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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Oak Ridge National Laboratory Nonradiological Wastewater Treatment Plant Optimization Report

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FOR THE UNITED STATES
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OAK RIDGE NATIONAL LABORATORY NONRADIOLOGICAL WASTEWATER TREATMENT PLANT OPTIMIZATION REPORT

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1. INTRODUCTION

1.1 HISTORY

Oak Ridge National Laboratory (ORNL), in Oak Ridge, Tennessee, is operated by Martin Marietta Energy Systems, Inc. for the United States Department of Energy (DOE). The primary missions of ORNL are:

1) Conduct applied research and engineering development in support of the Department of Energy's programs in fusion, fission, conservation, fossil, and other energy technologies; and to perform basic scientific research in selected areas of the physical and life sciences.

2) Operate "user facilities" for the benefit of researchers in universities and private industry, transfer science and technology to U.S. industry and universities, provide educational programs to help prepare the future scientific and technical work force, and supply radioactive isotopes that are not commercially available.

In carrying out these missions, various dilute liquid process wastewater streams are generated. For many years, non-radiological process wastewater streams which mainly consist of once-through cooling water underwent little or no treatment and were discharged directly to White Oak Creek (WOC). WOC flows across ORNL in a south-westerly direction and empties into the Clinch River. However, since the non-radiological process waste streams could potentially contain small quantities of organic and heavy metal pollutants, it was determined by the US Environmental Protection Agency (EPA) and the Tennessee Department of Health and Environment (TDHE) that the discharge of many of the process waste streams into WOC was not in compliance with state and federal environmental regulations. The Non-radiological Wastewater Treatment Project (NRWTP) was conceived as a means of collecting and treating non-radiological process wastewaters from a variety of outfalls and complying with the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) regulations.

The conceptual design report[1] for the NRWTP was completed in May, 1985. The design criteria[2] for defining functional/system requirements for the NRWTP was completed in July, 1985. To resolve some of the design uncertainties facing the wastewater treatment systems of the NRWTP, the Environmental Control Technology (ECT) group of the Chemical Technology Division performed a pilot-plant treatability study[3]. The results of the study were published in ORNL/TM-10046 on July 1986.

Final design and equipment selection for the NRWTP was completed on January 30, 1987 and construction began on February 4, 1987. Construction of the wastewater collection and treatment facilities was completed on August 31, 1989. By January 8, 1990, preoperational equipment checks were complete and chemical testing began. On February 3, 1990, chemical testing of the system was complete and approval was received by the ORNL Readiness Review Committee and the Environmental & Health Protection Division to began processing wastewater. The facility was operated effectively during February and March. On February 8, 1990, a Readiness Review Team from DOE-Oak Ridge Operations (DOE-ORO) was established to evaluate the plant during the final phase of testing. Their review resulted in several recommendations for improvement at the NRWTP; none of which were considered to have an impact on the start-up date of the facility. Official permission was granted by DOE-ORO to place the NRWTP in full operational service on March 30, 1990. With this startup date, the NRWTP successfully met the Compliance-Level-Attained date of March 31, 1990, mandated by the Federal Facility Compliance Agreement (FFCA).

The facility has operated under a one year evaluation period as specified in the NPDES permit. During the evaluation period, operation of the plant has been monitored and adjusted to optimize treatment performance. This report is intended to provide documentation of efforts to evaluate and optimize NRWTP performance and present the results obtained for submittal to the TDHE and EPA.

1.2 FACILITY DESIGN BASIS

The NRWTP was designed to remove heavy metals and toxic organic compounds from process wastewaters generated at various ORNL facilities. A maximum flow of 760 gallons per minute (gpm) may be treated at the facility with an anticipated yearly average volume of 213 million gallons. Specific waste streams include, but are not limited to, many formerly permitted outfalls listed as follows:

Former Outfall Number	Description
X03	1500 Area including Greenhouse Complex, Aquatic Sciences Lab, Controlled Environment and Animal Building, Mobile Office Unit, and the Environmental Sciences Lab.
X04	2000 Area including Inspection Engineering Lab and Solid State Lab Annex
X06	Wastewater formerly collected in and discharged from ponds 3539 and 3540 (also known as the 190 ponds) for the 4500 area and the High Temperature Materials Lab
X07	Wastewater treated for removal of radioactive contaminants and discharged from the Process Waste Treatment Plant (PWTP)
X08	Radiochemical Engineering Development Center (REDC) wastewaters formerly collected in 7909 and 7908 basins. Now collected in Melton Valley Process Waste Collection Tanks (MVCT) and pumped to the NRWTP.
X09	High-Flux Isotope Reactor (HFIR) process wastewaters formerly collected in 7905 basin. Now collected in the MVCT and pumped to the NRWTP.
X11	Steam plant boiler blowdown and ion-exchange demineralizer regeneration wastewater receiving pretreatment at the Acid Neutralization Facility.

Although waste minimization efforts at ORNL have reduced the waste load at the facility, it is anticipated that additional flow will be received in the future as a result of new research efforts, decommissioning work, and environmental restoration activities. Control of the additional waste streams will be maintained by the Waste Acceptance Criteria (WAC) developed for the facility by the ORNL Waste Management organization. Wastewater that may be amenable to treatment by the NRWTP but does not comply with the WAC may be accepted only through treatment scrutiny and approval by the ORNL Office of Waste Management and Remedial Actions and the Office of Environmental Compliance and Documentation.

1.3 FACILITY DESCRIPTION

The NRWTP consists of many unit operations: collection, flow equalization, chemical precipitation, clarification, filtration, sludge dewatering, air stripping, activated carbon adsorption, and pH adjustment. A process flow diagram is shown in Figure 1.1. The plant is located on a 2-acre site south of White Oak Creek and west of the High Temperature Materials Laboratory (HTML).

Prior to entering the NRWTP, wastewater from the various sources undergoes on-line segregation based on radioactivity or pH. There are two collection tanks at the NRWTP each with a capacity of 325,000 gallons. Tank F-1001, the Metals Equalization Tank, collects wastewaters which could potentially contain significant concentrations of heavy metals such as filter backwash, activated carbon backwash, containment area sump wastewaters, air stripper acid washes, and ion-exchange regenerant solutions. Tank F-1002, the Non-metals Equalization Tank collects wastewaters not likely to contain heavy metals, which includes most of the above former outfalls. Each of the collection tanks is equipped with pumps which recirculate the tank contents through jet mixers for wastewater equalization. On-line radiation monitors are used to determine the radiological content of the wastewater prior to reaching the NRWTP collection tanks. If the monitors indicate that the radioactive content of the wastewater exceeds predetermined levels, the wastewater is diverted to the Bethel Valley Storage Tanks (BVST) where it combines with other potentially contaminated process wastewater. This wastewater is treated for removal of radioactive contaminants at the PWTP and is then transferred to NRWTP tank F-1002. A development study[4] completed in November 1989 has shown that wastewater with pH levels less than 6 has a much greater likelihood of containing significant amounts of dissolved heavy metals. In addition, some heavy metals such as zinc can resolubilize at excessively alkaline conditions. As a result of these studies, on-line pH instrumentation has been installed which continuously monitors wastewater pH and automatically diverts the

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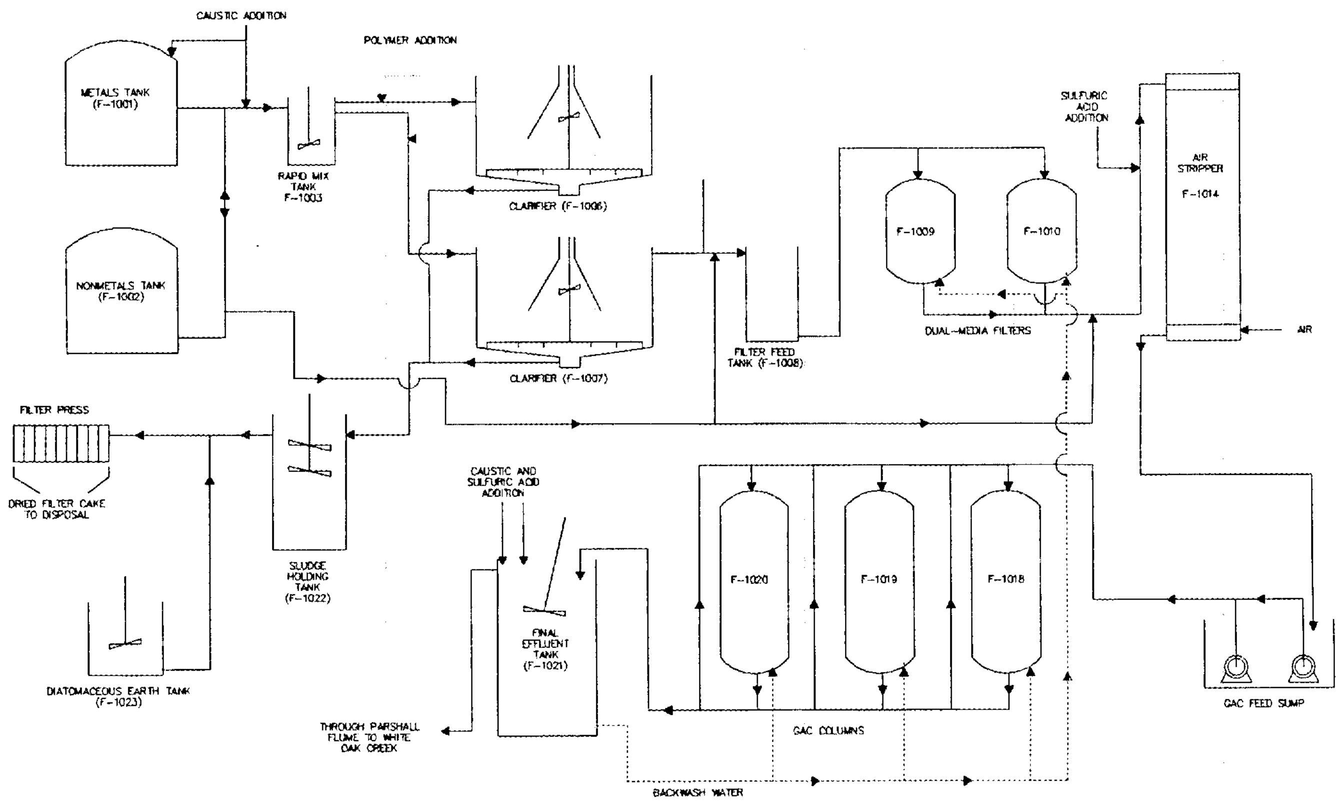

Fig. 1.1 NRWTP Process flow diagram

wastewater for heavy metals removal treatment when the pH is less than 6 or greater than 11. These pH diversions are routed to either the PWTP or the NRWTP alkaline precipitation systems which remove heavy metals from the wastewater. Former outfalls X04, X06, X08, and X09 each have on-line radiation monitors and former outfalls X03, X04, and X06 have on-line pH monitors.

Metals wastewater in tank F-1001 is treated for removal of heavy metals by chemical precipitation and clarification. A controlled wastewater flow is fed from F-1001 to the Rapid Mix Tank F-1003. At F-1003, the pH of the wastewater is elevated to 10.5 using sodium hydroxide. The pH adjusted wastewater flows to one or both 60,000 gallon reactor clarifiers F-1006 and F-1007. Each reactor clarifier is designed to treat 380 gpm maximum and they can be used in parallel or individually. The polymer used for flocculation and settling of the metal precipitates can be added either at the outlet of the rapid mix tank or at the center-located recirculator of the reactor clarifier. At the reactor clarifier recirculator, the incoming wastewater mixes with previously formed floc and enters a settling zone within a frustoconical skirt. The flocculated precipitates fall to the bottom where a sludge rake continuously moves the sludge toward a center well. The sludge in the center well is periodically drawn off and transferred to the Sludge Hold Tank F-1022 which can hold up to 10,000 gallons. The collected sludge is dewatered by a 24 cubic foot capacity filter press PFP-1024 and is containerized for disposal. The effluent from the reactor clarifier flows to the 3200 gallon Filter Feed Tank F-1008 where it combines with non-metals wastewater from tank F-1002. The combined waste stream is transferred through the Dual Media Filters F-1009 and F-1010 for removal of suspended solids. The filters are used in parallel and can treat up to 380 gpm each. The filtered wastewater then flows through a pH adjustment station where sulfuric acid is added to adjust pH to between 6 and 8.

After pH adjustment, the wastewater enters the top of Air Stripper S-1014 where it is discharged through four spray nozzles onto the tower packing. As the wastewater passes through the packing, air is blown into the bottom of the stripper and up through the packing to strip volatile organics out of the wastewater. The organics are released into the atmosphere in the gaseous form. A demister at the top of the stripper prevents release of water droplets.

Wastewater from the air stripper enters sump F-1017 where it is transferred to the Granular Activated Carbon (GAC) system. The GAC system consists of three columns, F-1018, F-1019, and F-1020, each of which holds about 22,000 pounds of carbon. The columns are piped such that two are operated in series while a third is on standby. The wastewater flows in downflow mode through the columns and organics are adsorbed and held onto the carbon. From the GAC system, the wastewater flows to a stirred 26,500 gallon effluent tank F-1021 where the pH is adjusted to between 6.5 and 8.5. The plant effluent flows through the NPDES monitoring station prior to discharge to White Oak Creek at outfall number X12.

