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LETTER REGARDING INFORMATION ON HEAVY METAL WASTEWATER TREATMENT SYSTEM (NP-7000) NTC ORLANDO FL
1/22/1999
HARDING LAWSON ASSOCIATES

24.06.04.0006
00698

TRANSMITTAL

To: Wayne Hansel, Nancy Rodriguez, David Grabka, Gary Whipple, Bob Cohose, Steve McCoy, Al Aikens

From: Rick Allen

Date: 1/22/99

Subject: Neutral Process System

As promised, here are three documents related to the NP System technology that Mark Salvetti has evaluated for the treatment of antimony in groundwater at Operable Unit 4. The first is a 4-pager that generally describes the system and how it works. The second is a 15 page FAX sent by the vendor (Geo-Chem Technologies) to Mark Todaro during his research for OU 4. And the third is a 2 page letter summarizing anticipated capital and O&M costs for antimony treatment at OU 4.

We only became aware of the technology recently (just in time to become part of the OU 4 FS). However, it shows promise for remediation of arsenic at OU 3, and HLA may include this as part of the OU 3 FS when that document goes final.

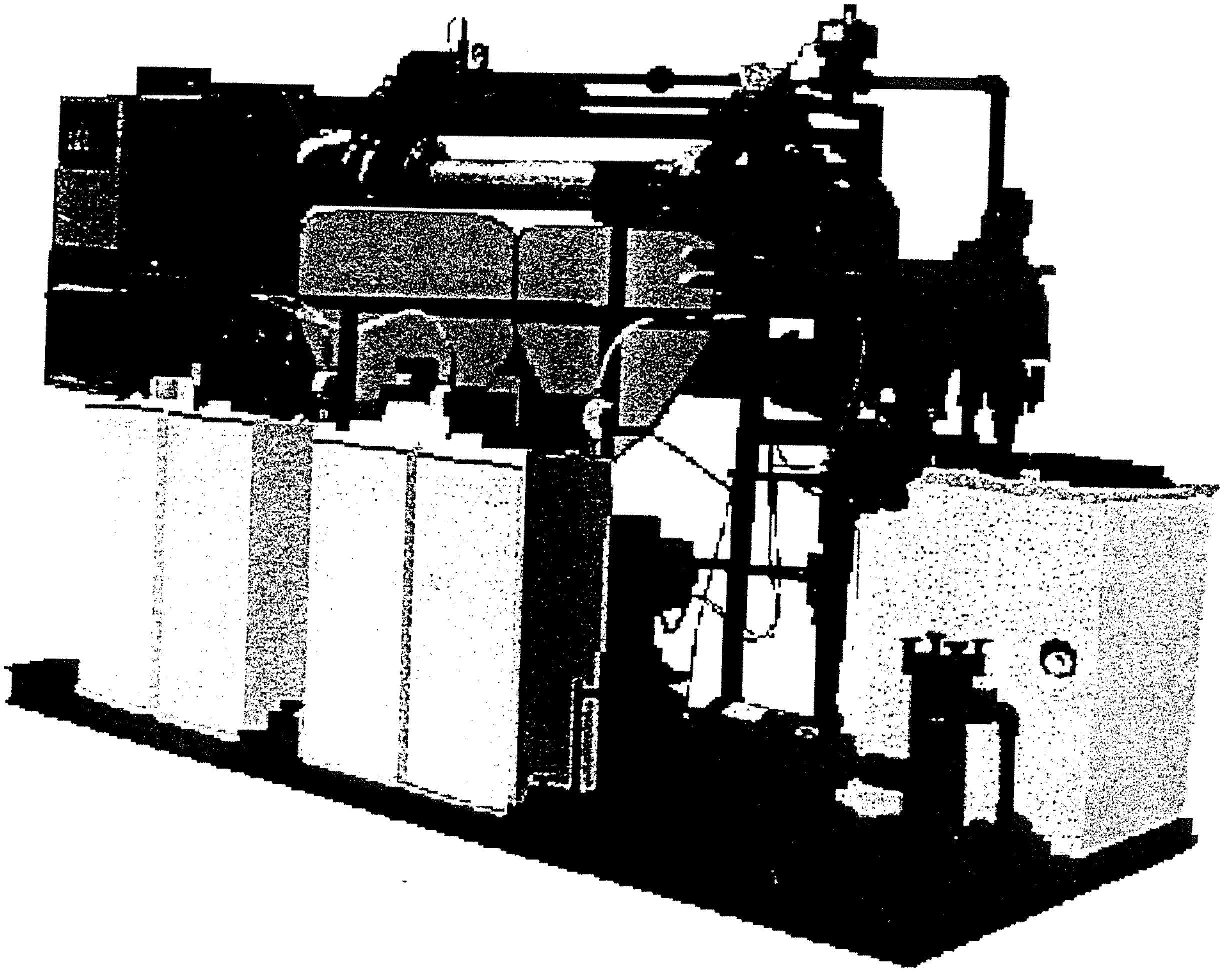
HLA

Harding Lawson Associates

Building 554
NAS Jacksonville, FL 32212— (904) 772-7688

P.O. Box 30399
Jacksonville, FL 32230

NP7000 System



Model NP7010 - 10 gpm Treatment Unit
(8 feet long x 4 feet deep x 6 feet high)

NP-7000 Series
Heavy Metal Wastewater Treatment System

THE NP-7000 SYSTEM

The NP-7000 Series 10 to 50 gpm Metal Removal System is a compact skid-mounted unit that removes hexavalent chromium and other heavy metals from industrial wastewater using neutral-pH precipitation and Cross-Flow MicroFiltration. When the system is operated properly, system effluent meets regulatory discharge standards. The dewatered chemical sludge cake can be disposed of as hazardous waste or sent to a reclamation facility for recycling the heavy metals. The Neutral Process does not treat for oil/removal, organic removal or destruction, or cyanide destruction. However, the system easily couples to these treatment systems.

HOW THE SYSTEM WORKS

Refer to the block diagram in Figure 1 for an overview and basic understanding of how the process works. The following description generally follows the flow of wastewater through the NP-7000 unit.

- The Influent Pump pumps influent wastewater into the pH Adjust Tank, which contains a pH probe and a mixer that agitates the influent to prevent solids from settling. The system computer monitors the solution pH and ensures that the pH is 7.2 or greater by telling a metering pump to add caustic from the Caustic Tank if necessary. This prevents the formation of hydrogen sulfide gas in the Concentrate Tank. Wastewater from the pH Adjust Tank overflows into the Concentrate Tank.

