Minnesota Technical Assistance Program

WASTE WATER REDUCTION IN METAL FINISHING AND IN CLEANING

MnTAP Intern Report—Summer 1997

Kurt Manufacturing Company

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Table of Contents

Table 2, Implementation Summary for Waste Reduction Optionsfor the Automatic Division: Cost savings include water costs, sewer costs, and RO system costs. In addition SAC liability savings is listed. Each SAC unit denotes 274 gallons per day.

Waste Reduction Option	**Waste Reduced (gal/yr)**	**SAC Reduced (units)**	**Cost Savings ($/yr)**	**SAC Liability Savings ($)**	**Status**
Cascade in Carousel	297,480	3	892	2,850	recommended
Cascade in Crest Washer	700,150	7	1,318	6.650	recommended
Spray Rinse in Carousel	1,005,000	10	3,015	9,500	recommended
Spray Rinse Modifications in Crest Washers	876,850	9	2,753	8,550	recommended
NPDES Permit	0	9	-1200	8,550	not recommended
RO Reject for Carousel	937,300	9	3,281	8,550	recommended

ABSTRACT

Kurt Manufacturing Company began in 1946 as a machining job shop. Since then, the company has acquired metal finishing abilities. In addition, the company offers part cleaning as a service. Both metal finishing and part cleaning require water for rinsing.

Specifically, the Machining Division and Kurt Gear Division offers metal finishing services. The Metal Finishing Line, which contains 16 five hundred gallon tanks, alone generates five million gallons of waste water annually.

Cascading rinse tanks and reducing carry-over volume will individually reduce waste water. Carry-over volume can be reduced by extending the drip-time, modifying the basket design, and by installing spray-rinsing.

Cascading rinse tanks can reduce waste water generation by 50% or 2.5 million gallons annually. In addition, an annul savings of 13 thousand dollars can be experienced. After rinse tanks are cascaded and the carry-over volume is reduced, the fresh water flow rates can be optimized to minimize waste of virgin rinse water. In addition, the characterization of rinse water will lead to less cleaning of rinse tanks and ultimately less waste water. Table 1 summarizes each option that was investigated and displays the implementation status of these options.

Table 1, Waste Reduction Option Implementation Summary for the Machining Division and Kurt Gear Division: Cost savings include water costs, sewer costs, RO system costs, and chemical costs.

Waste Reduction Option	**Waste Reduced (gal/yr)**		**Cost Savings ($/yr)**	**Status**
Cascade Rinse tanks				
Cascade 1	264,000		1,637	implemented
Cascade 2	1,926,000		9,992	not yet implemented
Include Tank 15 in Cascade 2	282,000		1,845	recommended
Cascade Tank 16 and Tank 15	0		-640	not feasible
Reduce Carry-Over Volume*	**Waste**	**Chemicals (/yr)**		
Extend Drip-Time	1950	6,814 lb 13 gal	2,513	recommended
Design New Basket	1350	3,364 lb 47 gal	1,423	recommended
Spray-Rinsing	—	—	—	recommended
Characterize Rinse Water	72,000		10,059	recommenced
Optimize Flow Rates	922,000		5,716	recommended

Additional work was done at the Automatic Division and Industrial Product Division. Waste water generation at the Automatic Division can be reduced by cascading rinse tanks, installing spray rinsing, and using reverse osmosis (RO) reject water for washing. These options were investigated to possibly reduce a service availability charge (SAC) liability. Table 2 summarizes the specific options for the Automatic Division.

Page

I. Background

A. Company Description
B. Process Description
C. Key People

A. Company Description

In 1946 Kurt Manufacturing Company began as a machine job shop. Since then the company has developed the capabilities to die cast, machine, test, finish, coat, deburr, and assemble. The corporate office of Kurt Manufacturing Company is located at 5280 Main St. NE in Fridley Minnesota (55421). Telephone and fax numbers are 612-572-1500 and 612-572-9878 respectively.

The company includes a total of nine divisions located at seven locations in the Minneapolis metro area, one in Nebraska, and the final location in Colorado. The general capabilities each of these divisions can best be described by the SIC codes. Fabricated metal products are represented with code 3499, which is shared by four divisions. Code 3451, shared by two facilities, denotes screw machine products. The code for aluminum die casting is 3363, and the code for electronic material is 3820. SIC Code 3544 represents special dies and tools, die sets, jigs and fixtures, and industrial molds. The final code utilized by Kurt Manufacturing company is 3842, which denotes orthopedic, prosthetic and surgical appliances, and supplies. Divisions do share capabilities, but each facility uses these abilities for different jobs. Table I-1 in displays division information, including the SIC codes, for each division.

Both the Machining Division and Kurt Gear Division are located at the Main St. address. The Machining Division is not only the largest division, but also the oldest. The division focuses on the design of anything from small screw machined parts to large fabrications and machined castings. Kurt Gear produces various types of high precision gears including spur, helical, worm, spiral, and coniflex bevel. Both divisions share metal finishing and heat treating capabilities. A combined workforce of 303 employees facilitate the needs of both divisions and SIC code 3499 represents the product lines of both divisions.

The Automatic Division, located in Coon Rapids, employs 132 people to manufacture equipment and parts for industrial use. Capabilities, denoted by SIC code 3451, of the division include automatic screw machine operation, centerless grinding, milling and secondary machining. Customers include the hydraulic, computer, military, medical, and commercial industries. The address for the Automatic Division is 1292 Northdale Blvd. NW, Coon Rapids (55448). The telephone and fax numbers are 612-572-4488 and 612-786-6336 respectively.

The Industrial Product Division located at 1325 Quincy St. NE in Minneapolis (55413) employs 94 people to fulfill specific needs of industry. The workholding product line includes power draw bars, high precision chucks, tooling blocks, and specialty vise jaws. These products are represented by SIC code 3544. The division telephone number is 612-572-4424 (800-328-2565) and the fax number is 612-623-3902.

The remaining sections of the company include the Pueblo Division, the Lyman Division, the Theradyne Division, the Kurt Die Casting Division, and finally the Electronic Division. The Pueblo Division, in Colorado, possesses Class 100 clean room facilities. These facilities allow the division to fulfill the machining needs of the computer industry. The Lyman Division, in Nebraska, maintains automatic screw machining capabilities, grinding abilities, and cutter operation capabilities. The Theradyne Division, in Jordan, manufactures products such as wheelchairs and truck bumpers. The remaining divisions, Kurt Die Casting and Electronic, are both located in Fridley. The Kurt Die Casting Division provides customers with trim dies and die maintenance. Finally, the Electronic Division increases the capabilities of Kurt Check Gaging Systems.

Each of the divisions will benefit from the reduction of water usage. Although, this project focuses on the specific needs at the Main St. address and at the Automatic Division. Some additional work has been done at the Industrial Product Division.

Table I-1, Division Locations, Contact Information, Number of Employees, and SIC Codes: Kurt Manufacturing Company is comprised of nine individual divisions. Seven of the divisions are located in the Minneapolis area, and the remaining divisions are located in Nebraska and Colorado.

Division	Address	Telephone	Fax	People	SIC Code
Corporate Headquarters	5280 Main St. NE Fridley, MN 55421	(612)572-1500	(612)572-9878	54	
Machining and Kurt Gear	5280 Main St. NE Fridley, MN 55421	(612)572-1500	(612)572-9878	303	3499
Automatic	1292 Northdale Blvd. NW Coon Rapids, MN 55448	(612)572-4488	(612)572-0801	132	3451
Industrial Product	1325 Quincy St. NE Minneapolis, MN 55413	(612)572-4424 (800)328-2565	(612)623-3902	94	3544
Pueblo	350 Keeler Pkwy. Pueblo, CO 81001	(719)948-4477	(719)948-3749	100	3499
Lyman	Jeffers and O St. Lyman, NE 69352	(308)787-1211	(308)787-1281	103	3451
Theradyne	395 Ervin Industrial Blvd. Jordan, MN 55352	(612)502-9190	(612)492-3443	92	3842 3499
Kurt Die Casting	7585 Highway 65 NE Fridley, MN 55432	(612)572-4650	(612)786-6336	155	3363
Electronics	7585 Highway 65 NE Fridley, MN 55432	(612)572-4597 (800)343-9884	(612)784-6055	17	3820

SIC Code Descriptions:
3499—fabricated metal products
3451—screw machine products
3544—special dies and tools, die sets, jigs and fixtures, and industrial molds
3842—orthopedic, prosthetic, and surgical appliances and supplies
3363—aluminum die casting
3820—electronic material

B. PROCESS DESCRIPTIONS

Waste water reduction in the Metal Finishing Line at the Main St. plant was the primary focus of the project. An additional area of waste water concern was the overall plant consumption at the Automatic Division. Finally, some time was spent analyzing the metal finishing line at the Industrial Product Division.

1. Machining Division and Kurt Gear Division

The Metal Finishing Line at the Main St. alone generates six million gallons of waste water annually. As shown in figure I-1, eight rinse tanks and eight process tanks form the Metal Finishing Line. A detailed diagram is included as figure V-3 in appendix C. Each tank in the line has a 500 gallon capacity. Figure I-1 also shows the annual waste generation for each tank.

Residue metals and surfactants from a preliminary deburring process are cleaned from the parts during metal finishing. Water soluble coolant films, from machining, need washed from the parts.

An automatic hoist moves baskets, which are filled with parts, from one tank to the next. Tank 1 in the line contains an alkaline, which is used to clean the parts before any further finishing. An acid cleaner, which is currently not in use, is contained in tank 2. Tank 4 contains a basic etchant, which is used for further cleaning of aluminum parts. Aluminum parts are cleaned further in tank 7 with an acidic deoxidizer. Die cast aluminum is again cleaned with a nitric acid cleaner in tank 10. To protect against corrosion, the parts can be treated with chromic acid conversion coatings in either tank 13 or tank 14. Tank 13 contains a clear iridite, while tank 14 contains a yellow iridite. The clear iridite coating is chosen when the parts will not be painted and the yellow finish is applied if the parts are

16 R	Hot Rinse: 130°F to 140°F 18M gal/year (sewer)	0 gph RO Dead Rinse
15 R	Iridite Rinse 300M gal/year (sewer)	RO 70.5 gph
14 cold	Yellow Iridite: 90°F 500 gal/year (hazardous)	
13 cold	Clear Iridite: 90°F 500 gal/year (hazardous)	
12 R	Rinse 2.5MM gal/year (sewer)	RO 600 gph 10 gpm
11 R	Acid Rinse 900M gal/year (sewer)	Tap water 211.5 gph 3.5 gpm
10 cold	Nitric Acid Cleaner 500 gal/year (hazardous)	
9 hot	Passivate: 120°F to 125°F 500 gal/year (hazardous)	
8 R	Deoxidizer Rinse 1MM gal/year (sewer)	RO 540 gph 9 gpm
7 cold	Deoxidizer: 90°F 6M gal/year (hazardous)	
6 R	Rinse 18M gal/year (sewer)	RO 0
5 R	Etchant Rinse 918M gal/year (sewer)	RO 75 gpm 450 gph
4 hot	Etchant: 100°F to 160°F 6M gal/year (sewer)	
3 R	Alkaline Rinse 300M gal/year (sewer)	RO 70.5 gph 1 gpm
2	Acid Cleaner (not in use)	
1 hot	Alkaline Cleaner: 150°F to 180°F 4.5M gal/year (sewer)	

300
500
2,500
900
1000
6
18
918
6
300
6400

Figure I-1, Original Schematic of the Metal Finishing Line at the Main St. Plant: The approximate amount of waste generated annually is included. The tank contents are at room temperature if not noted.

to be painted. Steel can also be finished in this line, with the passivate solution in tank 9.

Reverse osmosis (RO) water is fed to each of the rinse tanks except for tank 11 which is fed with tap water. Tanks 6 and 5 are operated in counter-current flow, while the remaining tanks each have fresh water feed. During operation the parts may be rinsed twice in separate dip-rinse tanks. This double rinsing occurs after the etchant process (tank 4), after the acid tanks (tank 9 or tank 10), and after iridite finishing (tank 13 or tank 14). Tank 9 is used only to passivate stainless steel and tank 10 is used only to clean die cast aluminum. No process utilizes both Tank 9 and Tank 10. The final rinse tank (tank 16) is a hot water rinse. Based on operator observation, the combination of the cold and hot water rinses following the iridite tanks allows for a smooth iridite finish on the parts.

Multiple processes may be operated in the Metal Finishing Line throughout any work day. The number of process tanks used depends on metal type and customer requests. Hence, the number of rinse tanks used depends on the process tanks used. Primary operation occurs between 6:00 a.m. and 4:00 p.m., Monday through Friday. Additional operation does occur during the evenings between 4:00 p.m. and 2:30 a.m. Metal finishing is rarely completed during the weekend.

After the parts are metal finished, they are shipped either to the customer or for further processing. Additional painting can be accomplished within the plant or by another source while, anodizing must be done by another company.

2. Automatic Division

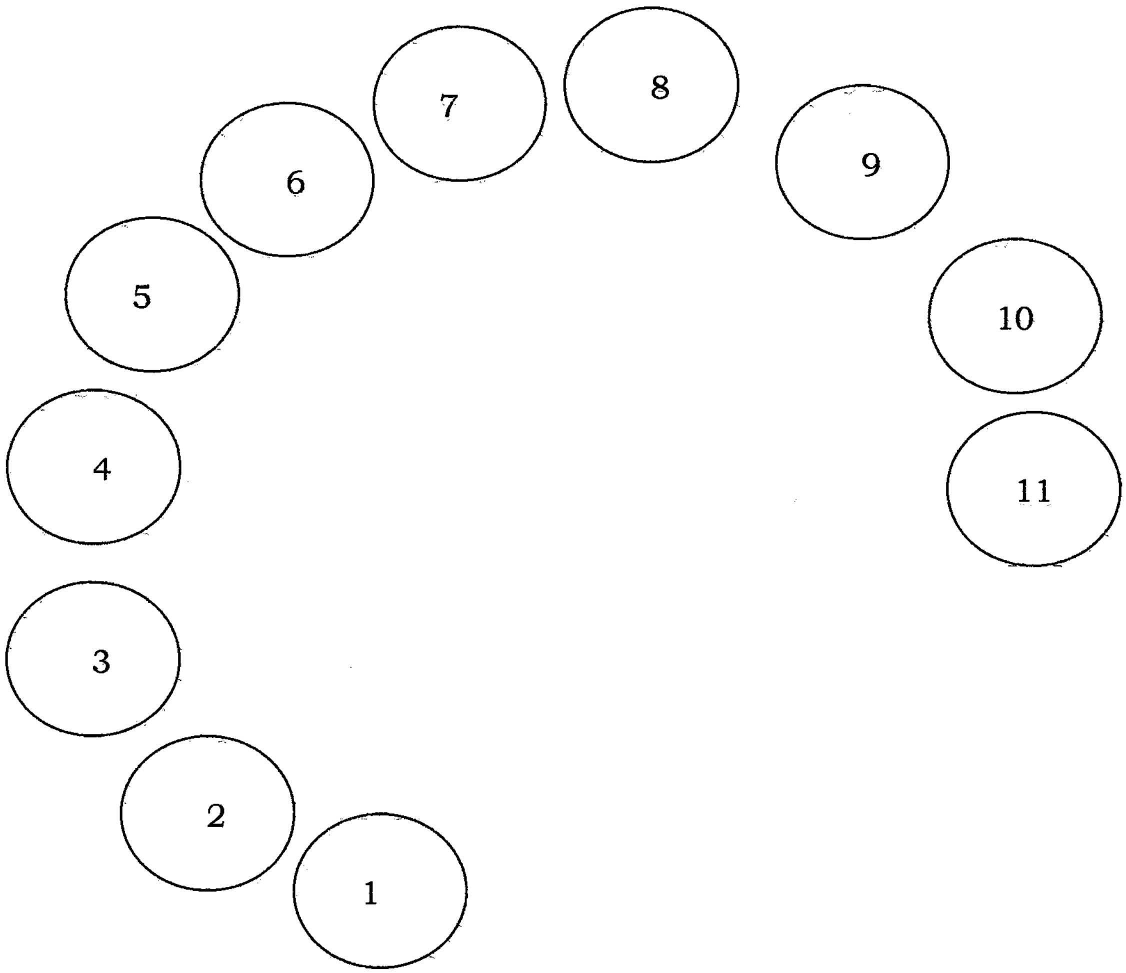
The Automatic Division faces a Service Availability Charge (SAC) liability. The SAC baseline is defined as the maximum amount of water that can be disposed of through a sanitary sewer in one working day. The baseline is specified by a unit, which is 274 gallons. The current SAC baseline is 43 units per day (11,782 gallons per day), but the facility operates at 81 units per day (22,194 gallons per day). In general, a facility is charged $950 per unit for any excess sewer disposal. Therefore the Automatic Division must reduce waster water disposal by 38 units (10,412 gallons per day) before the $36,100 SAC liability will be reduced. The main areas of waste water generation include the RO system and three washer systems. Possibilities for waste water reduction in each of these areas will be discussed.

In addition to the SAC liability, the facility has been experiencing problems with part quality. Specifically, the washer systems have not been adequately cleaning the spacers. Therefore the primary concern of the plant is correct this cleanliness problem. The threat of lost profit from poor part quality is a greater threat than the Sac liability. Hence changes that can reduce the SAC liability may be neglected. Although, these changes can be made for future cost reduction and for future waste water reduction.

Before the spacers are cleaned, they are placed in a grinding system. After grinding the spacers move through two separate washing systems. The first system, Carousel Washer System, initially washes the spacers with an alkaline cleaner and a deoxidizer. From the Carousel Washer System the rack of spacers is manually moved to one of two Crest Washer Systems. Each of the Crest Washer Systems perform a final cleaning of the spacers with an alcohol blend. After proper cleaning the parts are immediately packaged for the customer. Although some of the spacers may be sampled throughout the day for cleanliness quality.

a. Carousel Washer System

The primary use of the Carousel Washer System is to perform preliminary cleaning of parts. The parts move through the system on racks, which are moved from one tank to the next by an automatic arm. The system contains 11 tanks each with a 209 gallon capacity as shown in Figure I-2. Annual waste generation for each tank is included in the figure.



Tank	Description	Waste Generation	Comments
1	Alkaline Cleaner Alkalume 143	11M gal/year	
2	Alkaline Rinse	1.0MM gal/year	
3	Alkaline Cleaner Alkalume 143	11M gal/year	
4	Hot Alkaline Rinse	457M gal/year	
5	Hot Rinse	11M gal/year	Waste Feeds 4
6	Rinse	308M gal/year	
7	Rinse	11M gal/year	Waste Feeds 6
8	Deoxidizer Alkalume	2.5M gal/year	
9	Hot Deoxidizer Rinse	0 gal/year	Spray Rinse
10	Hot Rinse	1.0MM gal/year	Waste Feeds 9
11	Hot RO Rinse	4.1MM gal/year	

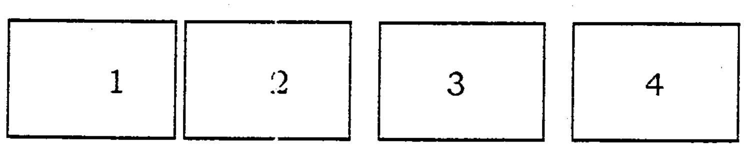
Figure I-2, Schematic of the Carousel Washer at the Automatic Division: Only one tank (tank 8) contains a hazardous material. The remaining tanks can be disposed of to the sewer without any pre-treatment. Tank 8 is cleaned monthly and the remaining tanks are cleaned weekly.

Parts are first cleaned with an alkaline cleaner in tank 1. The parts are then rinsed in tank 2 before being cleaned in tank 3 with the same alkaline cleaner. The parts then proceed through a series of four rinses in tanks 4, 5, 6, and 7. After the parts are thoroughly rinsed, they are cleaned with a deoxidizer in tank 8. Tank 9 is a spray rinse, which uses water from Tank 10, to rinses the parts before they are dip-rinsed in tanks 10 and 11. Water is also conserved by the use of two cascades, tanks 4 and 5, and tanks 6 and 7. Each of the tanks is cleaned weekly except tank 8 which is cleaned monthly. All tanks use well water except for tank 11 which uses RO water. After the parts are cleaned in the Carousel Washer System, they are moved to one of the Crest Washer Systems for additional cleaning.

b. Crest Washer Systems

Each of the two Crest Washer Systems utilize similar steps to generate clean parts. In each system the parts are rinsed initially rinsed in an ethoxylated alcohol blend. Then the parts enter a series of rinsing and drying steps.

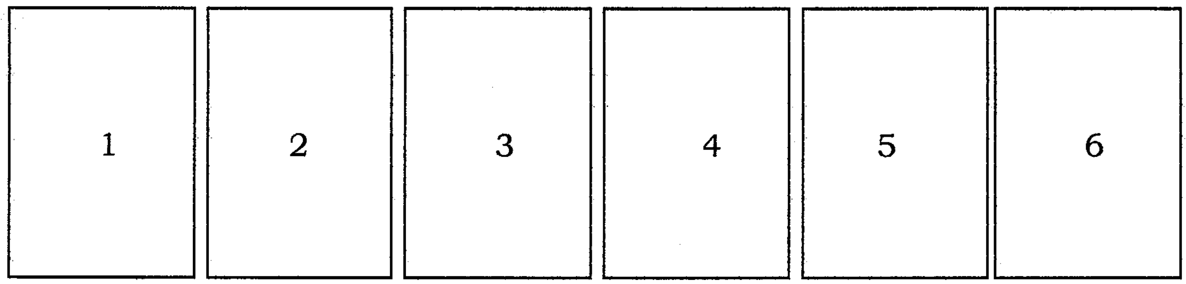
Figure I-3 shows a schematic of the Old Crest Washer Model K#1047. This washer system contains a total of four tanks. Tank O1 contains the ethoxylated alcohol blend. The remaining tanks are used for rinsing. Tank O2 is a hot spray rinse, tank O3 is a dip rinse, and tank O4 is a high pressure spray rinse. Each of the tanks uses RO water and has a 25 gallon capacity.



Tank	Description	Waste Generation	Comments
1	Ethoxylated Alcohol	18M gal/year	
2	Hot Alcohol RO Rinse	114M gal/year	Spray Rinse
3	RO Rinse	249M gal/year	
4	High Pressure RO Rinse	114M gal/year	Spray Rinse

Figure I-3, Schematic of the Old Crest Washer Model K#1047:
The entire system uses RO water and the tanks have a 25 gallon capacity.
All waste water can be disposed of through the sewer

The New Crest Washer Model K#2424, which contains six tanks, is depicted in figure I-4. Each of the tanks has a 48 gallon capacity. The first two tanks, N1 and N2, contain ethoxylated alcohol blends. Tank N3 is a spray rinse followed by rinse tanks, N4 and N5. Tank N6 is a spray rinse combined with a hot air dry. These six tanks also use RO water.



Tank	Description	Annual Waste Generation	Comments
1	Ethoxylated Alcohol	34M gal	
2	Ethoxylated Alcohol	34M gal	
3	Alcohol DI Rinse	114M gal	Spray Rinse
4	RO Rinse	265M gal	
5	RO Rinse	233M gal	
6	RO Rinse	114M gal	Spray Rinse and Hot Air Dry

Figure I-4, Schematic of the New Crest Washer Model K#2424: The entire system uses RO water and the tanks have a 48 gallon capacity. All waste water can be disposed of through the sewer

c. RO System

Essentially, the RO system is a membrane system that removes metals from tap water. Debris and large dirt particles are first removed from the water through mechanical separation. The water then passes through a membrane filtration system where calcium, magnesium, iron, and additional metals are removed from the water. The resistivity of the water is tested before it is discharged to the holding tank. About one-third of the water fed to the RO system is passed to the sewer as a reject stream.

Changes can be made to each of the systems to reduce the amount of water used. Immediate changes to the washer systems can reduce SAC costs significantly. Although these changes may not be feasible for product quality. Alterations can also be made to the system that will improve rinsing quality and effectiveness. These changes will reduce overall water consumption in the long-run, but may not reduce the SAC liability. Ultimately operating costs from water use and discharge can be decreased by altering the systems for improved rinsing quality. Operation occurs 24 hours per weekday and for eight hours each weekend day. The system is shut down each Monday for about six hours for cleaning. Hence the cleaning process is operated for 130 hours per week.

3. Industrial Products Division

A metal finishing line is currently not in use. Operation requires generous amounts of hazardous material disposal. The type of part does not allow for proper drainage of chromic acid. Hence an excess amount of chromic acid is carried from one tank to the next.

The process is similar to the one at the Main St. Plant where the parts are cleaned with an alkaline solution and an etchant. After cleaning the parts proceed to a chromic acid iridite line, where a conversion coating is applied. The problem occurs with the iridite half of the line, when the parts hold generous amounts of chromic acid. Hence, the first of three rinse tanks is quickly contaminated with chromic acid and must be disposed of as a hazardous material. Preliminary assessment of the problem was done and brief suggestions were made.

C. Key People

Many people contributed to the success of waste water reduction at Kurt Manufacturing Company. Table II-2 lists primary contributors and contact information and appendix E contains a full listing of resources contacts for the project.

Table II-2, Important Contributors to the Project:
Contact information for contributors and company position is listed below.

Name	**Position**	**Company**	**Telephone**
Karl DeWahl	Senior Engineer	MnTAP	(612)627-1904
Roger Knaus	Operator	Kurt Manufacturing	763 ~~(612)~~572-4565
Dave Muncy	Operator	Kurt Manufacturing	763 ~~(612)~~572-1500
Jim Sjoselius	EHS Manager	Kurt Manufacturing	763 ~~(612)~~572-4627
Chris Wiege	Contractor	Climatronics, HAVAC/R	763 ~~(612)~~427-4940

First, Karl DeWahl who is a senior engineer for the Minnesota Technical Assistance program (MnTAP) served as and an intern advisor. Karl contributed his technical knowledge about the metal finishing industry. Karl also provided valuable advice based on his engineering experience.

Next, Roger Knaus and Dave Muncy who are the current operators of the Metal Finishing Line at the Main St. Plant each supplied information about the history of and current operation of the Metal Finishing Line. Roger also provided warnings about the changes made to the process. Input from Dave included concerns about the current operation procedure.

Jim Sjoselius, Corporate Environmental Health and Safety Manager at Kurt, provided valuable insight into the waste water problems. Jim contributed with his knowledge and experience of health and safety issues regarding the project.

Finally, Chris Wiege who is an independent contractor completed the plumbing necessary for installing the cascades in the Metal Finishing Line. Input from Chris included plumbing options and ideas for constructing the new weir systems.

