports and consists mainly of the following:

- Use of one single line of four counterflow rinse tanks for the degreasing, silver plating, copper plating, and gold plating processes
- Use of an atmospheric evaporator to optimize rinsewater concentration on this four-tank line
- Retaining of the counterflow rinse line with three tanks used specifically for the nickel plating process
- Retaining of one electrowinning cell for recirculation on the first tank for each rinse line (two cells total)

B1. Description

The operating method for this new arrangement with a single rinse line for four different processes is very similar to the projects described in the original audit reports. A deionized water current is inserted into the first tank and circulates by overflowing in the opposite direction of the rinse for the workpieces. The weight of the solution dragged out by the workpieces to the rinse line, however, is about four times heavier; therefore, to maintain constant final rinse water quality in the tank, it is necessary to increase the amount of deionized water in the final rinse tank using the same proportions. The evaporation requirement for this rinse line thus necessitates using an atmospheric evaporator.

One additional consequence of this new approach is reflected in the contamination from the copper of the silver deposit on the cathodes of the electrowinning cell. After checking with a metal salvage plant not far from the city of Fès, it would seem that the value of the silver deposit would only drop by 20 percent.

B2. Summary Table of the Advantages and Disadvantages of the Rinse Treatment/Recovery Project Compared with Initial Recommendations

Advantages	Disadvantages
Adapts to available space since it requires fewer rinse tanks	The silver and copper deposit is mixed on the electrowinning cell's cathodes, causing a loss in value
Since the electrowinning cells are stationary, this solution can be permanently installed with hard plumbing, so that there are fewer risks of leaks, overflowing, etc.	Greater mechanical maintenance requirements due to the evaporator
Less labor is required to operate the system	Higher operating costs because of the need for more energy to evaporate four times more water
Air emissions are better controlled since nearly all the evaporators on the market use filter elements before discharging the water vapor	This is the least fault-tolerant system, because the operation of the four surface treatment lines with just one rinse line hinges on the operation of this system

C. Protecting the Silver Deposit from Oxidation

This project involves adding one additional tank after silver plating, filled with a chromate solution (hexavalent chromium with proprietary additives). The workpieces are simply put through one more electrolytic recovery process which deposits a protective layer that measures about 1/10 of a micron. The brilliancy of the silver deposit lasts longer and hence requires less "replating" to restore the initial shine. It should be noted that each of the facilities audited spends a portion of its resources keeping silver plated items shiny, particularly when the final product may be stored for more than two months. Until then, items in stock are unwrapped, inspected, and polished if necessary before they are shipped to the customer.

This process may provide an excellent opportunity to conquer new markets, especially for export-oriented businesses.

D. Wastewater Treatment Process in Surface Treatment Facilities

During the study trip, the Moroccan company managers were informed about the importance of on-site wastewater treatment to comply with official and other standards in effect in the states visited: Maine, New Hampshire, and Massachusetts.

The metal finishing process used in the units visited by the Moroccan company managers is comprised of the following operations:

- Chemical reduction of hexavalent chromium
- Destruction of cyanides
- Neutralization of acid/base effluent
- Flocculation/decantation
- Filtration
- Drying

D1. Chemical Reduction of Hexavalent Chromium

The chemical reduction of toxic hexavalent chromium into less toxic trivalent chromium takes place in an acidic medium by adding sodium bisulfate based on the following chemical reaction:

$$H_2Cr_2O_7+3NaHSO_3+H_2SO_4 \rightarrow Cr_2(SO_4)_3+3NaHSO_4+4H_2O$$

When the pH is very low (pH <2.5), the reaction is immediate. The critical limit for pH is not to exceed 3.5.

D2. Destruction of Cyanides

Destruction takes place in an alkaline medium with two succeeding stages that oxidize the cyanides into cyanates followed by a transition to the nitrogen state and bicarbonate. The oxidizing agent is sodium hypochlorite based on the following reaction:

$$NaCN+NaC_{10} \rightarrow NaCNO+NaC_1$$

This reaction takes from 30 minutes to two hours of exposure time and usually is performed with a pH greater than 12.