- The wastewater is pumped from the pH adjust Tank to the Concentrate Pipe. The liquid in the Concentrate Pipe is recirculated by the Cross-Flow Pump to maintain the Cross-Flow Pressure. Reagent A and B are added to reduce hexavalent chromium to trivalent chromium. A pH probe allows the computer to adjust pH via an acid metering pump. The reagents precipitate all the heavy metals and help form floc, or clumps of chemical sludge containing the heavy metals. This sludge is removed in the next process step.

- The Cross-Flow Pump pumps wastewater through the MicroFiltration Membrane Module, which allows clear effluent (permeate) to pass through the membrane wall, retaining sludge in the concentrate, thus concentrating the waste stream.

- Permeate from the MicroFiltration Membrane Module passes through the Flow Monitor to either of several exit points at two three-way valves. Permeate can be recycled back to the Concentrate Pipe, routed to the Cleaner Tank to mix citric acid for membrane cleaning, or discharged to surface or drain.

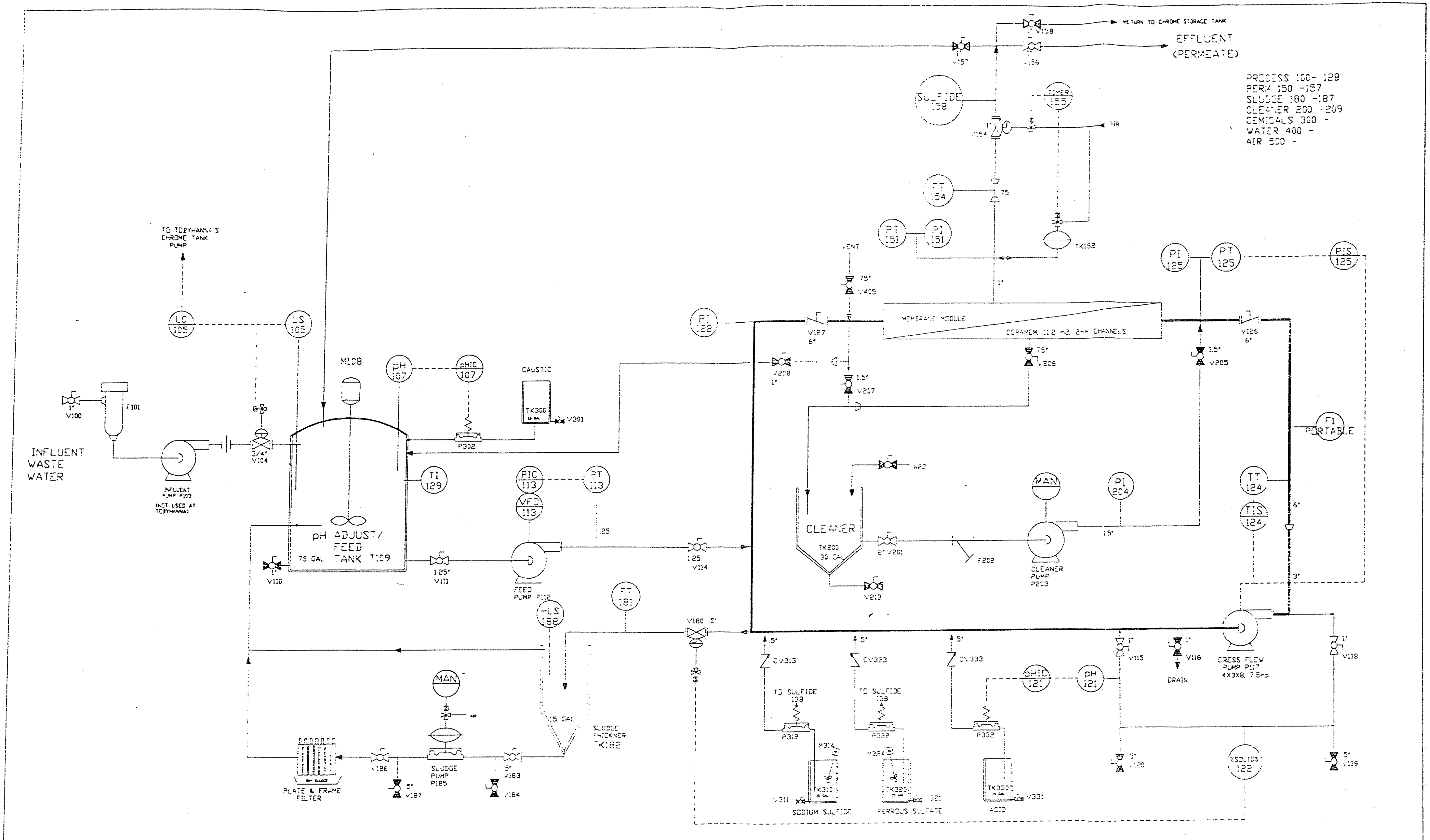
- Downstream from the Flow Monitor, a small sample of permeate is drawn through the Reagent Monitor, which monitors the amount of Reagent A remaining in the effluent. Data from the Reagent Monitor allows the computer to control the amount of Reagent A and B added to the Concentrate Tank.

- In Figure 1, note the Cross-Flow Loop, which is formed by the Concentrate Pipe, the Cross-Flow Pump, the MicroFiltration Membrane Module, and back to the Concentrate Tank.

- The percent solids in the Concentrate Pipe is monitored by a Solids Monitor. At the operator set percent solids, concentrate flows to the sludge settling tank. The Sludge Pump, powered by facility air, pumps settled sludge out of the tank to the Filter Press at intervals and for a duration set by the operator. Sludge must be pumped out often enough to prevent sludge from filling the Sludge Tank and returning to the waste stream. The Filter Press compresses the sludge into a cake than can be disposed of as hazardous waste. Since water pressed from the sludge cake can still contain heavy metals, it is returned to the pH adjust tank for further processing.