II. Waste Reduction Options: Machining Division and Kurt Gear Division

A. Waste Volume
B. Management Method
C. Reasons for Researching Option
D. Cascade Rinse Tanks
E. Reduce Carry-Over Volume
F. Characterize Rinse Water
G. Optimize Fresh Water Flow Rates
H. Implementation

A. Waste Volume

Currently, five million gallons of waste water is produced annually by the Metal Finishing Line. Before being drained to the sewer all waste water is gathered in a one thousand gallon tank where pH monitoring and adjustment occurs. An additional 10,500 gallons of hazardous material from the same process is disposed of annually. This hazardous material includes 1,500 gallons of chromic acid, four thousand gallons of aluminum deoxidizer, and five thousand gallons of nitric acid. The primary concern is to reduce waste water generation

B. Management Method

Presently, the only method of waste management employed is pH adjustment of the waste stream. Figure V-4 in appendix C shows a diagram of the pH adjustment system. This method accounts only for the waste water and not the hazardous materials. Increased documentation of hazardous material disposal and improved maintenance of the waste water will each improve waste management. In addition, improved communication between shift employees will help refine current management methods.

C. Reasons for Researching Options

The primary reason for researching waste water reduction options is to decrease operating costs for the Metal Finishing Line. In addition, the overall plant waste water discharge will be reduced. This reduction allows the facility to operate within its pre-determined SAC limit which is currently 147 SAC units or 40 thousand gallons daily. Health and safety of process operators is the final reason for system modifications. Analysis of this system will also eliminate inaccurate use of caustic for manual pH adjustment of Tank 11 rinse water and therefore chemical cost will be reduced.

Waste water generation can be reduced directly by cascading rinse tanks and by reducing fresh water flow rates. Although, reducing the fresh water flow rate cannot be performed unless rinse water quality will not be diminished. Therefore, process changes which reduce contamination of rinse water must occur so that the fresh water flow rates can be optimized. Methods that can be used to reduce this carry-over include, drip-time extension, spray-rinse implementation, and basket modification. Finally, development of a cleaning schedule which includes water quality testing will reduce both annual operating costs and process down-time. Specific modifications to the Metal Finishing Line and their benefits will be discussed.

D. Cascade Rinse Tanks

1. Type of Process Change

Implementation of cascading significantly reduces waste water volume produced by the Metal Finishing Line and decreases the annual operating cost of the process. Counter-current rinsing within the Metal Finishing Line requires equipment modification. This equipment modification includes weir construction and plumbing. In addition, an equipment change will be required to reduce the use of caustic for manual pH adjustment. Specifically, stainless steel tanks will be replaced with poly-propylene tanks. The combination of nitric acid and ammonium biflouride is corrosive to the stainless steel and after time cause the tanks to crack and leak.

Waste water can be reduced by employing counter-current rinsing or cascading the tanks, as shown in figure II-1. Essentially, fresh water is fed to the final rinse tank. The waste water from that tank is fed to another tank in the line. Theoretically, this scheme can continue until all of the rinse tanks are connected together. The parts are passed in the opposite direction of the water flow. Therefore, the final rinse tank will contain the cleanest water as compared to all of the rinse tanks in the line.

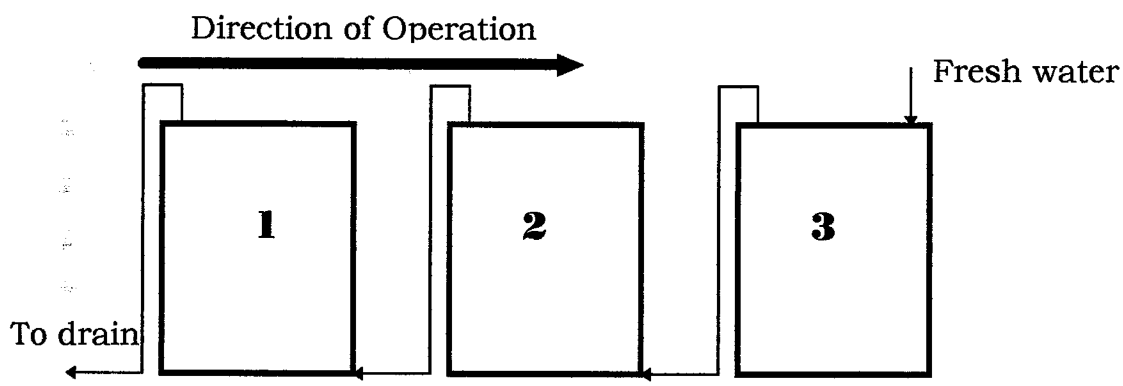


Figure II-1, Simple Schematic of Counter-Current Rinsing: The water from one tank is fed to the one just before it. The final tank in the line receives fresh water.

Counter-current rinsing can be applied to a process where chemical process baths are also utilized. Figure II-2 shows how the concept of cascading rinse tanks can be used in conjunction with chemical tanks. This cascading allows water, that would have been waste, to be re-used. New contaminants are never introduced into the rinse water. Rather chemicals from the process bath are rinsed in one tank and fed to the previous rinse tank in dilute concentrations. In general, the chemicals are passed from one rinse tank to another. Water is fed to the bottom of the tank to force dirt and contaminants away from the tank bottom, over the weirs and out of the tank. Although plumbing codes discourage fresh water from being fed to the bottom of the tank.

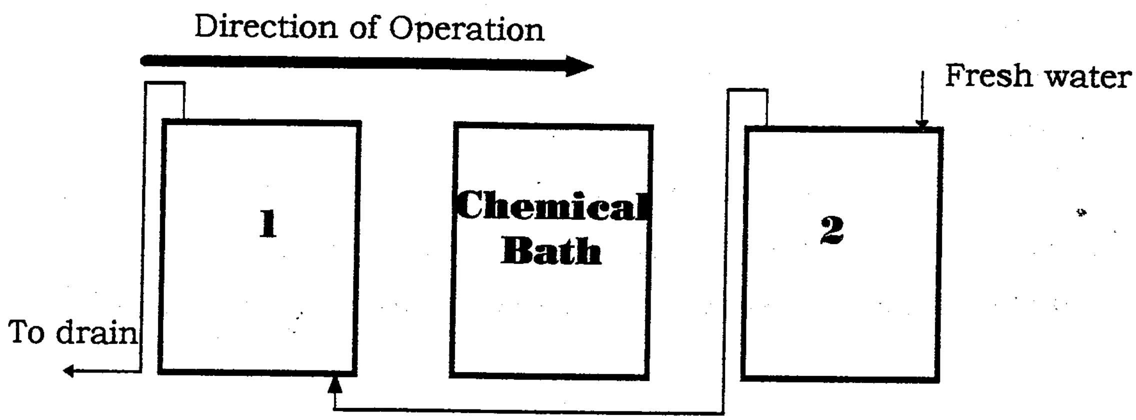


Figure II-2, Rinse Tanks Cascaded within a Chemical Process Line: Fresh water is fed to the final rinse tank and its waste water is fed to the rinse tank just before it. The soil contained in the waste water from rinse tank 2 is the same component as in the chemical bath.

Counter-current rinsing has been employed in past and was discontinued because of a lack of sufficient overflow from one tank to the next. Insufficient overflow occurred because the water level in each tank in the cascade series was even. Flow from one tank to the next can be forced by decreasing the water level in each tank. The last rinse tank in the series of cascades will have the highest water level and the first tank in the cascade series will have the lowest water level. For example, in figure II-2 tank 1 will have a lower water level than tank 2.

Four possibilities for cascading rinse tanks within the Metal Finishing Line have been investigated. Figure II-3 shows where cascading can be incorporated into the current system. Calculations in section 1-f of appendix A show how the water level difference was calculated and table III-1 summarizes these water level differences.

Table III-1, Water Level Differences for Cascading Options: Fluids calculations are shown in section 1-f of appendix A.

Cascade Connection	Water Level Difference (inches)
Tank 15 to Tank 12	1.2
Tank 12 to Tank 11	1.0
Tank 11 to Tank 8	1.2
Tank 4 to Tank 2	0.64

a. Cascade 1

The first option is to modify the first section of the line. Currently, the second tank remains inactive. This tank can be converted to a rinse tank. Then the third tank, currently the alkaline rinse, can be converted to an etch tank. This conversion, allows the next three tanks to be used as rinse tanks as originally designed. The waste water from tank 4 will also be fed to tank 2 as shown in figure II-3. Essentially, Cascade 1 will connect four rinse tanks—Tank 6, Tank 5, Tank 4, and Tank 2—through counter-current rinsing.

b. Cascade 2

Cascade 2 will contain three rinse tanks—Tank 12, Tank 11, and Tank 8. A low pH in tank 11 causes the stainless steel tank to corrode and begin leaking water. Therefore, pH is controlled with the manual addition of caustic solution. By feeding the waste water from tank 11 to tank 8, corrosion of tank 8 also becomes a problem. Hence, polypropylene tanks will replace the two stainless steel tanks. These new tanks will eliminate the need for manual pH monitoring.

c. Include Tank 15 in Cascade 2

Tank 15 can be included in Cascade 2. Because conversion coating is an option as specified by the customer, not every type of part needs to be dipped into either of the iridite tanks (Tank 13 or Tank 14). Hence, rinse water containing chromic acid may cause a problem when iridite is not specified for the part. Installation of a valve system will prohibit the problem of iridite contamination from occurring. Valves can be used to direct the waste water flow from Tank 15 to either Tank

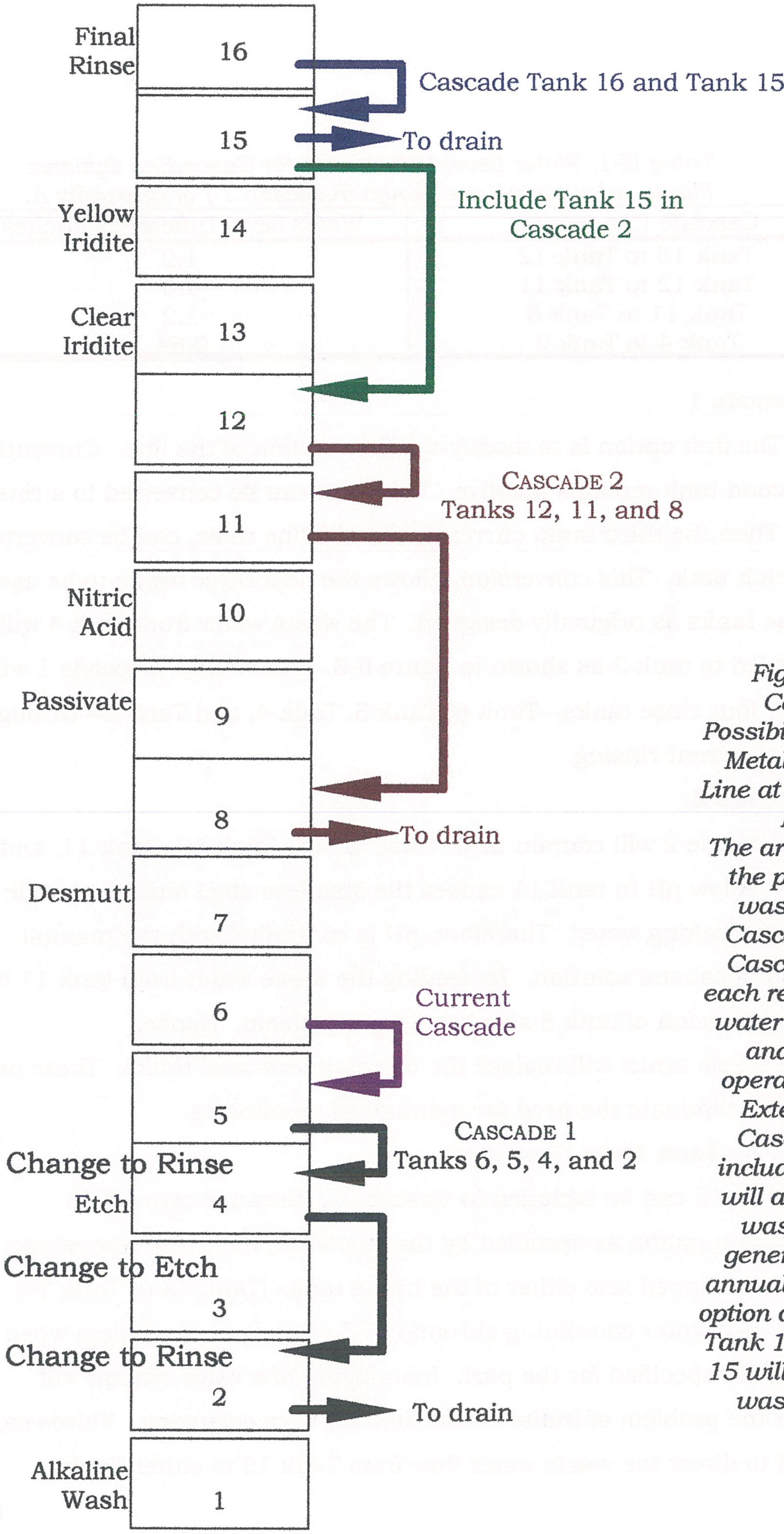


Figure II-3, Cascade Possibilities for the Metal Finishing Line at the Main St. Plant: The arrows depict the path of the waste water. Cascade 1 and Cascade 2 will each reduce waste water generation and annual operating costs. Extension of Cascade 2 to include Tank 15 will also reduce waste water generation and annual costs. The option of cascading Tank 16 and Tank 15 will not reduce waste water.

12 or to drain. Essentially, a valve system will allow cascading only when the iridite tanks (Tank 13 and Tank 14) are in use.

d. Cascade Tank 16 and Tank 15

The other option is to operate Tank 16 and Tank 15 as counter-current rinsing tanks. Currently, Tank 16 operates as a heated dead rinse and therefore heating costs for Tank 16 will be increased.

2. Benefits of Cascading Rinse Tanks

Appendix A, section 1-b shows the calculations of annual savings and of annual waste water reduction. In each cascade, the fastest previous fresh water flow rate was assumed to be the new fresh water flow rate for the cascade. In addition, it was assumed that the chemical costs for the rinse water would decrease with a decrease in waste water generation. Total cost and savings values are shown for all of the tanks in the Metal Finishing Line and for the rinse tanks alone.

a. Cascade 1

Modification for Cascade 1 will included moving the etch tank (Tank 4) from its current position to Tank 3. Tank 2 is currently not in use and therefore will be converted to a rinse tank. Three dip rinses after the etch tank provide a better rinse than two dip rinse tanks. By including tank 2 in the cascade, waste water generation will be reduced by 264 thousand gallons annually and annual operating costs will decrease by $1,637.

b. Cascade 2

Implementation of this cascade will reduce waste water generation by 1.9 million gallons each year and an annual savings of $9,992. Cascade 2 requires the construction of two new tanks. These two tanks will eliminate the safety concerns about handling caustic solution. Chemical costs will also be reduced because caustic solution will only be used in the automatic pH adjustment of the waste water.

Maintenance of Tank 11 water pH between 9 and 10 requires about a half gallon of 50% caustic solution. When Tank 11 is used, caustic solution is added to the tank manually after each dip-rinse. Acid is rinsed from the parts with this alkaline rinse water. Then the pH of the Rinse water drops drastically. Without any caustic addition, this trend continues until the pH reaches a value of about 2 and maintained for the duration of operation. Figure V-2 in appendix B, section 1-2 shows the pH profile of the rinse water in Tank 11. Hence, maintaining a pH of 9 requires about 10 gallons of 50% caustic solution throughout any one day of operation when Tank 11 is used for rinsing.

c. Include Tank 15 in Cascade 2

By including Tank 15 in Cascade 2, annual waste water generation will be reduced by an additional 282 thousand gallons. A additional operating costs savings of $1,845 will be experienced. Finally, clean rinse water can be maintained for use after the conversion coating is applied.

d. Cascade Tank 16 and Tank 15

Employing counter-current rinsing with tank 16 and Tank 15 does not result in any monetary or waste water reduction benefits. Although, a clean final rinse can be obtained. Temperature data is found in table V-29 in section 1-b of appendix B.

3. Economic Analysis

The economics of each cascade option will be discussed and summarized in Table II-2. In each case, the payback period is calculated after taxes assuming a 50% tax rate. In addition, a five year project lifetime and 15% rate of return is assumed. All economic calculations are shown in appendix A, section 1-e in the following tables; Table V-11, Table V-12, Table V-13, Table V-14, and Table V-15.

a. Cascade 1

Cascade 1 only requires plumbing and therefore the capital investment of $500 is minimal. Down-time can be avoided by modifying the tanks during the cleaning process. Annual savings of $1,637 or $819 after taxes will also be small. A payback period of eight months, a discounted cash flow rate of return of 162% and a net present value of $2,243 can be expected. Based on a five project lifetime the net present value is $2,243.

b. Cascade 2 tanks 12 → 11 → 8

Implementation of Cascade 2 will lead to a larger annual savings than Cascade 1. After a payback period of 15 months, an annual savings of $9,992 or $4,996 (50% tax) after taxes will be experienced. Because of the construction of new tanks, the total capital investment exceeds the minimal costs of plumbing. The tanks, constructed of polypropylene and having a ten year lifetime, will cost $1,800 each from UNIFAB, Inc. of St. Louis Park. Tank installation will cost an estimated $200 per tank. Added costs included $1,000 and $425 for plumbing and down-time respectively. Ultimately the total capital investment will be $5,425. The discounted cash flow rate of return is 88% and the net present value is $11,322.

c. Include Tank 15 in Cascade 2

Including tank 15 in Cascade 2 will save an additional $1,845 annually or $923 after taxes. Plumbing costs result in a minimal capital investment of $500. A seven month payback period and 184% discounted cash flow rate of return can be expected. Finally, a net present value of $2,592 will be experienced.

d. Cascade Tank 16 and Tank 15

As stated earlier Cascading Tank 16 and Tank 15 will result in no monetary savings. This option will cost $640 annually due to increased electric cost for heating the fresh water feed to Tank 16. Hence, employing counter-current rinsing to Tank 16 and Tank 15 yields no monetary benefits.

Table II-2, Economic Analysis Summary for the Cascade Options for the Metal Finishing Line at the Machining and Kurt Gear Divisions: Calculations are based on a five year project lifetime and a 50% tax rate. Appendix A, section 1-e displays all calculations.

Options	Cascade 1	Cascade 2	Include Tank 15 in Cascade 2	Cascade Tank 16 and Tank 15*
Capital Investment ($)	500	5,425	500	—
Annual Savings ($/year)	1,637	9,992	1,845	-640
Equipment Lifetime (years)	—	10	—	—
Payback Period (months)	8	15	7	—
Net Present Value ($/year)	2,243	11,322	2,592	—
Discounted Cash Flow Rate of Return	162%	88%	184%	—

E. Reduce Carry-Over Volume

1. Type of Process Change

Carry-over volume exists in two forms. The first form of carry- over volume is any type of solution that is trapped within holes of parts or freely drains from parts and racks. Extension of drip-time, and modification of the part basket will each reduce this type of carry-over

Using a sample of mesh such as used in the basket, RB measure hold up of 0.05 lb of water. This extrapolates to .325 lb or .039 gal on the basket

volume. The second type of carry-over volume exists as a film, which adheres to the part and basket. Spray rinsing will reduce the chemical film that can be carried from one tank to the next.

The use of each process tank dictates the annual carry-over volume from each tank. For example the alkaline wash tank is needed for every part, but the passivate tank is only used for finishing stainless steel. Spray rinsing installation and basket modification requires equipment changes. Drip-time extension requires a process change.

2. Benefits of Reducing Carry-Over Volume

The reduction of carry-over not only reduces chemical costs, but also allows the reduction of the fresh water flow rate. Therefore chemical, water, and sewer costs can be reduced.

A test was conducted to compare the carry-over from the original drip-time of five seconds to an increased drip time of 30 seconds. Table II-3 shows that the initial carry-over volume is decreased by 60%. This decrease in carry-over volume will decrease the annual chemical costs. For example, if the drip-time were increased and the carry-over volume was reduced by 60%, an annual chemical cost savings of $3,574 can be expected. Calculations are shown in appendix A, section 1-c.

Table II-3: Carry-Over Volume Estimation for a Typical Load
Carry-over was estimated for some drip-time after the basket was moved from one tank to the next. Increasing the drip-time does prevent chemicals from being carried into the next tank and therefore chemical cots will decrease. After the drip-time was increased to 30 seconds, carry-over volume was reduced by as much as 0.38 gallons or 60%

Drip-Time	Volume	Drip-Time	Volume
5 s	0.60 gallons	30 s	0.25 gallons
5 s	0.63 gallons	30 s	0.25 gallons

Because drip-time extension is only an option for the tanks that are not heated, spray-rinsing may be the best option for the heated tanks. Spray-rinsing washes the chemicals back into their respective tanks. This option also provides an additional method for rinsing parts. Spray rinsing will also replenish evaporative losses experienced by the heated process tanks.

A test results showed that the current basket design allows 270 gallons of solution to be carried from one tank to the next each year. By designing the baskets to reduce this carry-over volume up to two thousand dollars in chemical costs can be saved annually. In addition, the process time will not be increased at all.

Current basket design allows for a variety of parts to be metal finished. Baskets can be designed to remove some of the mesh material, but still have the ability to carry the largest parts. The sides of the baskets can be removed or be made smaller. In addition, the bottom of the baskets can be replaced with rails or bars. Small baskets, which fit inside the original basket, can be constructed to hold small parts.

3. Economic Analysis

The first carry-over reduction option, increasing the drip-time, significantly reduces the carry-over volume, but also increases the process time. Although annual chemical costs will decrease by $3,574, extended process time will potentially cost $18,889 annually. Process time losses will only be experienced if the line is operating at full capacity. Appendix A, section 1-c shows the savings calculation and the extended process time cost calculation is shown in section 1-c

Process time can also be claimed be decreasing the length of the rinse time. Less contamination will occur because the carry-over volume has been decreased. Hence, less rinsing time is necessary to clean the parts.

Another option of altering the basket design does not increase the process time and will save $1,423 in annual chemical costs. Calculations are also shown in appendix A, section 1-c. Although, this value assumes that all basket mesh will be eliminated for every cycle. Capital cost for altering the baskets will only be the cost of labor and has not yet been determined. The final option of spray-rinsing needs further investigation.

F. Characterize Rinse Water to Reduce Tank Cleaning

1. Type of Process Change

Currently, a rinse tank is cleaned when rinse water looks 'dirty' or has not been cleaned for 'a while'. Once each week the 'dirty' rinse water is dumped. The tanks are then scrubbed and partially inspected for any visible cracks. Fresh water fills the tank. This cleaning process does not included any prior testing of 'dirty' water. The tanks are drained rather quickly, but scrubbing of one rinse tank requires 45 minutes of down-time. This current system permits wasting rinse water and requires extensive down-time. A maintenance change of characterizing 'dirty' rinse water with conductivity and pH readings can decrease down-time and wasted rinse water. Although, conductivity and pH readings provide indirect measures of contamination. Therefore cleaning limits need to be chosen carefully. Additional care needs to be taken with the conductivity meter. In general conductivity meters are quite sensitive and must be calibrated on a regular basis.

2. Benefits of Characterizing Rinse Water

Some of the rinse tanks need to be cleaned more often than others, but on average each tank is cleaned 36 times per year. Currently, no system exists for determining when rinse water needs to be dumped. If tanks do not need to be cleaned as often operation down-time will be reduced significantly. In addition, waste water generation will be decreased. Conductivity and pH data are located in table V-28 and table V-30 respectively in appendix B section 1-a and section 1-c.

For example, if the tanks are cleaned out only 18 times per year, down-time is reduced by 108 hours annually and waste water generation will be decreased by 72 thousand gallons annually. Annual savings of $879 can be expected in water and sewer costs and potentially $9180 in down-time can be saved each year. Down-time savings can only be experienced at full capacity operation. Calculations assume that the tanks are cleaned half as much and hence only 9 thousand gallons of water is used for cleaning. The down-time calculation is shown in appendix A, section 1- b.

3. Economic Analysis

The only capital cost required to characterize rinse water is $500 for a bench-top conductivity meter. The actual savings and payback can only be calculated can only be done once it is determined how often the tanks will be cleaned. Although, an economic analysis was conducted on a scenario of cleaning the tanks half as much. By cleaning the tanks half as often $879 in water and sewer costs can be saved annually after a payback period of 16 months. A 15 % rate of return was assumed. Assuming a 50% tax rate, the annual savings will be $440. In addition, the net present values after five years will be $973 and the discounted cash flow rate of return is 84%. Section 1-e in appendix A shows the economic calculations.

In addition to water cost and sewer cost savings, less down-time will be experienced. This decrease in down-time from cleaning ca potentially result in an additional annual savings of $9,180 for a total annual savings of $10,059. The new payback period is then only one month with a discounted cash flow rate of return of 1008%. The net present value is $16,360 for a five year project lifetime.

G. Optimize Fresh Water Flow Rates

1. Type of Process Change

The present process does not control any of fresh water flow rates. Although, three rinse tanks— Tank 12, Tank 8, and Tank 6—each have a solenoid valve that times the flow of fresh water. The solenoid valves have programmed intervals to deliver fresh water for seconds and wait for 10 seconds. The remaining tanks each have a manual valve which delivers fresh water. Optimization of fresh water flow rates will keep clean rinse water from being wasted. In addition, the solenoid valves can be adjusted to deliver fresh water only when the rinse tanks are being used. Each of these options will require a process change.

2. Benefits of Optimizing Water Flow Rates

The conductivity and pH of the rinse water was monitored periodically for a number of weeks. During this time an experiment with decreased flow was conducted. The test results showed that by decreasing the fresh water flow rate, the water quality did not decrease significantly. This test suggested that the current fresh water flow rates allow virgin rinse water to be wasted. Essentially, optimization of fresh water flow rates will efficiently utilize rinse water and will ultimately reduce operating costs.

3. Economic Analysis

Fresh water flow rates can only be optimized after cascading is implemented. Ideally, the flow rates should be verified after any type of process change. Optimization of flow rates will cost nothing, but will save on annual water and sewer costs.

H. Implementation

Each of the options has the possibility to reduce waste water generation and to decrease annual operating costs. The changes require either small equipment changes or simple process modifications. The options of employing counter-current rinsing was fully investigated. Preliminary research and testing was done on the remaining options, and further investigation may be necessary before any modifications can be made. Progress of each waste reduction option is found in the Table II-4. In addition, cost savings and waste reduction volume is included.