The facility operations are controlled using a centralized distributed control system (DCS). The DCS provides all the necessary monitoring, indication, control, alarms, and recording functions for the plant. A DCS network is set up which allows these functions to be manipulated from several control stations at ORNL. DCS interfaces are located at the NRWTP control room, the PWTP control room, and at the Waste Operations Control Center (WOCC) at Building 3130 where the DCS is monitored 24 hours per day. There are local controls available for the more critical systems in case of computer outage.

1.4 PERMIT REQUIREMENTS

The discharge requirements of effluent from the NRWTP to White Oak Creek are currently defined in the Oak Ridge National Laboratory NPDES Permit No. TN0002941. The NPDES permit effluent limits for outfall X12 are shown in Table 1.1. Discharge limitations for permit compliance are established for seven heavy metals, cyanide, total toxic organics (TTO), oil and grease (O&G), total suspended solids (TSS), temperature, and pH. In addition, periodic monitoring is required for flow rate, biochemical oxygen demand, and 17 other contaminants. The permit is currently based on the EPA Best Available Technology (BAT) limits for metal finishing industries. The existing permit expired in March of 1991, and an application for renewal of the permit was submitted to TDHE by ORNL in September 1990. The proposed discharge limits for outfall X12 are shown in Table 1.2. The new permit proposes limits based on operational sampling of the system which has given a representation of treatment capability. Substantially lower limits for six heavy metals are proposed with a new limit for mercury, unchanged limits for some parameters, and continued monitoring for four other contaminants. Effluent quality will be further verified by continued NRWTP toxicity monitoring under the Toxicity Control and Monitoring Plan (TCMP).

This optimization report is intended to satisfy the conditions specified in Note "A", page I-41 of the former permit, which states that "Records indicating the optimization of treatment plant performance shall be made available to EPA and TDHE."

Table 1.1. Former permit limits

Parameter	Monthly Average	Daily Maximum
Flow, MGD	Monitor only	
Temp., degrees C	---	30.5
TSS	31.0	60.0
O&G	10.0	15.0
TTO	---	2.13
Cyanide	0.65	1.2
Cadmium	0.26	0.69
Chromium	1.71	2.77
Copper	2.07	3.38
Lead	0.43	0.69
Nickel	2.38	3.98
Silver	0.24	0.43
Zinc	1.48	2.61
BOD-5	Monitor only	
Nitrate as N	Monitor only	
Sulfate as SO_4	Monitor only	
Phosphorus	Monitor only	
Phenol	Monitor only	
Fluoride	Monitor only	
Arsenic	Monitor only	
Iron	Monitor only	
Mercury	Monitor only	
Selenium	Monitor only	
Benzene	Monitor only	

(continued)

Table 1.1 (continued)

Parameter	Monthly Average	Daily Maximum
Chlorobenzene	Monitor only	
Chloroform	Monitor only	
Dichlorobromomethane	Monitor only	
Methylene Chloride	Monitor only	
Tetrachloroethylene	Monitor only	
Trichloroethylene	Monitor only	
1,1 Dichloroethane	Monitor only	
pH, standard units	6.0 to 9.0	

* Units are mg/l unless otherwise noted

Table 1.2. ORNL NPDES permit application no. TN0002941 proposed effluent limits*

Parameter	Monthly Average	Daily Maximum
Flow, MGD	Monitor only	
Temp., degrees C	---	30.5
TSS	31.0	60.0
O&G	10.0	15.0
TTO	---	2.13
Cadmium	0.016	---
Chromium	0.05	---
Copper	0.10	---
Lead	0.17	---
Silver	0.028	---
Zinc	0.15	---
Nitrate as N	Monitor only	
Arsenic	Monitor only	
Iron	Monitor only	
Mercury	0.001	---
Selenium	Monitor only	
pH, standard units	6.0 to 9.0	

* Units are mg/l unless otherwise noted

2. OPERATIONAL OBSERVATIONS AND OPTIMIZATION ACTIVITIES

2.1 START-UP

Equipment testing for the NRWTP treatment system by ORNL Engineering and Waste Management Operations (WMO) began on June 13, 1989. Fire protection water (fire-water) was used to begin testing of tank and containment sump level controls, alarms, and alarm interlocks. Equalization tank level controllers were tuned to respond slowly so that flow rate changes to treatment systems are gradual and not likely to cause treatment upsets. Pump flow capacity tests, valve operations, flow controller tuning, and distributed control system (DCS) operational checks were also performed. On July 24, 1989, checkout began on the operation of air blowers, agitators, and sludge rakes. On August 15, 1989, most of the equipment checkout was complete and tests were being performed to determine optimum backwash flow rates for GAC columns and dual media (DM) filters and to develop automatic backwash valving sequence and other procedures. In addition, operational checkout was initiated for the filter press systems. On October 19, 1989, the facility was officially turned over to WMO for further operational testing.

During initial check-out of the transfer pumps for the equalization tanks, a small amount of vibration was detected during operation. Though the level of vibration was not considered to be an immediate safety concern, it was decided that improved support structures would be installed at the pumps to dampen the vibration. This work was performed as part of a separate "Phase II Improvements" project. The work began on November 13, 1990 and included improved base support structures for the equalization tank transfer pumps, improved base support structures for DM filter feed pumps, and also several ladders and access platforms to allow maintenance of ventilation fans and other equipment.

On November 20, 1989, WMO began preparation of the sulfuric acid storage and transfer systems. The sulfuric acid holding tank and lines were dried in preparation for loading. After loading the acid, tuning of the pH controller at the air stripper inlet commenced. Problems were encountered with pH control at this point due to the slow response of acid metering pumps and the lack of adequate acid/wastewater backmixing where the pH sensor was located. The sensor was located in a two gallon "pot" which received a sidestream from the process line where pH adjustment was being performed. The flow to the pot was inconsistent and the lag time between acid addition and pH sensing was variable, therefore, pH controller tuning was impossible. The problem was solved by installing a flow meter on the inlet line to the pH sensor pot and replacing the single-speed/variable stroke acid metering pumps with more responsive variable-speed/variable-stroke pumps. Some difficulty was encountered in the tuning of the pH controller for the effluent tank F-1021. The controller is equipped for either base or acid addition and in certain cases, both base and acid additions would occur simultaneously. The problem was solved by modifying the controller logic to prevent coinciding acid and base addition. Tuning of pH controllers for tanks F-1001 and F-1003 was accomplished without significant difficulty.

On January 8, 1990, testing of reactor clarifier F-1006 began. Fire-water and backwash water from DM filters and GAC columns had been collected in tank F-1001 and was fed to the rapid mixing tank for pH adjustment. Reactor clarifier performance was evaluated by periodic sampling and observation. The effective polymer feed rate was chosen and the polymer metering pump was calibrated to ensure the correct feed rates. Once the reactor clarifiers were operational, additional tuning of the air stripper pH controller was necessary due to the addition of higher pH reactor clarifier effluent to the air stripper feed wastewater.

On January 19, enough sludge had been collected in the sludge holding tank F-1022 to test the operation of the filter press. The operation of the filter press is almost entirely automatic. The only manual operations are the mixing of the diatomaceous earth (DE) slurries and the placement and removal of filter cake disposal containers. The operation involves precoating the filtering surfaces with DE and pumping the sludge from F-1022 to the press for a certain duration determined by either elapsed time or by the time between strokes of the sludge feed pump (as the press fills, the period of time between strokes of the feed pump lengthens). The filtering cycle duration was 7 hours for the first run. The filter cake produced was sufficiently dewatered and fell from the filter plates without manual scraping. The first several batches of cake were very dark in color (almost black) due to the presence of activated carbon fines from backwash exercises. A slight problem was caused by a small volume of water that was captured in the inlet line to the press when the filtering cycle was complete. When the press was opened, a gallon or so of this water would spill into the disposal containers. This problem was resolved by adding an air tap on the press to blow the water out of the inlet line prior to opening the press. To enhance safety, a "man in distress" alarm pull-cord (wired to the DCS) was added in the operating area in case of an accident while performing manual work on the press.

On January 24, 1990, a malfunction occurred at DM filter feed pump J-1008A. Maintenance investigation revealed that the shaft of the pump had broken. On January 28, the shaft of DM filter feed pump J-1008B also failed (at the same shaft location). After consultation with pump manufacturers, it was believed to be a flaw in the design of the shaft and possible cavitation of the pump. New shafts were provided by the manufacturer and both pumps were repaired and returned to operation by February 1, 1990. To reduce the potential of pump cavitation, the operating level of F-1008 was increased from 35% to 60%. Later during the year, additional shaft failures occurred. Additional measures taken to prevent shaft failure have included retuning of filter feed tank level controller, replacement of shafts with another design provided by an ORNL machine shop, and replacement of pump base structures.

On February 3, 1990 the plant began receiving and treating actual process wastewater.

2.2 EQUALIZATION TANKS

The metals and non-metals equalization tanks F-1001 and F-1002 each have a 325,000 gallon capacity. The purpose of the two tanks is to provide surge capacity and uniform wastewater composition for the treatment system. Both tanks are equipped with pumps which recirculate wastewater at a flow of 5800 gpm through jet mixers installed in the tanks. Tank F-1001 is used to collect wastewater which could potentially contain heavy metals, filter and GAC column backwash waters, sump waters, acidic air stripper cleaning solutions, and Steam Plant wastewaters (former outfall X11). To avoid corrosion problems and to provide a uniform pH wastewater for the metals removal system, F-1001 is equipped for pH control by caustic addition. The pH is controlled at a level between 9 and 10. Tank F-1002 collects all flows from the former outfalls described in Section 1.2 unless diversions are necessary due to radiological content or pH deviations. Tank F-1002 wastewater is not likely to contain heavy metals. The pH of wastewater entering F-1002 is expected to be uniform and slightly above 7, so caustic addition capability is not provided. A representative sampling of F-1001 pH data taken between August 1, 1990 and November 1, 1990 indicates that a pH of 9.5 +/- 0.5 is well maintained with a high of 9.82 and low of 8.98. During the same time period, the pH in tank F-1002 averaged 7.16 within a range of 6.5 to 7.8.

The wastewater collection procedures for tank F-1001 were modified during the year to allow for changes in the metals removal treatment procedures. It was anticipated before startup that the metals removal system would not be used at or near design capacity during normal operation. Waste management activities, wastewater segregation, and general employee awareness of the wastewater regulations have contributed to a decline in the amount of process wastewater which contains heavy metals. Estimates indicated that metals wastewater flow on a continuous basis would be less than 10 gpm. The lower limit of controllability is 70 gpm for the flow control system and pumps feeding the reactor clarifiers from F-1001. Based on these factors, it was decided to operate the reactor clarifiers in semi-batch mode at a flow rate of 100 gpm. The level of the metals equalization tank F-1001 was allowed to fluctuate between 50 and 15 percent operating levels for the semi-batch treatment. For the time period between February and September 1990, metals wastewater treatments were performed every 15 days (on the average). In each metals treatment campaign, approximately 123,000 gallons were treated from tank F-1001. In September, however, tank F-1001 began receiving all wastewater from former outfall X11, the spent regenerant solutions from the Steam Plant ion-exchange systems. Prior to this date, these wastewaters were being treated at the Coal Yard Runoff Treatment Facility. With the extra wastewater volumes entering F-1001, the frequency of metals removal treatments increased to one every 3 to 4 days. This complicated the semi-batch operating procedures significantly. On January 13, 1991, the decision was made to run the metals removal system at a constant flow of about 25 gpm. Since the pumps feeding wastewater from F-1001 and the flow control system cannot operate below 70 gpm, the pumps were deenergized and the wastewater was allowed to gravity flow from F-1001 to the metals treatment system. The operating level in tank F-1001 is allowed to vary between 40 and 70 percent to maintain the necessary hydraulic head for gravity flow. To date, the flow controller which manipulates the feed control valve has maintained constant flows of 10 to 25 gpm. The sustained level of flow depends on the height of the fluid in F-1001. Chemical additions are adjusted in accordance with the flow.

The level of tank F-1002 is controlled by adjusting the flow controller to maintain a tank level of about 30%. Flow adjustments are made by the plant operator based on tank level monitored by the DCS and also recorded by the operator on a log sheet every two hours. Flow control is preferred in order to facilitate gradual flow changes and avoid upsetting treatment systems.

On-line radiation monitors are used to determine the radiological content of the wastewater prior to reaching the NRWTP collection tanks. The monitors are very sensitive and are able to detect increases in wastewater activity. If the monitors indicate that the radioactive content of the wastewater exceeds a preset level, the wastewater is automatically diverted from the NRWTP tank F-1002 to the Bethel Valley Storage Tanks (BVST) where it combines with other potentially contaminated process wastewater. This wastewater is treated for removal of radioactive contaminants at the PWTP. The PWTP effluent stream (former outfall X07) is transferred to NRWTP tank F-1002. Former outfalls X04, X06, X08, and X09 each have on-line radiation monitors. Results of radiological analysis of wastewater samples from the NRWTP outfall are given in Table 2.1. The unit operations at the NRWTP do not significantly remove radioactive contaminants, therefore, the levels of radioactive contaminants in the plant effluent reflect very nearly what is present in the plant feed wastewater. (The sludges generated from metals wastewater treatment are very slightly contaminated, indicating that a small amount of activity in the metals wastewater is removed and concentrated in the sludge.) The data indicates that average contaminant levels are lower than the Derived Concentration Guidelines (DCG) of DOE Order 5400.5[5].