- At intervals preset by the operator, the Timer closes the Permeate Valve. This allows the small bladder tank to fill in about 2 seconds, after which a pulse of pressurized air (provided by the facility's air supply) forces the effluent back out of the bladder, back-flushing the MicroFiltration membrane. This dislodges sludge from the membrane surface, allowing the Cross-Flow to sweep the sludge back into the loop in an iterative treatment process. After the pulse, the two valves are automatically opened and closed, respectively, and normal operation resumes.

- When the Flow Monitor detects a sustained flow decrease (about 10 minutes), indicating that the membrane is plugged or is fouling, the system computer alarms. A manually-initiated Cleaning Cycle is required.



ERAD
ENVIRONMENTAL RESEARCH AND DEVELOPMENT, INC.

NEUTRAL PRECIPITATION / CROSS-FLOW
10 GPM PILOT UNIT, P&ID

3/28/96

GEO-CHEM TECHNOLOGIES™

57436 Gearharts Landing Road
Three Rivers, Michigan 49093

Telephone: (616) 244-5373
Fax: (616) 244-1266
E-mail: jcwilli@net-link.net

PRODUCTS FOR A CLEANER WORLD

December 1, 1998

Mr. Mark Todaro
HLA
Orlando, FL

Subject: Treatment for Antimony in Groundwater

Dear Mr. Todaro,

I have attached some information on two possible treatment schemes for antimony.

1. MetaLock 300™ is a wastewater treatment reagent that has been successfully used to remove antimony from industrial wastewater. Its effectiveness at the very low concentrations you are dealing with is unknown to me. Some laboratory testing would be necessary to verify its effectiveness. If it proves effective, it would be used with your equipment.
2. The Neutral Process is a complete wastewater treatment system that removes heavy metals to very low concentrations using advanced heavy metal precipitation chemistry and crossflow microfiltration. I believe for the project you have, this technology would be highly reliable and relatively easy to setup and monitor.

Please call me if you have any questions.

Very truly yours,

James C. Williamson

James C. Williamson, CEP, CHMM
Principal Environmental Consultant

Attachments:
MetaLock 300™
Neutral Process

GEO-CHEM TECHNOLOGIES™
PRODUCTS FOR A CLEANER WORLD

57436 Gearharts Landing Road
Three Rivers, Michigan 49093

Telephone: (616) 244-5373
Fax: (616) 244-1266
E-mail: jcwilli@net-link.net

METALOCK 300™

Multipurpose Waste Treatment Reagent for Heavy Metals

METALOCK 300™, is Geo-Chem Technologies breakthrough treatment reagent for the precipitation and stabilization of heavy metal contaminants in wastewaters, sludges, sediments, dusts, ash and soils. This product employs a potent mixture of inorganic and organic reagents and pH buffers designed to precipitate and chemically convert heavy metals to a mineral form that is insoluble, unleachable, and non-hazardous when tested using the TCLP or other test methods.

This new formula was made available to a select few of our high volume customers who tried and tested the product in their heavy metal removal and stabilization applications. The results even surprised us. In all situations, the new formula performed remarkably superior to other products, even our own, Cad-Con 1000™ which has been highly effective when used to precipitate and stabilize cadmium, lead and zinc. Customers have reported excellent results while using ***10 to 20% less product****. However, the new formula also treats a much broader spectrum of metals - up to 15 other metal contaminants have been effectively precipitated and/or stabilized. The list of* ***metals treated with METALOCK 300™*** *include:*

1. antimony,
2. arsenic,
3. barium,
4. beryllium,
5. cadmium,
6. chromium,
7. cobalt,
8. copper,
9. iron,
10. lead
11. mercury,
12. molybdenum,
13. nickel,
14. selenium,
15. silver,
16. thallium,
17. vanadium and
18. zinc.

We are now desiring to expand the usage of this product to a much broader array of applications in order to better determine its full market potential. We are seeking to identify environmental projects and industrial applications where heavy metal precipitation and/or stabilization is required. These include:

- **Process wastewater**
- **Quench water**
- **Lagoon water**
- **Mine-site runoff and pond water**
- **Contaminated stormwater**
- **Contaminated groundwater**
- **Landfill leachate**
- **Contaminated soils**
- **Stormwater sediments**
- **Contaminated river and lake sediments**
- **RCRA hazardous wastes**
- **Industrial process sludges**
- **Baghouse dusts**
- **Incinerator ash**
- **Sandblast residues**
- **Lead-based paint residues**

Heavy metals can cause difficult and expensive regulatory compliance problems when water concentrations exceed discharge standards or when levels in sludge, solid waste, ash, and soil exceed the RCRA hazardous threshold concentrations or land disposal leachability requirements. Chemical stabilization is an effective technology that converts soluble or leachable heavy metals to insoluble, unleachable forms. The reagent is simply blended with the waste or material using existing or readily available equipment. Aqueous wastes, after clarification or filtration, are suitable for discharge to the sewer or stream in accordance with discharge permit requirements or local codes. Solid waste, sludge, ash, dusts, and soils, etc., treated onsite in accordance with 40 CFR 262.34, are rendered non-hazardous/non-leachable and suitable for disposal as industrial solid waste.

Because of the unique character of every waste, the dosage of METALOCK 300™ is determined empirically through laboratory testing and practical experience. Dosages generally range between 6 and 25% of the dry weight of solid and semi-solid materials and between and 10 and 50% of the Total Solids (TS) concentration of an aqueous waste.

If you would like to assess our cutting edge, heavy metal stabilization reagent for your project or application, we want to send you an Evaluation Kit containing a generous quantity of MetaLock 300™ Reagent to conduct laboratory and small scale tests, an MSDS, dosage determination, evaluation guidelines, and pricing. Please provide the following information to help us understand your specific application, quantity requirements, and how best to serve your specific needs. In order to ensure bona fide responses to this offer, we are requesting a $39 fee plus $10.00 shipping, and handling to defray our costs of processing the kits refundable with your next order.

Name: ______________________ Title: ______________________

Company: ______________________

Street Address: ______________ City: ______________ State: ______ Zip: ______

Telephone: (   ) ______________ Fax: (   ) ______________ E-mail: ______________

Type of Business: ______________________

Briefly describe the project or application including : 1) Flow Rate or Generation Rate, 2) Source of the Water or Waste, 3) Metals and Initial Concentrations, 4) Required Final Concentrations, 5) Other lab data (pH, TSS, TS, etc.).