Table II-4, Waste Reduction Option Implementation Summary: Cost savings include water costs, sewer costs, RO system costs, and chemical costs.

Waste Reduction Option	Waste reduced (gal/yr)		Cost Savings ($/yr)	Status
Cascade Rinse tanks				
Cascade 1	264,000		1,637	implemented
Cascade 2	1,926,000		9,992	not yet implemented
Include Tank 15 in Cascade 2	282,000		1,845	recommended
Cascade Tank 16 and Tank 15	0		-640	not feasible
Reduce Carry-Over Volume*	**Waste**	**Chemicals (/yr)**		
Extend Drip-Time	1950	6,814 lb 13 gal	2,513	recommended
Design New Basket	1350	3,364 lb 47 gal	1,423	recommended
Spray-Rinsing	—	—	—	recommended
Characterize Rinse Water*	72,000		10,059	recommenced
Optimize Flow Rates*	922,000		5,716	recommended

*estimated values based on examples

1. Cascade Rinse Tanks

a. Cascade 1

Cascade 1 was recently implemented and therefore problems cannot be reported at this time. One anticipated problem is the inability to have enough overflow. The fresh water flow rate will need to be adjusted accordingly. Although, at the time of implementation no initial problems were sighted. Figure V-5 in appendix C shows a detailed diagram of the weir construction of Tank 2.

b. Cascade 2

Problems with implementation occurred with obtaining materials for modifications. In addition, problems with stopping production became an issue. Materials are currently ordered and this option will be implemented when the new tanks arrive.

c. Include Tank 15 in Cascade 2

Quality issues prohibit this option from being implemented immediately. Although, with testing and success of the other cascades the Metal Finishing Line can easily be modified to included this option.

d. Cascade Tank 16 and Tank 15

This is option is clearly not feasible because of the added cost for heating. Although if rinse water quality becomes an issue, the Metal Finishing Line can be adapted to accommodate this cascade.

2. Reduce Carry-Over Volume

Extension of the drip-time requires additional testing. Another drip-time (possibly 15 seconds) should be tested. This test will show if the carry-over volume plateaus at a given drip-time. The difficulty of modifying the baskets needs to be investigated. Spray-rinsing will definitely help reduce the carry-over volume and replenish evaporative losses. Although, the economic feasibility needs to be investigated.

Concern about increasing the entire process time has been expressed. Once the drip-time is increased, process time can be saved by reducing the allotted time for rinsing. Because chemicals will be allowed a longer time to drain less rinsing is necessary. This option requires contact with customers because of a procedural change. In general, contact of customers is resisted due to the number of customers and variety of products.

3. Characterize Rinse Water to Reduce Tank Cleaning

Better characteristics need to be determined before this option can be implemented. The current method of defining 'dirty' rinse water is so subjective that it is difficult to set conductivity and pH limits. In addition, tanks are not cleaned when the rinse water 'looks dirty' if production cannot be halted. Essentially, rinse tanks are only cleaned if it is convenient to stop production.

4. Optimize Fresh Water Flow Rates

This option cannot be implemented until each of the cascades are in place. Ideally, the fresh water flow rates should be adjusted each time a change is made to the metal finishing line.

III. Waste Reduction Options: Automatic Division

A. Waste Volume
B. Management Method
C. Reasons for Researching Option
D. Cascade Rinse Tanks
E. Spray-Rinsing
F. RO Reject Options
G. Implementation

A. Waste Volume

The Automatic Division, currently discharges five million gallons of waste water annually. The majority of this water is used for washing spacers. Specifically, the Carousel Washer System generates just over three million gallons of waste water each year and the Crest Washer Systems produce just over one million gallons of waste water annually. The remaining waste water is generated by the RO System, domestic use and other machines.

B. Management Method

No current method exists for managing waste water. Although, part quality is thoroughly tested each day. Karl DeWahl from MnTap was contacted in March 1997 about the waste water generation. Appendix D is a copy of his report of the situation. In addition, table V-33 in section 2-a of appendix B lists the original conductivity data from his visit.

C. Reasons for Researching Option

The primary reason for investigating waste reduction options is to avoid a SAC liability. The facility has a SAC baseline of 43 units or 12 thousand gallons per day, but operates at 81 units or 22 thousand gallons per day. Each SAC unit greater than the baseline limit costs $950. Hence, the facility will be charged $36,100 for 38 units greater than the allowed baseline.

Three general process modifications and equipment changes can individually reduce waste water generation. Rinse tanks within the carousel washer and crest washers can be cascaded. Additional spray rinsing can be implemented in the carousel washer to reduce waste water generation significantly. Finally, two options exist for the RO reject water. The first option is to obtain a permit for RO reject discharge and the other is to use the RO reject water for the carousel washer.

D. Cascade Rinse Tanks

1. Type of Process Change

Currently, two sets of tanks—Tank 4 and Tank 5, and Tank 6 and Tank 7—employ counter-current rinsing within the Carousel Washer System. These two sets can be connected together for only one series of cascaded tanks. One of the Crest Washer Systems can also be modified to included a cascade. Specifically, waste water from Tank N5 can be used to feed Tank N4. Plumbing modifications will be necessary for cascading rinse tanks.

2. Benefits of cascading Rinse Tanks

By cascading the tanks in the Carousel Washer System, waste water generation can be reduced by 297 thousand annually or by three SAC units daily. Annual savings will be $892 and the SAC liability will be reduced by $2,850. An additional waste water reduction of 700 thousand gallons annually or seven SAC units daily. Annual savings will increase by $1,318 and SAC liability will decrease by $6,650

3. Economic Analysis

Calculations, in appendix A (section 2-b and section 1-d), were made after taxes and assuming a 50% tax rate. In addition, a five year project lifetime and 15% rate of return was assumed. It was also assumed that SAC liability reduction was only experienced within the first year of the project. Results are tabulated in Table III-1.

Plumbing modifications for cascading in the Carousel Washer System will cost $1000. After a nine month payback period, a gross annual savings of $892 or after taxes a savings $446 will be experienced. An additional savings for SAC liability of $2,850 is also possible. The net present value will be $1,735 and the discounted cash flow rate of return will be 122%.

A capital investment of $1,000 includes all plumbing modifications needed to cascade Tank N5 and N4. After three months, a gross annual savings of $1,318 or after taxes a savings of $659 will be experienced. In addition, SAC liability will be decreased by $6,650. The discounted cash flow rate of return will be 319% and the net present value will be $4,100.

Table III-1, Economic Analysis Summary for the Cascade Options for the Automatic Division: Calculations are based on a five year project lifetime, 15% rate of return, and a 50% tax rate. Appendix A, section 2-d displays all calculations.

Options	Cascade in Carousel Washer	Cascade in Crest Washers
Capital Investment ($)	1,000	1,000
Annual Savings ($/year)	892	9,318
SAC Liability Reduction ($)	2,850	6,650
Payback Period (months)	9	3
Net Present Value ($/year)	1,735	4,100
Discounted Cash Flow Rate of Return	346%	319%

E. SPRAY-RINSING

1. Type of Process Change

Spray-rinsing is currently used within the Carousel Washer System and the Crest Washer Systems. After equipment modifications, an additional spray-rinse can be employed within the Carousel Washer System. Tank 2, a dip rinse tank in the Carousel Washer System, can be replaced with a spray-rinsing system and waste water from Tank 4 can be used for spray-rinse water. The current spray-rinses within the Crest Washer Systems can be modified to use waste water from the dip-rinses rather than fresh water. Specifically, Tank O3 waste water can be used to feed the spray-rinse in Tank O2 and Tank N4 waste water can be used to feed the spray rinse in Tank N3.

2. Benefits of Spray Rinsing

By installing additional spray-rinsing in the Carousel Washer System, annual waste water generation can be decreased by one million gallons annually or by 10 SAC units daily. Hence annual costs are decreased by $3,015 and the SAC liability is decreased by $9,500. Annual waste water generation can be decreased by an additional 877 thousand gallons or nine SAC units daily if modifications are made to the Crest Washer Systems. Annual savings will increase by $2,753 and SAC liability will decrease by $8,550.

3. Economic Analysis

Appendix A (section 2-b and section 1-d), shows the economic analysis calculations. These calculations assume a 50% tax rate, a five year project lifetime and 15% rate of return. It was also assumed that SAC liability reduction was only experienced within the first year.

Payback period calculations were made using an after taxes cash flow. Table III-2 summarizes the results.

Installation of spray-rinsing in the Carousel Washer System will save the most annually and will reduce the SAC liability the most as compared to all options. After a capital investment of $1,500 and a payback period of two months, an annual savings of $3,015 or after taxes a savings of $1,508 can be expected. The SAC liability can also be reduced by $9,500. The net present value is $7,684 and the discounted cash flow rate of return is 346%

Modification of the Crest Washer Systems will require a capital investment of $1,000. After a one month payback period, an annual savings of $2,753 can be expected. After taxes the annual savings will be $1,377. The SAC liability can also be reduced by $8,550. The net present value is $7,332 and the discounted cash flow rate of return is 493%.

Table III-2, Economic Analysis Summary for the Spray-Rinsing Options for the Automatic Division:
Calculations are based on a five year project lifetime, 15% rate of return, and a 50% tax rate. Appendix A, section 2-d displays all calculations.

Options	**Spray-Rinse in Carousel**	**Spray-Rinse Modifications in Crest Washers**
Capital Investment ($)	1,500	1,000
Annual Savings ($/year)	3,015	2,753
SAC Liability Reduction ($)	9,500	8,550
Payback Period (months)	3	1
Net Present Value ($/year)	7,684	7,332
Discounted Cash Flow Rate of Return	346%	493%

F. RO Reject Options

1. Type of Process Change

Essentially, two options exist for the RO reject water. The water can be discharged to the storm sewer with a NPDES permit. The other option is to use the RO reject water in the Carousel Washer System, which is an actual procedural change. The current procedure uses city well water in most rinse tanks.

2. Benefits of RO Reject Options

By discharging the RO reject water through the storm sewer or by using this water to feed the Carousel Washer System, waste water will be reduced by 937 thousand gallons per year or by nine SAC units per day. Obtaining a permit will only allow the SAC liability to be decreased, but the option of using the RO reject water for the Carousel Washer System will add water and sewer savings. Specifically, annual savings will be $3,281 and the SAC liability will be decreased by $8,550. The increased regulatory burden of maintaining the permit will also be avoided by using RO reject for the carousel washer.

3. Economic Analysis

Appendix A (section 2-b and section 1-d) shows the economic analysis calculations. These calculations assume a 50% tax rate, a five year project lifetime and 15% rate of return. Payback period was calculated with an after taxes cash flow. It was assumed that SAC liability decreases will only be experienced in the first year. Table III-3 summarizes the results

By using RO reject water to feed the Carousel Washer System, $3,281 can be saved annually or after taxes an annual savings of $1,641 will be experienced. Capital investment will be $1,500, which includes a storage tank for $500 and any plumbing. A payback period of three months is expected with a net present value of $1,640. The discounted cash flow rate of return is 328%. The option of obtaining a NPDES permit requires an annual fee of $1200 and an application fee of $85.

Table III-3, Economic Analysis Summary for the RO Reject Options for the Automatic Division: Calculations are based on a five year project lifetime, 15% rate of return, and a 50% tax rate. Appendix A, section 2-d displays all calculations.

Options	NPDES Permit	RO Reject for Carousel
Capital Investment ($)	85	1,500
Annual Savings ($/year)	-1,200	3,281
SAC Liability Reduction ($)	8,550	8,550
Payback Period (months)	—	3
Net Present Value ($/year)	—	1,640
Discounted Cash Flow Rate of Return	—	328%

G. IMPLEMENTATION

All of the options, except for one, are recommenced. Each option will reduce waste water generation and hence, decrease annual water and sewer costs. In addition, the options can significantly reduce SAC liability. Table II-4 summarizes the savings possibilities, waste reduction potential, and status of each option.

Table III-4, Implementation Summary for Waste Reduction Options: Cost savings include water costs, sewer costs, and RO system costs. In addition SAC liability savings is listed. Each SAC unit denotes 274 gallons per day.

Waste Reduction Option	Waste Reduced (gal/yr)	SAC Reduced (units)	Cost Savings ($/yr)	SAC Liability Savings ($)	Status
Cascade in Carousel	297,480	3	892	2,850	recommended
Cascade in Crest Washer	700,150	7	1,318	6.650	recommended
Spray Rinse in Carousel	1,005,000	10	3,015	9,500	recommended
Spray Rinse Modifications in Crest Washers	876,850	9	2,753	8,550	recommended
NPDES Permit	0	9	-1200	8,550	not recommended
RO Reject for Carousel	937,300	9	3,281	8,550	recommended

Essentially, implementation of each of the options is resisted for two reasons. First, any type of change to the current cleaning system risks harming product quality. The second problem is a general resistance to change and a low priority status of water conservation.

The option of obtaining a permit is not recommenced because of increased regulatory burden of reporting and because of the increased cost of maintaining the permit. In addition, a permit does not decrease the generation of waste water.

IV. Waste Reduction Options: Industrial Product Division

The Industrial Products Division performs metal cleaning and finishing for bomb casings. The parts are cleaned in one line of tanks and finished in another line of tanks. The area of concern is the second line of tanks where the casings are finished. In this line, the parts are dipped into an iridite tank and proceed through a series of three dip-rinse tanks. The carry-over volume from the iridite tank is so large that the first rinse tank quickly becomes contaminated and needs to be disposed of as hazardous material.

A preliminary analysis of the situation was done when the line was not in operation. Therefore only qualitative suggestions to reduce hazardous material disposal can be made. Carry-over volume can be reduced directly by increasing the drip-time over the process tank, or by tilting the casing for better drainage. Spray-rinsing can be used either above the process tank or in place of the first drip rinse. Finally, the first dip-rinse tank can be changed to a drip tank. A drip tank serves as an empty tank where solution can drain from the part and later be pumped back into the original process tank. Each of these options can be investigated for possible application and economic feasibility.

V. Appendices

A. Calculations
B. Test Results
C. Process Drawings
D. Additional Information
E. List of Resource People
F. Bibliography

A. Calculations

1. Machining Division and Kurt Gear Division

An example calculation is shown for each set of calculations. If more than one situation occurred, the spreadsheets for each different situation follow the example calculation.

a. Original Operating Costs and Water Usage

The evaporation rates were determined using figure V-1. Each heated tank has a temperature range, therefore the evaporative rate was calculated for each limit. Then an average value was found and used in further calculations. Tank dimensions are 78 inches by 43 inches. A sample calculation for Tank 1 is shown and table V-1 summarizes the evaporation rates for the four heated tanks.

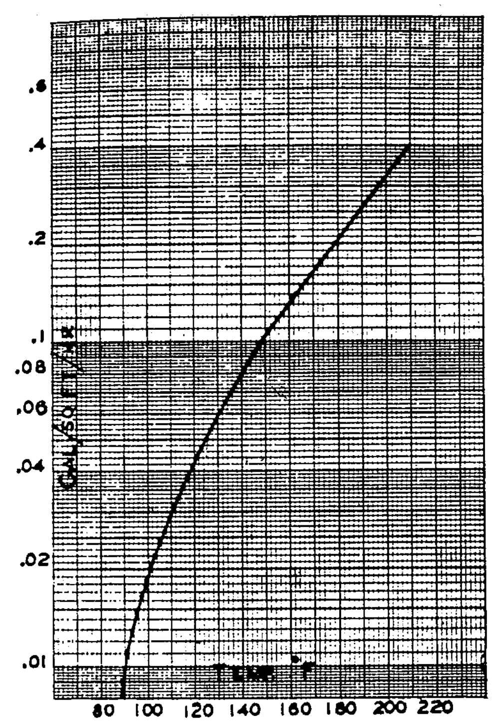


Figure V-1, Evaporation Rate Trend:
Evaporation rate is found assuming relatively still air (D1).
The dimensions of the tank are 78 inches by 43 inches.

Sample Calculations for Tank 1

Surface Area

$$(78\,in)(43\,in)\left(\frac{1\,ft^2}{12^2\,in^2}\right) = 23.29\,ft^2$$

Tank 1 150°F to 180°F

- 150°F 0.1 gal/ft²/hr (from plot)

$$\left(0.1\,\frac{gal}{ft^2}/hr\right)(23.29\,ft^2) = 2.33\,gal/hr$$

- 180°F 0.2 gal/ft²/hr (from plot)

$$(0.2\,gal/ft^2/hr)(23.29\,ft^2) = 4.66\,gal/hr$$

- Average (2.33 + 4.66) 1/2 gal/hr

$$\boxed{= 3.5\,gal/hr}$$

Table V-1, Evaporation Rates for the Heated Tanks:
Evaporation is negligible when the water temperature is less than 90°F

Tank	Temperature Range (°F)	Evaporation Rate (gal/hr)
1	150-180	3.5
4	100-160	2.0
13	120-125	1.1
14	130-140	1.5

Chemical costs were based on the amount purchased in one year. Table V-2 shows the chemical prices, chemical volume, and annual costs. The chemical usage column shows the total amount of chemical used in one year. The chemical process tanks are changed periodically throughout the year. Pure chemical is not added to the tank. Instead a solution of chemical dissolved in water is used to fill the tank. Table V-2 also shows the concentration of each process bath. The chemical changes column shows the amount of chemical used when the tanks are cleaned. Finally, the extra column shows the amount of extra chemical used for replenishing the process bath. It was assumed that this volume was lost from carry-over.

Table V-2: Annual Chemical Costs:
All values are on an annual basis. Prices were found on billing statements.

	Tank	Chemical Usage		Changes		Extra		Carry-Over (gal)	Price per	
Alkaline	1	2,700	lb	2,250	lb	450	lb	900	$0.95	lb
Etch	4	2,571	lb	2,256	lb	315	lb	840	$0.82	lb
Deoxidizer	7	367	gal	300	gal	67	gal	1,340	$7.60	gal
Passivate	9	4,497	lb	2,943	lb	1,554	lb	264	$0.18	lb
Nitric	10	85,356	lb	52,965	lb	32,391	lb	2,752	$0.18	lb
Pik-Aid	10	2,876	lb	1,500	lb	1,376	lb	2,752	$2.56	lb
Clear	13	70	lb	32	lb	38	lb	608	$6.60	lb
Yellow	14	350	lb	63	lb	288	lb	2,300	$9.00	lb

Tank	Annual Costs Changes	Extra	Total Cost
1	$2,137.50	$427.50	$2,565.00
4	$1,849.92	$258.30	$2,108.22
7	$2,280.00	$509.20	$2,789.20
9	$517.97	$273.44	$791.41
10	$9,321.84	$5,700.82	$15,022.66
10	$3,840.00	$3,522.56	$7,362.56
13	$211.20	$250.80	$462.00
14	$562.50	$2,587.50	$3,150.00
Totals	**$20,720.93**	**$13,530.12**	**$34,251.05**

Process Tank Concentrations

Tank	
1	8 oz/gal
4	6 oz/gal
7	5%
9	50%
10	100%
10	8 oz/gal
13	1 oz/gal
14	2 oz/gal

Fresh water flow-rates were determined using the bucket method. The amount of time needed to fill a five gallon pail was recorded. Three measurements were taken and the average flow-rate was calculated from these measurements.

The rinse water is changed an average of 36 times per year. Each time 500 gallons of water is drained through the sewer. Hence, an additional 18 thousand gallons was added to the total water usage and generation.

Water and sewer charges are found directly on billing statements. The disposal charge for hazardous materials is specific for each material and were found on account statements. The value for the RO system is based on the materials needed for a given time period and the amount of RO water produced during this time period. Material cost was found on a purchase order.

It was estimated that fresh water is fed to the tanks for four thousand hours per year. Three tanks—Tank3, Tank 11, and Tank15—have manual valves and hence the water is fed to these tanks for the full time. The remaining tanks—Tank 6, Tank 8 and Tank 12—have automated valves which alternate between feeding water and not feeding water. Therefore fresh water is fed to these tanks only half the time and two thousand hours per year was used for calculation purposes.

Table V-3 shows the current operating costs for the Metal Finishing Line. Additional chemical costs are for waste pre-treatment. The alkaline solution cannot be frothy when emptied into the sewer and the etch solution must be neutralized with sulfuric acid before sewer disposal. The caustic and acid costs are for the automatic pH adjustment system. It was assumed that each rinse tank utilizes equal amounts of chemical for pH adjustment. Although, Tank 11 consume more caustic solution because of manual pH adjustment.

Table V-3, Annual Operating Costs for the Metal Finishing Line:
Total values are shown for all of the tanks and for the rinse tanks alone.

Tank	(gal/hr) Evaporation	Flow	Water (gal/yr) Generation	Evaporation	Usage	Disposal	Price Data ($/gal) Disposal	Water	Sewer	RO System	
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027	
2								0.001	0.0025	0.0027	
3		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027	18000
4	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027	
5		450	918,000		18,000	sewer	0.00	0.001	0.0025	0.0027	18000
6		0	18,000		918,000	sewer	0.00	0.001	0.0025	0.0027	18000
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027	
8		540	1,098,000		1,098,000	sewer	0.00	0.001	0.0025	0.0027	18000
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027	
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027	
11		211.5	864,000		864,000	sewer	0.00	0.001	0.0025	0.0000	18000
12		600	1,218,000		1,218,000	sewer	0.00	0.001	0.0025	0.0027	18000
13			500		500	RCRA	2.01	0.001	0.0000	0.0027	
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027	
15		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027	18000
16	1.5	0	18,000	12,600	30,600	sewer	0.00	0.001	0.0025	0.0027	18000
		Total	**4,760,000**	**68,040**	**4,823,540**						
		Water	**4,749,500**	**68,040**	**4,808,300**						
		Hazardous	**10,500**								

rinse volume = 4,734,000 gpy
Flowing volume = 4,590,000 gpy

144,000 gpy
36 times perge

Tank	Annual Costs($/yr) Disposal	Water	Sewer	RO System	Chemical Cost ($/yr)		All	Total
					Clep 83M	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
2	0.00	0.00	0.00	0.00			0.00	$0.00
					Caustic	Acid		
3	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
					Clepo 30B	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
					Caustic	Acid		
5	0.00	18.00	2,295.00	48.60	190.00	3.23	193.23	$2,554.83
6	0.00	918.00	45.00	2,478.60	95.00	1.62	96.62	$3,538.22
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	1,098.00	2,745.00	2,964.60	190.00	3.23	193.23	$7,000.83
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	864.00	2,160.00	0.00	380.00	3.23	383.23	$3,407.23
12	0.00	1,218.00	3,045.00	3,288.60	190.00	3.23	193.23	$7,744.83
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
16	0.00	30.60	45.00	82.62	95.00	1.62	96.62	$254.84

water cost $1/1000 gal
sewer $2.50/1000
$3.50/1000

	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

b. Annual Savings and Water Reduction

A sample calculation is shown for Cascade 2. Table V-4 shows the results for Cascade 1, Table V-5 shows the results for Cascade 2, Table V-6 shows the results for including tank 15 in cascade 2, and Table V-7 shows the results for cascading Tank 16 and Tank 15. Annual savings for cleaning the tanks less often are shown in table V-8. It was assumed that the rinse tanks would be cleaned half the time. Potential savings from decreased down-time is not included in this table, but the calculation is also shown.

Sample Calculations for Annual Savings and Decreased Down-Time

Tank 8 cost for Cascade 2.

<u>New Operating cost.</u>

Chemical cost 190.00 + 3.23. = \$193.23/year

assume 600 gal/hr for the new flow rate.

$$\left(600\ \frac{\text{gal}}{\text{hr}}\right)\left(\frac{2000\ \text{hr}}{\text{year}}\right) = 1{,}200{,}000\ \text{gal/year generation}$$

↑ from automated valve system from part a.

from cleaning. 18,000 gal/year.

total generation. = 1,218,000 gal/year

total usage = 18,000 gal/year.

Remaining water is fed to tank 12. in the Cascade.

Sample Calculations continued

Water cost. $\left(\frac{18{,}000\text{ gal}}{\text{year}}\right)\left(\frac{\$.001}{\text{gal}}\right) = \$18.00/\text{year}.$

Sewer Cost $\left(\frac{1{,}218{,}000\text{ gal}}{\text{year}}\right)\left(\frac{\$0.0025}{\text{gal}}\right) = \$3{,}045/\text{year}$

RO Cost $\left(18{,}000\text{ gal/year}\right)\left(\frac{\$0.0027}{\text{gal}}\right) = \$48.60/\text{year}$

Total cost for Tank 8 = \$3,304.83
as shown in Table V-5

Decreased Down-Time Potential Savings

45 minutes to clean 1 tank
then for 8 tanks. and clean half as much.
clean 18 times per year (or less times per year)

$\left(\frac{18\text{ clean}}{\text{year}}\right)\left(\frac{8\text{ tanks}}{\text{clean}}\right) = 144\frac{\text{tanks}}{\text{year}}\left(\frac{0.75\text{ hr}}{\text{tank}}\right) = 108\frac{\text{hr}}{\text{year}}$

108 hrs saved per year @ \$85 per hour

$\left(\frac{108\text{ hr}}{\text{year}}\right)\left(\frac{\$85}{\text{hr}}\right) = \boxed{\$9{,}180/\text{year Potential Savings}}$

Table V-4, Cascade 1:
Annual Savings and waste water reduction for the rinse tanks alone and for all of the tanks.

