NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

# POST-CLOSURE MONITORING AND MAINTENANCE PLAN

VAN DER HORST PLANT NO. 1 SITE
CITY OF OLEAN, CATTARAUGUS COUNTY
CONTRACT NO. D003962
SITE NO. 9-05-008

April 2000

New York State Department of Environmental Conservation
GEORGE E. PATAKI, *Governor* JOHN P. CAHILL *Commissioner*

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# SECTION 1

## INTRODUCTION

This document presents a monitoring and maintenance operations plan for post-closure activities at the Van der Horst Plant #1(VDH#1) site which complies with the requirements set forth under New York Codes, Rules and Regulations, Title 6 (6 NYCRR), Part 360-2.15(k)(7). The plan describes groundwater monitoring, site cover inspection and maintenance, contingency plans, and reporting requirements. This plan also contains detailed instructions to be used by site personnel to assure efficient monitoring, groundwater sampling and analysis, and maintenance of facility components for a minimum period of 30 years after site closure.

## 1.1 PROJECT BACKGROUND

The Van Der Horst Plant No. 1 site consists of a 1.5-acre former industrial facility located within the northern section of the city of Olean, Cattaraugus County, New York. The property is bounded by a developed residential neighborhood on its north, east and south, by a railroad track on its west and by an industrial area on its west and southwest. The topography of the site is generally flat with the exception of the east side of the site which slopes gently to the east towards the residential area. Surface runoff from the site drains to the city's storm sewer system or percolates through the soil. The nearest surface water is Olean Creek which is approximately 0.25 miles east of the site. The Allegheny River is approximately 1.5 miles south of the site.

The Van Der Horst Corporation began chromium electroplating operations at Plant No. 1

in the early 1940s. There are two reported instances of subsurface process wastewater disposal at the plant site. One account has described a one-time dumping of iron-contaminated chromic acid into a shallow hole sometime during the early 1940s. Also, reference is made in the files of the County Health Department to an on-site wastewater disposal well, which was in operation until approximately 1952.

Since 1952, the process wastewater from the plant was discharged to the sewer system without any pretreatment. Until 1951, the plant used city water for its processes and other needs. In 1951, a 46-foot deep production well was installed on the Site. The County Health Department reported that this process supply well was found to be heavily contaminated with chromium by 1959. Use of this well was discontinued in 1960. In 1962, a new 91-foot deep process well was installed. Manufacturing operations at Plant No. 1 were ceased in July 1987.

In 1984, Plant No. 1 was listed on the NYSDEC Registry of Suspected Hazardous Waste Sites. In 1986, the Corporation received a proposed Order of Consent from the NYSDEC in reference to the facility's continued air releases through their stack emissions. In January 1987, the Corporation signed the Consent Order calling for a $5,000 fine and modifications to the emission control equipment.

In 1989, a summary abatement order was issued by NYSDEC to Van Der Horst Corporation stating that the physical conditions, due to chemical contamination at the Plant, constituted an imminent and substantial danger to public health and the environment. At the administrative hearing, held to review the case, substantial evidence was presented by the Van der Horst Corporation to prove that the company lacked financial resources to undertake remedial activities, thus making it necessary for the State to do so. Funds from the 1986 Environmental Quality Bond Act were subsequently used to investigate the site.

In 1989, another summary abatement order was issued requiring the immediate removal and disposal of large volumes of corrosive plating solutions and other hazardous substances which remained at Plant 1. The company responded with a proposed closure plan which fell short of requirements for closure, but did include financial statements which demonstrated that the company lacked financial resources to undertake the necessary activities for adequate closure. The NYSDEC requested USEPA to take action immediately because of the imminent threat posed by improperly stored chemicals inside the plant building. The chemicals inside the building were properly characterized, packaged, and removed. The removal action completed by USEPA eliminated the threat posed by the various chemicals and spent solutions which were improperly stored inside Plant No. 1.