____

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To defray the costs of processing, please enclose $39.00 plus $10.00 shipping and handling to: *Geo-Chem Technologies, 57436 Gearharts Landing Rd, Three Rivers, MI 49093 or call us at (616) 244-5373. We will immediately rush to you your MetaLock 300™ Reagent Evaluation Kit via UPS. Thank you for trying this exceptional new product. Remember; the entire cost of this kit is refundable with your next order.*

ERAD

NP (Neutral Process) SYSTEMS

WASTEWATER TREATMENT SYSTEMS
FOR
HEAVY METALS

GEO-CHEM TECHNOLOGIES ™

Geo-Chem Technologies, Inc.
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Three Rivers, Michigan 49093

Telephone: (616) 244-5373
Fax: (616) 244-1266
E-mail: jcwilli@net-link.net

PRODUCTS FOR CLEANER WORLD

NP (Neutral Process) SYSTEM

Cross-Flow MicroFiltration Membrane Heavy Metal Wastewater Treatment System

NP System is effective on
Chromium, Cadmium, Copper, Lead, Nickel, Zinc, Aluminum, Mercury, Gold, Silver, Cobalt, Iron, Arsenic, Strontium, More

Industrial Applications

Electronics
- Printed Circuit Board Wastewater
- Component Assembling Wastewater

Chemical and Petrochemical
- Chemical Production Heavy Metal Laden Wastewater
- Petrochemical Heavy Metal Laden Wastewater

Equipment Refurbishing
- Aircraft Engine Refurbishing Wastewater
- Aircraft Exterior Cleaning Washwaters
- Marine Engine Refurbishing Wastewater
- Trucks & Other Heavy Equipment Refurbishing Wastewater
- Electronic & Electrical Equipment Refurbishing Wastewater

Mining and Mineral Processing
- Mineral Processing Wastewater
- Mine Drainage
- Metal Recovery

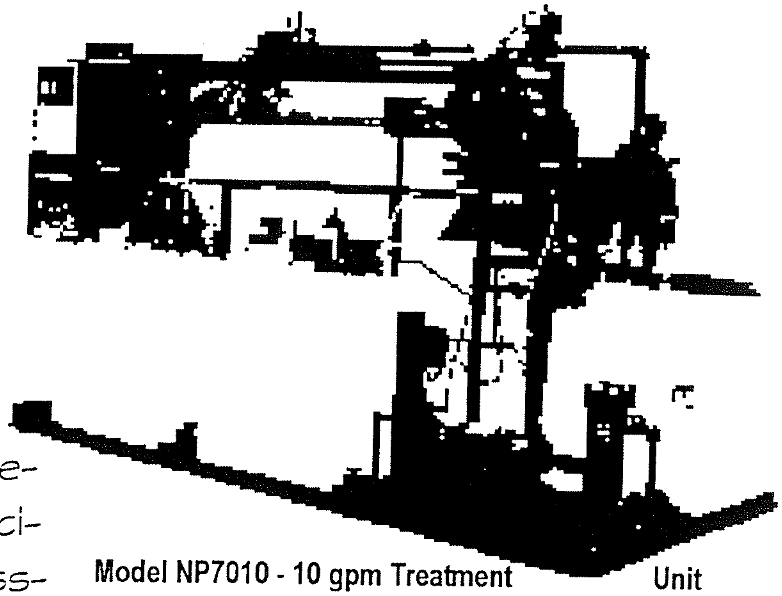
Metal Surface Finishing
- Metal Plating Wastewater
- Metal Surface Finishing Wastewater

Leather
- Leather Tanning Wastewater

Merchant Marine
- Bilge Water Treatment

All Heavy-Metal-Wastewater Producing Industries

NP-7000 System



The NP-7000 Series Metal Removal System is a 10 to 50 gpm compact skid-mounted unit that removes hexavalent chromium and other heavy metals from industrial wastewater using neutral pH precipitation chemistry and Cross-Flow MicroFiltration. The system is fully capable of achieving all regulatory effluent discharge standards. The dewatered chemical sludge cake can be disposed of as hazardous waste or industrial process waste, as appropriate, or can be processed to reclaim valuable metals.

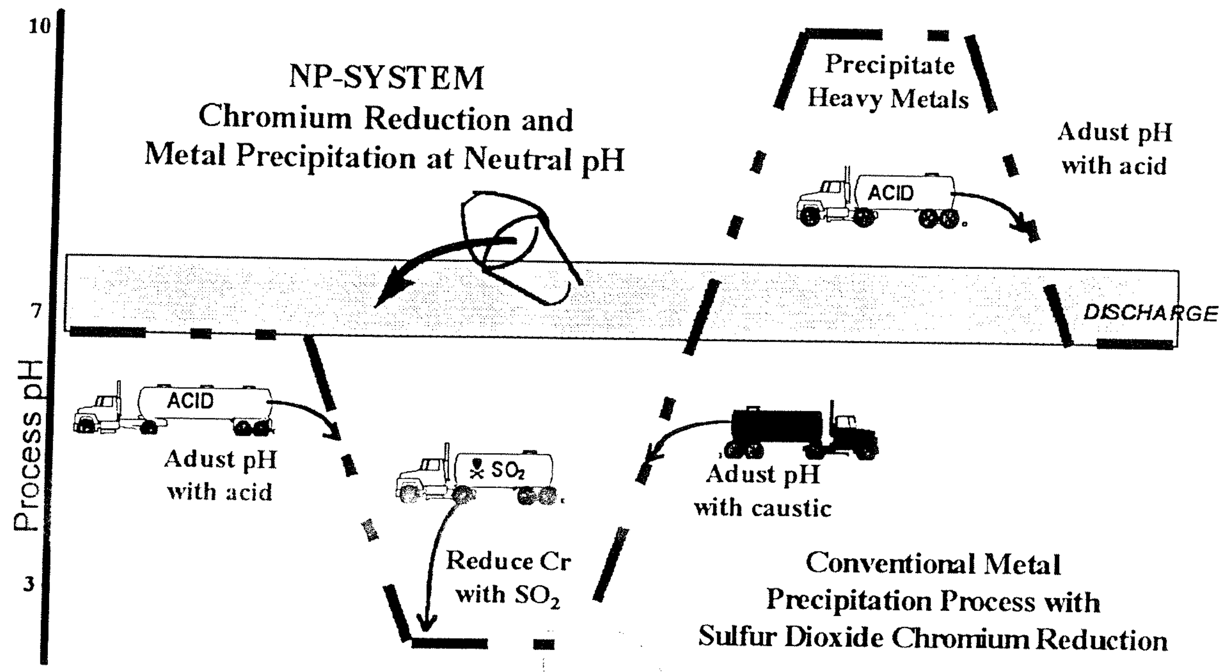
Model NP7010 - 10 gpm Treatment Unit
(8 feet long x 4 feet deep x 6 feet high)

NP-1000 System

The NP-1000 Series Metal Removal System is a small, 1 to 10 gpm capacity, skid-mounted unit that removes hexavalent chromium and other heavy metals from industrial wastewater also using our neutral pH precipitation chemistry and Cross-Flow Micro-Filtration. The system is fully capable of achieving all regulatory effluent discharge standards.