	(gal/hr)		Water (gal/yr)				Price Data ($/gal)			
Tank	Evaporation	Flow	Generation	Evaporation	Usage	Disposal	Disposal	Water	Sewer	RO System
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2		450	918,000		18,000	sewer	0.00	0.001	0.0025	0.0027
3	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027
4		0	18,000		18,000	sewer	0.00	0.001	0.0025	0.0027
5		0	18,000		18,000	sewer	0.00	0.001	0.0025	0.0027
6		0	18,000		918,000	sewer	0.00	0.001	0.0025	0.0027
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027
8		540	1,098,000		1,098,000	sewer	0.00	0.001	0.0025	0.0027
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027
11		211.5	864,000		864,000	sewer	0.00	0.001	0.0025	0.0000
12		600	1,218,000		1,218,000	sewer	0.00	0.001	0.0025	0.0027
13			500		500	RCRA	2.01	0.001	0.0000	0.0027
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027
15		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027
16	1.5	0	18,000	12,600	30,600	sewer	0.00	0.001	0.0025	0.0027

		Generation	Evaporation	Usage
Total gal/yr	**New**	**4,496,000**	**68,040**	**4,559,540**
	Original	4,760,000	68,040	4,823,540
	Reduced	**264,000**	**0**	**264,000**
		5.5%	0.0%	5.5%
Water	**New**	**4,485,500**	**68,040**	**4,544,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**264,000**	**0**	**264,000**
		5.6%	0.0%	5.5%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

	Annual Costs($/yr)				Chemical Cost ($/yr)			
Tank	Disposal	Water	Sewer	RO System			All	Total
					Clep 83M	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
					Caustic	Acid		
2	0.00	18.00	2,295.00	48.60	190.00	3.23	193.23	$2,554.83
					Clepo 30B	Acid		
3	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
					Caustic	Acid		
4	0.00	18.00	45.00	48.60	95.00	1.62	96.62	$208.22
5	0.00	18.00	45.00	48.60	95.00	1.62	96.62	$208.22
6	0.00	918.00	45.00	2,478.60	95.00	1.62	96.62	$3,538.22
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	1,098.00	2,745.00	2,964.60	190.00	3.23	193.23	$7,000.83
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	864.00	2,160.00	0.00	380.00	3.23	383.23	$3,407.23
12	0.00	1,218.00	3,045.00	3,288.60	190.00	3.23	193.23	$7,744.83
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
16	0.00	30.60	45.00	82.62	95.00	1.62	96.62	$254.84

New Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,559.54	$11,213.75	$9,977.96		$37,999.18	$88,765.43
Rinse	$0.00	$4,482.60	$11,175.00	$9,770.22		$1,542.63	$26,970.45
%Rinse	0.0%	98.3%	99.7%	97.9%		4.1%	30.4%

Old Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$0.00	$264.00	$660.00	$712.80		-$0.01	$1,636.79
Rinse	$0.00	$264.00	$660.00	$712.80		-$0.01	$1,636.79

2000 hr/yr

4255 hr/yr

Table V-5, Cascade 2:
Annual savings and waste water reduction for the rinse tanks alone and for all of the tanks.

	(gal/hr)		Water (gal/yr)				Price Data ($/gal)			
Tank	**Evaporation**	**Flow**	**Generation**	**Evaporation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**RO System**
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2							0.00	0.001	0.0025	0.0027
3		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027
4	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027
5		450	918,000		18,000	sewer	0.00	0.001	0.0025	0.0027
6		0	18,000		918,000	sewer	0.00	0.001	0.0025	0.0027
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027
8		600	1,218,000		18,000	sewer	0.00	0.001	0.0025	0.0027
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027
11		0	18,000		18,000	sewer	0.00	0.001	0.0025	0.0027
12		0	18,000		1,218,000	sewer	0.00	0.001	0.0025	0.0027
13			500		500	RCRA	2.01	0.001	0.0000	0.0027
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027
15		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027
16	1.5	0	18,000	12,600	30,600	sewer	0.00	0.001	0.0025	0.0027

		Generation	Evaporation	Usage
Total gal/yr	**New**	**2,834,000**	**68,040**	**2,897,540**
	Original	4,760,000	68,040	4,823,540
	Reduced	**1,926,000**	**0**	**1,926,000**
		40.5%	0.0%	39.9%
Water	**New**	**2,823,500**	**68,040**	**2,882,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**1,926,000**	**0**	**1,926,000**
		40.6%	0.0%	40.1%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

cutting the 65# 2 cascade by 40%
assuming 4000 hr/yr
reduces water by 720,000gpy
2880gpd
10 units

	Annual Costs($/yr)				Chemical Cost ($/yr)			
Tank	**Disposal**	**Water**	**Sewer**	**RO System**			**All**	**Total**
					Clep 83M	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$0.00
					Caustic	Acid		
3	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
					Clepo 30B	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
5	0.00	18.00	2,295.00	48.60	190.00	3.23	193.23	$2,554.83
6	0.00	918.00	45.00	2,478.60	95.00	1.62	96.62	$3,538.22
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	18.00	3,045.00	48.60	190.00	3.23	193.23	$3,304.83
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	18.00	45.00	48.60	95.00	1.62	96.62	$208.22
12	0.00	1,218.00	45.00	3,288.60	95.00	1.62	96.62	$4,648.22
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
16	0.00	30.60	45.00	82.62	95.00	1.62	96.62	$254.84

New Costs

Totals	**Disposal**	**Water**	**Sewer**	**DI System**		**Chemicals**	**Total**
All	$25,015.00	$2,897.54	$7,058.75	$7,823.36		$37,615.95	$80,410.60
Rinse	$0.00	$2,820.60	$7,020.00	$7,615.62		$1,159.40	$18,615.62
%Rinse	0.0%	97.3%	99.5%	97.3%		3.1%	23.2%

Old Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$0.00	$1,926.00	$4,815.00	$2,867.40		$383.22	$9,991.62
Rinse	$0.00	$1,926.00	$4,815.00	$2,867.40		$383.22	$9,991.62

Table V-6, include Tank 15 in Cascade 2:
Annual savings and waste water reduction for the rinse tanks alone and for all of the tanks.
Savings just for adding tank 15 are found by subtracting the values from table V-5.

Tank	(gal/hr) Evaporation	Flow	Water (gal/yr) Generation	Evaporation	Usage	Disposal	Price Data ($/gal) Disposal	Water	Sewer	RO System
1	3.5		3,500	29,400	32,900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2							[illegible]	[illegible]	[illegible]	0.0027
3		70.5	300,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	2		12,000	16,800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5		450	918,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0027
6		0	18,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7			4,000		4,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8		300	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1.1		500	9,240	9,740	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10			4,500		0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11		0	18,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12		0	18,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13			500		500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14			1,000		1,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15		0	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0027
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

		Generation	Evaporation	Usage
Total gal/yr	New	[illegible]	[illegible]	[illegible]
	Original	4,760,000	68,040	4,823,540
	Reduced	**2,208,000**	**0**	**2,208,000**
		46.4%	0.0%	45.8%
Water	**New**	**2,541,500**	**68,040**	**2,600,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**2,208,000**	**0**	**2,208,000**
		46.5%	0.0%	45.9%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

Tank	Annual Costs($/yr) Disposal	Water	Sewer	RO System	Chemical Cost ($/yr)		[illegible]	[illegible]
					Clep 83M	Defoam		
1	0.00	32.90	3.75	38.83	2,555.20	360.00	[illegible]	[illegible]
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]
					Caustic	Acid		
3	0.00	300.00	[illegible]	[illegible]	190.00	[illegible]	[illegible]	[illegible]
					Clepo 30B	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	[illegible]	[illegible]
5	0.00	18.00	2,295.00	48.60	[illegible]	[illegible]	[illegible]	[illegible]
6	0.00	918.00	45.00	2,478.60	[illegible]	[illegible]	[illegible]	[illegible]
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		[illegible]	[illegible]
					Caustic	Acid		
8	0.00	18.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	[illegible]
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	[illegible]	[illegible]
					Caustic	Acid		
11	0.00	18.00	45.00	48.60	95.00	[illegible]	[illegible]	[illegible]
12	0.00	18.00	45.00	48.60	95.00	[illegible]	[illegible]	[illegible]
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	[illegible]	[illegible]	[illegible]	[illegible]
14	2,010.00	1.00	0.00	2.70	[illegible]	[illegible]	[illegible]	[illegible]
					Caustic	Acid		
15	0.00	1,218.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	0.00	30.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

New Costs

Totals	Disposal	Water	Sewer	DI System		Chemicals	Total
All	$25,015.00	$2,615.54	$6,353.75	$7,061.96		[illegible]	[illegible]
Rinse	$0.00	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
%Rinse	0.0%	97.1%	99.4%	97.1%		3.1%	[illegible]

Old Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	[illegible]	[illegible]	$10,690.76		[illegible]	[illegible]
Rinse	$0.00	[illegible]	[illegible]	$10,483.02		$1,542.62	[illegible]
%Rinse	0.0%	[illegible]	[illegible]	98.1%		4.1%	31.6%

Savings

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$0.00	$2,208.00	$5,520.00	$3,628.80		$383.22	$11,740.02
Rinse	$0.00	$2,208.00	$5,520.00	$3,628.80		$383.22	$11,740.02

Table V-6, include Tank 15 in Cascade 2:
Annual savings and waste water reduction for the rinse tanks alone and for all of the tanks.
Savings just for adding tank 15 are found by subtracting the values from table V-5.

	(gal/hr)		Water (gal/yr)				Price Data ($/gal)			
Tank	**Evaporation**	**Flow**	**Generation**	**Evaporation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**RO System**
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2							0.00	0.001	0.0025	0.0027
3		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027
4	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027
5		450	918,000		18,000	sewer	0.00	0.001	0.0025	0.0027
6		0	18,000		918,000	sewer	0.00	0.001	0.0025	0.0027
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027
8		600	1,218,000		18,000	sewer	0.00	0.001	0.0025	0.0027
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027
11		0	18,000		18,000	sewer	0.00	0.001	0.0025	0.0027
12		0	18,000		18,000	sewer	0.00	0.001	0.0025	0.0027
13			500		500	RCRA	2.01	0.001	0.0000	0.0027
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027
15		0	18,000		1,218,000	sewer	0.00	0.001	0.0025	0.0027
16	1.5	0	18,000	12,600	30,600	sewer	0.00	0.001	0.0025	0.0027

		Generation	Evaporation	Usage
Total gal/yr	**New**	**2,552,000**	**68,040**	**2,615,540**
	Original	4,760,000	68,040	4,823,540
	Reduced	**2,208,000**	**0**	**2,208,000**
		46.4%	0.0%	45.8%
Water	**New**	**2,541,500**	**68,040**	**2,600,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**2,208,000**	**0**	**2,208,000**
		46.5%	0.0%	45.9%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

	Annual Costs($/yr)				Chemical Cost ($/yr)			
Tank	**Disposal**	**Water**	**Sewer**	**RO System**			**All**	**Total**
					Clep 83M	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$0.00
					Caustic	Acid		
3	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
					Clepo 30B	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
5	0.00	18.00	2,295.00	48.60	190.00	3.23	193.23	$2,554.83
6	0.00	918.00	45.00	2,478.60	95.00	1.62	96.62	$3,538.22
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	18.00	3,045.00	48.60	190.00	3.23	193.23	$3,304.83
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	18.00	45.00	48.60	95.00	1.62	96.62	$208.22
12	0.00	18.00	45.00	48.60	95.00	1.62	96.62	$208.22
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	1,218.00	45.00	3,288.60	190.00	3.23	193.23	$4,744.83
16	0.00	30.60	45.00	82.62	95.00	1.62	96.62	$254.84

New Costs

Totals	**Disposal**	**Water**	**Sewer**	**DI System**		**Chemicals**	**Total**
All	$25,015.00	$2,615.54	$6,353.75	$7,061.96		$37,615.95	$78,662.20
Rinse	$0.00	$2,538.60	$6,315.00	$6,854.22		$1,159.40	$16,867.22
%Rinse	0.0%	97.1%	99.4%	97.1%		3.1%	21.4%

Old Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$0.00	$2,208.00	$5,520.00	$3,628.80		$383.22	$11,740.02
Rinse	$0.00	$2,208.00	$5,520.00	$3,628.80		$383.22	$11,740.02

Table V-5, Cascade 2:
Annual savings and waste water reduction for the rinse tanks alone and for all of the tanks.

Tank	(gal/hr) Evaporation	Flow	Water (gal/yr) Generation	Evaporation	Usage	Disposal	Price Data ($/gal) Disposal	Water	Sewer	RO System
1	3.5		3,500	29,400	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2							[illegible]	[illegible]	[illegible]	0.0027
3		70.5	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	2		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5		450	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7			[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1.1		[illegible]	9,240	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10			[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11		0	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12		0	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13			500		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14			1,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15		70.5	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	1.5	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

		Generation	Evaporation	Usage
Total gal/yr	New	[illegible]	[illegible]	[illegible]
	Original	[illegible]	[illegible]	[illegible]
	Reduced	**1,926,000**	**0**	**1,926,000**
		40.5%	0.0%	39.9%
Water	**New**	**2,823,500**	**68,040**	**2,882,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**1,926,000**	**0**	**1,926,000**
		40.6%	0.0%	40.1%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

Tank	Annual Costs($/yr) Disposal	Water	Sewer	RO System	Chemical Cost ($/yr)		All	Total
					Clep 63M	[illegible]		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	[illegible]	[illegible]
2	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]
					Caustic	Acid		
3	0.00	300.00	750.00	810.00	190.00	[illegible]	[illegible]	[illegible]
					Clepo 203	Acid		
4	0.00	28.80	30.00	77.76	2,109.22	[illegible]	[illegible]	[illegible]
5	0.00	18.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	0.00	918.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]			
7	6,040.00	4.00	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
					Caustic	Acid		
8	0.00	18.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					Acid	Pik Aic		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	[illegible]	[illegible]
10	14,715.00	0.00	0.00	0.00	15,022.66	[illegible]	[illegible]	[illegible]
					Caustic	Acid		
11	0.00	18.00	45.00	48.60	95.00	1.62	[illegible]	[illegible]
12	0.00	1,218.00	[illegible]	[illegible]	95.00	1.62	[illegible]	[illegible]
					Iridite	Nitric		
13	1,005.00	0.50	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	2,010.00	1.00	0.00	2.70	[illegible]	[illegible]	[illegible]	[illegible]
					Caustic	Acid		
15	0.00	300.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	0.00	30.60	45.00	82.62	95.00	1.62	96.62	$254.84

New Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$2,897.54	$7,058.75	$7,823.36		$37,615.95	$80,410.60
Rinse	$0.00	$2,820.60	$7,020.00	$7,615.62		$1,159.40	$18,615.62
%Rinse	0.0%	97.3%	99.5%	97.3%		3.1%	23.2%

Old Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$0.00	$1,926.00	$4,815.00	$2,867.40		$383.22	$9,991.62
Rinse	$0.00	$1,926.00	$4,815.00	$2,867.40		$383.22	$9,991.62

Table V-7, Cascade Tank 16 and Tank 15:
Values are shown for the rinse tanks alone and for all of the tanks.

	(gal/hr)		Water (gal/yr)				Price Data ($/gal)			
Tank	**Evaporation**	**Flow**	**Generation**	**Evaporation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**RO System**
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2							0.00	0.001	0.0025	0.0027
3		70.5	300,000		300,000	sewer	0.00	0.001	0.0025	0.0027
4	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027
5		450	918,000		18,000	sewer	0.00	0.001	0.0025	0.0027
6		0	18,000		918,000	sewer	0.00	0.001	0.0025	0.0027
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027
8		540	1,098,000		1,098,000	sewer	0.00	0.001	0.0025	0.0027
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027
11		211.5	864,000		864,000	sewer	0.00	0.001	0.0025	0.0000
12		600	1,218,000		1,218,000	sewer	0.00	0.001	0.0025	0.0027
13			500		500	RCRA	2.01	0.001	0.0000	0.0027
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027
15		70.5	300,000		18,000	sewer	0.00	0.001	0.0025	0.0027
16	1.5	0	18,000	12,600	312,600	sewer	0.00	0.001	0.0025	0.0027
	Total	**New**	**4,760,000**	**68,040**	**4,823,540**					
	gal/yr	**Original**	4,760,000	68,040	4,823,540					
		Reduced	**0**	**0**	**0**					
			0.0%	0.0%	0.0%					
	Water	**New**	**4,749,500**	**68,040**	**4,808,300**					
		Original	4,749,500	68,040	4,808,300					
		Reduced	**0**	**0**	**0**					
			0.0%	0.0%	0.0%					
	Hazardous	**New**	**10,500**							
		Original	10,500							
		Reduced	**0**							
			0.0%							

	Annual Costs($/yr)				Chemical Cost ($/yr)			
Tank	**Disposal**	**Water**	**Sewer**	**RO System**			**All**	**Total**
					Alkaline	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$0.00
					Caustic	Acid		
3	0.00	300.00	750.00	810.00	190.00	3.23	193.23	$2,053.23
					Etch	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
					Caustic	Acid		
5	0.00	18.00	2,295.00	48.60	190.00	3.23	193.23	$2,554.83
6	0.00	918.00	45.00	2,478.60	95.00	1.62	96.62	$3,538.22
					Deox			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	1,098.00	2,745.00	2,964.60	190.00	3.23	193.23	$7,000.83
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	864.00	2,160.00	0.00	380.00	3.23	383.23	$3,407.23
12	0.00	1,218.00	3,045.00	3,288.60	190.00	3.23	193.23	$7,744.83
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	18.00	750.00	48.60	190.00	3.23	193.23	$1,009.83
16	0.00	312.60	45.00	844.02	95.00	1.62	96.62	$1,298.24

New Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Old Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00
Rinse	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00

concentration

Table V-8, tanks are Cleaned Less Often (Half as Much)
Values are for the rinse tanks alone and for all of the tanks.

	(gal/hr)		Water (gal/yr)				Price Data ($/gal)			
Tank	**Evaporation**	**Flow**	**Generation**	**Evaporation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**RO System**
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2								0.001	0.0025	0.0027
3		70.5	291,000		291,000	sewer	0.00	0.001	0.0025	0.0027
4	2		12,000	16,800	28,800	sewer	0.00	0.001	0.0025	0.0027
5		450	909,000		9,000	sewer	0.00	0.001	0.0025	0.0027
6		0	9,000		909,000	sewer	0.00	0.001	0.0025	0.0027
7			4,000		4,000	RCRA	1.51	0.001	0.0000	0.0027
8		540	1,089,000		1,089,000	sewer	0.00	0.001	0.0025	0.0027
9	1.1		500	9,240	9,740	RCRA	2.49	0.001	0.0000	0.0027
10			4,500		0	RCRA	3.27	0.001	0.0000	0.0027
11		211.5	855,000		855,000	sewer	0.00	0.001	0.0025	0.0000
12		600	1,209,000		1,209,000	sewer	0.00	0.001	0.0025	0.0027
13			500		500	RCRA	2.01	0.001	0.0000	0.0027
14			1,000		1,000	RCRA	2.01	0.001	0.0000	0.0027
15		70.5	291,000		291,000	sewer	0.00	0.001	0.0025	0.0027
16	1.5	0	9,000	12,600	21,600	sewer	0.00	0.001	0.0025	0.0027

Total gal/yr	**New**	**4,688,000**	**68,040**	**4,751,540**
	Original	4,760,000	68,040	4,823,540
	Reduced	**72,000**	**0**	**72,000**
		1.5%	0.0%	1.5%
Water	**New**	**4,677,500**	**68,040**	**4,736,300**
	Original	4,749,500	68,040	4,808,300
	Reduced	**72,000**	**0**	**72,000**
		1.5%	0.0%	1.5%
Hazardous	**New**	**10,500**		
	Original	10,500		
	Reduced	**0**		
		0.0%		

	Annual Costs($/yr)				Chemical Cost ($/yr)			
Tank	**Disposal**	**Water**	**Sewer**	**RO System**			**All**	**Total**
					Clep 83M	Defoam		
1	0.00	32.90	8.75	88.83	2,565.00	390.00	2,955.00	$3,085.48
2	0.00	0.00	0.00	0.00			0.00	$0.00
					Caustic	Acid		
3	0.00	291.00	727.50	785.70	142.50	2.60	145.10	$1,949.30
					Clepo 30B	Acid		
4	0.00	28.80	30.00	77.76	2,108.22	1,415.50	3,523.72	$3,660.28
					Caustic	Acid		
5	0.00	9.00	2,272.50	24.30	142.50	2.60	145.10	$2,450.90
6	0.00	909.00	22.50	2,454.30	95.00	0.63	95.63	$3,481.43
					Clepo 503			
7	6,040.00	4.00	0.00	10.80	2,789.20		2,789.20	$8,844.00
					Caustic	Acid		
8	0.00	1,089.00	2,722.50	2,940.30	142.50	2.60	145.10	$6,896.90
					Acid	Pik Aid		
9	1,245.00	9.74	0.00	26.30	791.41	0.00	791.41	$2,072.45
10	14,715.00	0.00	0.00	0.00	15,022.66	7,362.56	22,385.22	$37,100.22
					Caustic	Acid		
11	0.00	855.00	2,137.50	0.00	213.75	2.60	216.35	$3,208.85
12	0.00	1,209.00	3,022.50	3,264.30	142.50	2.60	145.10	$7,640.90
					Iridite	Nitric		
13	1,005.00	0.50	0.00	1.35	462.00	200.00	662.00	$1,668.85
14	2,010.00	1.00	0.00	2.70	3,150.00	200.00	3,350.00	$5,363.70
					Caustic	Acid		
15	0.00	291.00	727.50	785.70	142.50	2.60	145.10	$1,949.30
16	0.00	21.60	22.50	58.32	47.50	0.63	48.13	$150.55

New Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,751.54	$11,693.75	$10,520.66		$37,542.16	$89,523.11
Rinse	$0.00	$4,674.60	$11,655.00	$10,312.92		$1,085.61	$27,728.13
%Rinse	0.0%	98.4%	99.7%	98.0%		2.9%	31.0%

Old Costs

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	98.4%	99.7%	98.1%		4.1%	31.6%

Savings

Totals	**Disposal**	**Water**	**Sewer**	**RO System**		**Chemicals**	**Total**
All	$0.00	$72.00	$180.00	$170.10		$457.01	$879.11
Rinse	$0.00	$72.00	$180.00	$170.10		$457.01	$879.11

Table V-7, Cascade Tank 16 and Tank 15:
Values are shown for the rinse tanks alone and for all of the tanks.

Tank	(gal/hr) Evaporation	Flow	Water (gal/yr) Generation	Evaporation	Usage	Disposal	Price Data ($/gal) Disposal	Water	Sewer	RO System
1	3.5		3,500	29,400	32,900	sewer	0.00	0.001	0.0025	0.0027
2							[illegible]	[illegible]	[illegible]	[illegible]
3		70.5	300,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	2		12,000	16,8[illegible]	28,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5		150	18,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7			4,000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1.1		500	9,240	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10			4,500		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11		211.5	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13			500		500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14			1,000		1,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

		Generation	Evaporation	Usage
Total gal/yr	New	4,760,000	68,040	4,823,540
	Original	4,760,0[illegible]	68,040	4,823,540
	Reduced	0	0	0
		0.0%	0.0%	0.0%
Water	New	4,749,500	68,040	4,808,300
	Original	4,749,500	68,040	4,808,300
	Reduced	0	0	0
		0.0%	0.0%	0.0%
Hazardous	New	10,500		
	Original	10,500		
	Reduced	0		
		0.0%		

Tank	Annual Costs($/yr) Disposal	Water	Sewer	RO System	Chemical Cost ($/yr)		All	Total
					Alkaline	Defoam		
1	0.00	32.90	[illegible].75	[illegible]8.83	[illegible].565.00	390.00	2,955.[illegible]	[illegible]
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]
					Caustic	[illegible]		
3	0.00	300.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					Elon	Acid		
4	0.00	28.80	[illegible]0.00	[illegible].76	[illegible]108.[illegible]	1,415.[illegible]	[illegible]	[illegible]
					Caustic	Acid		
5	0.00	18.00	2[illegible]	[illegible]8.60	[illegible]90.00	[illegible]	[illegible]	[illegible]
6	0.00	918.00	[illegible]5.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]			
7	6,040.00	4.00	[illegible].00	[illegible]	[illegible]		[illegible]	[illegible]
					Caustic	Acid		
8	0.00	1,098.00	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					Acid	Pik Aid		
9	1,245.00	9.74	[illegible].00	6.30	[illegible]91.41	0.00	[illegible]	[illegible]
10	14,715.00	0.00	[illegible].00	[illegible].00	[illegible].022.66	7,362.56	[illegible]	[illegible]
					Caustic	Acid		
11	0.00	864.00	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	0.00	1,218.00	3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]idite	Nitric		
13	1,005.00	0.50	[illegible].00	[illegible]	[illegible]62.00	200.00	[illegible]	[illegible]
14	2,010.00	1.00	[illegible].00	[illegible].70	[illegible].150.00	200.00	3,350.00	[illegible]
					Caustic	Acid		
15	0.00	18.00	750.00	48.60	190.00	3.23	193.23	$1,009.83
16	0.00	312.60	45.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

New Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4,746.60	$11,835.00	$10,483.02		$1,542.62	$28,607.24
%Rinse	0.0%	9[illegible].4%	9[illegible].7%	98.1%		4.1%	31.6%

Old Costs

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$25,015.00	$4,823.54	$11,873.75	$10,690.76		$37,999.17	$90,402.22
Rinse	$0.00	$4[illegible]46.60	[illegible]	[illegible]		$1,542.62	$28,607[illegible]
%Rinse	0.0%	9[illegible]%	[illegible]	[illegible]%		4.1%	31.6%

Savings

Totals	Disposal	Water	Sewer	RO System		Chemicals	Total
All	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00
Rinse	$0.00	$0.00	$0.00	$0.00		$0.00	$0.00

want to reduce drag out in cold chem tanks 7, 10, 13, 14
only 2 would be used in same process
also drain the preceeding rinse, time increase = 4 × 25 = 100 sec (1.7 min)
1.7 min | 20/day | 200 day/yr | hr/60 min | $85/hr = $9600/yr
1 tank/cycle = $4800/yr

c. Savings from Decreased Carry-Over Volume

Estimated carry-over volume was calculated and then subtracted from the original number. Table V-9 and table V-10 show the annual savings from increased drip-time and from a modified basket design respectively. Calculations are explained below.

carry over value
2 tank/cycle | 1 gal/tank | 20 cycle/day | 200 day/yr = 3200 gal/day of diluted
chromates too dilute to recover unless waste treatm

Calculation Explanation for Carry-Over Volume Reduction

if nitric is used 10/day
800 of dilute nitric
4000 gpy of concentrat

In all cases non heated tanks experience carry-over volume reduction (Tanks 7, 10, 13 and 14)

Extend Drip time

- 60% of drainable carry-over is recovered
- for example
  100 gallons total carryover
  only half is drainable (50 gallons)
  $(100 - 0.60(50))$ gallons = 70 gallons new carry-over

Potential Process time increase

increase average of 4 min/cycle

$$\left(\frac{4\,\text{min}}{\text{cycle}}\right)\left(\frac{20\,\text{cycles}}{\text{day}}\right)\left(\frac{\text{day}}{24\,\text{hr}}\right)\left(\frac{4000\,\text{hr}}{\text{year}}\right)\left(\frac{\text{hr}}{60\,\text{min}}\right)\left(\frac{\$85}{\text{hr}}\right) = \boxed{\frac{\$18{,}889}{\text{year}}}$$

→ 167 day/yr

Basket Modification

$$\left(\frac{0.0389\,\text{gal}}{\text{basket}}\right)\left(\frac{20\,\text{baskets}}{\text{day}}\right)\left(\frac{350\,\text{days}}{\text{year}}\right) = 272.3\ \text{gal/year}$$

have 2 operators
2 shifts 40 hr/wk = 4000 hr = 200 work days
~~with over time~~

270 gallons subtracted from original value

process time increase
4 min/cycle | 20 cycle/day | 200 wkday/yr | hr/60 min | $85/hr = $22,700/yr

basket saving
.0389 gal | 20 baskets | 200 day = [illegible].6 gal/yr per chemical tank

Table V-9, Increase Drip-Time to reduce Carry-Over Volume:
All values listed in the table are annual values.
It was assumed that the drainable carry-over was reduced by 60%.