In 1989, the NYSDEC contracted with ERM-Northeast to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Site. The RI for the Site was done in three phases. Phase 1 involved sampling and analyzing the surface and subsurface soil, ground water, and Olean Creek sediments. Soil samples from the backyards of the residences adjacent to the Site were also taken during the Phase I RI. The samples were analyzed for volatile, semi-volatile and metals. The major contaminants detected were:

- chromium, lead and arsenic in soil/sediment; and
- chromium, lead, and tetrachloroethylene in ground water.

These contaminants were determined to be associated with the past Plant activities.

The Phase III RI focused mainly on the investigation of the building interior at the Plant. Several monitoring wells and borings were drilled inside the building to collect and analyze ground water and subsurface soil samples. At several places inside the building, wipe and dust samples were collected for chemical analysis. The results of these analysis showed that the soil and ground water beneath the building are contaminated with chromium, lead, arsenic and a few volatile organic compounds. Some of the pipelines inside the building were found to have asbestos insulation.

The highest chromium concentration detected in Plant No. 1 surface soil was 585,000 parts per million (ppm).

In March 1992, a Record of Decision (ROD) was executed for Van Der Horst Corporation Plant No.1.

The selected remedy for the for Plant No. 1 site consists of:

1. Plant building decontamination.

2. Asbestos removal from the building and off-site disposal.

3. Plant building demolition and off-site disposal.

4. Olean Creek sediment removal.

5. Storm sewer cleaning and sediment removal.

6. Surface and subsurface soil removal, on-site solidification and placement.

7. Site restoration.

8. Possible ground water recovery, treatment, and discharge to the local POTW pending the results of groundwater monitoring following the removal of contaminated soil from the property.

9. Long-term ground water monitoring for 30 years.

Remedial tasks nos.1 through 3 were completed in September 1995. Remedial tasks nos. 4 through 7 were completed in October 1997. The Work described in this report covers additional remedial work that was initiated due to the discovery of an additional mass of highly contaminated subsurface soils during the previous phase of site work.

The Scope of Work for this Contract addressed the following remedial items for Plant No.1:

- Excavation and off-site disposal of approximately 4,700 cubic yards of on-site soils.
- Pumping and treating 3 million gallons of contaminated groundwater from the excavation prior to backfill.
- Backfill and restoration of excavated area.

## 1.2 POST-CLOSURE SITE CONDITION

The Van der Horst Plant #1 Site was remediated in several phases between 1994 and 1999. The activities completed during the remediation of the site complied with the remedial tasks outlined above in the Record of Decision The major element of the remedial activities consisted of the demolition of all plant buildings and structures, removal of contaminants in Olean Creek and the excavation of all known areas of the site that contained soil values that exceeded the clean-up goals of the project. Clean up goals for the site were established for total chromium in surface soil (0 to 15 feet below grade) of 50 mg/kg and subsurface soils (greater than 15 feet below grade) of 500 mg/kg. All areas of contaminated soil and sediment that had been identified by NYSDEC through the Remedial Investigation and the construction activities was excavated and disposed off-site at a permitted disposal facility with the exception of accumulated sediment within the flood control levee along Olean Creek. Minor amounts of contamination remain in place within the levee structure. The specifics of this portion of the project can be found in the report entitled, *Remediation Summary Report, Soil Excavation and Site Restoration Project, Van der Horst Plant #1 Site, Contract No. D003494*, NYSDEC dated March 1998. The site was fully revegetated to control erosion. No fence was installed on the site so there are no access controls in place (Appendix A Record Drawings). Specific details of remedial activities can be found in the report entitled "*Remediation Summary Report, Van der Horst Plant #1 Site, Contract No. D003494*", NYSDEC, dated March 2000.

## 1.3 ORGANIZATION OF MONITORING AND MAINTENANCE PLAN

This plan is organized into five sections, including this introduction (Section 1). Section 2 provides a description of groundwater monitoring; Section 3 provides a description of site cover and drainage system inspections and correction procedures; Section 4 is a contingency plan; and Section 5 provides information on record keeping and the various reports that must be submitted. As-built drawings, a site health and safety plan, and post-closure inspection and maintenance report forms for post-closure field activities are contained in Appendices A, B, and C, respectively.