Model NP1000 - 1 gpm Treatment Unit
(4 feet long x 3 feet deep x 5.5 feet high)

ULTIMATE CHOICE FOR YOUR Cr^{+6} and HEAVY METAL WASTEWATER TREATMENT NEEDS



Conventional System vs NP-System

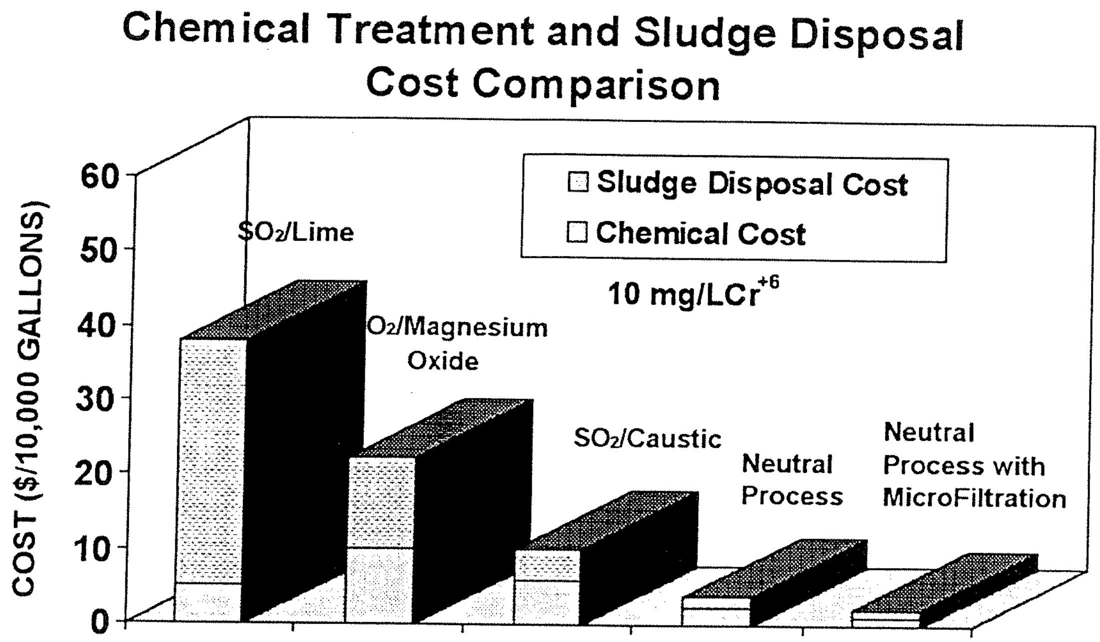
The most commonly used conventional process to treat heavy metal wastewater is lime precipitation and caustic precipitation. This process requires bi-directional pH adjustment to create both acidic and alkaline conditions and generates large amounts of residual waste sludge.

In addition, when treating hexavalent chromium, the process first requires the reduction of hexavalent chromium to the trivalent form with sulfur dioxide or other reducing agents in an acidic environment. This further increases chemical cost and the generation or sludge.

In the Neutral Process, the reaction occurs at the neutral pH, all heavy metals precipitate, and a clean, recyclable effluent is consistently achieved via the Cross-Flow Micro-Filtration Membrane System.

Hexavalent chromium is reduced and all heavy metals present are precipitated and removed at the neutral pH.

With far less chemicals required for treatment, the Neutral Process substantially reduces chemical cost, sludge generation and handling, and waste disposal costs.



The Neutral Process Results in Significant Cost Savings from reduced Chemical Usage and Sludge Disposal.

Treatment Costs for NP-7000 Series Cross-Flow MicroFiltration Membrane Heavy Metal Wastewater Treatment System Tobyhanna Army Depot (TYAD)

Chemical	Use	Cost/Unit (U.S. $)	Cost (U.S. $)	Conventional Treatment Cost (U.S. $)
Sodium Metabisulfite	None	--	None	⇩
Sulfuric Acid	30 gals/yr	$3.50/gallon	$105/yr	⇩
ERF-60	96 lbs/yr	$0.29/lb	$28/yr	⇩
ERS-150	156 lbs/yr	$1.00/lb	$156/yr	⇩
Polymer	None	--	None	⇩
Caustic Soda (50 %)	30 gals/yr (1 drum)	$115/drum	$115/yr	⇩
Total Chemical Costs	⇨	⇨	$447/yr	$4,634/yr
Sludge Disposal Cost	3,000 lbs/yr	$0.729/lb	$2,187/yr	$9,398/yr
Total	⇨	⇨	$2,634/yr	$14,032/yr

Costs are based on the treatment of 4,620,066 gallons of heavy metal contaminated wastewater from August 1993 through July 1994.
Cost Savings of over 80 percent achieved compared to the same amount of wastewater treated by the Sulfur Dioxide Reduction method of conventional treatment.

ADVANTAGES OF NEUTRAL PROCESS OVER CONVENTIONAL HEAVY METAL TREATMENT PROCESSES

- ✓ The system's small footprint saves space.
- ✓ The faster reaction kinetics allow the NP System to eliminate mixing tanks, lowering system and operational costs.
- ✓ Eliminates the need for clarifiers reducing capital cost and size.
- ✓ Proven performance record meeting low discharge limits.
- ✓ Chemical reaction, metal precipitation, and effluent discharge at Neutral pH.
- ✓ Equally effective as a batch or continuous process.
- ✓ Eliminates the need for polymers or flocculation aids; thus reduced costs.
- ✓ Automatic controls, thus reduced labor time and skill level.
- ✓ State of the art ceramic membranes.
- ✓ Not adversely affected by surfactants and chelating agents.
- ✓ Effluent water is recyclable.