	Tank	Chemical Usage		to charge tank Changes		Extra to replenish Pounds		Carry-Over (gal)	Price	per
hot Alkaline	1	2,700	lb	2,250	lb	450	lb	~~900~~	$0.95	lb
hot Etch	4	2,571	lb	2,256	lb	315	lb	~~840~~	$0.82	lb
Deoxidizer	7	347	gal	300	gal	47	gal	938	$7.60	gal
hot Passivate	9	4,497	lb	2,943	lb	1,554	lb	~~264~~	$0.18	lb
Nitric	10	75,634	lb	52,965	lb	22,669	lb	1,926	$0.18	lb
Pik-Aid	10	2,601	lb	1,500	lb	1,101	lb	2,202	$2.56	lb
Clear	13	59	lb	32	lb	27	lb	426	$6.60	lb
Yellow	14	247	lb	63	lb	184	lb	1,472	$9.00	lb

New Values

Tank	Annual Costs Changes	Extra	Total Cost
1	$2,137.50	$427.50	$2,565.00
4	$1,849.92	$258.30	$2,108.22
7	$2,280.00	$356.44	$2,636.44
9	$517.97	$273.44	$791.41
10	$9,321.84	$3,989.75	$13,311.59
10	$3,840.00	$2,818.56	$6,658.56
13	$211.20	$175.73	$386.93
14	$562.50	$1,656.00	$2,218.50
Totals	**$20,720.93**	**$9,955.71**	**$30,676.64**

Original Values

Tank	Annual Costs Changes	Extra	Total Cost
1	$2,137.50	$427.50	$2,565.00
4	$1,849.92	$258.30	$2,108.22
7	$2,280.00	$509.20	$2,789.20
9	$517.97	$273.44	$791.41
10	$9,321.84	$5,700.82	$15,022.66
10	$3,840.00	$3,522.56	$7,362.56
13	$211.20	$250.80	$462.00
14	$562.50	$2,587.50	$3,150.00
Totals	**$20,720.93**	**$13,530.12**	**$34,251.05**

Savings

Tank	Annual Savings Changes	Extra	Total	lb concentrate
1	$0.00	$0.00	$0.00	—
4	$0.00	$0.00	$0.00	—
7	$0.00	$152.76	$152.76	20.1 gal = 200 lb
9	$0.00	$0.00	$0.00	—
10	$0.00	$1,711.07	$1,711.07	9500 lb
10	$0.00	$704.00	$704.00	725 lb
13	$0.00	$75.08	$75.08	
14	$0.00	$931.50	$931.50	10!!
Totals	**$0.00**	**$3,574.41**	**$3,574.41**	10069

nitric tank $2411/yr $9775 lb/yr
67% 97%

poor assumption

Table V-10, Basket Modification to Reduce Carry-Over Volume:
It was assumed that carry-over was only reduced for the non-heated tanks.

	Tank	Chemical Usage		Changes		Extra Pounds		Carry-Over (gal)	Price	per	Concentra
Alkaline	1	2,700	lb	2,250	lb	450	lb	900	$0.95	lb	8%
Etch	4	2,571	lb	2,256	lb	315	lb	840	$0.82	lb	2%
Deoxidizer	7	354	gal	300	gal	54	gal	1,070	$7.60	gal	7% cold
Passivate	9	4,497	lb	2,943	lb	1,554	lb	264	$0.18	lb	40%
Nitric	10	82,178	lb	52,965	lb	29,213	lb	2,482	$0.18	lb	20% cold
Pik-Aid	10	2,741	lb	1,500	lb	1,241	lb	2,482	$2.56	lb	
Clear	13	53	lb	32	lb	21	lb	338	$6.60	lb	.8% cold
Yellow	14	316	lb	63	lb	254	lb	2,030	$9.00	lb	.8% cold

New Values

Tank	Annual Costs Changes	Extra	Total Cost
1	$2,137.50	$427.50	$2,565.00
4	$1,849.92	$258.30	$2,108.22
7	$2,280.00	$406.60	$2,686.60
9	$517.97	$273.44	$791.41
10	$9,321.84	$5,141.51	$14,463.35
10	$3,840.00	$3,176.96	$7,016.96
13	$211.20	$139.43	$350.63
14	$562.50	$2,283.75	$2,846.25
Totals	**$20,720.93**	**$12,107.49**	**$32,828.42**

Original Values

Tank	Annual Costs Changes	Extra	Total Cost
1	$2,137.50	$427.50	$2,565.00
4	$1,849.92	$258.30	$2,108.22
7	$2,280.00	$509.20	$2,789.20
9	$517.97	$273.44	$791.41
10	$9,321.84	$5,700.82	$15,022.66
10	$3,840.00	$3,522.56	$7,362.56
13	$211.20	$250.80	$462.00
14	$562.50	$2,587.50	$3,150.00
Totals	**$20,720.93**	**$13,530.12**	**$34,251.05**

Savings

Tank	Annual Savings Changes	Extra	Total
1	$0.00	$0.00	$0.00
4	$0.00	$0.00	$0.00
7	$0.00	$102.60	$102.60
9	$0.00	$0.00	$0.00
10	$0.00	$559.31	$559.31
10	$0.00	$345.60	$345.60
13	$0.00	$111.38	$111.38
14	$0.00	$303.75	$303.75
Totals	**$0.00**	**$1,422.63**	**$1,422.63**

d. Electric Cost for Cascading Tank 16 and Tank 15

Table V-29 in appendix B, section 1-b shows the temperature data used for the following calculation.

$$Q = m C_p \Delta T$$

$$C_p = 1 \text{ Btu/lb °F}$$

$$1 g/cm^3$$

$$453.593 g = 1 lb$$

$$28317 cm^3 = 7.4805 gal$$

$$9.486 \times 10^{-4} \text{ Btu} = 2.778 \times 10^{-7} \text{ kWh}$$

350 days/year

$\Delta T = 4°F \Rightarrow (123-119)°F$ from Temperatur data

$$Q = \left(\frac{500 \cancel{gal}}{hr}\right)\left(\frac{1 \text{ Btu}}{°F \cancel{lb}}\right)\left(\frac{1 lb}{453.593 g}\right)\left(\frac{1 g}{\cancel{cm^3}}\right)\left(\frac{28317 \cancel{cm^3}}{7.4805 \cancel{gal}}\right)(4°$$

↑from tanksize.

$$Q = 16691 \frac{\cancel{Btu}}{hr}\left(2.778 \times 10^{-7} \frac{kWh}{\cancel{Btu}}\right)$$

$$Q = 5 kW$$

$$5 \cancel{kW}\left(\frac{4000 hr}{year}\right)\left(\frac{\$0.032}{kWh}\right) = \boxed{\$640/\text{year in electric costs}}$$

e. Economic Analysis

The calculations for the economic analysis are explained below. Table V-11 shows the economics for Cascade 1, table V-12 shows the economics for Cascade 2, and Table V-13 shows the calculations for including Tank 15 in Cascade 2. Table V-14 shows the economics of purchasing a conductivity meter without considering the annual savings from decreased down-time, while table V-15 shows the economic analysis when down-time is considered.

Explanation of Economic Calculations

$$NPV = C_0 + \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$$

C_0 capital investment

C_i Cash flow

r rate of return (assume 15%)

n life of project (assume 5 years)

C_i = Savings − t(Savings)

t tax rate (assume 50%)

DCFRR discounted cash flow rate of return

let NPV=0 let r be the variable
iterate to solve for r

Break Even Point or Payback Period
make a plot.

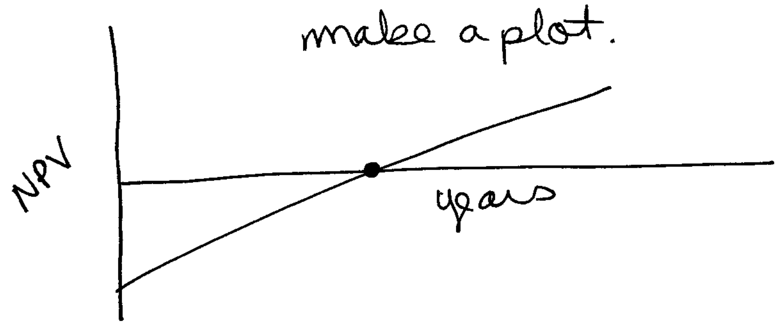


Table V-11, Economic Analysis for Cascade 1:
A 50% tax rate was assumed and a 15% rate of return was assumed

hours down	price/hour down
0	$85.00

Savings ($/year)	Savings ($/month)	Down Time ($)	Cascade ($)	Meter ($)
1,636.79	136.40	0.00	500.00	0.00

Cash Flow/year	Liners ($)	Total Cost ($)
$818.40	0.00	500.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-500.00			
1	211.65	711.65	162.4%	311.93
2	830.48	618.83	162.4%	118.89
3	1,368.59	538.11	162.4%	45.32
4	1,836.51	467.92	162.4%	17.27
5	2,243.40	406.89	162.4%	6.58
	per year	$2,243.40		$0.00

	Payback Time	
years	0.69	0.00
months	8.26	

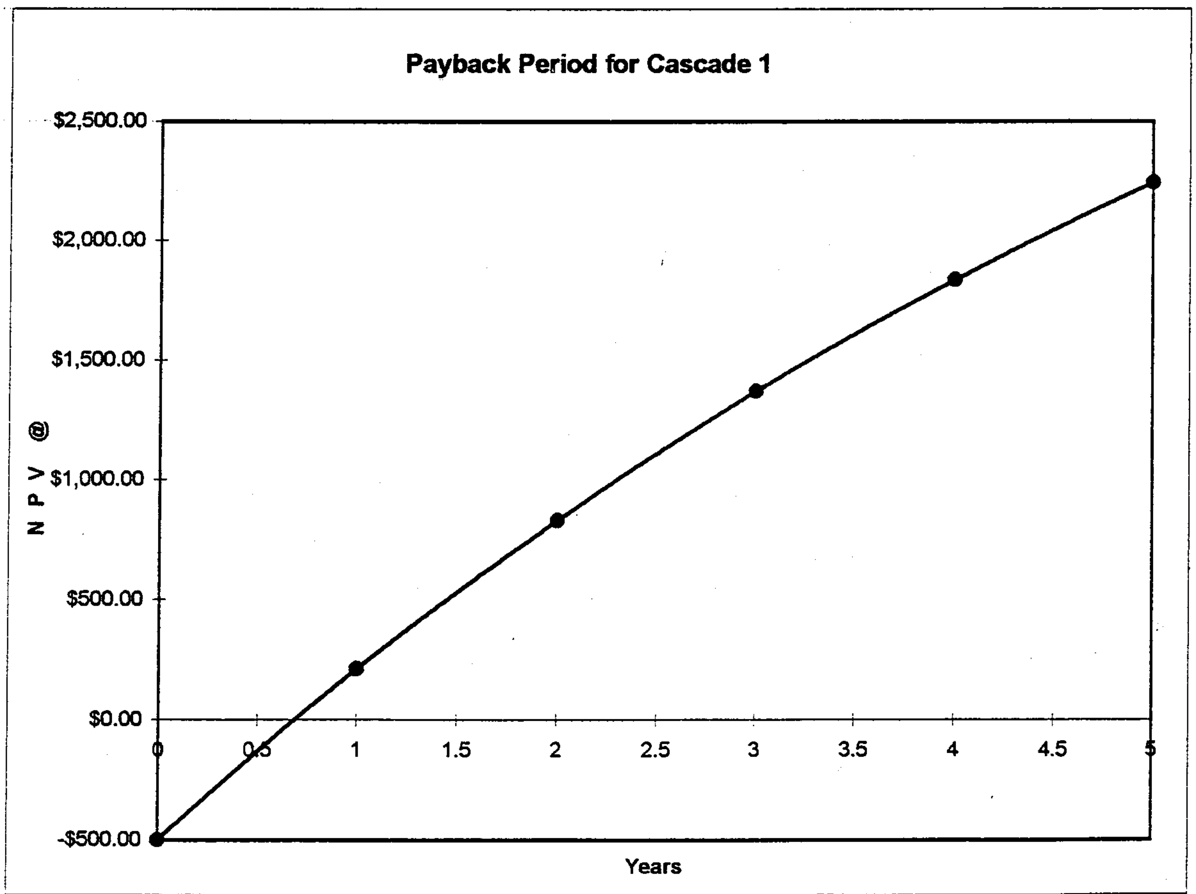


Table V-12, Economic Anlysis for Cascade 2:
A 50 % tax rate and 15 % rate of return was assumed.

hours down	price/hour down
5	$85.00

Savings ($/year)	**Savings ($/month)**	**Down Time ($)**	**Cascade ($)**	**Meter ($)**
9,991.62	832.64	425.00	1,000.00	0.00

Cash Flow/year
$4,995.81

Liners ($)	**Total Cost ($)**
4,000.00	5,425.00

Year	**Payback Time**	**NPV @15%**	**r**	**DCFRR**
0	-5,425.00			
1	-1,080.82	4,344.18	88.2%	2,654.71
2	2,696.73	3,777.55	88.2%	1,410.68
3	5,981.56	3,284.83	88.2%	749.61
4	8,837.93	2,856.37	88.2%	398.33
5	11,321.73	2,483.80	**88.2%**	211.67
	per year	**$11,321.73**		$0.00

	Payback Time	
years	**1.27**	0.00
months	**15.27**	

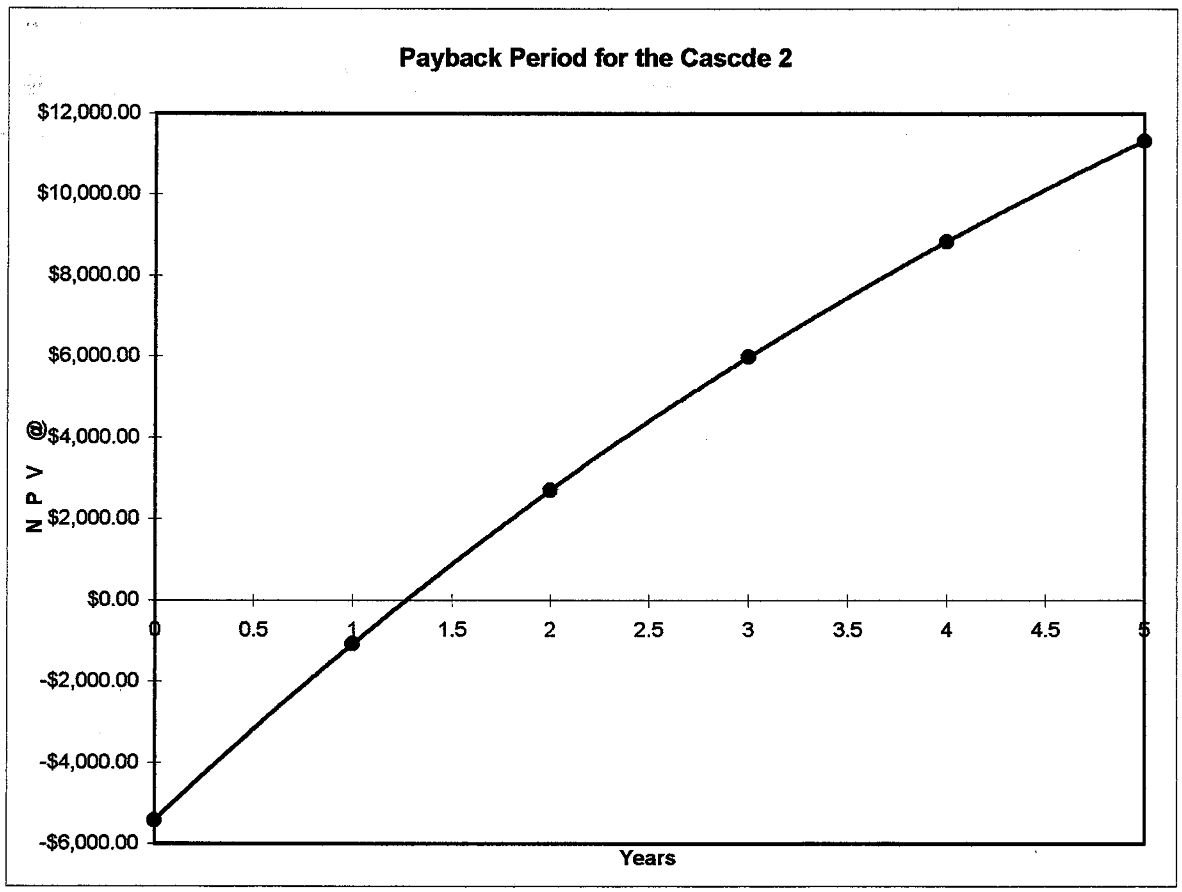


Table V-13, Economic Analysis for adding Tank 15 to Cascade 2:
A 15% rate of return and 50% tax rate were assumed.

hours down	price/hour down
0	$85.00

Savings ($/year)	Savings ($/month)	Down Time ($)	Cascade ($)	Meter ($)
1,845.01	153.75	0.00	500.00	0.00

Cash Flow/year
$922.51

Liners ($)	Total Cost ($)
0.00	500.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-500.00			
1	302.18	802.18	183.5%	325.41
2	999.73	697.55	183.5%	114.78
3	1,606.30	606.57	183.5%	40.49
4	2,133.75	527.45	183.5%	14.28
5	2,592.40	458.65	183.5%	5.04
	per year	$2,592.40		$0.00

	Payback Time	
years	0.61	0.00
months	7.27	

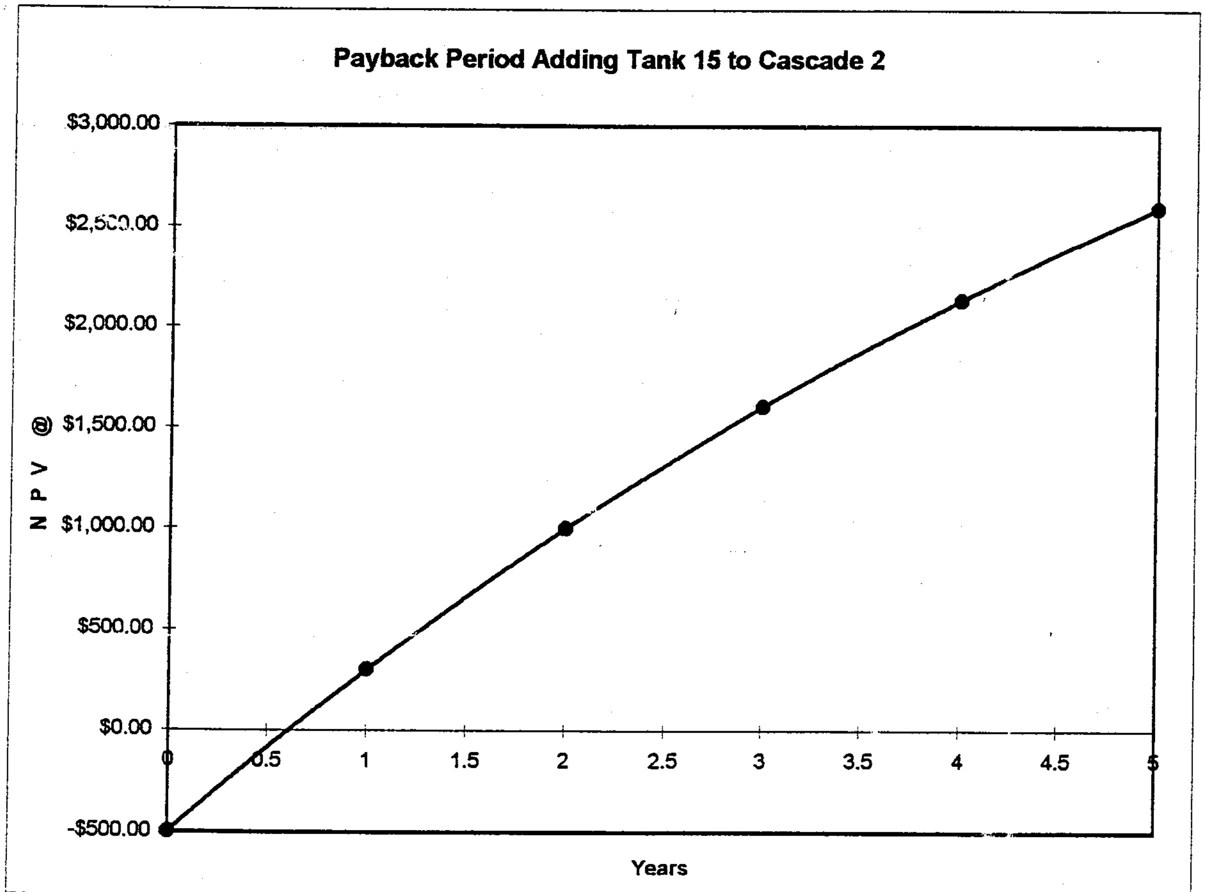


Table V-14, Economic Analysis for a Conductivity Meter Without Down-Time Savings: A 50 % tax rate and 15% rate of return was assumed for calcualtions.

Number of Tanks	hours down	price/hour down
0	13.5	$85.00

Savings ($/year)	Down Time ($)	Total Savings ($/year)	Savings ($/month)
879.11	0.00	**879.11**	73.26

Cash Flow/year	Meter ($)	Total Cost ($)
$439.56	500.00	500.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-500.00			
1	-117.77	382.23	83.7%	239.27
2	214.60	332.37	83.7%	130.24
3	503.61	289.02	83.7%	70.89
4	754.93	251.32	83.7%	38.59
5	973.47	218.54	**83.7%**	21.01
	per year	**$973.47**		$0.00

	Payback Time	
years	**1.34**	0.00
months	**16.07**	

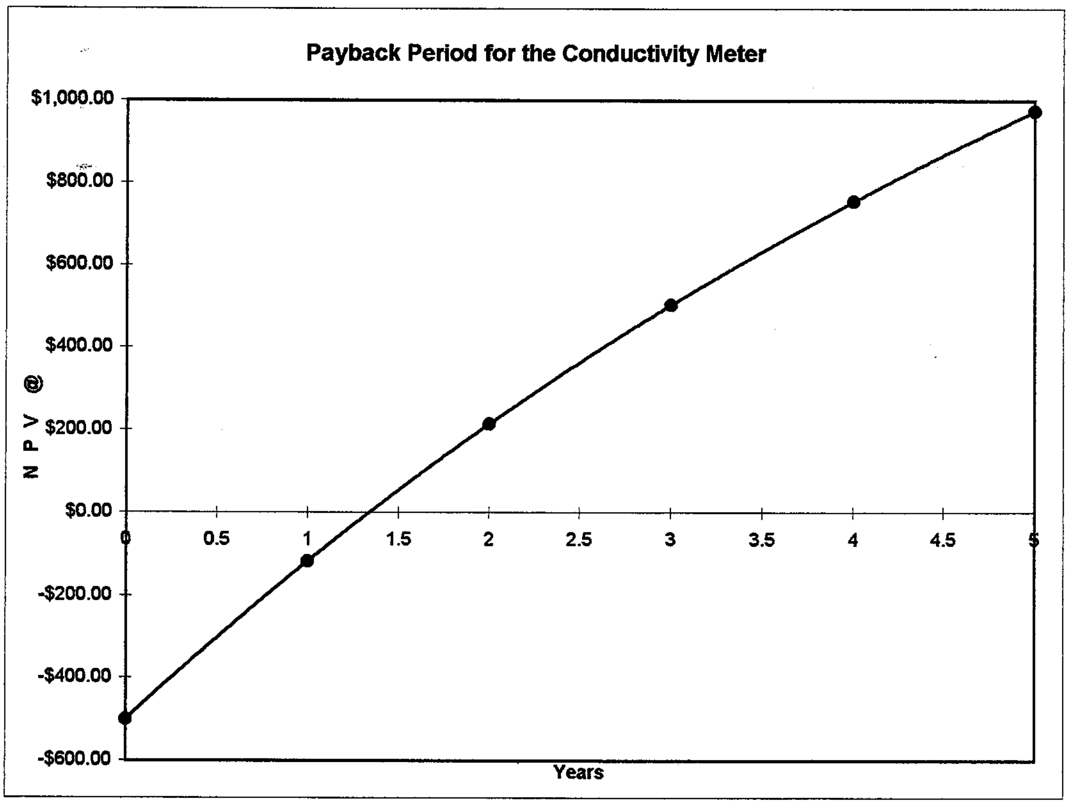


Table V-15, Economic Analysis for a Conductivity Meter with Down-Time Savings Included: A 50% tax rate and 15% rate of return was assumed.