## SECTION 2

## GROUNDWATER MONITORING

### 2.1 GENERAL

Groundwater monitoring will be a routine part of the VDH site post-closure operations. The following subsections will describe the procedures for sampling monitoring wells, analysis of samples, and evaluation of sample results.

### 2.2 MONITORING WELL LOCATIONS

All existing wells are shown in Appendix A - Final Site Survey, and Figure C.2 - Monitoring Well Location Plan and include a total of eleven monitoring wells. The wells were installed during the Remedial Investigation conducted from 1989 to 1993 and during remedial project from 1994 to 1999. The wells to be sampled as part of this plan include two representative off-site upgradiant wells (MW-1s & 12s) and nine downgradient wells ( Onsite - MW-5s, 5d, 17s, 17d, ) and (Off-site MW- 7d, 11s, 11d, 19d, & 30s). Information regarding the wells is provided in Table C.1 & C.5. A total of twenty-nine (29) monitoring wells have been installed at the site or on contingent properties for the long term monitoring of this project. As per this plan all wells are to be sampled once per year for the first two years of post remediation monitoring. With the exception of the first two year monitoring these other monitoring wells will remain available on the site but will not be included in the long term sampling plan unless sampling data indicates that a change in monitoring locations is warranted. The plan may be changed at any time to address changes in hydrogeologic conditions encountered as part of this monitoring program. All monitoring wells constructed for the project are shown in the respective figures and the available construction data is included in this report in the appropriate sections.

## 2.3 GROUNDWATER SAMPLING AND ANALYSIS

### 2.3.1 Frequency of Sampling

Groundwater sampling and analysis of eleven (11) site wells will be conducted quarterly the first two years and annually thereafter, depending on the analytical results. The eleven wells will effectively monitor contaminant migration in all directions from the site. Should a well yield repeated high contaminant levels or a sudden rise in contamination, the well may be monitored quarterly in lieu of annually upon approval from the NYSDEC project manager. Additional site wells may be added if needed. In addition, all wells (29) are to be sampled once per year for the first two years of post remediation monitoring.

### 2.3.2 Sample Container Preparation

Sample containers will be properly washed and decontaminated by the laboratory prior to use. The containers will be tagged and Chain of Custody initiated before shipping to the sampling site in coolers. The types of containers and preservation techniques are shown in Table C.2. All bottles will need to have preservatives, added prior to being filled. Following sample collection, the bottles will be placed on ice in the shipping cooler. The samples will be cooled to 4°C but not frozen.

### 2.3.3 Field Procedures

The following is a step-by-step sampling procedure to be used to collect the groundwater samples. Well sampling procedures will be recorded on the form shown on Table C.1.

- Assemble all field equipment necessary for sample collection (Table C.3).
- Inspect equipment to ensure it is working properly.
- Select up gradient well (ex. MW-1s) as the initial sampling location.
- Prior to purging and sampling, measure the static water level from the surveyed well elevation mark on the top of the casing with a water level indicator. Water levels will be measured to nearest 0.01 foot and recorded on the Groundwater Sampling Record (Table C.1).
- Decontaminate the water level indicator. (See Section 2.3.4 for decontamination procedures.)
- Purge the well by removing a minimum of three well volumes of water. Purging will be conducted with a bailer or a stainless steel centrifugal pump (Grundflos® pump) and dedicated polyethylene tubing. The centrifugal pump will be equipped with a gate valve on its discharge. If the well goes dry before the required volumes are removed, the well

may be sampled when it recovers sufficiently. The purged water from all on-site wells should be collected and disposed of in the Sanitary sewer located on Vine Street adjacent to the site. Purged water from off-site wells may be disposed on the ground surface a minimum of ten feet away from the well in a downhill location. *Sample collection must be performed within 24 hours of purging the well.*

- Collect samples from each well with a dedicated bailer lowered by a dedicated nylon line. Temperature, conductivity, dissolved oxygen, pH, and turbidity will be measured, and sample description and location noted on the Groundwater Sampling Record (Table C.1). Specific conductance and pH will be measured by precalibrated electronic probes. Temperature will be measured by a precalibrated probe or thermometer.