Wastewaters of former outfalls X03, X04, and X06 are diverted for metals removal treatment if the pH of the wastewater is greater than 11 or less than 6. It was originally planned to divert this wastewater to tank F-1001 for subsequent metals removal treatment at the NRWTP. However, it was decided in November 1989 that it would be important to minimize the amount of heavy metals sludge generated at the NRWTP and that the pH diversions of former outfall X06 would be routed to the PWTP collection system instead of the NRWTP. Former outfalls X03 and X04 divert to F-1001 due to their low flows and insignificant impact on sludge generation. At the PWTP, the X06 wastewater is treated in an existing chemical softening process at pH 11.5 followed by filtration and ion-exchange polishing. The wastewater from the PWTP is transferred to the NRWTP for treatment as a nonmetals waste stream. The precipitated metals combine with the sludge created in the PWTP softening process. This sludge is dewatered using the existing PWTP filter press and is drummed for storage.

In November and December of 1990, problems were experienced with the equalization tank transfer pumps. Shaft failures occurred on both J-1002A and J-1002B of the nonmetals equalization tank and J-1001A of the metals equalization tank. The pumps are the same manufacturer and design as those used for the filter feed tank which have experienced shaft failures frequently during the year. The base plates for both sets of transfer pumps were replaced as part of the Phase II Improvements project. Two of the failures occurred before replacement of the base plates which took place in December 1990. One failure occurred immediately after a base replacement and may have been caused by shaft misalignment. No further shaft failures have occurred since December.

Table 2.1. NRWTP Effluent Radiological Content

Contaminant	DCG** Bq/l	Detection limit Bq/l	Mean Bq/l	Max. Bq/l	Min. Bq/l	Number Analyzed	Number Detected
Gross Alpha	N/A	10	10	10	10	1815	0
Gross Beta	N/A	20	28	190	20	1815	1060
Co-60	185	10	10	13	10	755	1
Cs-137 *	111	10	28	140	10	755	741

* Routine gamma scan of the wastewater detects any gamma emitter at levels greater than 10 Bq/l.

** DCG: Derived Concentration Guideline of DOE Order 5400.5

2.3 SODIUM HYDROXIDE AND SULFURIC ACID FEED SYSTEMS

Sodium hydroxide (caustic) is used to adjust the pH of the wastewater in equalization tank F-1001, rapid mix tank F-1003, and effluent tank F-1021. The caustic system consists of a storage tank F-1025 and a recirculation system which distributes the caustic to the feed points. The DCS pH control systems independently regulate each of the control valves located at the three feed points. The caustic is delivered to the plant as a 50% solution which is diluted to 18% in tank F-1025. The dilution lowers the freezing point of the solution. The only startup problem experienced with the caustic system involved freezing of the 50% caustic solution in the piping during loading of tank F-1025. The lines were externally heated to thaw the caustic and complete the loading. To prevent a recurrence, all caustic lines where subsequently heat traced and insulated. In January 1991, the F-1001 caustic flow control by-pass valve, which normally remains closed, began to leak and allow too much caustic to enter F-1001. This resulted in high pH wastewater entering the metals removal system. This, however, had no adverse effect on metals removal systems and the pH controller on the air stripper successfully compensated and brought the pH down to within acceptable values. Within hours, the valve was repaired and F-1001 pH control was restored.

The sulfuric acid system consists of the holding tank F-1026 and two acid metering pumps. The acid is supplied to the pH adjustment station at the air stripper inlet and to the effluent tank F-1021. The sulfuric acid concentration is 93%. To improve pH control, the two single-speed, variable-stroke metering pumps were replaced with two variable-speed, variable-stroke pumps. In September, 1990, pH control at the effluent tank F-1021 became difficult. It was found that the acid feed line between the acid holding tank F-1026 and the effluent tank was plugged with sludge. The acid supplier was consulted and it was suggested that the line could be plugged with iron sulfate caused by intrusion of water and corrosion of the steel pipeline. Prior to plant startup, the tank and lines had been dried and the tank vent is equipped with a desiccant unit, therefore, water intrusion was considered unlikely. The line to the effluent tank is open to the atmosphere, however, and may have collected moisture as a result of the line draining back to the holding tank and bringing in humid air (also unlikely due to the presence of check-valves at the metering pumps). To reestablish flow and to mitigate possible iron sulfate formation, the steel pipe between the metering pumps and the effluent holding tank was replaced with a 316L stainless steel line. ORNL Quality Assurance personnel performed ultrasound testing to evaluate the wall thickness of the holding tank F-1026. The results of the test were compared to results of a similar test performed before the tank had received any acid. It was concluded that the results of the tests were not significantly different and that F-1026 was not exhibiting signs of corrosion. Further investigation is planned for inspection of the acid holding tank interior and determining the amount of sludge in the tank.

2.4 HEAVY METALS REMOVAL SYSTEM

The NRWTP metals removal system treats several waste streams including backwash waters, plant sump waters, acid cleaning solutions, and former outfalls X03 and X04 when diverted to F-1001 due to pH value. The treatment process involves addition of sodium hydroxide to adjust raise pH to 10.5 and precipitate the metals as hydroxide compounds. This is followed by addition of flocculants to speed the settling of precipitates and clarify the wastewater in the reactor clarifier units.

Preoperational testing of the metals removal systems was performed using fire-water as a surrogate waste stream. Since the source of a large portion of the actual process wastewater is once-through cooling water, it was felt that fire-water would exhibit similar characteristics. According to the pilot plant treatability study[3] the optimum pH for metals removal was 10.5. However, due to the lack of significant heavy metals concentrations in the fire-water, the optimum pH could not be verified in preoperational testing. The polymer recommended in the treatability study for flocculation of precipitates was Betz[1] 1100. Adequate performance of this polymer was verified by observing precipitation and flocculation of hardness compounds naturally present in the fire-water. Jar tests performed using samples from F-1001 had indicated that very little precipitation of hardness compounds could be expected at pH 10.5, therefore, it was decided to elevate the pH to 11.5 to improve precipitation and provide better conditions for observing clarifier performance. The initial pH tuning for the rapid mix tank was performed without significant difficulty. The mechanical systems of the reactor clarifier (recirculator and rake) operated flawlessly. Using an operational pH of 11.5, various polymer dosages were used while observing the reactor clarifier effluent and analyzing effluent grab samples for total suspended solids. Total hardness titrations were performed for reactor clarifier inlet and outlet samples to verify precipitation of hardness compounds. The reactor clarifier inlet hardness concentrations were usually within the range of 100 to 140 ppm. The effluent hardness concentrations after filtration through DM filters were 40 to 60 ppm. Total suspended solids (TSS)

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[1]Trademark of Betz Laboratories, Inc.

in the effluent stream averaged about 14 ppm. Based on these tests, a polymer dosage of 2.5 ppm was chosen.

While performing these tests, an optimum polymer feed tank mixture concentration was chosen which would allow operation of the polymer metering pumps within the designed operating range and also minimize the waste of short-shelf-life polymer solutions. Betz 1100 polymer is supplied as a dry powder and water solutions of the polymer have only a two day shelf life. The use concentration chosen for the Betz 1100 was 0.08%. At a wastewater flow of 100 gpm, the required flow of the Betz solution is 18.5 gallons per hour. The two polymer feed pumps were calibrated to verify correct feed rates.

For the initial 10 months of operation, the metals removal system was operated in semi-batch mode. In the initial design phases for the NRWTP, it was anticipated that all wastewater entering the plant would require removal of heavy metals, therefore, the reactor clarifiers are designed to treat up to 380 gpm each on a continuous basis. However, the total flow of wastewater requiring metals removal treatment including X03 and X04 pH diversions, backwash waters, acid cleaning wastes, and plant sump waters, was less than 6 gpm for the first 6 months of operation. To maintain a near-design flow capacity, it was necessary to operate in semi-batch mode. Metals wastewater was allowed to collect in tank F-1001 until the 50% level was attained. About 123,000 gallons of the wastewater was then treated in the reactor clarifier at a flow rate of 100 gpm lowering the tank level to about 15%. The reactor clarifiers are designed for continuous flow and recirculation of previously precipitated sludge to enhance the precipitation reaction. Since generation of a sludge layer requires many hours of operation, the reactor clarifiers are not well suited for semi-batch operation. In consideration of this, it became a routine procedure to leave some sludge in the reactor clarifier after a metals treatment run. When a subsequent metals treatment run was performed, the sludge from the previous run was recirculated with the feed to enhance precipitation. From March 1990 until October 1990, batches were treated for heavy metals removal every 15 days on the average.

Starting in October, 1990, the plant began to receive greater quantities of wastewater from the former outfall X11, ORNL steam plant wastewater from boiler blowdown and regeneration of ion-exchange resins. This wastewater was previously being treated at the Coal Yard Runoff Treatment Facility (CYRTF). Due to permit restrictions, however, CYRTF treatment of this wastewater had to be discontinued. Due to the metals content of this wastewater, it is received in the NRWTP metals equalization tank F-1001 and treated through the metals removal system. As a result of receiving this wastewater, the frequency of metals removal semi-batch treatments increased from one every 15 days to one every 3 to 4 days. In addition, the concentration of calcium, magnesium, and other metals increased as did the amount of sludge generated from the precipitation reaction. The frequent startup and shutdown of the system was awkward from an operational standpoint and sludge carryover from the startup operation began to plug the dual media filters more frequently. To improve operations, it was decided to attempt to run the metals treatment system on a continuous basis at a low flow rate. The wastewater transfer pumps for the metals wastewater could not be used at such low flows due to the design of the flow control system, however, by allowing the operating level in the metals equalization tank to increase to the 40 to 70 percent range, the hydrostatic head pressure was sufficient for gravity flow through the reactor clarifier system. A constant flow of 10 to 25 gpm has successfully been maintained since January 13, 1991. The polymer feed system procedures were modified for metering a more dilute (0.02% by weight) polymer solution at a feed rate proportional to the wastewater flow.

Table 2.2 is a summary of the metals content of the reactor clarifier inlet and outlet wastewaters. Table 2.3 is a summary of removal rates for many of the metals regulated by the EPA and TDHE. As indicated in Table 2.2 and 2.3, removal of heavy metals has been effective. The metal concentrations of the reactor clarifier effluent were well below the former permit levels (Table 1.1). Some of the metals exceed the new limits proposed in the September 1990 NPDES permit application (Table 1.2), however, subsequent filtration and mixing with the non-metals wastewater reduces the metal concentrations to levels below the proposed limits. The change in mode of operation from semi-batch to continuous appears (based on limited monitoring) to have reduced DM filter plugging and improved removal of iron, copper, aluminum, and lead. A slightly negative impact is shown for removal of chromium and manganese, and no significant change in removal rates for nickel and zinc. Table 2.4 shows a comparison of the metals effluent concentrations for semi-batch and continuous operations.

As discussed in Section 2.2, former outfall X06 is diverted to the PWTP for removal of heavy metals which occurs in conjunction with the PWTP softening process. Based on monitoring of pH diversions, the total volume of metals wastewater diverted to the PWTP is only about 27,000 gallons per month. This small amount of wastewater has an insignificant impact on PWTP operations where an average 5.7 million gallons of wastewater are treated per month. Analysis of wastewaters collecting in the nonmetals tank F-1002 indicates that metals are effectively removed from PWTP wastewaters prior to entering the NRWTP.