Number of Tanks	hours down	price/hour down
8	13.5	$85.00

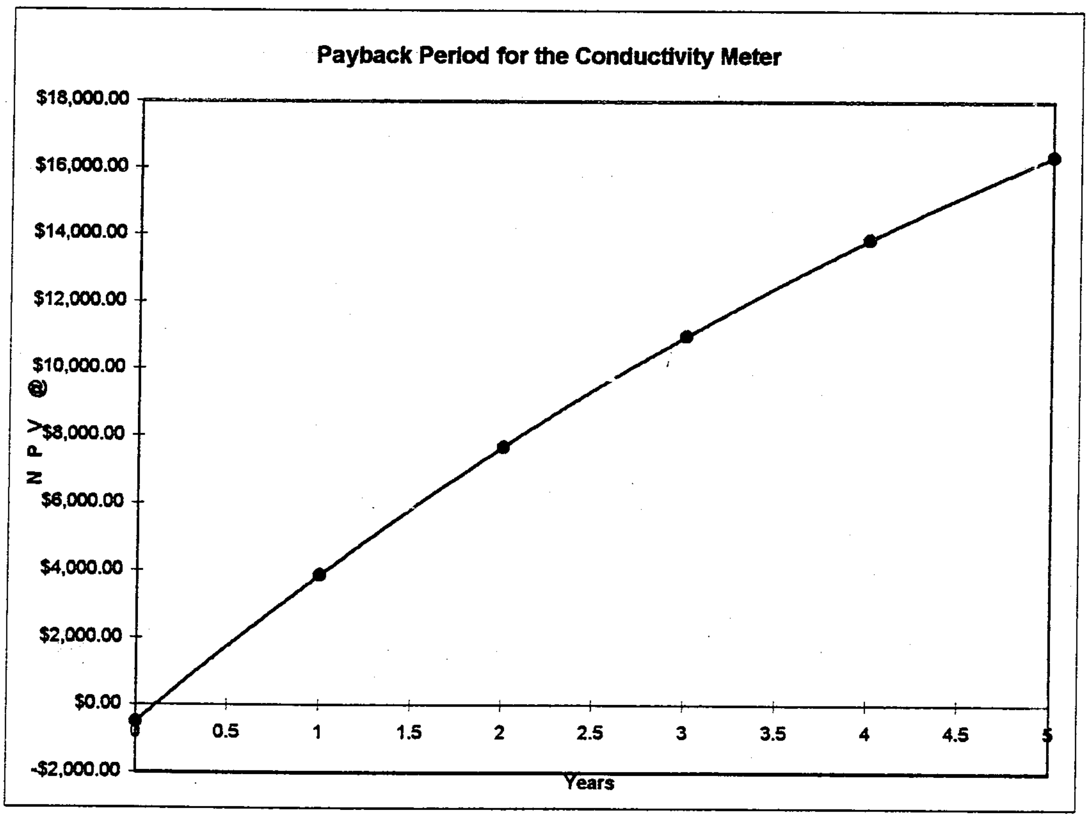
Savings ($/year)	Down Time ($)	Total Savings ($/year)	Savings ($/month)
879.11	9,180.00	**10,059.11**	838.26

Cash Flow/year
$5,029.56

Meter ($)	Total Cost ($)
500.00	500.00

Year	Payback Time	NPV@15%	r	DCFRR
0	-500.00			
1	3,873.53	4,373.53	1005.9%	454.79
2	7,676.60	3,803.07	1005.9%	41.12
3	10,983.62	3,307.02	1005.9%	3.72
4	13,859.28	2,875.67	1005.9%	0.34
5	16,359.87	2,500.58	1005.9%	0.03
	per year $16,359.87			$0.00

	Payback Time	
years	**0.11**	0.00
months	**1.29**	



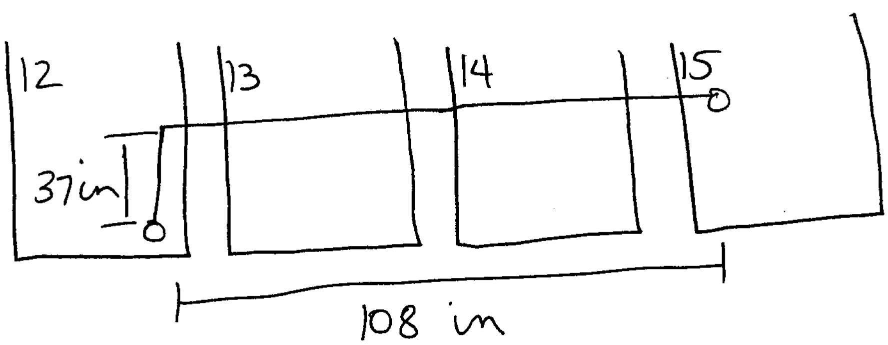
f. Water Levels for Cascaded Tanks

A sample calculation is shown for the calculation of tank water level and table V-16 summarizes the results for each set of connections.

Table V-16, Water Level Differences for Each Set of Connections: The desired water level difference for between the two tanks is summarized. This water level difference is necessary for constant overflow.

Connection	Water Level Difference (inches)
15 to 12	1.2
12 to 11	1.0
11 to 8	1.2
4 to 2	0.64

Sample Calculation of Tank Water Level



$L = (108 + 37 + 4)in$

4 from the 2 ends.

$L = 149\ in$

$$\tfrac{1}{2}\alpha\left(\cancelto{0}{v_2^2 - v_1^2}\right) + \frac{g}{g_c}(z_2 - z_1) + \frac{\cancelto{0}{P_2 - P_1}}{\rho} + \frac{\sum F}{g_c} + \cancelto{0}{W_s} = 0$$

$V_2 = V_1$

$P_2 = P_1 = 1atm$

No shaftwork

$$\frac{\cancel{g}}{\cancel{g_c}}(z_2 - z_1) = -\frac{\sum F}{\cancel{g_c}}$$

$$(z_2 - z_1) = -\sum F/g$$

Need Reynolds number.

$$Re = \frac{D V \rho}{\mu} \qquad D = 2\,in$$

$V = 12.25\,in/s$

$\rho = 0.0360\,lb/in^3$

$\mu = 5.00\times10^{-5}\,lb/in\,s$

$$\left(\frac{600\,gal}{hr}\right)\left(\frac{1728\,in^3}{7.4805\,gal}\right)\left(\frac{hr}{60\,min}\right)\left(\frac{min}{60\,s}\right)\left(\frac{1}{\pi(1\,in^2)}\right) = 12.25\frac{in}{s}$$

$$Re = \frac{2\,in\,(12.25\,in/s)(0.0360\,lb/in^3)}{5.00\times10^{-5}\,lb/in\,s} = 17{,}640.$$

$$\Sigma F = \left(K_c + K_{ex} + K_f + \frac{4fL}{D}\right)\frac{V^2}{2}$$

$K_f = 0.9$ 3 elbows

$f = 0.007$ from friction factor plot.

$\epsilon/D = 5.91\times10^{-5}/2\,in = 0.0000295$ smooth pipe

$K_{ex} = 1$

$K_c = 0.55$

$$(z_2 - z_1) = \left(0.55 + 1 + 3(0.9) + 4\frac{(0.007)(149\,in)}{2\,in}\right)\left(\frac{12.25\,in}{s}\right)^2 \left(\frac{s^2}{32.174\,ft^2}\right)\left(\frac{ft}{12\,in}\right)\frac{1}{2}$$

$$\boxed{\Delta z = 1.2\,in}$$

2. Automatic Division

a. Original Operating Costs and Water Usage

The original operation costs were calculated similar to the costs of the Metal Finishing Line in section 1-a. Although, chemical costs were not included for the washer systems and the total hours of operation was assumed to be 6,700 annually. Table V-17 shows the results for the Carousel Washer System and table V-18 shows the results for the Crest Washer Systems.

Table V-17, Current Operating Costs for the Carousel Washer System: Waste water generation, annual costs and SAC usage is included.

Tank	Flow (gal/hr)	Water (gal/yr)			Price Data ($/gal)			
		Generation	Usage	Disposal	Disposal	Water	Sewer	DI System
1		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
2	150	1,015,868	1,015,868	sewer	0.00	0.001	0.0020	0.0000
3		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
4		457,068	10,868	sewer	0.00	0.001	0.0020	0.0000
5	66.6	10,868	457,068	sewer	0.00	0.001	0.0020	0.0000
6		308,348	10,868	sewer	0.00	0.001	0.0020	0.0000
7	44.4	10,868	308,348	sewer	0.00	0.001	0.0000	0.0000
8		2,508	2,160	RCRA	2.06	0.001	0.0020	0.0000
9		0	0	sewer	0.00	0.001	0.0020	0.0000
10	150	1,015,868	1,015,868	sewer	0.00	0.001	0.0020	0.0000
11	60	412,868	412,868	sewer	0.00	0.001	0.0020	0.0027
	Total	**3,256,020**	**3,255,672**					
	gallons/day	**9,303**						
	SAC Units/day	**34**						

Tank	Annual Costs($/yr)				Total	heated tanks
	Disposal	Water	Sewer	DI System		
1	0.00	10.87	21.74	0.00	$32.60	
2	0.00	1,015.87	2,031.74	0.00	$3,047.60	
3	0.00	10.87	21.74	0.00	$32.60	
4	0.00	10.87	914.18	0.00	$925.04	x
5	0.00	457.09	21.74	0.00	$478.82	x
6	0.00	10.87	616.70	0.00	$627.56	
7	0.00	308.35	0.00	0.00	$308.35	
8	5,166.48	2.16	5.02	0.00	$5,173.66	
9	0.00	0.00	0.00	0.00	$0.00	
10	0.00	1,015.87	2,031.74	0.00	$3,047.60	x
11	0.00	412.87	825.74	1,114.74	$2,353.35	x

	Disposal	Water	Sewer	DI System	Total
All Tanks	$5,166.48	$3,255.67	$6,490.30	$1,114.74	$16,027.20
Rinse Tanks	$0.00	$3,231.78	$6,441.82	$1,114.74	$10,788.34
	0.0%	99.3%	99.3%	100.0%	67.3%

Table V-18, Current Operating Costs for the Crest Washer Systems: Waste water generation and annual costs is included.

	Tank	Flow (gal/hr)	Water (gal/yr) Generation	Usage	Disposal	Price Data ($/gal) Disposal	Water	Sewer	DI System
O	1		17,500	17,500	sewer	0.00	0.001	0.0020	0.0027
O	2	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
O	3	34.5	248,650	248,650	sewer	0.00	0.001	0.0020	0.0027
O	4	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
N	1		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	2		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	3	17	113,900	113,900	sewer	0.00	0.001	0.0000	0.0027
N	4	34.5	264,750	264,750	sewer	0.00	0.001	0.0020	0.0027
N	5	34.5	233,454	233,454	sewer	0.00	0.001	0.0020	0.0027
N	6	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
		Total	**1,287,154**	**1,287,154**					

	Tank	Annual Costs($/yr) Disposal	Water	Sewer	DI System	Total
O	1	0.00	17.50	35.00	47.25	$99.75
O	2	0.00	113.90	227.80	307.53	$649.23
O	3	0.00	248.65	497.30	671.36	$1,417.31
O	4	0.00	113.90	227.80	307.53	$649.23
N	1	0.00	33.60	67.20	90.72	$191.52
N	2	0.00	33.60	67.20	90.72	$191.52
N	3	0.00	113.90	0.00	307.53	$421.43
N	4	0.00	264.75	529.50	714.83	$1,509.08
N	5	0.00	233.45	466.91	630.33	$1,330.69
N	6	0.00	113.90	227.80	307.53	$649.23

Disposal	Water	Sewer	DI System	Total
$0.00	$1,287.15	$2,346.51	$3,475.32	$7,108.98
$0.00	$1,202.45	$2,177.11	$3,246.63	$6,626.19
0.0%	93.4%	92.8%	93.4%	93.2%

b. Annual Savings and Water Reduction

Annual savings for cascading and spray rinsing were calculated in the same way as in section 1-b. The annual savings for the options for the Carousel Washer System are shown in table V-19 and table V-20. Table V-21 and Table V-22 show the annual savings for the options for the Carousel Washer Systems.

Table V-19, Cascade in the Carousel Washer System:
Annual Savings are shown for the rinse tanks alone and for all of the tanks.

		Water (gal/yr)			Price Data ($/gal)			
Tank	**Flow (gal/hr)**	**Generation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**DI System**
1		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
2	150	1,015,868	1,015,868	sewer	0.00	0.001	0.0020	0.0000
3		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
4		457,088	10,868	sewer	0.00	0.001	0.0020	0.0000
5		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
6		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
7	66.6	10,868	457,088	sewer	0.00	0.001	0.0000	0.0000
8		2,508	2,160	RCRA	2.06	0.001	0.0020	0.0000
9		0	0	sewer	0.00	0.001	0.0020	0.0000
10	150	1,015,868	1,015,868	sewer	0.00	0.001	0.0020	0.0000
11	60	412,868	412,868	sewer	0.00	0.001	0.0020	0.0027
	Total	**2,958,540**	**2,958,192**					
	Original	**3,256,020**	**3,255,672**					
	Savings	**297,480**	**297,480**					
	gallons/day	**850**						
	SAC units/day	**3**						

	Annual Costs($/yr)					heated
Tank	**Disposal**	**Water**	**Sewer**	**DI System**	**Total**	**tanks**
1	0.00	10.87	21.74	0.00	$32.60	
2	0.00	1,015.87	2,031.74	0.00	$3,047.60	
3	0.00	10.87	21.74	0.00	$32.60	
4	0.00	10.87	914.18	0.00	$925.04	x
5	0.00	10.87	21.74	0.00	$32.60	x
6	0.00	10.87	21.74	0.00	$32.60	
7	0.00	457.09	0.00	0.00	$457.09	
8	5,166.48	2.16	5.02	0.00	$5,173.66	
9	0.00	0.00	0.00	0.00	$0.00	
10	0.00	1,015.87	2,031.74	0.00	$3,047.60	x
11	0.00	412.87	825.74	1,114.74	$2,353.35	x

New Costs

Disposal	Water	Sewer	DI System	Total
$5,166.48	$2,958.19	$5,895.34	$1,114.74	$15,134.76
$0.00	$2,934.30	$5,846.86	$1,114.74	$9,895.90
0.0%	99.2%	99.2%	100.0%	65.4%

Original Costs

Disposal	Water	Sewer	DI System	Total
$5,166.48	$3,255.67	$6,490.30	$1,114.74	$16,027.20
$0.00	$3,231.78	$6,441.82	$1,114.74	$10,788.34
0.0%	99.3%	99.3%	100.0%	67.3%

Savings

Disposal	Water	Sewer	DI System	Total
$0.00	$297.48	$594.96	$0.00	$892.44
$0.00	$297.48	$594.96	$0.00	$892.44

Table V-20: Spray-Rinsing in the Carousel Washer:
Values are shown for all of the tanks and for the rinse tanks alone.

		Water (gal/yr)			Price Data ($/gal)			
Tank	**Flow (gal/hr)**	**Generation**	**Usage**	**Disposal**	**Disposal**	**Water**	**Sewer**	**DI System**
1		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
2	0	10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
3		10,868	10,868	sewer	0.00	0.001	0.0020	0.0000
4		308,348	10,868	sewer	0.00	0.001	0.0020	0.0000
5	44.4	10,868	308,348	sewer	0.00	0.001	0.0020	0.0000
6		457,088	10,868	sewer	0.00	0.001	0.0020	0.0000
7	66.6	10,868	457,088	sewer	0.00	0.001	0.0000	0.0000
8		2,508	2,160	RCRA	2.06	0.001	0.0020	0.0000
9		0	0	sewer	0.00	0.001	0.0020	0.0000
10	150	1,015,868	1,015,868	sewer	0.00	0.001	0.0020	0.0000
11	60	412,868	412,868	sewer	0.00	0.001	0.0020	0.0027
	Total	**2,251,020**	**2,250,672**					
	Original	**3,256,020**	**3,255,672**					
	Savings	**1,005,000**	**1,005,000**					
	gallons/day	**2,871**						
	SAC units/day	**10**						

	Annual Costs($/yr)					heated
Tank	**Disposal**	**Water**	**Sewer**	**DI System**	**Total**	**tanks**
1	0.00	10.87	21.74	0.00	$32.60	
2	0.00	10.87	21.74	0.00	$32.60	
3	0.00	10.87	21.74	0.00	$32.60	
4	0.00	10.87	616.70	0.00	$627.56	x
5	0.00	308.35	21.74	0.00	$330.08	x
6	0.00	10.87	914.18	0.00	$925.04	
7	0.00	457.09	0.00	0.00	$457.09	
8	5,166.48	2.16	5.02	0.00	$5,173.66	
9	0.00	0.00	0.00	0.00	$0.00	
10	0.00	1,015.87	2,031.74	0.00	$3,047.60	x
11	0.00	412.87	825.74	1,114.74	$2,353.35	x

New Costs

Disposal	Water	Sewer	DI System	Total
$5,166.48	$2,250.67	$4,480.30	$1,114.74	$13,012.20
$0.00	$2,226.78	$4,431.82	$1,114.74	$7,773.34
0.0%	98.9%	98.9%	100.0%	59.7%

Original Costs

Disposal	Water	Sewer	DI System	Total
$5,166.48	$3,255.67	$6,490.30	$1,114.74	$16,027.20
$0.00	$3,231.78	$6,441.82	$1,114.74	$10,788.34
0.0%	99.3%	99.3%	100.0%	67.3%

Savings

Disposal	Water	Sewer	DI System	Total
$0.00	$1,005.00	$2,010.00	$0.00	$3,015.00
$0.00	$1,005.00	$2,010.00	$0.00	$3,015.00

Table V-21, Crest Washer Systems Cascade Options:
Values are shown for the rinse tanks alone and for all of the tanks.

			Water (gal/yr)			Price Data ($/gal)			
	Tank	Flow (gal/hr)	Generation	Usage	Disposal	Disposal	Water	Sewer	DI System
O	1		17,500	17,500	sewer	0.00	0.001	0.0020	0.0027
O	2	0	248,650	0	sewer	0.00	0.001	0.0020	0.0027
O	3	34.5	17,500	248,650	sewer	0.00	0.001	0.0020	0.0027
O	4	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
N	1		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	2		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	3	0	233,454	0	sewer	0.00	0.001	0.0000	0.0027
N	4		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	5	34.5	33,600	233,454	sewer	0.00	0.001	0.0020	0.0027
N	6	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
		Total	**879,304**	**828,204**					
		Original	**1,756,154**	**1,756,154**					
		Savings	**876,850**	**927,950**					
		gallons/day	**2,505**						
		SAC units/day	**9**						

		Annual Costs($/yr)				
	Tank	Disposal	Water	Sewer	DI System	Total
O	1	0.00	17.50	35.00	47.25	$99.75
O	2	0.00	0.00	497.30	0.00	$497.30
O	3	0.00	248.65	35.00	671.36	$955.01
O	4	0.00	113.90	227.80	307.53	$649.23
N	1	0.00	33.60	67.20	90.72	$191.52
N	2	0.00	33.60	67.20	90.72	$191.52
N	3	0.00	0.00	0.00	0.00	$0.00
N	4	0.00	33.60	67.20	90.72	$191.52
N	5	0.00	233.45	67.20	630.33	$930.98
N	6	0.00	113.90	227.80	307.53	$649.23

New Costs

Disposal	Water	Sewer	DI System	Total
$0.00	$828.20	$1,291.70	$2,236.15	$4,356.05
$0.00	$743.50	$1,122.30	$2,007.46	$3,873.26
0.0%	89.8%	86.9%	89.8%	88.9%

Original Costs

Disposal	Water	Sewer	DI System	Total
$0.00	$1,287.15	$2,346.51	$3,475.32	$7,108.98
$0.00	$1,202.45	$2,177.11	$3,246.63	$6,626.19
0.0%	93.4%	92.8%	93.4%	93.2%

Savings

Disposal	Water	Sewer	DI System	Total
$0.00	$458.95	$1,054.81	$1,239.17	$2,752.93
$0.00	$458.95	$1,054.81	$1,239.17	$2,752.93

Table V-22, Spray-Rinse Options for the Crest Washer Sytstem:
Values for the rinse tanks alone and for all of the tanks are shown.

			Water (gal/yr)			Price Data ($/gal)			
	Tank	Flow (gal/hr)	Generation	Usage	Disposal	Disposal	Water	Sewer	DI System
O	1		17,500	17,500	sewer	0.00	0.001	0.0020	0.0027
O	2	0	248,650	0	sewer	0.00	0.001	0.0020	0.0027
O	3	34.5	17,500	248,650	sewer	0.00	0.001	0.0020	0.0027
O	4	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
N	1		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	2		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	3	0	233,454	0	sewer	0.00	0.001	0.0000	0.0027
N	4		33,600	33,600	sewer	0.00	0.001	0.0020	0.0027
N	5	34.5	33,600	233,454	sewer	0.00	0.001	0.0020	0.0027
N	6	17	113,900	113,900	sewer	0.00	0.001	0.0020	0.0027
		Total	**879,304**	**828,204**					
		Original	**1,756,154**	**1,756,154**					
		Savings	**876,850**	**927,950**					
		gallons/day	**2,505**						
		SAC units/day	**9**						

		Annual Costs($/yr)				
	Tank	Disposal	Water	Sewer	DI System	Total
O	1	0.00	17.50	35.00	47.25	$99.75
O	2	0.00	0.00	497.30	0.00	$497.30
O	3	0.00	248.65	35.00	671.36	$955.01
O	4	0.00	113.90	227.80	307.53	$649.23
N	1	0.00	33.60	67.20	90.72	$191.52
N	2	0.00	33.60	67.20	90.72	$191.52
N	3	0.00	0.00	0.00	0.00	$0.00
N	4	0.00	33.60	67.20	90.72	$191.52
N	5	0.00	233.45	67.20	630.33	$930.98
N	6	0.00	113.90	227.80	307.53	$649.23

New Costs

Disposal	Water	Sewer	DI System	Total
$0.00	$828.20	$1,291.70	$2,236.15	$4,356.05
$0.00	$743.50	$1,122.30	$2,007.46	$3,873.26
0.0%	89.8%	86.9%	89.8%	88.9%

Original Costs

Disposal	Water	Sewer	DI System	Total
$0.00	$1,287.15	$2,346.51	$3,475.32	$7,108.98
$0.00	$1,202.45	$2,177.11	$3,246.63	$6,626.19
0.0%	93.4%	92.8%	93.4%	93.2%

Savings

Disposal	Water	Sewer	DI System	Total
$0.00	$458.95	$1,054.81	$1,239.17	$2,752.93
$0.00	$458.95	$1,054.81	$1,239.17	$2,752.93

c. RO Reject Potential

The calculation for the potential annual savings from the use of RO reject water for the Carousel Washer System is shown below. Table V-34 in appendix B, section 2-b shows the average daily RO reject volume of 2,678 gallons, which was used for the following calculations.

$$\left(2{,}678\,\frac{\text{gal}}{\text{day}}\right)\left(\frac{350\text{ day}}{\text{year}}\right) = 937{,}300\text{ gal/year.}$$

water $\Rightarrow$ \$0.001/gal
sewer $\Rightarrow$ \$0.0025/gal.

$$\left(937{,}300\,\frac{\text{gal}}{\text{year}}\right)\left(\frac{\$0.001}{\text{gal}} + \frac{\$0.0025}{\text{gal}}\right)$$

$$\boxed{= \$3{,}280.55 \text{ Annual Savings}}$$

d. Economic Analysis

Economic calculations were performed in the same manner as in section 1-d. Table V-23 and table V-24 show the economic analysis for the Carousel Washer System. Table V-25 and table V-26 show the economic calculations for the Crest Washer Systems. Finally, table V-27 shows the economics of using the RO reject water for the Carousel Washer System.

Table V-23, Economic Analysis for Carousel Washer System Cascde Option: A 50% tax rate and 15% rate of return was assumed.

Annual Savings Carousel ($/yeart)	Crest ($/year)	SAC Savings Carousel ($)	Crest ($)	DI ($)
892.44	0.00	2,850.00	0.00	0.00

Annual Savings ($/year)	SAC Savings ($)
892.44	**2,850.00**

Cash Flow/year	Cash Flow Year 1
$446.22	**$1,871.22**

Costs

Cascade($)	Spray ($)	DI ($)	Other ($)	Total Cost ($)
1,000.00	0.00	0.00	0.00	1,000.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-1,000.00			
1	627.15	1,627.15	122.2%	842.32
2	964.55	337.41	122.2%	90.42
3	1,257.95	293.40	122.2%	40.70
4	1,513.08	255.13	122.2%	18.32
5	1,734.93	221.85	**122.2%**	8.25
	per year	1,734.93		$0.00

	Payback Time	
years	**0.75**	0.00
months	**9.01**	

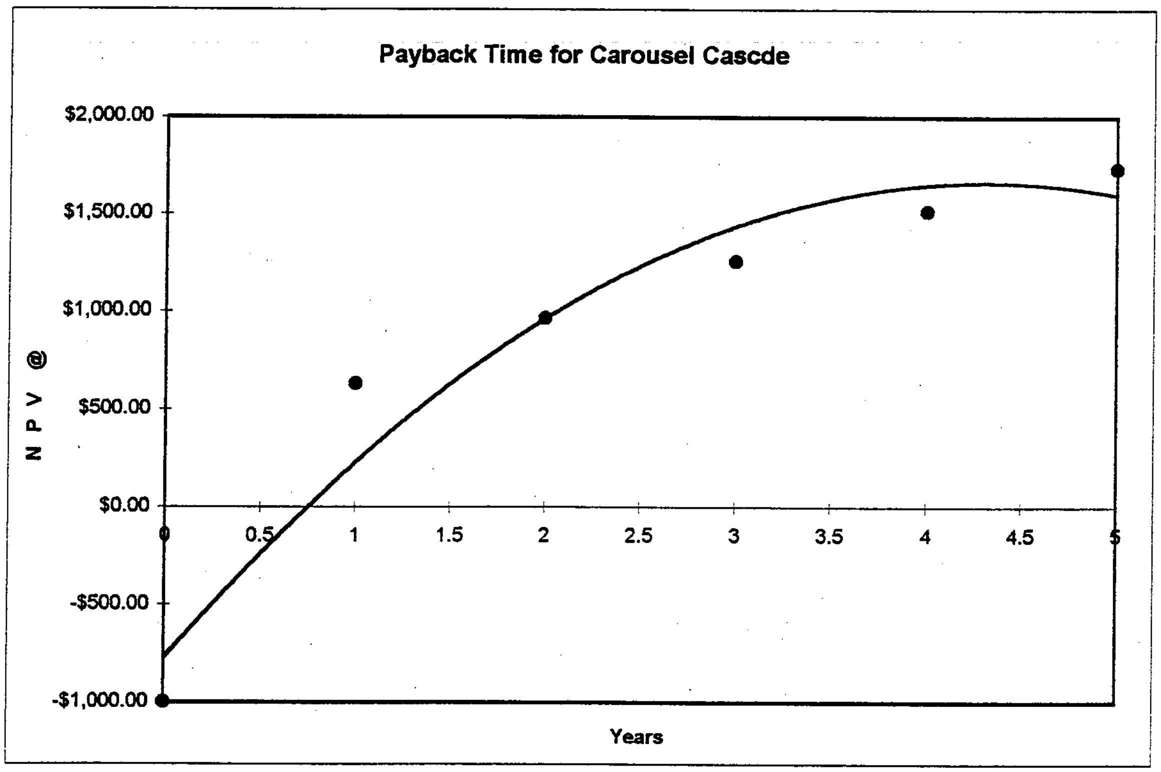


Table V-25, Economic Analysis for the Cascade Options for the Crest Systems: A 50% tax rate and a 15% rate of return was assumed.