NP SYSTEM'S
EFFLUENT QUALITY FOR AN INDUSTRIAL WASTEWATER TREATMENT PLANT (1.5 MGD)

Sample	Cadmium (mg/L)	Copper (mg/L)	Chromium (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
1	0.005	0.01	0.02	0.05	0.02	0.008
2	0.005	0.02	0.02	0.05	0.02	0.014
3	0.005	0.01	0.01	0.05	0.02	0.036
4	0.005	0.03	0.03	0.05	0.02	0.014
5	0.005	0.01	0.01	0.05	0.02	0.005

The high reactivity of the complexing agents with heavy metal ions in the neutral process produces low solubility metal complexes. The result is a cleaner effluent meeting the stringent requirements for surface discharges.

CASE HISTORY

Tobyhanna Army Depot U S Army Pennsylvania

Average Influent and Effluent Wastewater Analysis for NP-7010 Tobyhanna Army Depot (TYAD)		
Constituent	Influent	Effluent
pH Units	5.84	7.26
Turbidity (FTU)	42.8	0
Cr^{+6} (mg/L)	0.02	BDL*
Cr Total (mg/L)	0.14	0.029
Cd (mg/L)	0.296	0.094
Cu (mg/L)	0.37	0.116
Fe (mg/L)	0.68	0.208
Pb (mg/L)	0.246	0.076
Ni (mg/L)	5.21	0.158
Zn (mg/L)	0.21	0.104

* below detection limit

Background:

Tobyhanna Army Depot (TYAD) manufactures and refurbishes medical and communication equipment for the US Army. TYAD generates inorganic wastewater from electronics and metal finishing operations.

Problem:

TYAD was experiencing high treatment and disposal costs from the treatment of its 4 million gallons per year heavy metal contaminated wastewaters. These wastewaters were treated to achieve the required discharge limit in their SO_3/Caustic precipitation waste treatment plant at a cost of $4,630 per year for chemicals and $9,400 per year for sludge disposal (total cost $14,030 per year).

Solution:

With lowering cost as the main objective, the MicroFiltration Cross-Flow Membrane Inorganic Treatment System (NP-7010) was developed.

Results:

Based on 1994 operational data, (4,620,066 gallons of wastewater were treated), the patented Neutral Process has provided an immense reduction in treatment costs. The usage of large quantities of acid and caustic were eliminated for pH adjustments, thus the chemical cost was reduced to an estimated $623 per year (a reduction of 87%). The MicroFiltration technology eliminated the need for coagulation/flocculation polymers and a clarifier. Sludge generation and the associated disposal costs were reduced by 77% to $2,187 per year. Despite the tremendous savings, effluent quality was maintained well below surface discharge requirements.

NP-1000 SERIES
Cross-Flow MicroFiltration Membrane Heavy Metal Wastewater Treatment System

Specifications

Model	Capacity (gpm)	Influent Pump (gpm)	Cross-Flow Pump (gpm)	Membrane Module	Automatic Control	Solids Monitor	Chemical Feed Control	pH Control	Air (SCFM)
NP-1001	1.0	3	20	8	yes	no	yes	yes	3
NP-1003	3.0	9	50	6	yes	no	yes	yes	3
NP-1005	5.0	10	80	10	yes	no	yes	yes	4

NP-7000 SERIES
Cross-Flow MicroFiltration Membrane Heavy Metal Wastewater Treatment System

Specifications

Model	Capacity (gpm)	Influent Pump (gpm)	Cross-Flow Pump (gpm)	Membrane Module	Automatic Control	Solids Monitor	Chemical Feed Control	pH Control	Air (SCFM)
NP-7010	10	20	400	1	yes	yes	yes	yes	5
NP-7020	20	40	400	2	yes	yes	yes	yes	7
NP-7030	30	57	400	3	yes	yes	yes	yes	9
NP-7050	50	75	1500	5	yes	yes	yes	yes	10
NP-7120	120	150	1400 X 2	16	yes	yes	yes	yes	15

* Systems over 100 gpm requires custom design

OTHER SYSTEM REQUIREMENTS

- **Electrical power supply available at 110 1Φ 220/440 3Φ**
- **Some potable water**

Chromium Reduction and Heavy Metal Precipitation at Neutral pH with the Neutral Process

The Neutral Process, which reduces hexavalent chromium using sulfide catalyzed by ferrous iron, reduces hexavalent chromium at a neutral pH while all heavy metals are precipitated at pH's of 7.4 to 8.4. The reaction kinetics for the chromium reduction are rapid, i.e. within seconds with the Neutral Process while conventional reduction at acidic pH's takes about 15 minutes or more.

The Neutral Process, a process patented by the U.S. Air Force, is used to treat heavy metal-containing wastewaters. Further process development has been performed by ERD, Inc., including process controls development along with coupling the treatment process to Cross-Flow MicroFiltration, which eliminates the need for large clarifiers. This research was funded by the U.S. Army Construction Engineering Research Laboratory. The resulting treatment units have small footprints--a 10 gpm unit is 8 ft long by 4 ft deep by 6 ft high. Doubling the capacity of the unit does not double the size as only the membrane capacity needs to be increased.

Background

The most commonly used conventional treatment system for heavy metal-containing wastewaters is the hydroxide precipitation process with heavy metal precipitation at pH's ranging from 8 to 12. Hexavalent chromium cannot be precipitated without prior reduction to trivalent chromium; reduction with sulfur dioxide is the most commonly used method, which requires reduction at acidic pH's of 2 to 3. Other acidic reduction methods include the use of sodium bisulfite, and ferrous compounds, however the ferrous ion is not efficient by itself in reducing hexavalent chromium as only one electron is available per iron atom and a large quantity of iron hydroxide sludge is produced. The quantity of sludge produced by the different reducing agents can vary dramatically.