Table 2.2. NRWTP reactor clarifier influent and effluent metals concentrations

Summary of 38 samples

Metal	Reactor Clarifier Inlet Concentrations (mg/l)				Reactor Clarifier Effluent Concentrations (mg/l)			
	Mean	Max.	Min.	No. Det	Mean	Max.	Min.	No. Det
Ag	0.023	0.22	0.005	30	0.0055	0.02	0.005	2
Al	3.3	53.0	0.05	35	0.13	0.86	0.03	17
As	0.055	0.13	0.05	6	0.054	0.14	0.05	3
B	0.084	0.17	0.08	2	0.082	0.16	0.08	2
Ba	0.23	1.7	0.012	38	0.077	0.17	0.001	37
Be	0.0008	0.01	0.0002	15	0.0005	0.01	0.0002	4
Ca	422	900	23	38	325	720	17	38
Cd	0.007	0.046	0.005	4	0.006	0.02	0.005	5
Co	0.0056	0.031	0.004	17	0.0042	0.013	0.004	1
Cr	0.061	0.41	0.011	38	0.016	0.059	0.004	33
Cu	0.45	2.7	0.023	38	0.045	0.3	0.007	37
Fe	11.6	77	0.13	38	0.55	9.8	0.05	35
Li	15	15	15	0	15	15	15	0
Mg	54.6	170	4.9	38	30.1	76.7	2	38
Mn	0.32	3.7	0.0015	38	0.0093	0.1	0.001	33
Mo	0.04	0.04	0.04	0	0.04	0.04	0.04	0
Na	301	580	40	38	321	550	70	38
Ni	0.066	0.35	0.004	32	0.0071	0.05	0.004	9
P	5.9	89	0.3	36	0.36	1.1	0.3	9
Pb	0.21	0.9	0.046	26	0.057	0.18	0.03	4
Sb	0.052	0.12	0.05	1	0.05	0.05	0.05	0

(continued)

Table 2.2. (continued)

Metal	Reactor Clarifier Inlet Concentrations (mg/l)				Reactor Clarifier Effluent Concentrations (mg/l)			
	Mean	Max.	Min.	No. Det	Mean	Max.	Min.	No. Det
Se	0.049	0.053	0.02	2	0.05	0.072	0.04	1
Si	12.5	100	1	38	3.4	29	0.59	38
Sn	0.053	0.15	0.05	1	0.05	0.05	0.05	0
Sr	0.58	1.4	0.05	38	0.46	0.91	0.038	38
Ti	0.10	1.5	0.02	21	0.02	0.02	0.02	0
V	0.0060	0.053	0.002	31	0.0023	0.006	0.002	8
Zn	2.2	22	0.018	38	0.12	0.91	0.005	37
Zr	0.021	0.043	0.02	3	0.02	0.02	0.02	0

Reactor clarifier inlet samples were taken at the transfer pumps of the metals equalization tank F-1001. Reactor clarifier effluent samples were taken from the reactor clarifier effluent weir. The effluent samples were set aside for one hour (to allow settling of suspended solids) and decanted to another sample container. Both inlet and effluent samples were acidified with nitric acid after collecting.

Table 2.3. NRWTP reactor clarifier performance - removal rates of selected metals

Metal	Mean Inlet Concentration (mg/l)	Mean Outlet Concentration (mg/l)	Average Percent Removal
Ag	0.023	0.0055	76.1
Al	3.3	0.13	96.1
As	0.055	0.054	1.8
Ba	0.23	0.077	66.5
Cd	0.007	0.0062	11.4
Cr	0.061	0.016	73.8
Cu	0.45	0.045	90.0
Fe	11.6	0.55	95.3
Mn	0.32	0.0093	97.1
Ni	0.066	0.0067	89.8
P	5.9	0.36	93.9
Pb	0.214	0.057	73.3
Se	0.049	0.05	-2.0
Si	12.5	3.4	72.8
Zn	2.2	0.12	94.5

The extent to which removal rate may be determined is limited by the detection limit of the metal. In cases where the metal is rarely detected such as As, Cd, and Se, the average removal rate has little meaning.

Table 2.4. Comparison of NRWTP reactor clarifier performance for batch and continuous treatment of metals wastewater

Metal	Batch treatment effluent metal concentrations 9/27/90 to 1/8/91 Mean of 15 samples (mg/l)	Continuous treatment effluent metal concentrations 1/28/91 to 3/31/91 Mean of 9 samples (mg/l)
Ag	0.005	0.005
Al	0.20	0.063
As	0.058	0.050
Ba	0.092	0.130
Cd	0.005	0.005
Cr	0.011	0.025
Cu	0.029	0.017
Fe	0.21	0.10
Mn	0.0051	0.0073
Ni	0.005	0.004
P	0.31	0.33
Pb	0.063	0.050
Se	0.051	0.050
Si	2.5	7.9
Zn	0.050	0.056

2.5 FILTER PRESS

When a metals removal batch is complete, the metals sludge is transferred to a sludge holding tank to await dewatering in a Perrin recessed-plate filter press. Positive-displacement double diaphragm pumps transfer sludge from the sludge tank into the filter press. The sludge is compressed into a cake by pumping it into filter chambers formed by the recessed plates. The sludge, which is retained by the filter media, fills the chambers and the water is displaced or "squeezed" out. It is important that enough sludge be available in the sludge holding tank to fill all the chambers of the filter press. If there is not enough sludge in the holding tank to fill the press, the free space in the press will be occupied by water and a wet cake will be produced. Filter cake containing free water is not acceptable from a disposal standpoint. The filter press is designed to hold a maximum of 24 cubic feet of dewatered sludge (or filter cake). The filtrate from the filter press operation could potentially contain sludges, particularly if the filter material of the filter press is damaged. The filtrate, therefore, is transferred to the plant sump where it is recycled to the metals equalization tank F-1001. Some modification of operating procedures and resolution of additional details were needed to operate the filter press. The initial operating procedures stated that the sludge holding tank needed to be filled to the 40 percent operating level before operating the press. However, it was also necessary to know the solids content of the dilute sludge in order to determine if the filter press could be filled and produce a cake with no free water. Samples were taken from the sludge holding tank and the solids content was determined to be about 2.7 percent. A minimum sludge tank level was determined by assuming a filter cake solids content of 40 percent and a specific gravity of 1.4. The first run of the filter press produced an acceptable dewatered cake. The solids content of the cake was 27 percent and the specific gravity was 1.15. This data was used to recalculate the minimum sludge tank level for running the filter press. However, the solids content of the holding tank sludge was found to vary by a large degree after subsequent sludge transfers from the reactor clarifier to the tank. It was found to be too dilute in some cases to justify operating the filter press, even though the tank level was high. To allow concentration of the dilute sludge in the holding tank, a decanting pipeline was installed at the 40 percent operating level of the tank. To decant water from the tank, the sludge mixer is deenergized and the sludge is allowed to settle for 90 minutes. This waiting period typically allows the sludge to settle below the 40 percent level. The valve on the decant line is then opened to allow the extra water to drain to the plant sump for recycle to tank F-1001. The decanting increases sludge concentration and allows for addition of more dilute sludge to the tank. A sample line was also installed at the 10 percent level of the sludge tank to allow sampling and determination of sludge concentrations. A simple test was developed which uses the settled height of the sludge in a sample from the sludge tank to estimate the solids content. Once solids content reaches 3 percent or higher (on a dry basis) at a sludge tank level of 40 percent, there is more than enough sludge to fill the filter press and produce a dewatered cake.

The filter press has been operated 28 times in the first year of operation and has consistently produced adequately dewatered filter cake. The operation requires little in terms of manual operation. The length of the filtering cycle may be controlled by one of two timers. The first timer automatically shuts the press down after a preset cycle time, usually 6 hours. The second timer monitors the time between the strokes of the double diaphragm pump which transfers sludge to the press. When the time between strokes increases to a preset duration, usually 90 seconds, the press automatically shuts down. A cycle time of 1.5 hours has been found to adequately dewater the sludge. The press is remotely opened and the plates are remotely and automatically separated. The filter cake typically drops from the plate into the disposal container without manual scraping of the filtering surfaces. Diatomaceous earth (DE) is used as a precoat and is prepared in tank F-1023. Centrifugal pumps recirculate a slurry of DE through the filter press which precoats all filtering surfaces. The precoat inhibits plugging of the filter media and acts as a release agent to allow the filter cake to fall off the filter media without manual scraping.

The sludges are loaded into 64 cubic foot capacity steel boxes and each box is sampled for characterization purposes. Results of EPA Extraction Procedure (EP) toxicity testing summarized in Tables 2.5, 2.6, 2.7 indicate that the sludge is not likely to be considered a RCRA hazardous waste. It does, however, contain small quantities of radioactive contaminants and will be handled and stored as a Low Specific Activity (LSA) waste. The currently required EPA Toxicity Characteristic Leaching Procedure (TCLP) testing will be performed on samples that have been archived from each disposal box and on future sludge samples as needed to characterize hazardous properties.

2.6 DUAL MEDIA FILTERS

The dual media filters receive wastewater effluent from the reactor clarifiers and wastewater from the Non-metals Equalization Tank F-1002. The two filter feed streams combine in the Filter Feed Tank F-1008 and are pumped through the two filters in parallel. Each filter is designed for a maximum flow of 380 gpm. As the name implies, each filter is packed with a two-layer bed of sand

Table 2.5. NRWTP metals sludge EP Tox analysis and other characeristics

Sample #1 taken 3/20/90			
EP Tox analysis			
Metal	RCRA Limit (mg/l)	Sludge Concentration (mg/l)	EP Tox Leachate Concentration (mg/l)
Ag	5	6	<0.022
As	5	<9.4	<0.17
Ba	100	42	0.044
Cd	1	<0.51	<0.01
Cr	5	9.1	<0.01
Hg	0.2	3	<0.008
Ni		7.1	<0.031
Pb	5	23	<0.061
Se	1	<7.2	<0.18
Tl		<3	<0.1
Other Characteristics		Concentration (%)	
Total Organic Carbon		1.13	
Total Solids		28.3	

(Continued)

Table 2.5 (continued)

Sample #1 taken 3/20/90	
Radiological content	
Radionuclide	Concentration (Bq/g)
C-14	296
Co-60	< 11
Cs-137	2.6
Gross Alpha	11
Gross Beta	600
Sr-90	20

Table 2.6. NRWTP metals sludge EP Tox analysis and other characteristics

Sample #2 taken 3/20/90			
EP Tox analysis			
Metal	RCRA Limit (mg/l)	Sludge Concentration (mg/l)	EP Tox Leachate Concentration (mg/l)
Ag	5	6.1	<0.022
As	5	<7.5	<0.17
Ba	100	50	0.068
Cd	1	<0.41	<0.01
Cr	5	9.1	<0.01
Hg	0.2	3.2	<0.008
Ni		7.4	<0.031
Pb	5	23	<0.061
Se	1	<5.8	<0.18
Tl		<2.4	<0.1
Other Characteristics		Concentration (%)	
Total Organic Carbon		2.2	
Total Solids		30.9	

(Continued)

Table 2.6. (continued)

Sample #2 taken 3/20/90	
Radiological content	
Radionuclide	Concentration (Bq/g)
C-14	< 1
Co-60	< 11
Cs-137	3.8
Gross Alpha	11
Gross Beta	315
Sr-90	2.9

Table 2.7. NRWTP metals sludge EP Tox analysis and other characteristics

Sample #3 taken 6/20/90			
EP Tox analysis			
Metal	RCRA Limit (mg/l)	Sludge Concentration (mg/l)	EP Tox Leachate Concentration (mg/l)
Ag	5	20	< 0.1
As	5	< 708	1.1
Ba	100	71	0.36
Cd	1	< 47	< 0.05
Cr	5	45	< 0.05
Hg	0.2	< 165	< 0.18
Ni		< 165	0.11
Pb	5	0.9	0.03
Se	1	< 29	< 0.18
Tl		< 3	< 0.1
Other Characteristics		Concentration (%)	
Total Organic Carbon		1.52	
Total Solids		20.1	

(Continued)

Table 2.7. (continued)

Sample #3 taken 6/20/90	
Radiological content	
Radionuclide	Concentration (Bq/g)
C-14	238
Co-60	< 15
Cs-137	4.4
Gross Alpha	< 1.0 Bq/l
Gross Beta	55
Sr-90	2.3
U-235	< 1.0 Bq/l

and anthracite which removes suspended solids from the wastewater before reaching the air stripper and activated carbon system. As the filters collect solids, the pressure drop across the filters increases. When the pressure drop reaches 15 psig, the operator initiates the backwashing cycle which removes the collected solids from the filter media and typically reduces the pressure drop to less than 1 psi. A 2-minute air scour process is used as part of the backwash cycle to assist in removing particles from the filter media. Backwash water is transferred from the effluent tank F-1021 at a flow rate of 800 gpm for a 5 minute duration. On the average, the filters have required backwashing once every 48 hours of operation. The filters can be taken off-line and backwashed individually without interrupting flow through the system. If both filters need backwashing, the filters may be bypassed with flow going directly to the air stripper until backwashing is complete. The spent backwash water is returned to the Metals Equalization Tank F-1001 for treatment through the metals removal system.

Due to experience with other granular media filters and the difficulty encountered when replacement of the media is required, it was decided that a routine periodic backwash schedule was preferred rather than delaying until the pressure drop showed a significant increase. Under certain conditions, large quantities of sludge can build up on filter media surfaces before the pressure drop begins to increase. This sludge buildup can be difficult toremove if allowed to accumulate for lengthy time periods. The accumulated sludge can cause the media to cake together, which leads to flow channelling and reduced filtering efficiency. When the media is to be replaced, the caked media is very difficult to remove from the filter vessel. For these reasons, the DM filters were placed on a 48-hour backwash schedule. High pressure drop across the filter, however, will always take priority in indicating the need for a backwash operation.

A significant problem associated with filter operation has been the filter feed pump difficulties (discussed in Section 2.1). On four separate occasions, a shaft failure has occurred on one of the two pumps. The manufacturer supplied several replacement shafts with slightly different designs to correct what appeared to be a weak point in the previous shaft. In September 1990, it was discovered that the level controller of tank F-1008 was causing the pump discharge valve to open and close wildly in responding to level changes, thus causing erratic and severe cavitation. The controller was retuned to respond smoothly and gradually to level changes. Despite the retuning and new shaft design, however, a shaft failure occurred in October. Yet another designed shaft was supplied by an ORNL machine shop to replace one of the suppliers shafts. This shaft performed well until, during a seal replacement activity, the shaft was damaged and had to be replaced with another vendor shaft.