Annual Savings		SAC Savings		
Carousel ($/yeart)	Crest ($/year)	Carousel ($)	Crest ($)	DI ($)
1,317.56	0.00	0.00	6,650.00	0.00

Annual Savings ($/year)	SAC Savings ($)
1,317.56	6,650.00

Cash Flow/year	Cash Flow Year 1
$658.78	$3,983.78

Costs

Cascade($)	Spray ($)	DI ($)	Other ($)	Total Cost ($)
1,000.00	0.00	0.00	0.00	1,000.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-1,000.00			
1	2,464.16	3,464.16	319.0%	950.86
2	2,962.29	498.13	319.0%	37.53
3	3,395.45	433.16	319.0%	8.96
4	3,772.11	376.66	319.0%	2.14
5	4,099.64	327.53	319.0%	0.51
	per year	4,099.64		$0.00

	Payback Time	
years	0.21	0.00
months	2.57	

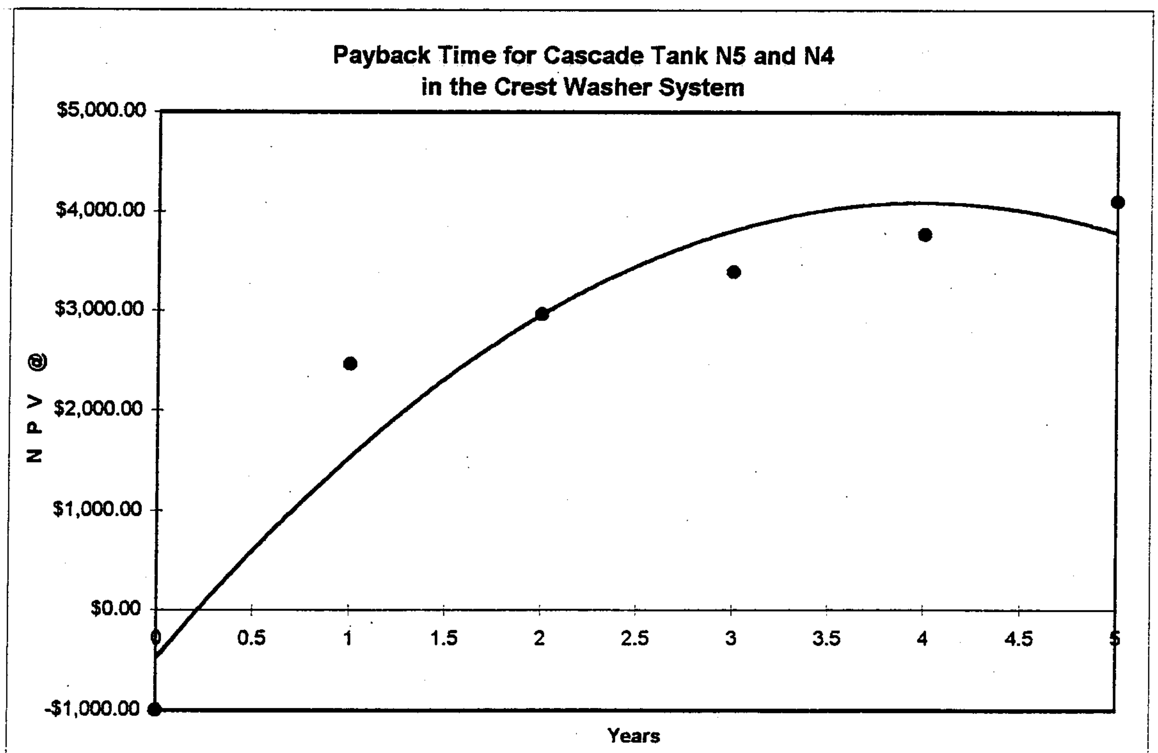


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Table V-26, Economic Analysis for the Cascade Options for the Crest Washer Systems: A 50% tax rate and a 15% rate of return was assumed.

Annual Savings		**SAC Savings**		
Carousel ($/yeart)	**Crest ($/year)**	**Carousel ($)**	**Crest ($)**	**RO ($)**
2,752.93	0.00	0.00	8,550.00	0.00

Annual Savings ($/year)	**SAC Savings ($)**
2,752.93	**8,550.00**

Cash Flow/year	**Cash Flow Year 1**
$1,376.47	**$5,651.47**

Costs

Cascade($)	**Spray ($)**	**RO ($)**	**Other ($)**	**Total Cost ($)**
0.00	1,000.00	0.00	0.00	1,000.00

Year	**Payback Time**	**NPV @15%**	**r**	**DCFRR**
0	-1,000.00			
1	3,914.32	4,914.32	493.0%	952.96
2	4,955.13	1,040.81	493.0%	39.14
3	5,860.18	905.05	493.0%	6.60
4	6,647.18	787.00	493.0%	1.11
5	7,331.53	684.35	**493.0%**	0.19
	per year	7,331.53		$0.00

	Payback Time	
years	**0.10**	0.00
months	**1.16**	

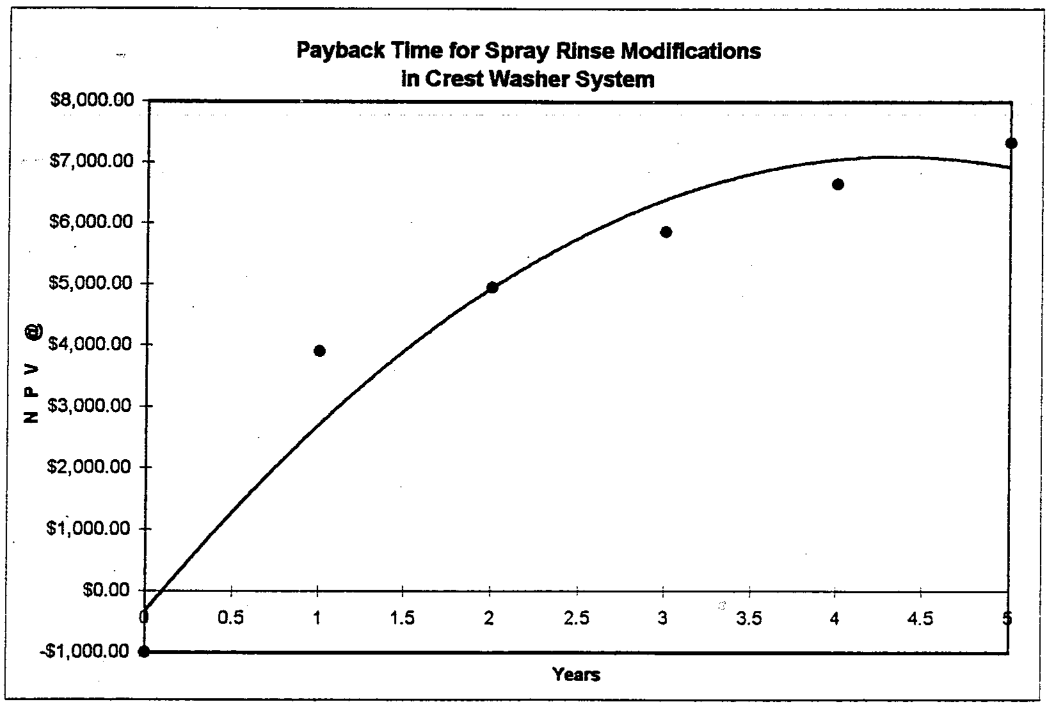


Table V-27, Economic Analysis of RO Reject Option: A 15 % rate of return and 505 tax rate was assumed.

Annual Savings Carousel ($/yeart)	Crest ($/year)	SAC Savings Carousel ($)	Crest ($)	RO ($)
3,280.55	0.00	0.00	0.00	8,550.00

Annual Savings ($/year)	SAC Savings ($)
3,280.55	8,550.00

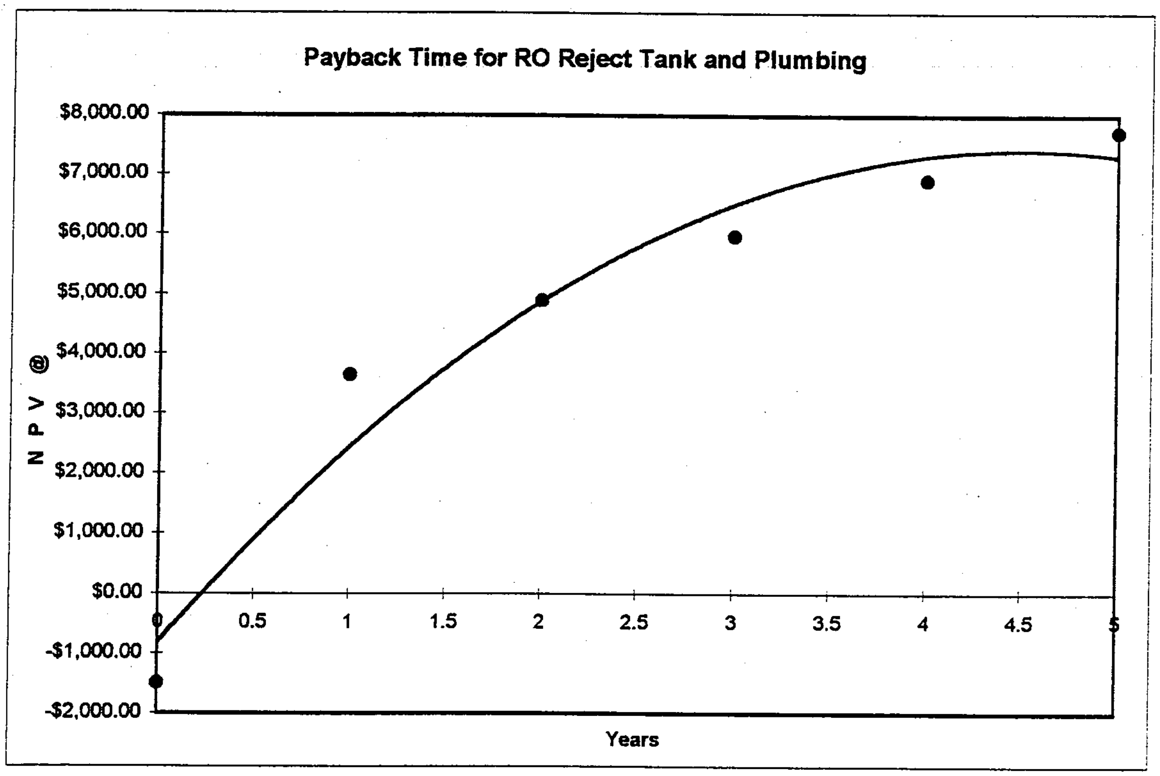
Cash Flow/year	Cash Flow Year 1
$1,640.28	$5,915.28

Costs

Cascade($)	Spray ($)	RO($)	Other ($)	Total Cost ($)
0.00	0.00	1,500.00	0.00	1,500.00

Year	Payback Time	NPV @15%	r	DCFRR
0	-1,500.00			
1	3,643.72	5,143.72	327.6%	1,383.27
2	4,884.00	1,240.29	327.6%	89.70
3	5,962.52	1,078.51	327.6%	20.98
4	6,900.35	937.84	327.6%	4.91
5	7,715.86	815.51	327.6%	1.15
	per year	1,640.28		$0.00

	Payback Time	
years	0.23	0.00
months	2.77	



B. Test Results

1. Machining Division and Kurt Gear Division

a. Conductivity Data

Table V-28, Conductivity Readings Measured in μS/cm: Events are noted by the given date. Readings were taken throughout the day.

	Tank	3	5	6	8	11	12	15	16	well	RO	city (c)	city (h)
6/27/97	2:45	75	519	141	1161	5720	16	85	9		1		
M 6/30/97	3:00	83	571	14	996	1311	36	1	2		1		
	4:15	74	555	12	985	1411	39	1	1		1		
7/1/97	3:25	77	391	20	1595	1030	43	8	3		7		
7/2/97	10:15	59	222	5	818	2400	17	58	3	601	1		
	10:50	51	206	6	905	1847	22	53	3	643	0		
	1:15	53	181	5	767	1730	30	47	4	587	0		
tanks cleaned	2:15	54	210	13	831	1685	24	55	3	635	0		
7/3/97	10:30	0	0	0	0	527	0	0	0	506	0		
M 7/7/97	10:00	0	0	0	0	516	0	0	0	513	0	388	418
	1:15	18	162	0	115	813	6	0	10	546	0	297	430
	3:30	55	353	7	218	1545	16	0	21	450	0	286	361
7/8/97	10:30	61	200	5	303	1302	11	45	10	289	0	132	284
	11:30	39	188	4	351	1138	11	29	21	459	0	281	477
	1:30	59	210	3	389	1872	16	47	19				
	2:20	75	259	3	426	1599	13	50	20				
7/9/97	8:45	112	237	3	525	2030	7	109	19	509	0		
cascade 15,16	1:15	101	135	2	508	1404	12	120	12	578	0		
7/10/97	10:15	61	105	0	260	598	4	7	4	305	0		
	11:15	87	104	3	597	663	5	122	7	515	0		
	12:45	96	105	5	641	236	3	71	2	316	0		
	1:15	70	60	0	317	312	1	84	2	360	0		
7/11/97	10:00	61	129	2	526	717	5	78	2	561	0		
	11:00	93	155	3	716	1155	5	111	1	575	0		
	12:00	98	142	2	678	890	5	121	4				
	2:00	98	109	0	578	761	7	109	3	499	0		
M 7/14/97	10:15	103	75	2	605	754	0	0	0	760	0		
slow flows	10:45	116	36	5	631	630	2	30	0	552	0		
	1:15	161	64	2	619	680	5	97	2	52	0		
	4:00	87	72	2	732	585	3	82	2	556	0		
7/15/97	9:00	70	32	5	163	261	7	20	7	161	0		
	12:00	58	275	5	92	97	2	14	1				
7/16/97	9:15	82	539	10	324	2480	12	29	4				
	11:30	103	265	6	81	1400	9	8	4	226	0		
	1:00	138	306	6	61	1600	11	7	4				
F 7/18/97	3:30	94	180	5	630	758	8	93	3				
W 7/23/97	11:15	89	94	2	125	738	9	30	5				
	12:00	39	133	3	182	1345	14	51	9				
	2:00	192	374	6	740	1435	17	88	30				

Table V-28 shows all conductivity readings of the rinse water. Fresh water flow-rates were decreased on July 14. The conductivity of the rinse water did not change significantly with the reduced fresh water flow-rates. This suggest that the virgin rinse water is being drained. Tank 11 is fed with city well water and hence the conductivity readings are significantly greater than the rest of the rinse water.

b. Temperature Data

In general, the RO water has a higher temperature than the city well water. The temperature of the water in Tank 16 and Tank 15 was recorded throughout the days when the two tanks were cascaded. All of the recorded temperature readings are found in table V-29. From these numbers an average temperature change could be determined. From that value the additional cost for heating Tank 16 was calculated.

Table V-29, Temperature Readings: The temperature difference between the set temperature of 136°F and the actual temperature for tank 16 is recorded. This temperature difference was used to determine the additional electric cost needed for heating the water if constant overflow occurs.

		Temperature (°F)					
Date	**Time**	**well**	**Tank 11**	**Tank 15**	**RO**	**Tank 16**	**ΔT**
7/9/97	8:45	62	62	82	72	120	16
	1:15	66	64	100	76	136	0
7/10/97	10:15	66	65	87	75	135	1
	11:15	62	64	87	76	136	0
	12:45	61	64	89	79	123	13
	1:15	63	61	94	75	136	0
7/11/97	10:00	60	62	101	75	119	17
	11:00	59	60	102	75	123	13
7/14/97	10:15	71	71	75	80	123	13
	10:45	69	72	72	78	136	0
	1:15	80	72	85	80	136	0
	4:00	60	60	96	81	136	0
7/15/97	9:00	58	61	102	78	126	10
7/16/97	11:30	65	65	101	79	135	1

c. pH Data

Table V-30, pH Readings:
Events are noted by the given date. Readings were taken throughout the day. In general, the pH of the rinse water in each tank plateaus after a certain point is reached. The rinse water pH does depend on the pH of the fresh water.

	Tank	3	5	6	8	11	12	15	16	well	RO	city (cold)	city (hot)
6/27/97	2:45	9.19	10.83	8.22	3.03	7.00	5.30	4.01	4.87		5.74		
6/30/97	3:00	9.15	10.93	7.91	3.13	7.00	5.18	6.41	5.71		5.75		
	4:15	9.15	10.91	8.11	3.14	7.00	5.00	6.34	5.54		6.04		
7/1/97	3:25	8.97	10.49	7.83	2.78	7.26	4.78	5.10	5.51		5.39		
7/2/97	10:15	9.01	10.28	7.39	2.96	8.54	5.41	3.97	5.27	7.61	5.08		
	1:15	9.03	10.21	7.39	2.90	8.09	4.63	4.05	5.95	7.49	5.39		
tanks cleaned	2:15	8.97	10.32	7.65	2.91	8.11	4.56	4.02	5.99	7.44	5.67		
7/3/97	10:30	6.53	6.33	6.36	8.46	7.62	7.52	5.13	6.23	6.69	5.60		
7/7/97	10:00	8.21	6.17	5.85	6.72	7.42	5.14	4.96	4.99	7.41	5.19	7.28	7.02
	1:15	9.06	10.67	7.41	4.01	7.00	5.56	5.39	4.52	7.57	4.62	7.39	7.00
	3:30	8.95	10.75	7.39	4.01	7.00	4.86	5.19	4.01	7.54	5.43	7.44	7.00
7/8/97	10:30	8.66	10.52	7.96	3.09	6.28	5.28	3.95	3.91	7.50	5.51	7.24	7.03
	11:30	8.97	10.63	8.11	3.07	3.59	4.58	3.89	3.92	7.51	5.73	7.37	7.10
	1:30	9.00	10.75	7.69	2.99	6.53	5.16	3.92	3.91				
	2:20	8.99	10.70	7.44	2.99	6.57	4.78	3.81	3.86				
7/9/97	8:45	9.00	10.66	7.49	3.10	6.72	5.74	3.67	4.10	7.55	5.50		
cascade 15, 16	1:15	9.00	10.29	7.34	3.01	7.04	5.43	3.62	4.68	5.58	7.55		
7/10/97	10:15	8.94	10.03	8.14	2.92	7.27	5.10	3.62	4.54	7.45	5.32		
	11:15	8.95	10.06	7.74	2.86	7.59	5.07	3.50	4.12	7.50	4.68		
	12:45	8.79	10.02	7.40	2.84	7.90	4.89	4.38	4.39	7.39	5.64		
	1:15	8.94	9.98	7.03	2.84	7.94	4.76	3.34	4.37	7.48	5.51		
7/11/97	10:00	8.92	10.24	7.42	2.95	7.53	5.27	3.63	4.79	7.49	5.92		
	11:00	8.97	10.24	7.14	2.96	7.59	5.29	3.55	4.96	7.52	5.72		
	12:00	8.96	10.26	7.51	2.94	7.61	5.49	3.91	5.14				
	2:00	8.96	10.02	7.32	2.95	7.76	5.43	3.45	4.80	5.59	7.52		
7/14/97	10:15	9.84	9.60	6.90	2.85	7.81	6.06	5.63	7.54	7.54	5.50		
slow flows	10:45	8.96	9.54	6.56	2.81	7.89	5.56	4.96	5.19	7.03	5.40		
	1:15	8.86	9.61	7.13	2.93	8.03	5.53	3.69	5.18	7.29	5.44		
	4:00	8.96	9.61	7.07	2.85	7.75	5.00	3.68	5.47	7.39	5.05		
7/15/97	9:00	9.05	10.62	7.32	3.08	7.00	5.14	4.13	5.53	7.59	5.15		
	12:00	9.07	10.65	8.18	3.95	7.38	5.20	3.92	5.18				
7/16/97	9:15	9.02	10.69	7.58	3.40	6.10	5.97	4.30	5.48				
	11:30	9.05	10.85	8.03	4.20	4.95	4.93	4.45	4.66	7.62	5.57		
	1:00	9.06	11.01	7.94	3.75	6.44	4.95	4.33	4.37				
7/18/97	3:30	8.90	9.98	6.37	2.96	7.55	4.80	3.29	4.33				
7/23/97	11:15	8.62	10.23	6.55	3.18	6.47	4.25	3.27	4.01				
	12:00	8.64	10.36	6.47	3.27	10.01	4.02	3.56	4.01				
	2:00	8.62	10.36	5.01	3.33	3.94	4.50	4.50	4.01				

Table V-30 shows all pH readings of the rinse water. Fresh water flow-rates were decreased on July 14. After the floe-rates were decreased, the pH of the rinse water did not change significantly with the reduced fresh water flow-rates. This again suggests that the virgin rinse water is being drained. Because Tank 11 is fed with city well water, the pH change is not on the same scale as the other rinse tanks. RO water generally maintains a pH of about 5 and city well water usually has a pH of about 7.

d. pH and Conductivity Measurements when Tanks were Cleaned

Table V-31 summarizes the pH and conductivity measurements for the days when the tanks were cleaned out. These measurements show the variability and inconsistency of rinse tank cleaning.

Table V-31, pH and Conductivity Measurements when Tanks are Cleaned: Readings were taken before the tanks were drained and cleaned. The conductivity is measured in µS/cm. Only some of the tanks are cleaned each week.

Date Tank	7/3/97 µS/cm	pH	7/11/97 µS/cm	pH	7/18/97 µS/cm	pH
3	54	8.97			94	8.90
5	210	10.32			180	9.98
6	13	7.65			5	6.37
8	831	2.91	678	2.96	630	2.96
11	1685	8.11				
12	24	4.56	5	5.49		
15	55	4.02	121	3.91	93	3.29
16	3	5.99				

e. Tank 11 Profile Data

Specific concern was expressed about the pH of the rinse water in Tank 11. Manual addition of caustic was not done throughout the testing day. Hence the natural course or the rinse water pH and conductivity could be monitored. Table V-32 shows the collected rinse water data.

tap water 211.5 gph

Table V-32, Tank 11 Rinse Water Measurements:
Conductivity and pH measurements were taken throughout the day.

Time (min)	pH		Time (min)	Conductivity (µS/cm)	comment
0	6.32		0	776	
5	2.73		5	447	after parts rinsed
10	2.73		10	471	
15	2.75		15	430	
20	8.57		20	902	caustic was added
27	5.91		27	801	after parts rinsed
35	6.01		35	854	
40	6.11		40	692	
50	6.73		50	678	
60	6.32		60	614	
65	6.41		65	683	Δ=69
75	3.09		75	641	after
80	3.13		80	539	
85	3.14		85	369	
90	3.15		90	399	
95	2.55		95	471	
100	2.57		100	1667	Δ= 1196
105	2.59		105	629	
110	2.61		110	700	
115	2.64		115	702	
120	2.33		120	689	after
125	2.34		125	795	Δ=106
130	2.36		130	508	
140	2.38		140	668	
145	2.19		145	1969	Δ=1301 after
150	2.21		150	3180	Δ=1211 } 2512
155	2.23		155	757	
160	2.24		160	1085	
165	2.24		165	944	
170	2.11		170	1380	after parts rinsed
175	2.11		175	1064	Δ=436
180	2.12		180	438	
185	2.13		185	720	
190	2.09		190	7760	after parts rinsed
195	2.09		195	4580	Δ=7040
230	2.04		230	5320	
235	2.03		235	3810	
240	2.03		240	5610	
245	1.99		245	7710	after parts rinsed
250	2.01		250	7900	Δ= 4090
255	2.07		255	7660	
265	2.13		265	6940	

Because of the concerns caustic solution is added to the tank manually. One option is to install an pH metering pump control system. Before this could be done, the necessity of such a system needed to be investigated. Figure V-2 shows the pH profile of the rinse water in Tank 11. The pH profile shows how the pH of the water drops quickly until a value of pH 2 is reached.

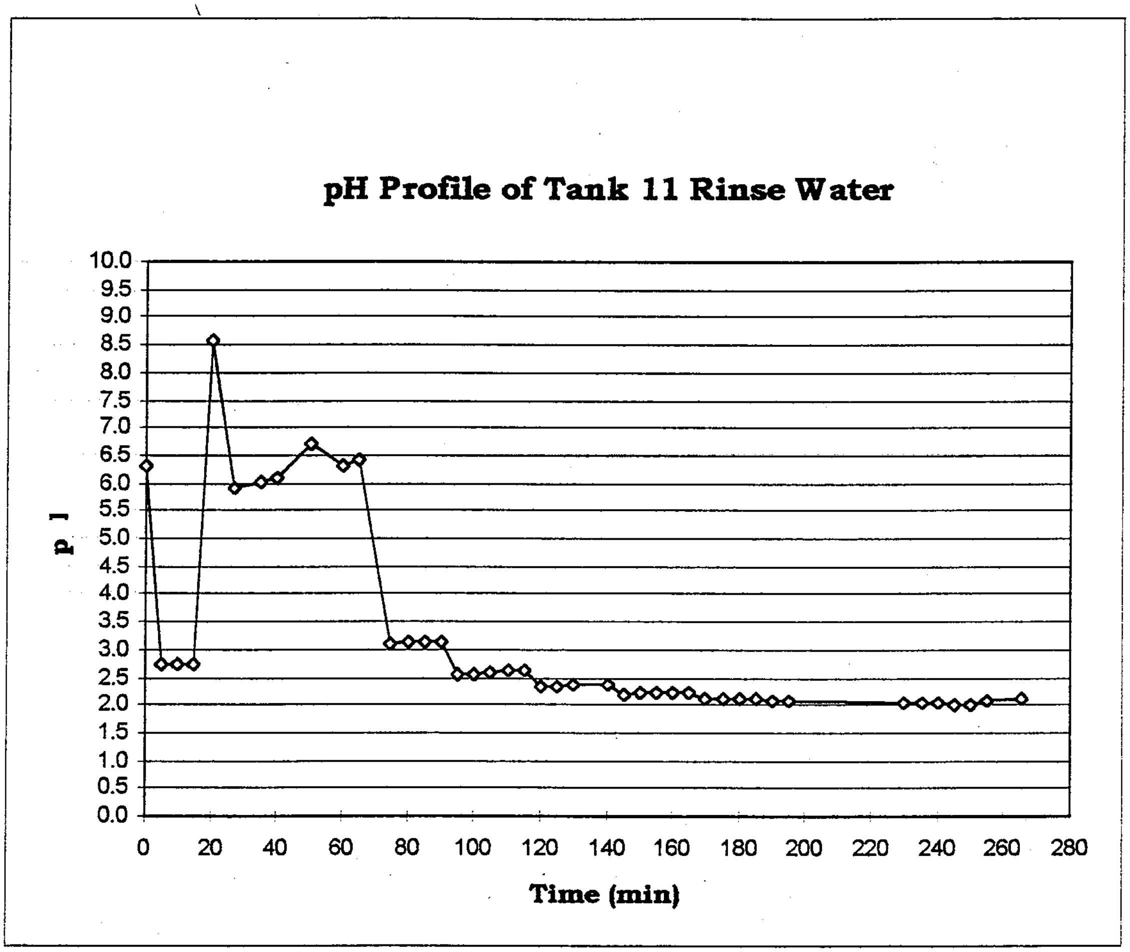


Figure V-2, Plot of the Rinse Water pH for Tank 11: The peak at 9.5 occurred after caustic solution was added to the tank manually. After parts are rinsed, the pH drops drastically until it reaches a value of about pH 2.