The second reaction to convert from cyanate to nitrogen is written as follows:

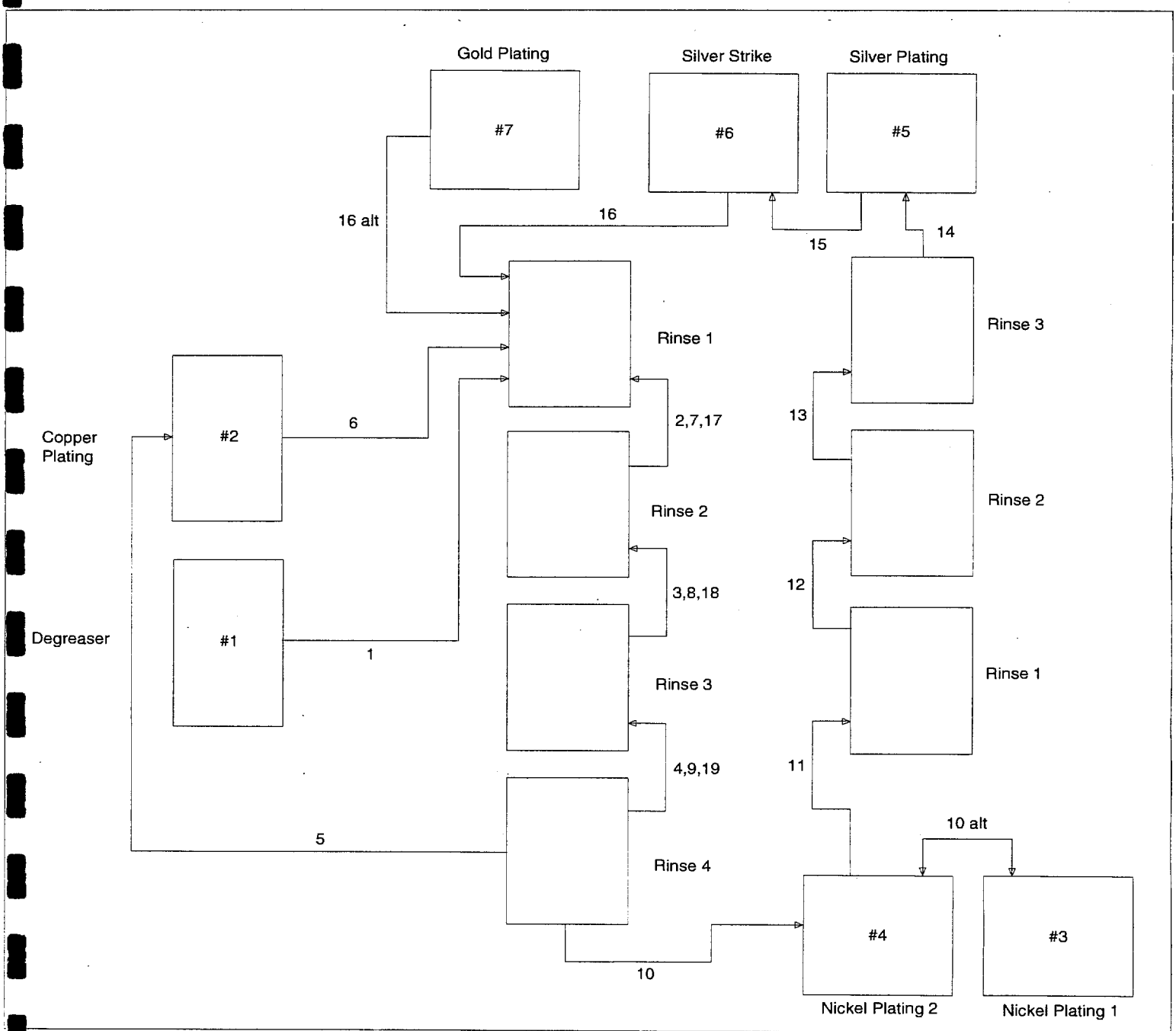
$$2NaCNO+C_{12}+6NaOH \rightarrow 2NaHCO_3+N_2+6NaCl+2H_2O$$

The pH must also be greater than 12 and reaction time is from 45 minutes to three hours.