- Fill sample containers to be analyzed for chromium(t), parameter. Sample containers will be labeled in accordance with historic monitoring well titles shown on Figure 2.1. *Care should be taken to obtain a sample with the least amount of turbidity possible (<50 ntu).*

- The groundwater samples will be placed in a laboratory cooler, packed on ice and driven directly to or shipped overnight to the laboratory. Quality assurance blanks will be sent with each sample shipment. Chain-of-Custody procedures will be strictly followed as outlined in Section 2.3.5.

### 2.3.4 Equipment Decontamination

Prior to sampling equipment use, and between sampling points, all non-dedicated equipment (bailers, water-level indicators, etc.) coming in contact with well water will be properly decontaminated. The decontamination procedure is as follows: (Water-level indicator is used as an example.)

- Thoroughly clean the water-level indicator with a biodegradable detergent, such as Alconox and tap water.
- Triple rinse the water-level indicator with distilled water.
- Allow water-level indicator to air dry or wipe dry using disposable paper towels.
- Wrap water-level indicator in aluminum foil or place in clean plastic bag so that no outside contaminants are introduced.
- Between rinses, equipment will be placed on polyethylene sheets or aluminum foil if necessary. At no time will washed equipment be placed directly on the ground.

To prevent cross-contamination between wells, separate bailers and rope will be used for each well.

### 2.3.5 Field Sample Custody

Evidence of sample traceability and integrity is provided by Chain-of-Custody (COC) procedures. These procedures document the sample traceability from the selection and preparation of the sample containers by the laboratory, to sample collection, to sample shipment, to laboratory receipt and analysis. A sample is considered to be in a person's custody if the sample is:

- In a person's possession;
- Maintained in view after possession is accepted and documented;
- Locked and tagged with Custody Seals so that no one can tamper with it after having been in physical custody; or
- In a secured area which is restricted to authorized personnel only.

A COC record (Figure C.2) accompanies the sample containers from selection and preparation at the laboratory, during shipment to the field for sample containment and preservation, and during return to the laboratory. Triplicate copies of the COC must be completed for each sample set collected.

The COC lists the field personnel responsible for taking samples, the project name and number, the name of the analytical laboratory to which the samples are sent, and the method of sample shipment. The COC also lists a unique description of every sample bottle in the set. If samples are split and sent to different laboratories, a copy of the COC record will be sent with each sample.

The REMARKS space is used to indicate if the sample is a matrix spike, matrix spike duplicate or matrix duplicate. Since they are not specific to any one sample point, trip and field blanks are indicated on separate rows. Once all bottles are properly accounted for on the form, the sampler will write his or her signature and the date and time on the first "RELINQUISHED BY" space. The sampler will also write the method of shipment, the shipping cooler identification number, and the shipper air bill number on the top of the COC. Mistakes will be crossed out with a single line and initialed by the author.

One copy of the COC is retained by sampling personnel and the other two copies are put into a sealable plastic bag and taped inside the lid of the shipping cooler. The cooler lid is closed, custody seals provided by the laboratory are affixed to the latch and across the back and front lids of the cooler, and the person relinquishing the sample signs his name across the seal. The seal is taped, and the cooler is wrapped tightly with clear packing tape. It is then relinquished by field personnel to personnel responsible for shipment, typically an overnight carrier. The COC seal must be broken to open the container. Breakage of the seals before receipt at the laboratory may indicate tampering. If tampering is apparent, the laboratory will contact the designated person, and the sample will not be analyzed.