2. Automatic Division

a. Conductivity Measurements

A preliminary assessment of the waste water generation problem at the Automatic Division was conducted on March 19, 1997. Karl DeWahl, MnTAP, collected conductivity and water flow measurements from the Carousel Washer System. The report can be found in appendix D. Table V-33 summarizes the conductivity measurements of the rinse tanks within the Carousel Washer System.

Table V-33, Conductivity Measurements from the Carousel Washer System: All tanks receive city well water as a feed stream except for Tank 11 which receives RO water as a feed.

Tank	Conductivity (μS/cm)
2	394-396
4	395-410
5	395-405
6	394-399
7	360
9	397-404
10	375-380
11	4

b. Meter Readings

After the original 30-day waste water generation study, specific areas of the plant were monitored for waste water generation. Meter readings indicated that the Carousel Washer System generated most of the waste water as compared all systems. Tank 9 was converted from a dip-rinse to a spray-rinse. In addition, the four tank dip-rinse series— Tank 4, Tank 5, Tank 6, and Tank 7—was converted to two sets of cascaded dip-rinses—Tank 4 and Tank 5, and tank 6 and Tank 7. After these modifications were made to the Carousel Washer System, an additional 14-

day study was conducted. Table V-34 shows the meter readings from the 14-day study. In addition, the top portion of the table displays the meter readings which determined the areas of high waste water generation.

Table V-34, Meter Readings at the Automatic Division: All values are recorded in gallons. The total column is the sum of the RO Feed (RO system Usage) and Washer (Carousel Washer System Usage).

	Date	**RO Feed**	**RO Stored**	**RO Reject**		**Washer**	**Total**	**Reading**
	20-May					6677		
	21-May	8032	5214	2818	35.1%	9520	17552	
	22-May	7432	4834	2598	35.0%	8470	15902	
F	23-May	5833	3808	2025	34.7%	7016	12849	
T	27-May	14020	9220	4800	34.2%	3144	17164	
	28-May	5239	3438	1801	34.4%	8997	14236	
	29-May	6817	4432	2385	35.0%	9373	16190	
F	30-May	7497	4886	2611	34.8%	9390	16887	
M	2-Jun	15663	10165	5498	35.1%	21197	36860	
	3-Jun	6020	3935	2085	34.6%	14219	20239	
	4-Jun	6280	4105	2175	34.6%	3114	9394	
	5-Jun	6694	4342	2352	35.1%	9170	15864	
F	6-Jun	7510	4885	2625	35.0%	10070	17580	
M	9-Jun	13468	8770	4698	34.9%	15472	28940	
	10-Jun	5183	3349	1834	35.4%	7188	12371	
	11-Jun	7104	4604	2500	35.2%	9303	16407	
	12-Jun	4071	2672	1399	34.4%	3491	7562	
F	13-Jun	2821	1856	965	34.2%	2081	4902	
	14-day study begins							
T	17-Jun	15019	9801	5218	34.7%	29279	44298	50650
	18-Jun	4975	3249	1726	34.7%	2884	7859	11840
	19-Jun	4276	2827	1449	33.9%	1114	5390	9040
F	20-Jun							11980
M	23-Jun							30010
Th	26-Jun							37260
F	27-Jun							19690
M	30-Jun							21000
	1-Jul							32640
	2-Jul							13860
Th	3-Jul							10620
T	8-Jul							34620
	9-Jul							19370
	10-Jul							15630
F	11-Jul							17510
	14-day study ends							
M	14-Jul							22790
	15-Jul							15900
	16-Jul							20400

C. Process Drawings

Figure V-3 shows a detailed schematic of the Metal Finishing Line. Piping, heating units, and control valves are shown on the diagram. A drawing of the pH adjustment system is shown in figure V-4. Finally, figure V-5 shows a drawing of the weir construction used for Cascade 1 and suggested for Cascade 2.

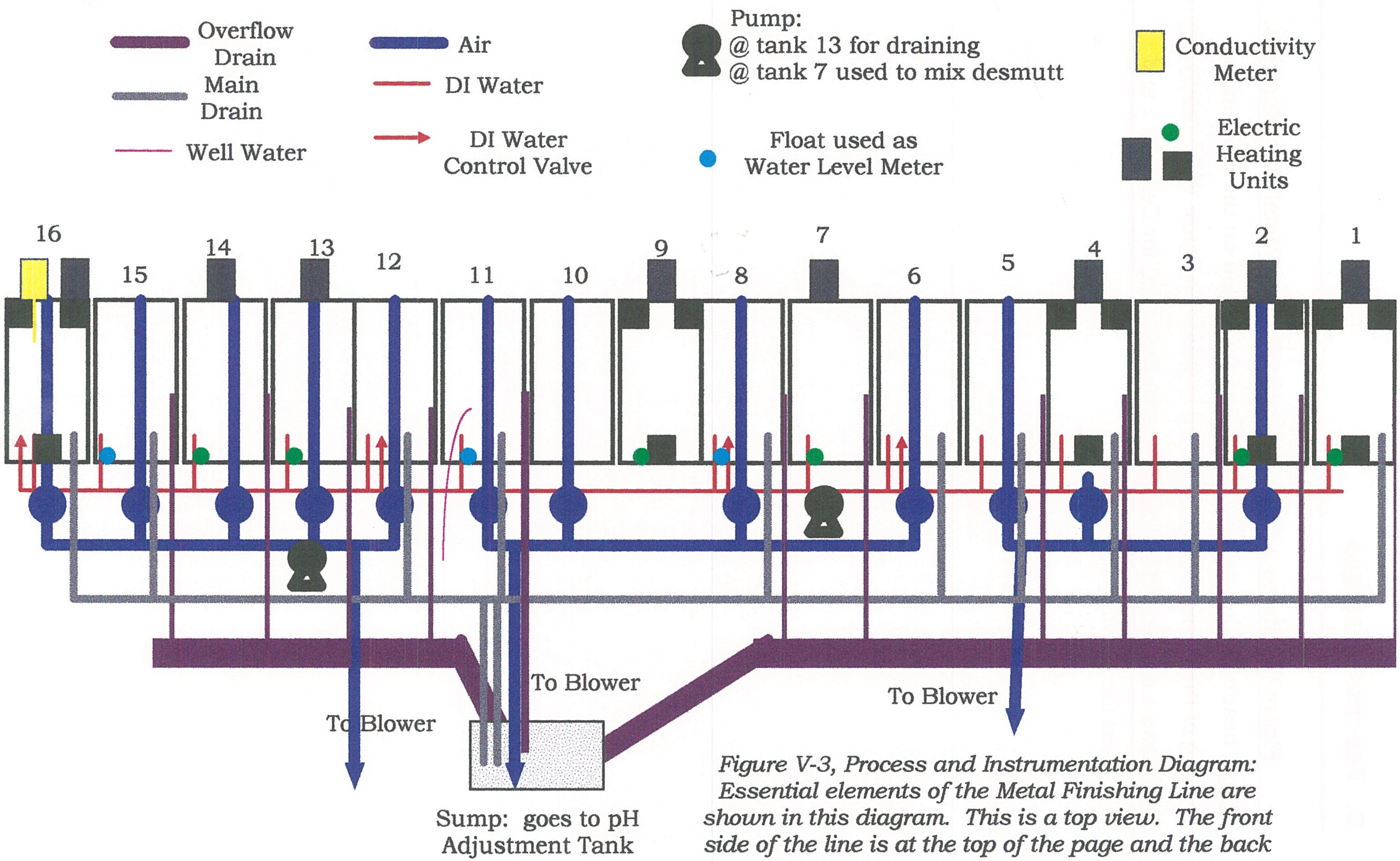


Figure V-3, Process and Instrumentation Diagram: Essential elements of the Metal Finishing Line are shown in this diagram. This is a top view. The front side of the line is at the top of the page and the back side of the line is at the bottom of the page. The back side of the line faces the wall.

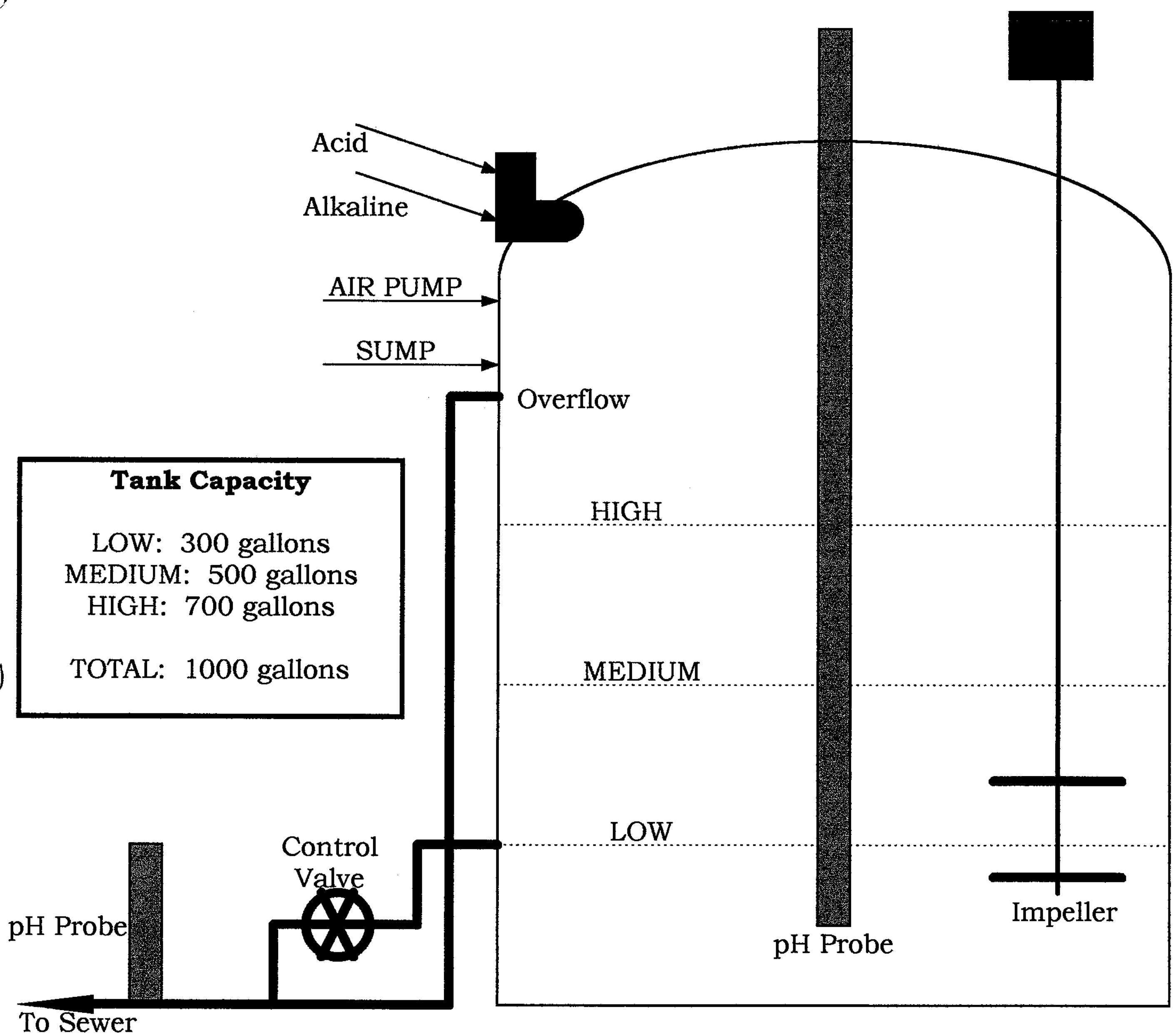
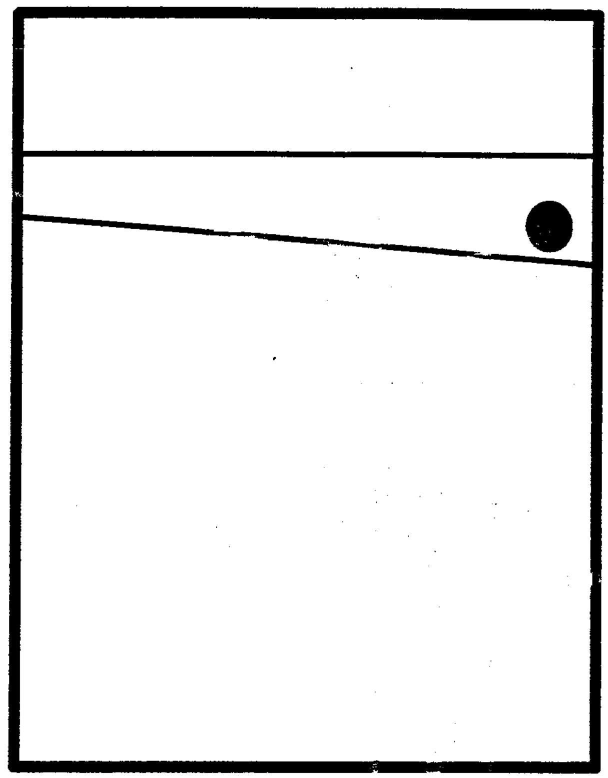
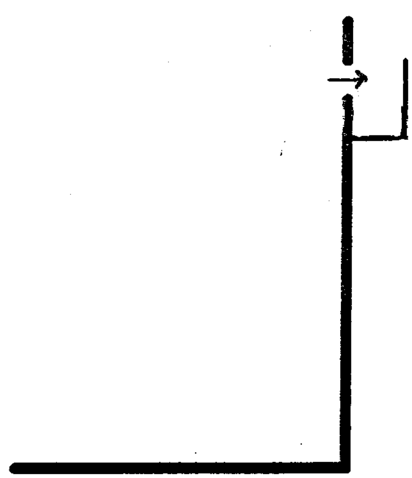


Figure V-4: Schematic of the pH Adjustment System for the Metal Finishing Line. Throughout processing waste water enters the tank through the sump line, but when the tanks are cleaned waste water enters the tank through the air pump line. The pH probe inside the tank triggers pumps to add sulfuric acid and caustic when the pH is above 9.5 and below 5.5 respectively. While the pH is being adjusted, the control valve closes to keep the waste water from entering the sewer. Once the pH has reached a valid number the valve opens and waster water is emptied into the sewer. Finally , the second pH probe monitors the pH of the water entering the sewer. An alarm will light up when the waste stream pH is outside of the regulated range (5 to 10).



(a) Front View



(b) Side View

Figure V-5, Diagram of Weir Construction:
(a) The weir itself is located on the outside of the tank. One side is two inches wide and the other is three inches wide. The slope helps push water down the drain. The drain opening in shown.
(b) One inch holes are evenly spaced in a straight line. These holes are in the side of the tank and allow flow into the outside weir.

D. Additional Information

Karl DeWahl from MnTAP visited the Automatic Division in March 1997 to access the facilities waste water generation. Rinse water conductivity measurements and water flow rates were collected for the Carousel Washer System. Water reduction options, which can also improve rinse quality, were suggested. The four suggestions include reusing RQ water, redesign or modify current tank system, check carousel arms for leaks, and clean tank walls. After this initial meeting in March, the Carousel Washer System was modified to include a spray rinse in Tank 9 and two sets of cascaded rinse tanks—Tank 4 and Tank 5, and Tank 6 and Tank 7. The report is attached on the following pages.

Jim Sjoselius
Kurt Manufacturing Company
5280 Main St
Minneapolis, MN 55421

April 1, 1997

Dear Jim Sjoselius:

On 3/19/97 we collected water flow rates and bath conductivity measurements at the Northdale facility. We did not have a facility water use total to compare, but the sum of the individual flows seems considerably less than I expected to find based on your general comments. Further efforts to identify other water uses or leaks may be necessary. However, the reading taken do suggest a number of possible ways to reduce water usage and probably also to improve rinsing effectiveness. I will summarize the flow and conductivity data we collected and then present the conclusions I draw from the data and what I see as your water reduction alternatives.

The flows we identified were:

	conductivity(μs)	estimated gpy	estimated gpm	estimated value
domestic water 20 gpd x # of people		not calculated	-	$-/yr
carousel washer tank #1 alk cleaner		small	-	-
tank #2 rinse	394-396	480,000	2.0	1536
tank #3 alk cleaner		small	-	-
tank #4 heated rinse	395-410	120,000	0.5	384
tank #5 heated rinse	395-405	120,000	0.5	384
tank #6 rinse	394-399	240,000	1	768
tank #7 rinse	360	240,000	1	768
tank #8 desmut		small	-	-
tank #9 rinse (cloudy)	397-404	1,440,000	6	4608
tank #10 heated rinse	375-380	600,000	2.5	1920
tank #11 hot DI rinse	4	240,000	1.0	768
crest console tank #1 alk cleaner		small	-	-
tank #2 dead rinse		small	-	-
tank #3 spray rinse on 190s out of 400		1,032,000*	2.2	3302
tank #4 rinse } continuous flow		168,000	0.7	537
tank #5 rinse		168,000	0.7	537
tank #6 &7 dry		no water use		
vibratory deburring		unknown		
thermal deburring		unknown		
coolant make-up		unknown		
	total =	over 4,848,000		over $15,500

Note that the water cost does not reflact the additional cost of providing deionized water.

Observations & Conclusions

1. Incoming city water feeds had a conductivity of about 190µs. Seven of the eight rinse tanks had conductivities around 400µs which did not noticeably change as parts loads were brought into the tanks or taken out. Parts as they were immersed in additional rinses as they went through the first 7 did not come into contact with cleaner water.

Conclusion - Fresh water feeds to each tank is not producing fresh water results. Parts go into "used" water that has twice the ionic contamination of tap water.

2. The DI rinse had a significantly lower conductivity than any other rinse, but this conductivity did not increase as parts were placed in the tank.

Conclusion - The de-ionized water is being under-utilized. It is being sent to drain in nearly virgin condition - it is certainly much cleaner than the tap water being used for most of the rinses.

3. Tanks turn-over their volume in 25 minutes for tank #9 and 300 minutes for tanks #4&5, compared to the time between loads of roughly 5 minute for each tank.

tank size
15"x48"x48"
top view

Conclusion - The tanks are too large for efficient rinsing. Contaminants rinse off parts and are dispersed & diluted in a large volume of water, and then are only slowly purged from the system. I estimate tank volumes at roughly 150 gallons each, while the space a loaded rack can fit in is about 8 gallons. estimated rack 8"w x 15"l x 16"l

4. Inlets and outlets are located within inches of each other on tanks 4 & 5.

5. Tank conductivity occasionally spiked when a carousel arm carrying no load entered a tank.

Conclusion - The welded tubular, carousel structure may have pin-hole leaks that serve to transport far greater amounts of contaminants from tank to tank than the than parts carry-over does.

6. Conductivity changed slightly with location, The center of the tank had the highest conductivity, while area near the wall had the lowest.

Conclusion - There is very little mixing in the rinse tanks. Contaminants are moved away from surfaces by diffusion - a slow process.

7. There is a small build-up of scale or solids on the walls of most of the tanks. This may be a source of buffering or internal storage of ionic contamination that may serve to make the rinse water dirtier than it needs to be.

Water use reduction options

A. **Reuse the DI water**. Cascade it back into previous rinses as many times as possible, until its conductivity or other characteristics show it is degraded worse than tap water. Other characteristics that might be important are pH, turbidity, and oil content. We did not measure the conductivity on any rinses in the Crest console wash, but odds are that effluent could be reused on the carousel system also, and could be used in one of three ways:

- Replace the present carousel DI feed, cutting overall DI water consumption.
- Add flow (greater tank turn-over and mixing) to cascaded rinses.
- Replace tap water flow on up stream rinses if the DI water from cascading tank #9 water becomes too contaminated to replace all the fresh water feeds.

B. **Redesign or modify the tank system**. I realize the carousel washer was not designed for the current product and that there is a value in retaining capacity for future flexibility.

- Reduce the effective size of the tanks to improve turn-over, mixing and the purging of contaminants. One way to accomplish this without replacing the current tanks is to fill unused space with removable foam blocks (care is required to avoid creating recesses where contaminants can accumulate and perhaps recontaminate parts). A second way would be to mount new small tanks inside the current tanks.

- Improve flow from inlets to outlets. Inlets and outlets on tanks 4 & 5 are within inches of each other, allowing fresh water to short circuit through the tank. This should be corrected. Most of the tanks have inlets and outlets on opposite sides of the tank at the same level. This is OK, but could be further improved by using plastic hose to feed fresh water to the bottom of the tank so diagonal flow is achieved (an air break would be needed to prevent back siphoning). This could also be used with foam spacers, discussed above, if fresh water feed is distributed over the bottom of the tank or from behind any spacers - flow would be through any cracks or seams and should effectively purge these recesses.
- Improve mixing so water currents move high contaminant concentrations away from part surfaces. This can be accomplished by increasing rinse flow (use cascaded rinses so flows go through all tanks); installing pumps to recirculate rinse water within a tank; or have the carousel lift and descend 5-10 times in each tank. for each step.

C. **Check the tubular arms of the carousel for leaks** that can carry significant volumes of liquid from tank to tank. The simplest solution is to drill 3/8" holes at the top and bottom of each vertical arm so the arm becomes free draining. Alternatively identify leakers and seal them.

D. **Clean scale and solids from tank walls.**

I hope this information is useful, please let me know if I can be of further assistance. Please share this letter with both the supervisor that was so helpful to us and with the cleaning room operators. This information is important to their understanding of the problem, and they may both have other useful information about the water use problem and ideas for solutions.

Sincerely

Karl DeWahl

Karl DeWahl

also put in contact w. Ken Brown

E. List of Resource People

a. Resource People Involved at All Locations

Table V-35 lists the resource people that were involved with the project at all locations. The specific relationship and contact information of each person is cited in the table.

Table V-35, Contact People for General Information about the Project: Names addresses and telephone numbers are included in the table. In addition, a brief relationship to the project is listed.

Contact	Telephone Number	Address	Relationship to Project
Karl DeWahl	(612)627-1904	MnTAP 1313 5th St. SE Minneapolis, MN 55414-4504	Intern Advisor
Pat Dick	(612)572-4426	Kurt Manufacturing Company 5280 Main St, NE Minneapolis, MN 55421	general information about water usage and waste generation
Jim Sjoselius	(612)572-4627	Kurt Manufacturing Company 5280 Main St, NE Minneapolis, MN 55421	Intern Supervisor

b. Machining Division and Kurt Gear Division

Contacts listed in Table V-36 are directly related to water conservation at the Machining Division and the Kurt gear Division. The people listed included those involved with the general operation of the Metal Finishing Line and those people involved with any of the implementation process. In addition, contact information for the chemical supplier and is included. The final contact listed provided information about the billing process for both sewer charges and water charges.

Table V-36, Contacts Specific to the Machining Division and Kurt Gear Division: People listed include those which can provide general information and those that can provided specific information about implementation and success.

Contact	**Telephone Number**	**Address**	**Relationship to Project**
William Balnchet	(612)378-7581	Industrial Chemical and Equipment 3230 E. Hennepin Ave. Minneapolis, MN 55413	chemical supplier for Metal Finishing Line
Roger Knaus	(612)572-4565	Kurt Manufacturing Company 5280 Main St, NE Minneapolis, MN 55421	Metal Finishing Line operator (day shift)
Judy Melham	(612)572-3529	City of Fridley	water charges and sewer charges information
Marty Meyer	(612)926-6713	UNIFAB, Inc. 3850 Edgewood Ave. St. Louis Park, MN 55426	polypropylene tank construction
Dave Muncy	(612)572-1500	Kurt Manufacturing Company 5280 Main St, NE Minneapolis, MN 55421	Metal Finishing Line operator (night shift)
Bruce Powers	(612)572-4419	Kurt Manufacturing Company 5280 Main St, NE Minneapolis, MN 55421	Maintenance Supervisor
Chris Wiege	(612)427-4940	Climatronics, HVAC/R 11833 Douglas Dr. N. Minneapolis, MN 55316	plumbing and weir construction

c. Resource People Involved at the Automatic Division

Table V-37 lists the resource people that were involved with the project at the Automatic Division.

Table V-37, Contact People for Information about the Project at the Automatic Division: Names addresses and telephone numbers are included in the table. In addition, a brief relationship to the project is listed.

Contact	Telephone Number	Address	Relationship to Project
Laura Engen	(612)602-4712	Metropolitan Council Environmental Services Mears Park Centre 230 E 5th St. St. Paul, MN 55101-1633	SAC information
Mike Frantz	(612)572-4549	Kurt Manufacturing Company 1292 Northdale Blvd. Coon Rapids, MN 55448	Maintenance Department
Tom Loeschke	(612)572-4488	Kurt Manufacturing Company 1292 Northdale Blvd. Coon Rapids, MN 55448	Quality Supervisor

F. Bibliography

Dowd, Patrick. "Conserving Water and Segregating Waste Streams." *Plating and Surface Finishing* May 1985.

(D1) Durney, Lawrence J. *Electroplating Engineering Handbook.* New York: Van Nostrand Reinhold Company Fourth Edition.

Jones, William C. "Testing Surfaces for Cleanliness." *Metal Finishing* October 1985.

Ledding, Albert E. "Estimating Chemical Concentration in Rinse Tanks." *Metal Finishing* June 1986

McPherson, Lori. "How Good are your Values for Toal Dissolved Solids?" *Chemical Engineering Progress November 1995*

North Carolina Department of Natural Resources and Community Development. Pollution Prevention Pays Program. *Water Conservation for Electroplaters: Counter-Current Rinsing.* 1985.

North Carolina Department of Natural Resources and Community Development. Pollution Prevention Pays Program. *Water Conservation for Electroplaters: Drag-Out Management for Electroplaters.* 1985.

North Carolina Department of Natural Resources and Community Development. Pollution Prevention Pays Program. *Water Conservation for Electroplaters: Rinse Water Reuse.* 1985.