To reduce pump vibration, the pump base plates were replaced as part of the Phase II Improvements project which began in November 1990. Shaft failure for the filter feed pumps has not occurred since October 23, 1990.

Minor problems were experienced with a pressure relief rupture disc which was replaced after prematurely failing, and with two check valves which had to be replaced after allowing water to enter the air scour blower.

2.7 AIR STRIPPER

The Air Stripper S-1014 is designed for removal of small amounts of volatile organic contaminants from the waste stream. The feed stream to the air stripper consists of the combined and filtered streams from the Non-metals tank F-1002 and the reactor clarifiers. Prior to entering the air stripper, the pH of the wastewater is adjusted to 7 to prevent precipitation of water hardness compounds and possible plugging of air stripper packing and activated carbon columns. The wastewater enters the top of air stripper where it is discharged through four spray nozzles onto the towers packing. The packing disperses the wastewater as it makes contact with air which is blown into the bottom of the stripper and up through the packing. The organic compounds in the wastewater are desorbed or stripped from the water into the air stream. The organics are released into the atmosphere in the gaseous form. A demister at the top of the stripper prevents release of water droplets.

The air flow to the air stripper is regulated to a range of 5500 to 8000 cfm. This provides an average 184 to 1 air to liquid ratio. The pressure drop across the column is monitored on a continuous basis to track the accumulation of materials which can plug the column packing, particularly algae growth. The air stripper is cleaned if an increase in pressure drop or decrease in air flow is observed. A pressure drop of 2 psig or an air flow less than 5500 cfm triggers the need for air stripper cleaning. The cleaning procedure consists of recirculating a solution of 5% sulfuric acid for 4 to 5 hours. From the startup of operations, algae had been observed slowly building up inside the air stripper column. A site glass is provided near the bottom of the column which had become coated with algae after several months of operation. Although high pressure drop or low air flow were not observed, sampling indicated that conditions in the air stripper were approaching those which support the growth of the bacteria associated with Legionnaires' disease. For this reason and to reduce algae accumulation, the air stripper was shut down for cleaning in March 1990. At that time, it was decided that the air stripper would be acid cleaned on a quarterly basis unless high pressure drop or low air flow indicated the need for a more frequent cleaning schedule. The cleanings have since been performed each quarter and control of algae accumulation has been adequate. Pressure drop and air flow data have not indicated the need for additional cleanings.

To assess the performance of the air stripper, the wastewater entering and leaving the air stripper is analyzed for volatile and semi-volatile organics. Table 2.8 lists all the organic compounds analyzed and the detection limit for each compound. The data summarized in Tables 2.9 and 2.10 give a summary of the compounds detected in the waste water entering and leaving the air stripper. The tables identify only those organic compounds which were either confirmed to be present at levels above the detection limit or tentatively identified at levels below the detection limit. In many cases, the mean concentration of the compound is lower than the detection limit. This is because the mean is calculated using the tentatively identified concentrations which are below the detection limit of the compound. The number of organic compounds and the mean concentrations of the compounds are lower in the wastewater leaving the air stripper, indicating that the air stripping is effective.

2.8 GAC SYSTEM

The effluent from the air stripper enters the GAC feed sump F-1017 and is transferred to the GAC columns for removal of mercury and organic contaminants not removed by air stripping. The GAC system consists of three columns, two on-line in series flow and the third on standby. Each column contains about 22,000 pounds of Cecarbon[2] GAC 30 granular activated carbon. When the plant officially began treating wastewater on March 31, 1990, column F-1020 was in the lead position, column F-1019 was in the lag position, and column F-1018 was on standby. On December 6, 1990, column F-1020 was taken out of service for repair of a leaking pressure relief device. By this time, columns F-1020 and F-1019 had accumulated throughputs of 115.3 million gallons while the standby column F-1018 had been used for only short periods of time during backwash of the other columns. Column F-1019 was then placed in the lead position and column F-1018 was placed in the lag position with column F-1020 on standby. This column arrangement was used through March 31, 1991. From December 6, 1990 to March 31, 1991 column F-1019 received an additional 53.1 million

[2]Trademark of Atochem Inc., Ceca Division

Table 2.8. List of volatile and semivolatile organics analyzed for evaluation of NRWTP air stripper and GAC system performance

Organic Compound	Detection Limit (μg/L)
Volatile Organic Compounds	
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene chloride	5
Acetone	10
Carbon disulfide	5
1,1-dichloroethene	5
1,1-dichloroethane	5
1,2-dichloroethene (total)	5
Chloroform	5
1,2-dichloroethane	5
2-butanone	10
1,1,1-trichloroethane	5
Carbon tetrachloride	5
Vinyl acetate	10
Bromodichloromethane	5
1,2-dichloropropane	5
Cis-1,3-dichloropropene	5
Trichloroethene	5
Dibromochloromethane	5
1,1,2-trichloroethane	5

(Continued)

Table 2.8. (continued)

Organic Compound	Detection Limit (µg/L)
Benzene	5
Trans-1,3-dichloropropene	5
Bromoform	5
4-methyl-2-pentanone	10
2-hexanone	10
Tetrachloroethene	5
1,1,2,2-tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5
Styrene	5
Xylene	5
Semivolatile Organic Compounds	
Phenol	10
Bis(2-chloroethyl)ether	10
2-chlorophenol	10
1,3-dichlorobenzene	10
1,4-dichlorobenzene	10
Benzyl alcohol	10
1,2-dichlorobenzene	10
2-methylphenol	10
Bis(2-chloroisopropyl)ether	10
4-methylphenol	10
N-nitroso-di-n-propylamine	10
Hexachloroethane	10

(Continued)

Table 2.8. (continued)

Organic Compound	Detection Limit (µg/L)
Nitrobenzene	10
Isophorone	10
2-nitrophenol	10
2,4-dimethylphenol	10
Benzoic acid	50
Bis(2-chloroethoxy)methane	10
2,4-dichlorophenol	10
1,2,4-trichlorobenzene	10
Naphthalene	10
4-chloroaniline	10
Hexachlorobutadiene	10
4-chloro-3-methylphenol	10
2-methylnaphthalene	10
Hexachlorcyclopentadiene	10
2,4,6-trichlorophenol	10
2,4,5-trichlorophenol	50
2-chloronaphthalene	10
2-nitroaniline	50
Dimethyphthalate	10
Acenaphthalene	10
2,6-dinitrotoluene	10
3-nitroaniline	50
Acenaphthene	10
2,4-dinitrophenol	50
4-nitrophenol	50

(Continued)

Table 2.8. (continued)

Organic Compound	Detection Limit (µg/L)
Dibenzofuran	10
2,4-dinitrotoluene	10
Diethylphthalate	10
4-chlorophenyl-phenylether	10
Fluorene	10
4-nitroaniline	50
4,6-dinitro-2-methylphenol	50
N-nitrosodiphenylamine (1)	10
4-bromophenyl-phenylether	10
Hexachlorobenzene	10
Pentachlorophenol	50
Phenanthrene	10
Anthracene	10
Di-n-butylphthalate	10
Fluoranthene	10
Pyrene	10
Butylbenzylphthalate	10
3,3'-dichlorobenzidine	20
Benzo(a)anthracene	10
Chrysene	10
Bis(2-ethylhexyl)phthalate	10
Di-n-octylphthalate	10
Benzo(b)fluoranthene	10
Benzo(k)fluoranthene	10
Benzo(a)pyrene	10

(Continued)

Table 2.8. (continued)

Organic Compound	Detection Limit (μg/L)
Indeno(1,2,3-cd)pyrene	10
Dibenzo(a,h)anthracene	10
Benzo(g,h,i)perylene	10
Pesticides	
Alpha-BHC	0.05
Beta-BHC	0.05
Delta-BHC	0.05
Gamma-BHC (Lindane)	0.05
Heptachlor	0.05
Aldrin	0.05
Heptachlor epoxide	0.05
Endosulfan I	0.05
Dieldrin	0.10
4,4'-DDE	0.10
Endrin	0.10
Endosulfan II	0.10
4,4'-DDD	0.10
Endosulfan sulfate	0.10
4,4'-DDT	0.10
Methoxychlor	0.50
Endrin ketone	0.10
Alpha chlordane	0.50
Gamma chlordane	0.50
Toxaphene	1.00
Aroclor-1016	0.50

(Continued)

Table 2.8. (continued)

Organic Compound	Detection Limit (μg/L)
Aroclor-1221	0.50
Aroclor-1232	0.50
Aroclor-1242	0.50
Aroclor-1248	0.50
Aroclor-1254	1.00
Aroclor-1260	1.00

Table 2.9. Volatile and semivolatile organic content of NRWTP air stripper feed wastewater

Summary of 17 samples

Organic Compound	Detect Limit (μg/L)	Mean μg/L	Max μg/L	Min μg/L	No. Det.
Volatile Organic Compounds					
Methylene chloride	5	5.8	26	1	11
Chloroform	5	18.1	140	4	17
Bromodichloromethane	5	4.3	5	1	4
1,2-dichloropropane	5	4.9	5	4	1
Trichloroethene	5	4.6	5	1	2
Dibromochloromethane	5	4.4	5	1	3
Bromoform	5	4.5	5	1	3
Tetrachloroethane	5	4.6	5	2	2
Semivolatile Organic Compounds					
Butylbenzylphthalate	10	9.7	10	5	1
Chrysene	10	9.6	10	4	1
Pesticides					
Aldrin	0.05	0.047	0.05	0.001	1
Endosulfan sulfate	0.10	0.096	0.1	0.03	1
Alpha chlordane	0.5	0.47	0.5	0.03	1
Gamma chlordane	0.5	0.45	0.5	0.01	1
Heptachlor	0.05	0.05	0.05	0.049	1

Table 2.10. Volatile and semivolatile organic content of NRWTP air stripper effluent wastewater

Summary of 17 samples

Organic Compound	Detect Limit (μg/L)	Mean μg/L	Max μg/L	Min μg/L	No. Det.
Volatile Organic Compounds					
Methylene chloride	5	5	5	5	1
Acetone	10	10.6	20	10	1
Carbon disulfide	5	5.9	24	2	2
Tetrachloroethane	5	4.8	5	3	2
Pesticides					
Endosulfan sulfate	0.10	0.095	0.1	0.02	1
Alpha chlordane	0.5	0.47	0.5	0.02	1

In several cases for Tables 2.9 and 2.10, the mean concentration of a compound is less than the detection limit. This occurs when tentative identifications are reported at concentrations less than the detection limit for the compound. These concentrations are used when calculating the mean, which sometimes reduces the mean value to levels below the detection limit.

gallons throughput in the lead position, column F-1018 received 52.1 million gallons throughput in the lag position, and column F-1020 remained on standby for use during backwash of the other columns.

Like the air stripper, samples of waste water from the inlet and outlet of the columns are analyzed for organic materials. Analytical data summarized in Tables 2.11, 2.12, and 2.13 indicate that very few detectable organic pollutants have either entered or exited the GAC system. As shown in Table 2.14, mercury is detected at very low levels in the GAC influent stream and is removed to levels below the detection limit in the effluent wastewater. When organic or mercury analytical data for the lead column indicates breakthrough of compounds that should normally be adsorbed by the carbon, the standby column will be placed on-line (in the lag position), the former lag column will be placed in the lead position, and the former lead column will be taken off line for reloading with fresh carbon. The spent activated carbon will be dewatered, containerized, and disposed of. Though radiological contaminants enter the plant at levels lower than discharge limits, some accumulation may occur on activated carbon making it slightly radioactive. ORNL Health Physics personnel have performed surveys at the NRWTP and results indicate that the radiation field on the surface of the GAC columns is no higher than background levels. Radiological analysis will be performed on spent activated carbon samples prior to disposal. In addition, TCLP tests will be performed on the carbon to determine if it is a characteristically hazardous waste.

The GAC system is equipped for backwashing to remove accumulated solids (mostly algae from the air stripper). When the pressure drop across a column reaches 13 psig, an alarm is received and the operator initiates the automatic backwash cycle. Backwashing is preceded by a 2-minute air scour which agitates the carbon and loosens the accumulated particles. Following the air scour, the backwash pumps are energized and transferwastewater from the effluent tank F-1021 to the column at a flow rate of 800 gpm for a 7 minute duration. On the average, the GAC columns have operated 440 hours between backwashes.