When the ferrous ion is present together with sulfide, the hexavalent chromium is rapidly reduced at neutral and alkaline pH. The theoretical basis for ferrous and sulfide reduction of hexavalent chromium is based on the 1983 research by Higgens and Sater. The ferrous ion appears to catalyze the sulfide reduction. At a neutral pH, the proposed reaction is:

$$3HS^{-} + 6FeSO_4 + 4CrO_4^{-2} + 13H_2O + OH^{-} \rightarrow$$

$$6Fe(OH)_{3(s)} + 4Cr(OH)_{3(s)} + 6SO_4^{-2} + 3S_0$$

Most metal hydroxides have a relatively high solubility, with increased solubility of the metal hydroxide at high pH. Hydroxide precipitation of all heavy metals is not reliable as the minimum solubility of the mixed heavy metal hydroxides does not occur at the same pH--many of the metal hydroxide precipitates are amphoteric in nature and dissolve at high pH values. In addition, the presence of complexing agents, such as ammonia or ethylenediamine tetraacetate (EDTA), prevents effective heavy metal removal.

Metal precipitation by soluble sulfides requires a sulfide source more soluble than the metal to be precipitated such as sodium sulfide. Sodium sulfide disassociates readily into the sodium and sulfide ions such that the free sulfide can react to precipitate a heavy metal.

Advantages of the sulfide process include the extreme low solubilities of most metal sulfides, the sulfide ability to reduce hexavalent chromium in the presence of the ferrous ion, and its increased ability to precipitate metals complexed with at least some of the complexing agents. The high reactivity of sulfides with heavy metal ions and the low solubility of heavy metal sulfides over a broad pH range are attractive features when compared to the hydroxide precipitation process. The metal sulfides tend to be at least 4 or 5 orders of magnitude less soluble than their corresponding metal hydroxides.

The Neutral Process-Overview

The Neutral Process utilizes sulfide catalyzed by ferrous iron to reduce hexavalent chromium and sulfide to precipitate heavy metals at a pH of 7.4 to 8.4. Chromium cannot be precipitated as a sulfide, but is precipitated as the hydroxide at the minimum solubility of chromium hydroxide.

Process evaluation shows the reaction kinetics of this process to be very rapid in contrast to the conventional chromium reduction process, which means a wastewater treatment unit for this process does not require the large reaction tanks associated with conventional treatment plants. Hexavalent chromium is reduced to below detection in seconds with this process.

All the reactions and heavy metal precipitation processes occur at pH 7.4 to 8.4 with this process, eliminating lowering the pH to 2 to 3 for the chromium reduction process followed by raising the pH to 8.5 to 12 for the heavy metal precipitation. Process chemical requirements are reduced as the sulfide and ferrous are added based on the heavy metal concentrations in the wastewater, reducing chemical costs by 40 to 80% over conventional methods. Sludge generation is also reduced.

Treatment Benefits

The Neutral Process, which exceeds current EPA NPDES discharge limits, has the following treatment benefits:

- Hexavalent chromium reduction is not limited at low concentrations of 0.1 mg/L or less.
- Since the reduction of hexavalent chromium is instantaneous, multiple, large retention tanks are not required.
- Because hexavalent chromium reduction occurs at a near neutral pH, less acid and caustic have to be purchased and stored on site.
- Operation at neutral pH instead of at acidic conditions reduces tank corrosion and increases tank life.
- The process reduces hexavalent chromium that can slip through from other feed streams, avoiding potential discharge limit violations.
- Implementation into existing Industrial Wastewater Treatment Plants (IWTP) allows the removal of large sulfur dioxide tanks, eliminating a safety hazard.
- Flocculants and coagulants are not needed in the process with Cross-Flow MicroFiltration, and chelating agents and soaps do not interfere with the metal precipitation process.
- The process reduces chromium at low concentrations which may hinder acidic chromium reduction.

Process Applications

Albany, GA. This process was implemented in the Albany, GA Marine Corps Logistic Base IWTP in the summer of 1997. The base is a major supply and maintenance depot serving the U.S. Marine Corps. The IWTP is designed to process 200 to 250 gpm of industrial wastewater from processing wastes, washwaters, and rinsewater from maintenance and test shop operations, all of which is normally low in pollutants. Concentrated wastes such as waste caustic solutions, waste chromic acid solutions, and waste acid solutions are segregated and trucked to the plant where they are loaded into holding tanks and metered into the industrial wastewater for treatment. Groundwater is also pumped to the IWTP for treatment. Prior to implementation, the IWTP was using the sulfur dioxide caustic process for wastewater treatment.

Implementation of the Neutral Process into the existing IWTP required changing location of the acid and caustic feed lines, installation of a zeta potential detector, turbidity monitor, and sludge depth meter. Note, the latter three would have been beneficial to the original treatment process. The pH of the influent wastewater is maintained greater than 7.2 with the addition of waste alkali and commercial caustic as required. The alkali pump is shut off at pH 8.0. The pH is maintained less than 8.5 with waste acid, which reduces the volume of acid required later in the process and also helps the operation of the Dissolved Air Flotation Unit used for oil and grease removal. Waste chromic acid is fed as available.

At the first reaction tank sulfide solution is fed and at the second reaction tank ferrous sulfate and sulfuric acid is fed. The pH is maintained between 7.4 and 8.4, with chromium reduction occurring in the second reaction tank. Cationic and anionic polymers are added to coagulate and flocculate the precipitate. The cationic polymer feed is controlled with the zeta potential control. The solids are settled in the Upflow Clarifier where the treated wastewater flows up through the sludge blanket. Sludge recirculation is used to buoy up the sludge bed and help with pin floc removal. The wastewater now meets discharge requirements as shown in Table 1. The estimated cost savings for chemical usage and sludge disposal is approximately $116,500 or 47% compared to the old process.

Keyport, WA. The IWTP at the Naval Undersea Warfare Center (NUWC) at Keyport, WA was selected for a full-scale demonstration of the process. The IWTP had been using the sulfur dioxide caustic process, and based on jar tests and prior pilot plant tests conducted at NAS Pensacola, feeds of chemical were optimized and design modifications were implemented at Keyport with start-up in September 1995. The new process was evaluated over a nine-month operational period.

The process treated the NUWC industrial wastewater with hexavalent chromium as high as 310 mg/L , meeting current and proposed EPA discharge limits. A cost comparison of the new process with the old process indicated a 59% reduction in chemical cost and a 31% reduction in sludge disposal costs. On an annual basis, the total cost savings amounted to $31,950 or 34% over the old treatment process. At concentrations of hexavalent chromium greater than 100 mg/L, sludge generation and disposal costs were reduced by 17%. The IWTP treated batches of wastewater up to 39,000 gallons over a two-day period. In addition, a reduction in processing time was realized, as the Keyport operators were able to treat and clarify the 39,000-gallon batch of wastewater in one shift during the day.