### 2.3.6 Sample Analysis

As required in 6NYCRR Part 360-2.11(c)(5)(ii)(a), groundwater will be analyzed for routine parameters (Table 2.1). The following table illustrates the proposed routine sampling plan for the site:

| Time period | Frequency | Parameters | Locations |
|---|---|---|---|
| First Year<br>(3 monitoring events) | Quarterly | Cr(T)<br>TRPH (shallow wells only) | Upgradiant - MW-1s & 12s<br>Downgradient wells -<br>Onsite - MW-5s, 5d, 17s, & 17d,<br>Off-site MW- 7d, 11s, 11d, 19d, & 30s |
| Second Year<br>(3 monitoring events) | Quarterly | Cr(T) | Downgradient wells -<br>Onsite - MW-5s, 5d, 17s, & 17d,<br>Off-site MW- 7d, 11s, 11d, 19d, & 30s |
| First & Second Year<br>(1 monitoring event each year) | Annual | Cr(T) | Upgradiant - MW-1s, 1d, 8s, 10s, 12s, 13s & 15s<br>Downgradient wells -<br>Onsite - MW-4s, 5s, 5d, 16s, 17s, & 17d,<br>Off-site MW- 7d, 9s, 9d, 11s, 11d, 11vd, 14s, 19s, 19d, 20s, 20d, 20vd, 21s, 21d, 21vd, & 30s |
| Third Year to completion of monitoring | Yearly | Cr(T) | Downgradient wells -<br>Onsite - MW-5s, 5d, 17s, & 17d,<br>Off-site MW- 7d, 11s, 11d, 19d, & 30s |

Note: Monitoring parameters and frequencies may be modified based on the outcome of the routine monitoring results.

Sampling will be conducted on quarterly basis for the first two years after completion of the remedial activities. There after, only an annual sampling event is anticipated which will vary by season (ie: spring, summer, fall, winter) to evaluate season groundwater changes.

After the first four rounds of analysis, the need for monitoring additional selected monitoring wells will be evaluated. If repeated low levels are also found in existing monitoring wells, reduced monitoring frequency may be evaluated in these wells.

After five years, the parameter list and monitoring well sampling locations will be reevaluated based on the post-closure sampling results.

Samples will be analyzed by a laboratory which is New York State Department of Health

(NYSDOH) Environmental Laboratory Approval Program (ELAP) approved in all categories of solid and hazardous waste and is certified for Contract Laboratory Protocols (CLP). Reduce laboratory deliverables ( Category A package in lieu of Category B) submittals maybe requested because of the long term sampling that will be conducted as part of this O&M plan. The number of samples to be analyzed annually are summarized in Table 2.3.

### 2.3.7 Quality Assurance/Quality Control

In addition to water samples collected from monitoring wells, and the sample port two types of "blanks" will be collected and submitted to the chemical laboratory for analysis. The blanks will consist of 750 ml plastic bottles, as follows:

a. Trip Blank - A Trip Blank are prepared before the sample bottles are sent by the laboratory. It consists of a sample of distilled, deionized water which accompanies the other sample bottles into the field and back to the laboratory. A trip blank will be included with each shipment of water samples, where sampling and analysis for volatile organic compounds is planned. The Trip Blank will be analyzed for volatile organic compounds as a measure of the internal laboratory procedures and their effect on the results.

b. Field Blank - Field Blanks are prepared by the laboratory before the sample bottles are sent to the field for use.

### 2.3.8 Health and Safety

A Health and Safety Plan is provided in Appendix B which includes information on chemical and physical hazards anticipated during maintenance and monitoring at the site, personnel protection and monitoring equipment, accident prevention and contingency plan, sample handling, monitoring well decommissioning, and decontamination.

### 2.3.9 Data Evaluation and Reporting

The results of each monitoring event will be summarized quarterly in a letter report. Analytical results will be evaluated quarterly with respect to background levels detected in monitoring wells during the Remedial Investigation, and applicable NYSDEC and NYSDOH standards and guidance values. Analytical results showing an increase in contamination must be reported to the NYSDEC project manager within 14 days of such determination. Background will be determined from the review of contaminant levels in upgradiant well (MWs-1s) and from the review of historical data (Table C.4).