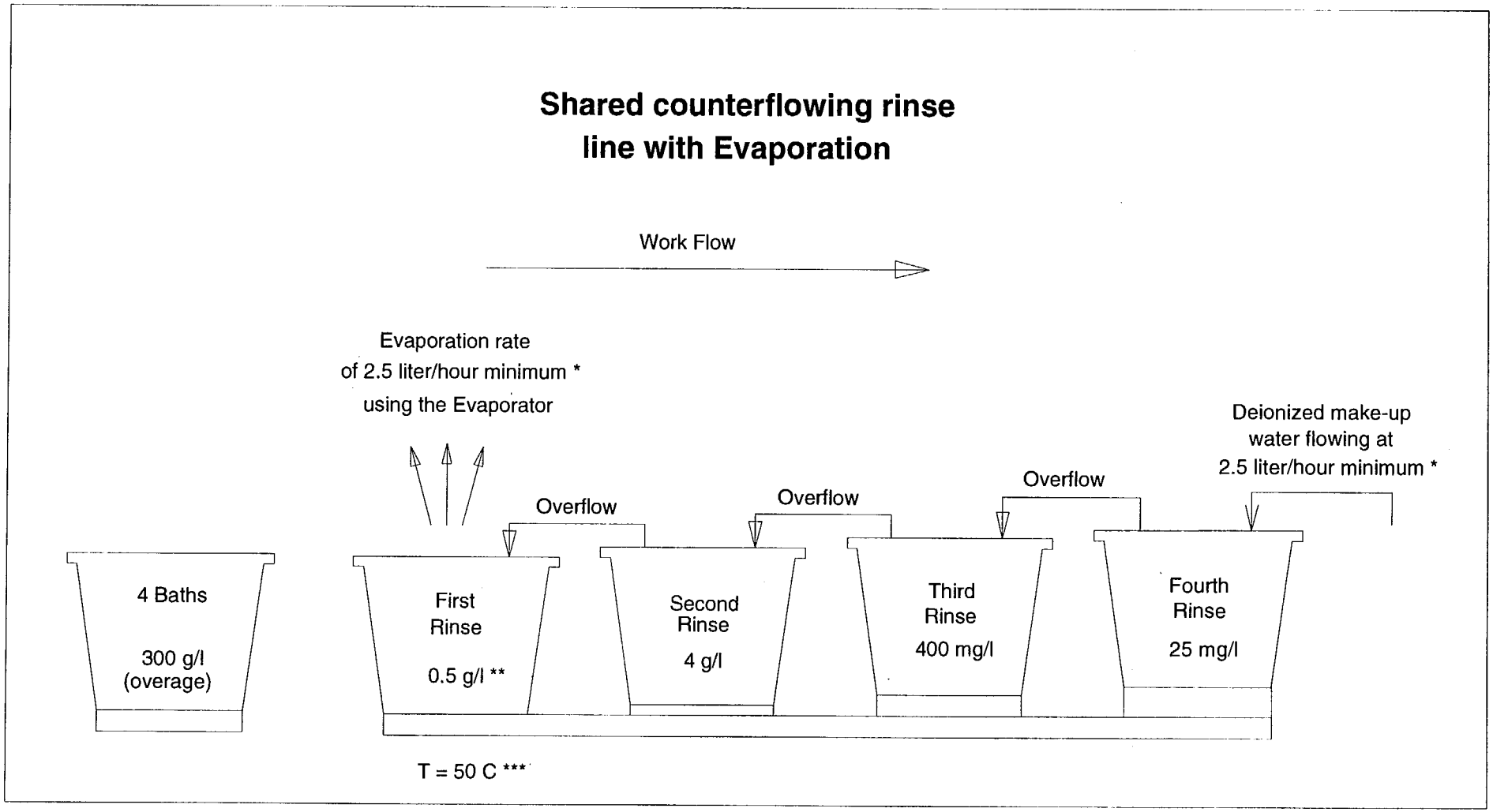
D3. Neutralization of Acid/Base Effluent, Flocculation/Decantation, Filtration, and Drying

All the effluent from the facilities--except effluent laden with hexavalent chromium and cyanide that receives the above mentioned treatments before it is placed in the neutralization tanks--are neutralized and then pumped into the flocculation and decanting tanks. Chromium- and cyanide-treated effluent is also neutralized. The light phase, after decantation, is cleaned and may be reused in the process. The heavy phase, comprised of decantation sludge, goes to a press filter. The liquid is recycled and the cake is dried before it is sent to a company that specializes in this type of work.

Schematic Principle of the Rinse Treatment/Recovery Project



220



Note: The above-mentioned values were generated using a mathematical model and should be used as indicators only.
*: This is the minimum evaporation rate required for proper operation of the rinsing line.
A small evaporator will suffice to reach this value.
**: This concentration is reached when the electrowinning cell operates continuously.
***: This is a maximum temperature. The 2.5 liter/hour evaporation rate can be reached at 40 C.