The current schedule of once-per-month sampling for the lead GAC column will continue. Conservatively assuming that the wastewater contains 1.0 ppm of organics that are adsorbed by the GAC system and that each column can remove 1000 pounds of organics, it will take 120 million gallons to exhaust one GAC column. At an average flow rate of 320 gpm, a single column should last 261 days. Other factors, however, may reduce the life of the carbon such as accumulation of algae or calcium carbonate. If high pressure drop across a column and excessive backwashing

Table 2.11. Volatile and semivolatile organic content of NRWTP GAC lead column feed wastewater

Summary of 17 samples

Organic Compound	Detect Limit (µg/L)	Mean µg/L	Max µg/L	Min µg/L	No. Det.
Volatile Organic Compounds					
Methylene chloride	5	5	5	5	1
Acetone	10	10.6	20	10	1
Carbon disulfide	5	5.9	24	2	2
Tetrachloroethane	5	4.8	5	3	2
Pesticides					
Endosulfan sulfate	0.10	0.095	0.1	0.02	1
Alpha chlordane	0.5	0.47	0.5	0.02	1

Table 2.12. Volatile and semivolatile organic content of NRWTP GAC lead column effluent wastewater

Summary of 7 samples

Organic Compound	Detect Limit (µg/L)	Mean µg/L	Max µg/L	Min µg/L	No. Det.
Volatile Organic Compounds					
Methylene chloride	5	4.9	5	4	1
Tetrachloroethane	5	4.6	5	2	1
Pesticides					
Endosulfan sulfate	0.10	0.089	0.1	0.02	1
Alpha chlordane	0.5	0.43	0.5	0.02	1

Table 2.13

Volatile and semivolatile organic content of NRWTP GAC lag column effluent wastewater

Summary of 6 samples

Organic Compound	Detect Limit (µg/L)	Mean µg/L	Max µg/L	Min µg/L	No. Det.
Volatile Organic Compounds					
Methylene chloride	5	3.8	5	1	2
Chloroform	5	4.5	5	2	1
Tetrachloroethane	5	4.7	5	3	1
Pesticides					
Endosulfan sulfate	0.10	0.087	0.1	0.02	1
Alpha chlordane	0.5	0.42	0.5	0.02	1

In many cases for Tables 2.11, 2.12, and 2.13, the reported mean concentration of a compound is less than the detection limit. This occurs when tentative identifications are reported by the analytical laboratory at concentrations less than the detection limit for the compound. These concentrations are used when calculating the mean, which sometimes reduces the mean value to levels below the detection limit.

Table 2.14

NRWTP GAC system mercury removal data

Sample source	Number of Samples	Detect Limit (µg/L)	Mean µg/L	Max. µg/L	Min. µg/L	Number Detected
Nonmetals equalization tank F-1002	24	0.05	4.1	66.4	0.16	24
Plant effluent	55	0.05	0.055	0.2	0.05	3

becomes a problem, replacement of the carbon will be performed regardless of the extent of exhaustion.

2.9 EFFLUENT TANK

The effluent from the GAC system enters Effluent Tank F-1021 for pH adjustment prior to discharge to White Oak Creek. The tank also serves as a 26,300 gallon reservoir for backwash water used for DM filters and GAC columns. A continuous mixer and built-in tank baffles ensure uniform pH of the wastewater prior to discharge.

Two backwash pumps, each designed for up to 1600 gpm are provided along with discharge control valves. The backwash system is controlled by DM filter and GAC system automatic backwash cycles. When the backwash cycle starts, a pump is energized and the discharge flow control valve is opened until the desired flow rate is achieved. Alarms and interlocks are provided to ensure that the level in the effluent tank is high enough to perform the backwash without dropping the tank level lower than mid-level.

During startup, some difficulty was encountered in tuning of the pH controller for the effluent tank. The controller is equipped for either base or acid addition and in certain cases, both base and acid additions would occur simultaneously. The problem was alleviated by modifying the controller logic to prevent coinciding acid and base addition. Since there are separate controllers for acid and base addition, the set points for each controller can be adjusted independently. When the set points are adjusted such that there is at least a 0.25 pH unit span between the two (ie, 7.00 for base controller and 7.25 for acid controller), competing acid a base addition does not occur. pH sampling data indicates that adequate pH control has been achieved. The average pH of the NRWTP effluent has been 7.5 with a maximum of 8.0 and a low of 6.9.

3. MAINTENANCE, SAFETY, AND TRAINING ACTIVITIES

3.1 MAINTENANCE

Significant maintenance activities performed as a result of operational problems during the first year of operation are shown in Table 3.1. There are many routine activities performed on a

Table 3.1. Significant NRWTP maintenance activities from January 1990 to March 1991

Date	Circumstance	Activity
Jan. 25, 1990	J1008A DM filter feed pump shaft failed.	Shaft was replaced with vendor-supplied improved shaft.
Jan. 29, 1990	J1008B DM filter feed pump shaft failed.	Shaft was replaced with vendor-supplied improved shaft.
Feb., 1990	Problems with sulfuric acid metering pump used for air stripper.	Pump was replaced with a different model pump with no adverse operational impacts.
Mar. 17, 1990	Transformer feeding power to NRWTP failed.	Spare transformer on alternate power feed placed in service. No adverse impacts.
Mar., 1990	None	Replaced acid metering pump used for plant effluent pH adjustment.
Apr., 1990	F-1002 jet mixer seal leaking.	Replaced seal. No impact on operations.
May 13, 1990	Fallen tree knocked out power to NRWTP.	Power rerouted and restored in 7 hours.
May, 1990	Filter feed pump seal leaking.	Replaced seal. No impact on operations.
May, 1990	Transformer failure in March.	Replaced transformer with no impact on operations.
July, 1990	Transformer feeding 3608 damaged by lightning.	Short power loss. Power feed switched to other transformer. Additional grounding added to transformers.
July 2, 1990	J1008A DM filter feed pump shaft failed.	Switched flow to standby pump. No impact on operations. Shaft replaced several days later.
Sept., 1990	Improperly adjusted timer relay causing abnormal alarms during DM filter backwash.	Timer relay adjusted with no impact on operations.
Sept., 1990	Acid feed line to effluent tank plugged with sludge.	Acid feed at air stripper used to control effluent pH. Problem being investigated.

(continued)

Table 3.1. (continued)

Date	Circumstance	Activity
Oct. 6, 1990	Relief valve on 1020 GAC column leaking.	1020 GAC column was taken off line until the valve could be repaired.
Oct. 23, 1990	Shaft broke on DM filter feed pump.	Switched flow to standby pump. No impact on operations. Shaft replaced several days later.
Nov. 12, 1990	J1001A Metals wastewater transfer pump shaft failed.	Flow switched to standby pump. Shaft replaced with no impact on operations.
Nov., 1990	Previous shaft failures of DM filter feed pumps.	Level controller for filter feed tank retuned for smoother response.
Nov., 1990	Operator Interface Unit (OIU) monitor problems.	Spare OIU monitor installed with no impact on operations.
Nov., 1990	Problems with polymer feed pump.	Used spare pump and replaced malfunctioning pump with no impact on operations.
Dec. 20, 1990	J1002B Non-metals wastewater transfer pump shaft failed.	Flow switched to standby pump. Shaft replaced with no impact on operations.
Dec. 26, 1990	J1002A Non-metals wastewater transfer pump shaft failed.	Flow switched to standby pump. Shaft replaced with no impact on operations.
Jan. 22, 1991	Rupture disc failed on DM filter vessel	Switched to standby DM filter until repairs could be made.
Feb. 20, 1991	Check valve on air scour blower leaking water back into blower discharge.	Replaced check valve with no impact on operations.
Feb. 28, 1991	J1001 Jet mixer seal leaking.	Shut down jet mixer until repairs could be made.
Mar. 28, 1991	None	J1001 Jet mixer seal replaced. No impact on operations.

periodic basis to ensure uninterrupted and reliable plant operation. No attempt is made to detail the routine maintenance activities in this report.

As shown in Table 3.1, there is a high frequency of pump shaft failures. The failures have been investigated and attributed to many potential problems including poor shaft design, cavitation of pump due to low head pressure, vibration from poorly designed support structures, and shaft misalignment. The manufacturer supplied a redesigned shaft which also failed in several cases. One of the shafts was replaced with a shaft manufactured at the ORNL machine shop, however, this shaft was damaged during a pump seal replacement and was replaced with a vendor shaft. Nearly all the pump base plates were replaced with improved structures to reduce vibration. The level controller for the filter feed tank was retuned to respond gradually to changing feed flow rates and eliminate cavitation. Shaft failure has not recurred since December 1990, however, pump seals have begun to leak on a fairly frequent basis. Due to the ongoing difficulties with these pumps, WMO plans to replace all of these pumps with similar type pumps made by another company. It is expected that the replacements will be installed within the next year.

3.2 SAFETY

Safety is a key to the successful operation of any facility. The site specific safety program for the NRWTP is an integral part of a comprehensive ORNL safety program. Safety reviews were performed during every phase of development, engineering, and construction of the plant. Safety is an ongoing process at the NRWTP involving worker safety training, routine facility safety inspections, weekly safety meetings, routine maintenance of safety systems, preparation of safe work procedures, and other activities. Procedures prepared for operation of the NRWTP include emergency procedures used in case of power outage or other uncontrolled situations. Operators are drilled on these emergency procedures as part of the training exercises. Managers, supervisors, and plant operators all receive training for handling hazardous chemicals as required by the Superfund Amendments Reauthorization Act (SARA) and the Occupational Safety and Health Act (OSHA). In order for any non-WMO support employee to gain access to the NRWTP, he must complete the General Employee Access Training provided periodically by WMO. This training describes the activities at the plant,potential hazards, minimum safety equipment needed for access, and emergency procedures.

Design improvements have been implemented at the NRWTP which have enhanced operational safety. Platforms have been added and existing ladders and platforms modified to improve accessibility of equipment which requires frequent maintenance. Discharge lines from pressure relief devices have been piped to sump drains where workers cannot be exposed should a over-pressuring problem occur. A "man-in-distress" pull-rope alarm was added near the filter press in case of emergency. The pull-rope is wired to the DCS to ensure communication to the control center operator. Employees are encouraged to point out safety related problems and to make safety improvements through maintenance work orders.

3.3 TRAINING

There was a considerable amount of work performed in ensuring that the operating personnel were well qualified to operate the plant. Training and operating procedures were developed for the NRWTP and have undergone intense scrutiny and revision by ORNL and DOE staff personnel. The result has been a well-trained, qualified operating group who have successfully brought the plant on-line and maintained its operation with a minimum of errors. As operation of the plant continues, procedures and training are continually evaluated and will remain a high priority in maintaining successful operation of the plant.

4. OPERATIONAL DATA AND ANALYTICAL RESULTS

4.1 GENERAL SYSTEM MONITORING

Three operational check sheets are used on a routine basis by plant operating personnel. The 3608 Check Sheet is used to record wastewater flow rates, pH, polymer tank level, and effluent radiological readings. pH readings are recorded every two hours from system controller indicators and twice per shift for samples taken from six sample locations. Wastewater flows are recorded every two hours and effluent radiological results are recorded every 4 hours. The 3608 Shift Check Sheet is used by plant operators to ensure that important visual checks are performed and operating parameters are monitored. The sheet includes information vital to the operation of wastewater filters, air filters, pumps, the air stripper, chemical feed tanks, and the plant sump. The GAC Columns sheet is used to monitor the operation of the GAC system. A separate sheet is maintained for each column and includes run dates, flow rates, cumulative flow, cumulative run time, and pressure drop data. Pump discharge pressures are recorded periodically on the Non-rad Pump Discharge Pressure log sheet. Figures 4.1, 4.2, 4.3, and 4.4 show the above described check sheets.

4.2 HYDRAULIC LOADING

The NRWTP has treated and discharged 168.4 million gallons of wastewater since April 1, 1990. Table 4.1 shows the monthly volumes discharged during this time period. The maximum flow during this time period was 730,000 gallons/day with an average flow of 460,000 gallons/day. The plant is designed to treat up to 1.09 million gallons/day. The flow rate is continuously monitored by a NPDES monitoring station installed at the outlet of the plant effluent tank F-1021.

4.3 CHEMICAL USAGE AND SLUDGE GENERATION

The NRWTP uses sodium hydroxide and sulfuric acid on a continuous basis for pH adjustment. In the first year of operation, the plant has used about 9000 gallons of 50% by weight sodium hydroxide and 2300 gallons of 93% by wt. sulfuric acid. Betz 1100 polymer is used to flocculate and improve the settling characteristics of precipitated metals and diatomaceous earth is used the precoat the filter press for sludge dewatering. Approximately 650 pounds of dry Betz 1100 and 1400 pounds of diatomaceous earth were used in the first year of operation.

Based on a filter press capacity of 24 cubic feet and a total of 28 filter press runs performed during the first year of operation, 672 cubic feet of sludge from the NRWTP metals treatment process have been generated. The sludge has been packaged in 14 steel boxes, each with a capacity of 64 cubic feet. It is further handled by the Solid Waste Operations Department as an LSA waste and will be transported for storage to the DOE K-25 facility in Oak Ridge, TN.