Tobyhanna Army Depot. The process coupled with Cross-Flow MicroFiltration was pilot tested at a 10 gpm treatment unit at Tobyhanna Army Depot Metal Pretreatment Plant, which manufactures and refurbishes medical and communications equipment. Wastewaters containing heavy metals are generated from their electronics and metal finishing operations. The hexavalent chromium containing wastewater was segregated for treatment with sulfuric acid and sodium sulfite to reduce the chromium. Following chromium reduction, the wastewater was mixed with the remaining wastewater, and the pH was adjusted to 9 to 10 with caustic. Ferrous sulfate was added as a coagulant and as needed, sulfide was added to precipitate the heavy metals to discharge requirements. Chemical costs for the operation was $4,630 per year and sludge disposal was $9,400. Operation of the 10 gpm Neutral Treatment Unit demonstrated a projected chemical cost of $623 per year and a sludge disposal cost of $1,560 per year. The overall cost reduction for sludge disposal and chemical cost was 70%.

The unit operates automatically with process controls to monitor and control the pH and chemical feeds. The chemical feeds are controlled with a continuous analyzer, which colorimetrically determines excess treatment chemicals in the effluent and controls the concentration at 0.005 mg/L. Maintenance requirements include maintaining and calibrating the pH probes and ensuring chemicals are present. The ceramic membrane is cleaned as needed with a citric acid cleaning cycle. A solids monitor/controller controls the solids in the recirculating cross flow at 2 to 4%. Solids are wasted to a sludge tank, and the thickened sludge is filtered using a plate and frame filter press, which is mounted on the skid mounted treatment unit.

Albuquerque, NM. This process is applicable to the treatment of a number of industrial wastewater containing heavy metals. If cyanide is present, cyanide pretreatment is required prior to heavy metal precipitation. The process can be coupled to oil/water separation and organic treatment processes. Kirkland AFB in Albuquerque, NM has purchased three treatment units for the treatment of washwater from wipes used in aircraft and vehicle maintenance. The wipes are contaminated with heavy metals, oils, and some light solvents. Disposal of the rags as a hazardous waste costs one shop $120,000 per year. Washing the wipes will eliminate the associated disposal costs, and the wipes can be reused. The treatment unit consists of oil/water separation with Cross-Flow MicroFiltration, the Neutral Process, and ozone to degrade the solvent. The treatment unit will have a six-month pay back period.

Table 1. Discharge Limits Before and After the Neutral Process

Parameter	Discharge Limits (mg/L)	Neutral Process (mg/L)
Cadmium, Total	0.036	0.010
Chromium, Hexavalent		BDL[1]
Chromium, Total	0.600	BDL
Copper, Total	0.113	BDL
Iron, Total		0.194
Lead, Total	0.380	0.044
Nickel, Total	2.400	0.080
Zinc, Total	1.500	0.092

[1]BDL=Below Detection Limits

For Additional Information about how you can implement **the Neutral Process** at your facility Contact:

James C. Williamson, CEP, CHMM
Geo-Chem Technologies, Inc.
Phone: 616 244-5373 or
E-mail: jcwilli@net-link.net

GEO-CHEM TECHNOLOGIES™
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January 18, 1999

Fax Transmission To:
(407) 896-6150

Mr. Mark Todaro
Harding Lawson Associates, Inc.
4763 South Conway Road
Orlando, FL 32812

Subject: Neutral Process Arsenic Removal

Dear Mr. Todaro:

Our experience with arsenic removal stems from testing that was done to determine the efficacy of the process for removal of arsenic from the Berkeley Mine Site acid mine drainage water in Montana. The test involved treating a sample of the water using the Neutral Process, then determining the concentrations of As in before and after treatment samples.

As concentration (before treatment) = 0.09 mg/l
As concentration (after treatment) = BDL*

Detection limit was 0.04 mg/l

Although data is limited, because As occurs naturally as a sulfide mineral, confidence is very high that the Neutral Process will remove As efficiently to very low concentrations, as proven.

As a next step in the feasibility evaluation, we would suggest that a sample of the contaminated water be sent to us for treatment. We will run the sample through the Neutral Process and

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December 4, 1998

**Fax Transmission To:
(407) 896-6150**

Mr. Mark Todaro
Harding Lawson Associates, Inc.
4763 South Conway Road
Orlando, FL 32812

Subject: Preliminary Cost Estimate

Dear Mr. Todaro:

I have developed some preliminary costs regarding the use of the Neutral Process for remediation of groundwater contaminated with antimony. The facts and assumptions I used regarding the project are as follows:

1. Groundwater will be extracted at the a rate of 10 gpm.
2. The project will last 5 years.
3. The target metal is antimony (Sb) which ranges in concentration from 2 to 20 ppb and averages 12 ppb.
4. Discharge criterion for antimony is 6 ppb max.
5. Other groundwater constituents are:
   - pH 6.5
   - TDS....................... 20 mg/l (believed to be primarily Ca/Mg hardness)
   - TSS............................ BDL
   - VOCs .... Present
   - Other heavy metals..... BDL

Significant capital costs and factors directly related to O&M costs are estimated to be:

1.	NP-7010 (10 gpm unit)	$126,500
2.	Chemicals	less than $500/year
3.	Sludge generation (presumed not to be hazardous)	less than 1,000 lbs/year
4.	Labor (monitoring, chemical levels, sludge accumulation, etc.)	2-4 hours/week

Note that filter membranes (these are ceramic membranes) typically last 3 to 5 years under much more demanding conditions involving high strength industrial wastewater. Therefore, I have assumed that the no replacement of the membrane will be necessary during the 5-year life of the project.

I trust this information will be sufficient for your preliminary feasibility evaluation. I have put in the mail some additional technical information and schematic diagrams on the NP-7010 which you should receive the first of next week.

Please let me know when your are ready to proceed further. At that time I would suggest some testing by our laboratory either on an actual water sample or a synthesized sample to verify the efficacy of the process with regard to removing antimony at the low concentrations required. In the meantime, let me know if I can provide any additional information. Thank you.

Very truly yours,

James C. Williamson

James C. Williamson, CEP, CHMM
Principal Environmental Consultant