4.4 PLANT INFLUENT AND EFFLUENT CONTAMINANT LEVELS

Samples of influent and effluent wastewaters are taken at the plant to monitor the composition of the plant feed wastewater, assess the performance of treatment systems, and to demonstrate compliance with the NPDES permit. Plant influent grab samples to be analyzed for organic contaminants are taken from the non-metals equalization tank F-1002. The wastewater from

3608 CHECK SHEET

Date ________________ Operator ________________ (0700-1900) ________________ (1900-0700)

Time	Flow rate (gpm)		pH readings (from DCS)					Polymer tank level
	F-1001	F-1002	F-1001	F-1002	F-1003	F-1013	F-1021	
0800								
1000								
1200								
1400								
1600								
1800								
2000								
2200								
2400								
0200								
0400								
0600								

pH readings (from samples)			Radiation readings				
	1000	2200	Time	Alpha	Beta	Co	Cs
F-1001			0800				
F-1002			1200				
F-1003			1600				
F-1013			2000				
F-1017			2400				
F-1021			0400				

Reviewed 1900-0700 Shift Foreman ________________

TX-5537, R 0 (10/23/90)

Fig. 4.1. 3608 Check Sheet

3608 SHIFT CHECKS

Date ____________________ Operator ________ (0700-1900) ________ (1900-0700)

			(0700-1900)	(1900-0700)
1.	Check the containment area sumps once per shift to confirm no leaks (indicate by check).		________	________
2.	Check caustic tank and pumps once per shift and record tank level. If <20%, notify Supervisor.		________	________
3.	Check the acid feed pumps once per shift and record tank level. If <20%, notify Supervisor.		________	________
4.	Record the level in the polymer tank once per shift at the indicated times.		________ (0900)	________ (2100)
5.	Check flow through F-1013 at least twice per shift (indicate by checks).		____ ____	____ ____
6.	Check pump oil cups at least twice per shift (indicate by checks).		____ ____	____ ____
7.	Record the pressure drop across the air stripper and confirm each rotameter is set at 1/2 scale (if the pressure drop exceeds 2 psi, clean the air stripper).		______ psi (0900)	______ psi (2100)

			Inlet	Outlet (Local)	DCS ΔP
8.	Record the pressure drop across the dual-media filters once per shift (if the pressure drop exceeds 15 psi, backwash the filters).	F-1009 (0900)	____psi	____psi	____psi
		F-1009 (2100)	____psi	____psi	____psi
		F-1010 (0900)	____psi	____psi	____psi
		F-1010 (2100)	____psi	____psi	____psi

		Pre	ABS.1	ABS.2
9.	Record the pressure drop across the HEPA filters once per day in filter press room.	______	______	______

10.	Visually check final effluent tank discharge for inadvertent chemical or GAC discharge.	________	________

Comments ____

Reviewed 1900-0700 Shift Foreman ______________________________

TX-5536, R 2 (04/17/91)

Fig. 4.2. 3608 Shift Checks

GAC COLUMNS

Date ____________________ Operator ____________ (0700-1900) ____________ (1900-0700)

Column No. ____________________

Date column placed in service ____________________

Time column placed in service ____________________

Flow through the column while in lead: Accumulated flow in lead: ____________ gal

___ h x ___ gpm x 60 = _________ gal Accumulated run time in lead: ____________ h

___ h x ___ gpm x 60 = _________ gal

Flow through the column while in lag: Accumulated flow in lag: ____________ gal

___ h x ___ gpm x 60 = _________ gal Accumulated run time in lag: ____________ h

___ h x ___ gpm x 60 = _________ gal

Date of termination ____________________

Time of termination ____________________

	Pressure readings across GAC column		
	Inlet (psi) (local)	Outlet (psi) (local)	ΔP (DCS)
0900			
1300			
1700			
2100			
0100			
0500			

Reviewed by 1900-0700 Shift Foreman ____________________

TX-5542, R 1 (12/20/90)

Fig. 4.3. GAC Columns (log sheet)

NON-RAD PUMP DISCHARGE PRESSURE

Date ____________ 0700-1900 ________________ 1900-0700 ________________

[illegible]	1001A	1001B	1002A	1002B	1008A	1008B	1025A	1025B	1021A	1021B	1017A	1017B
[illegible]	(40 to 60 psig)		(40 to 60 psig)		(50 to 70 psig)		(40 psi)		(40 to 55 psig)		(70 to 90 psig)	
0700												
0800												
0900												
1000												
1100												
1200												
1300												
1400												
1500												
1600												
1700												
1800												
1900												
2000												
2100												
2200												
2300												
2400												
0100												
0200												
0300												
0400												
0500												
0600												

Comments ____

TX-5543, R 1 (1/9/91) Reviewed by 1900-0700 Shift Foreman ____________

Fig. 4.4. Non-Rad Pump Discharge Pressure (log sheet)

Table 4.1. NRWTP monthly wastewater flows

Month	Flow (gal X 10^6)
April, 1990	12.51
May	14.15
June	12.78
July	14.57
August	15.24
September	13.58
October	13.46
November	12.71
December	13.04
January, 1991	16.15
February	14.01
March	16.18

metals equalization tank F-1001 which comprises less than 8 percent of the total plant flow is not likely to contain organic contaminants. It is composed of ion-exchange regenerant solutions from the Steam Plant, acid cleaning solutions, and recycled backwash water which contains essentially no organic contaminants. The non-metals wastewater from F-1002, therefore, is used to monitor the levels of organic contaminants entering the plant. Grab samples are also taken from F-1002 for metals analysis to verify that metals and non-metals wastewaters are adequately segregated. The samples are taken at the F-1002 transfer pumps by Waste Management Operations and submitted to ORNL Analytical Chemistry Division for analysis of volatile organics, semi-volatile organics, and total metals. To characterize the plant feed wastewater during the plant startup, samples were taken on a daily basis for the entire month of March, 1990. After March, sampling frequency was reduced to once per month.

Additional grab samples are taken to verify pH and analyze for radiological composition. To verify the pH readings of the on-line pH monitors located in F-1002 equalization tank and F-1021 effluent tank, grab samples are drawn every 12 hours and checked using a bench-top pH meter. pH discrepancies are reported to the shift foreman. Plant effluent grab samples are drawn every 4 hours and submitted for radiological analysis.

To demonstrate compliance with the NPDES permit, plant effluent samples are taken by the Office of Environmental and Health Protection for analysis of the regulated contaminants. The compliance samples are taken by an automatic sampler once per week as a 24 hour composite.

The results of metals analysis of the influent wastewater which collects in the non-metals equalization tank F-1002 is summarized in Table 4.2. The samples are grab samples taken from the discharge of the F-1002 pump which transfers wastewater to the filter feed tank F-1008. The samples are collected in one-liter containers and acidified with nitric acid which dissolves any metals that may have existed as a suspended precipitate. In some cases, the metal concentrations exceed the discharge limits proposed in the September 1990 NPDES permit renewal application, however, they are usually in the form of suspended precipitates which are removed by the plant DM filters. The results confirm that the segregation of metals and non-metals wastewater for the two equalization tanks has been successful. Table 4.3 summarizes the metals analysis results of compliance samples taken at the plant effluent. The samples are 24-hour composites taken once per week. The metal concentrations are well below the former discharge permit levels and only one exceedance (copper at 0.23 ppm) of the proposed discharge limits of the renewal application is indicated. The zinc concentration has approached, but not exceeded the proposed discharge limit on several occasions.

Table 4.2 Metals content of NRWTP non-metals wastewater
Summary of 41 samples

Metal	Detection Limit (mg/l)	Mean (mg/l)	Max. (mg/l)	Min. (mg/l)	Number Detected
Ag	0.005	0.0069	0.023	0.005	2
Al	0.05	0.10	0.88	0.03	13
As	0.05	0.05	0.05	0.05	0
B	0.08	0.083	0.16	0.08	2
Ba	0.001	0.024	0.11	0.0073	41
Be	0.0003	0.0012	0.01	0.0002	0
Ca	0.01	21	100	14	41
Cd	0.005	0.0099	0.049	0.005	5
Co	0.004	0.004	0.004	0.004	0
Cr	0.004	0.013	0.056	0.004	15
Cu	0.005	0.11	1.5	0.005	31
Fe	0.01	1.5	11	0.029	41
Hg *	0.00005	0.0043	0.066	0.00016	24
Li	15	15	15	15	0
Mg	0.03	5.5	20	3.9	41
Mn	0.001	0.013	0.14	0.0015	31
Mo	0.04	0.04	0.04	0.04	0
Na	0.03	74	150	6.6	41
Ni	0.005	0.022	0.12	0.0043	16
P	0.3	0.34	1.7	0.3	5
Pb	0.05	0.054	0.29	0.03	10
Sb	0.05	0.051	0.075	0.05	4
Se	0.05	0.043	0.05	0.04	0
Si	0.05	1.8	3.1	0.2	41
Sn	0.05	0.05	0.05	0.05	0
Sr	0.005	0.054	0.2	0.038	41
Ti	0.02	0.02	0.02	0.02	0
V	0.002	0.0036	0.0049	0.002	2
Zn	0.002	0.32	3.1	0.039	41
Zr	0.02	0.02	0.02	0.02	0

* A separate grab sample was obtained and submitted for mercury analysis. A total of 24 samples were acquired for mercury analysis during the year.

Samples from the non-metals equalization tank F-1002 were grab samples taken from the discharge of the F-1002 transfer pumps. A one liter sample is taken and acidified with nitric acid to preserve. Any precipitated suspended metals in the sample are dissolved as a result of the acidification.

Table 4.3. Metals content of NRWTP effluent wastewater

Metal	Number of samples	Mean (mg/l)	Max. (mg/l)	Min. (mg/l)	Number Detected
Ag	56	0.0052	0.015	0.005	1
Al	18	0.067	0.16	0.05	13
As	56	0.05	0.05	0.05	0
B	18	0.08	0.08	0.08	0
Ba	18	0.015	0.036	0.001	17
Be	18	0.00026	0.0003	0.0002	0
Ca	18	28	81	18	18
Cd	56	0.0051	0.007	0.005	0
Co	18	0.0041	0.0053	0.004	1
Cr	56	0.0061	0.028	0.004	29
Cu	56	0.012	0.23	0.005	14
Fe	56	0.047	0.12	0.01	17
Hg	55	0.000055	0.0002	0.00005	3
Li	18	15	15	15	0
Mg	18	6.2	12	0.5	18
Mn	18	0.001	0.001	0.001	0
Mo	18	0.04	0.04	0.04	0
Na	18	79	120	24	18
Ni	56	0.0048	0.0095	0.004	6
P	70	0.35	1.0	0.1	41
Pb	56	0.049	0.063	0.03	1
Sb	18	0.05	0.05	0.05	0
Se	56	0.049	0.05	0.04	0
Si	18	1.9	2.7	0.27	18
Sn	18	0.05	0.05	0.05	0
Sr	18	0.063	0.14	0.044	18
Ti	18	0.02	0.02	0.02	0
V	18	0.002	0.002	0.002	0
Zn	56	0.024	0.097	0.005	53
Zr	18	0.02	0.02	0.02	0

The above samples were 24-hour composite samples taken on a weekly basis taken by the Office of Environmental and Health Protection.

An NPDES monitoring station is provided which continuously monitors wastewater pH and flow rate at the outlet of the effluent holding tank F-1021. The average pH of the plant effluent for the first year of operation was 7.5 with a maximum of 8.0 and a minimum of 6.9. The average flow through the plant for the first year of operation was 460,000 gallons/day with a maximum of 730,000 gallons/day and a minimum of 240,000 gallons/day. No permit violations were experienced for these two parameters.

Table 4.4 summarizes the results of volatile and semivolatile organic analyses of wastewater from tank F-1002. As shown, organics that are typically detected in the wastewater include acetone, chloroform, and methylene chloride. They are present at levels below 1 ppm and are effectively removed from the wastewater by the air stripper and GAC system. Plant effluent organic analyses are summarized in Table 4.5. In most cases, effluent organic compounds are non-detectable. The only organic compounds detected at measurable levels above the detection limit were bis(2-ethylhexyl)phthalate and di-n-octylphthalate. These compounds are not regulated for waters where fish and aquatic life must be protected. Although White Oak Creek is not used for recreation, the Tennessee Water Quality Criteria Summary regulates these compounds in recreational waters at levels several orders of magnitude above the concentrations found in these samples. In many cases in Tables 4.4 and 4.5, organic compounds are only tentatively identified at levels below the actual detection limit. When these concentration values are used to calculate the mean concentration of the material, the mean values are sometimes below the detection limit of the compound.

Analysis of mercury concentrations of the wastewater grab samples from tank F-1002 and the plant effluent compliance sampling indicates that effective mercury removal is performed. The mercury is adsorbed by activated carbon of the GAC system. Table 2.14 summarizes the analytical data.

4.5 REACTOR CLARIFIER PERFORMANCE SAMPLING

Grab samples of wastewater from the metals equalization tank F-1001 and the effluent of the reactor clarifiers were taken by Waste Management Operations once during each semi-batch treatment and once per week once continuous treatment commenced. The samples are submitted for metals analysis to monitor the performance of the metals removal systems. pH readings and polymer tank level are recorded on check sheets every two hours to ensure proper conditions for metals removal.

Table 4.4. Volatile and semivolatile organic content of NRWTP plant feed wastewater

Summary of 36 samples

Organic Compound	Detect Limit (µg/L)	Mean µg/L	Max µg/L	Min µg/L	No. Det.
Volatile Organic Compounds					
Acetone	10	196	900	3	28
Benzene	5	6.5	19	4	8
Bromodichloromethane	5	4.8	5	2	3
Carbon tetrachloride	5	5.1	9	5	3
Chloroform	5	25.5	150	5	36
Dibromochloromethane	5	4.9	5	1	1
Methylene chloride	5	16.1	170	1	29
Toluene	5	5.6	22	5	6
Trichloroethene	5	5.2	14	5	1
Xylene	5	4.7	10	2	10
Semivolatile Organic Compounds					
Bis(2-ethylhexyl)phthalate	10	31.2	470	10	4
Diethylphthalate	10	9.84	10	4	1
Pesticides					
Aldrin	0.05	0.049	0.05	0.01	1
Alpha chlordane	0.10	0.098	0.1	0.02	1
Endosulfan sulfate	0.10	0.098	0.105	0.03	2
Gamma chlordane	0.5	0.49	0.5	0.01	1

Table 4.5. Volatile and semivolatile organic content of NRWTP effluent wastewater

Summary of 53 samples

Organic Compound	Detect Limit (µg/L)	Mean µg/L	Max µg/L	Min µg/L	No. Det.
Volatile Organic Compounds					
Acetone	10	14	200	2	10
Carbon Disulfide	5	5.1	22	1	3
Chloroform	5	4.2	5	0.8	12
Methylene chloride	5	4.0	5	0.4	15
Tetrachloroethene	5	4.9	6	1	1
Toluene	5	4.6	5	1	5
Semivolatile Organic Compounds					
Bis(2-ethylhexyl)phthalate	10	19	240	5	6
Di-n-butylphthalate	10	9.9	11	1	1
Di-n-octylphthalate	10	14	160	4	5
Diethylphthalate	10	8.8	11	1	9
TTO*	10	24	240	10	7

* TTO - total toxic organics is the sum of all EPA priority organic pollutants detected at levels greater than 10 ppb.

The above data was collected by the Office of Environmental and Health Protection from 24-hour composite samples taken on a weekly basis.

Samples of wastewater entering and exiting the reactor clarifiers indicate that heavy metals were effectively removed. Table 2.2 gives the reactor clarifier influent and effluent concentrations of metals during the semi-batch operation. To remove some of the suspended solids prior to analysis, the effluent samples were allowed to settle for one hour and were decanted into another sample container. After decanting, the effluent samples were acidified with nitric acid to preserve the sample. Since the samples were not filtered, any remaining suspended solids were redissolved upon acidification. In many cases, the effluent concentration of the metal was less than the detection limit making it impossible to determine the full extent to which the metal was removed. Table 2.3 gives the average percent removals of the metals. The use of the detection limit as the lower limit of removal, and the fact that the effluent samples were not filtered gives significant conservativeness to the removal rates. When the operation of the metals removal system was changed from semi-batch to continuous, samples of the reactor clarifier inlet and outlet wastewater were taken on a weekly basis. Table 2.4 summarizes the results of the sample analyses. The data indicates that metals removal is improved for some metals and not quite as good for others, although NPDES permit compliance is maintained. The operational difficulties and suspended solids carry-over from semi-batch treatment are no longer a problem with the continuous treatment mode.

4.6 AIR STRIPPER SAMPLING

Initial sampling of the plant influent and effluent wastewaters indicated that organic contaminants were effectively removed by the GAC system and air stripper. After 7 months of operation, sampling of air stripper inlet and outlet wastewaters commenced. Grab samples are taken once per week by Waste Management Operations. The samples are analyzed for volatile and semi-volatile organic content to evaluate air stripper performance.

Sample results given in Tables 2.9 and 2.10 indicate that volatile organic contaminants are successfully removed. The tables indicate only those organics that were detectable during the complete volatile and semi-volatile organic analyses as given in Table 2.8. The levels of organics are typically very low at the air stripper inlet and in many cases, the levels are below the detection limit and are only tentatively identified. It is clear, however, that the number of tentative identifications is much lower in the air stripper effluent stream.

4.7 GAC SYSTEM SAMPLING

In the early months of plant operation, the removal of organics was evaluated based on analysis of samples taken at the plant inlet (tank F-1002) and outlet (tank F-1021). Based on the organic content of the feed wastewater, it was decided that breakthrough of the activated carbon was extremely unlikely until several months of operation had transpired. After 5 months of plant operation, sampling of GAC column inlet and outlet wastewater commenced to determine the extent of carbon exhaustion. Grab samples at the inlet and outlet of the lead GAC column and the outlet of the lag column are taken once per month by Waste Management Operations. The samples are analyzed for volatile and semi-volatile organics and mercury. Plant effluent wastewater samples (which are essentially samples of the lag column outlet wastewater) are taken more frequently by Environmental Compliance, and are also used as a means of evaluating GAC system performance.

In most cases, the test results indicate very low or non-detectable levels of organic materials and mercury in the GAC system influent stream. Table 2.11, the lead GAC column inlet data, is also the data which represents the organic content of the air stripper outlet wastewater. Tables 2.12 and 2.13 give a summary of lead and lag column effluent streams for a limited number of samples. Only those organics that were detected during the full volatile and semivolatile organic analysis are given. In every case, the organic compounds were detected on a tentative basis at levels below the normal detection limit. The analysis of the plant effluent wastewater given in Table 4.5 represents a more extensive analysis of the lag GAC column outlet. The effluent data indicates that acetone is the only volatile organic compound whose mean level is above the detection limit. Acetone is not removed by activated carbon as well as many other organic materials due to its polar nature and high solubility in water. The higher levels of acetone in the plant feed wastewater (Table 4.4), however, is an indication that air stripping and activated carbon remove a large portion of the acetone. Several phthalate compounds were detected both in the plant feed and effluent wastewaters. As discussed in Section 4.4, the levels of these compounds are not of concern based on the TDHE Water Quality Criteria Summary and the non-recreational use of White Oak Creek.

Table 2.14 summarizes the GAC system influent and effluent concentrations of mercury. In most cases, mercury concentrations are reduced to levels below the detection limit. With the detection limit as the baseline mercury concentration, the average removal rate is 98%.

The analytical data collected since plant startup has not indicated that the carbon in any of the columns has been exhausted. Monthly grab samples will continue to be taken for complete organic and mercury analyses of the influent and effluent wastewater for the lead GAC column.

4.8 SLUDGE SAMPLING

In characterization of filter cake samples in the pilot plant treatability study, it was found that the sludge did not contain heavy metals in high enough concentrations to be considered a hazardous waste based on the Resource Conservation and Recovery Act (RCRA) Extraction Procedure (EP) toxicity tests. However, the sludge was found to contain low amounts of radioactive contaminants and it was therefore anticipitated that the sludges would be handled as Low Specific Activity (LSA) wastes. EP toxicity tests and radionuclide analyses have been conducted on the actual sludge produced at the NRWTP with similar results as shown in Tables 2.5, 2.6, and 2.7.

Radiation field intensity on the surface of the sludge containers as measured by ORNL Radiation Protection representatives has varied from 0.2 to 1.0 mr/hr which is far below the K-25 Waste Acceptance Criteria limit of 50 mr/hr and the Department of Transportation limit of 200 mr/hr for LSA waste. A total of 672 cubic feet of waste sludge has been produced since February 1990. Further testing of the sludges is being performed using the Toxicity Characteristic Leaching Procedure (TCLP), now required by the EPA, to verify the non-hazardous nature of these sludges.

4.9 EFFLUENT TOXICITY MONITORING

As required in Part V of the existing ORNL NPDES permit, toxicity testing has been conducted every two months since February 1990. The required 7-day chronic tests were conducted using both *Ceriodaphnia* and fathead minnows. In all of the seven tests conducted, the no-observed-effect-concentration (NOEC), the highest tested concentration causing no reduction in survival or reproduction of *Ceriodaphnia* was 100 percent. In the case of the fathead minnow, the NOEC for survival and growth was also 100 percent in every case.

5.0 DESIGN IMPROVEMENTS AND FUTURE ACTIVITIES

Many design improvements have been made during the first year of plant operation to improve performance and safety at the NRWTP. In addition to these, there are plans for future upgrades which will more fully utilize the NRWTP systems for process wastewater treatment.

5.1 PHASE 1 IMPROVEMENTS

In April 1990, a group of miscellaneous design improvements were identified and implemented in a package designated "Phase 1 Improvements". The design improvements included the following:

1) Rerouting of air release valve discharge lines on the GAC columns and DM filters to the trench drain.

2) Installation of a platform for access to the top of the caustic tank F-1025.

3) Platform improvements for maintenance in the filter press room.

4) Rerouting the air stripper acid wash discharge to the diked area sump.

These improvements enhanced the safe operation of the plant and reduced the risk of accidental uncontrolled release of wastewater. The Phase 1 improvements were complete in November 1990.

5.2 SULFURIC ACID SYSTEM

The problem experienced with the sulfuric acid system is still under investigation. The source of the sludge which plugged the transfer line from the holding tank to the effluent tank F-1021 is yet to be determined. The transfer line has been replaced with a 316 L stainless steel line and the flow of acid through the line has gone uninterrupted for several weeks. In removing the old carbon steel line, visual inspection revealed that the line was plugged along the entire length and that the pipe walls had not undergone significant thinning. This would indicate that the source of the sludge may be the holding tank. The holding tank has been inspected by ORNL Quality Assurance personnel and no significant thinning of the tank walls was detected. Since there is little evidence of excessive corrosion of transfer lines or the holding tank, it is suspected that the acid, as supplied, may have contained large amounts of sludge. Samples of the suppliers acid, however, were not obtained in the past on a routine basis and recent samples do not appear to have a high sludge content.

The tank contents must be inspected to determine the amount of sludge present, however, breaching of a sulfuric acid holding tank for inspection and cleaning is a major undertaking. All the acid must be removed and the tank must be redried before reloading with acid. Safety and work procedures must be extensive and very carefully prepared. At the present time, the volume of acid in the tank is being reduced to a minimum with normal usage. In addition, options are being investigated for inspection and detection of sludge in the tank using ultrasonic or sonar equipment. This equipment might be used to inspect the tank contents without breaching the tank.

5.3 IMPROVEMENT OF TRANSFER PUMP BASE STRUCTURES

During pre-startup checkout of NRWTP systems, vibration was noted in the vicinity of several wastewater transfer pumps. Though the vibration was not at a level that would have justified delay of plant startup, plans were made to modify and improve the base and support structures of the transfer pumps. These activities began in November, 1990 as a part of the Phase II Improvements project. The support structures of wastewater transfer pumps for equalization tanks F-1001 and F-1002, and the filter feed tank F-1008 were modified and improved to dampen vibration. The work was complete by January 1991.

5.4 EQUIPMENT ACCESS IMPROVEMENTS AND ROOF DRAIN REROUTING

Phase II improvements also included addition and modification of equipment access structures and rerouting of roof drains from the NRWTP plant sump to a storm drain location. These activities improve the safety of maintenance activities and prevent unnecessary treatment of the rainwater runoff from the roof of building 3608. Modifications to existing access ladders were performed and additional access platforms were constructed for several areas of the plant. The access ladder for tank F-1001 was modified to improve the safety of two ladder platforms. Platforms with handrails were added for maintenance activities for the HVAC system located over the control room and restroom areas in building 3608. The roof drains for building 3608 were modified to divert the rainwater from the plant sump to a storm drain and a Category II outfall at White Oak Creek. These improvements were completed in January 1991.

5.5 REACTOR CLARIFIER MODIFICATIONS

A General Plant Project is currently being planned for increasing the wastewater feed capacity of the PWTP, which treats wastewater for removal of trace quantities of radioactive contaminants and discharges effluent to the NRWTP non-metals equalization tank F-1002. The plan involves making use of the extra capacity of the NRWTP metals treatment system by modifying one of the two reactor clarifiers and using it to soften radiological process wastewater prior to ion-exchange treatment. The existing softener/clarifier at the PWTP limits the throughput of the plant. The metals wastewater currently generated for treatment at the NRWTP would be combined with the radiological wastewater in tank F-1001. The softening reaction will be performed at a wastewater pH of 11.5 which is suitable for removal of heavy metals. The existing reactor clarifier will be modified to allow operation as a sludge-blanket clarifier. This will involve installation of internals which will provide a larger slow-mix zone and an up-flow sludge blanket zone. The effluent from the modified reactor clarifier will be transferred to the PWTP for ion-exchange treatment. The additional quantities of sludge generated at the NRWTP will be handled using the existing sludge holding tank and filter press. The current schedule for this upgrade shows construction beginning in late 1992 or early 1993.

6. SUMMARY AND CONCLUSIONS

During the first year of operation, the NRWTP received and successfully treated 168.4 million gallons of process wastewater. With the help of effective training programs and operating procedures, the plant operating staff has successfully brought the plant on-line and maintained its operation with a minimum of errors. The system has performed very well despite some equipment problems that were encountered. None of the former NPDES permit limits were violated and wastewater effluent toxicity studies indicate no detrimental effect to aquatic life. Some changes were necessary to improve operation of the metals removal system due to the change in feedwater conditions. Based on analytical results, there was no basis for changing the operating conditions of either the air stripper or the GAC system. Sludge handling systems, likewise, have operated in an acceptable manner. Many design improvements have been provided which have enhanced employee safety and plant reliability. Safety will continue to be a top priority in operation of the plant. Optimization activities will not end with completion of this report, but will continue as an ongoing process to ensure the highest possible wastewater quality and to respond effectively to addition of new feed wastewaters and changing wastewater conditions.

7. REFERENCES

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