An annual summary report will be prepared which compares background levels, individual sampling round results and applicable water quality standards. Included in the report will be a table with the following information:

- *Sample identification number*
- *Sample collection date*
- *Well identification including description of upgradiant wells*
- *Analytical results*

- *Method Detection Limits (MDL)*
- *Chemical Abstracts Service (CAS) numbers for all compounds*
- *Applicable water quality standards*

Delineation of samples with accedences of background levels, standards, guidance values, or statistical triggers.

A summary and discussion of all accedences of background levels, standards, values, or statistical triggers and any proposed modifications to the sampling and analysis schedule will also be included.

The NYSDEC office responsible for this project is:

Mr. Gerald Rider, P.E.
Chief, Operation, Maintenance & Support Section
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The NYSDEC office responsible for implementation of this program is:

Mr. Peter Buechi, P.E.
Regional Engineer - Environmental Remediation
New York State Department of Environmental Conservation
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Buffalo Albany, NY 14203-2999
(716) 851-7220

### 2.3.10 Contingency Monitoring Plan

This Contingency Monitoring Plan provides for increased water quality monitoring should an increase or migration of contaminants be determined. This plan has been developed in accordance with NYCRR Part 360-2.11(c)(5)(iii).

If increasing contamination for one or more routine parameters is found, then those affected monitoring wells will be sampled and analyzed for routine parameters during the next quarter and quarterly thereafter. The quarterly sampling will continue until the elevated parameter(s) is shown not to be site-derived, the contaminant release is remediated, or it is determined there is no threat to public health or the environment.

In addition, periodic sampling of all wells for the site may be conducted to assess the overall condition of groundwater within the project area. Additional sampling parameters that should be considered for analysis during these expanded sampling events would include:

Hexavalent chromium (cr+6)

Manganese (Mn)

Iron (Fe)

Total Recoverable Petroleum Hydrocarbons (TRPH) - Shallow wells only

# TABLE 2.1

## GROUNDWATER QUALITY ANALYSIS TABLE

| **FIELD PARAMETERS** | **METHOD** |
|---|---|
| Static water level (in wells) | x |
| Specific Conductance | 9050 |
| Temperature - °C | x |
| pH | 9040/9041 |
| Turbidity - ntu | x |

| **METALS/PETROLEUM** | |
|---|---|
| Chromium (total) | 218.2 CLP-M (d.l. < 10 ug/l) |
| Hexavalent Chromium ($Cr^{+6}$) | 218.4 CLP-M (d.l. < 10 ug/l) |
| Iron (total) | 236.12 CLP-M (d.l. < 10 ug/l) |
| Manganese (total) | 243.1 CLP-M (d.l. < 10 ug/l) |
| Total Recoverable Petroleum Hydrocarbons (TRPH) | 418.1 (IR Spectrophotometer)(d.l. < 5 mg/l) |

This list may be modified as needed.

All samples must be whole and unfiltered except as otherwise specified by the NYSDEC project manager.

1 Any unusual conditions (colors, odors, surface sheens, etc.) noticed during well development, purging, or sampling must be reported.

## TABLE 2.2

## NUMBER OF GROUNDWATER SAMPLES FOR LABORATORY ANALYSIS PER SAMPLING EVENT

| Parameter | No. Of Samples per event(1) Year 1 | No. Of Samples per event Year 2 + |
|---|---|---|
| Metals | 11 | 9 |
| TRPH | 4 | 0 |
| Duplicate | 1 | 1 |
| Field Blank | 0 (2) | 0 (2) |
| MS/MSD | 1 | 1 |
| Total | 17 | 11 |

(1) - 1 sample/each well for 11 wells sampled each quarterly event for chromium(t) + 1 sample/each shallow well for TRPH.

(2) - No field blanks will be collected on a routine basis unless laboratory contamination of glassware is suspected.

# SECTION 3

# POST CLOSURE LANDFILL CARE AND MAINTENANCE

## 3.1 INTRODUCTION

This section contains procedures for post-closure care and maintenance of the soil cover, drainage structures and other site items. It should be noted that because the source contamination has been removed from the site, no formal cap structure was installed as part of the final remedy. The current cover consists of a simple vegetative cover (residential grass mixture) over a 6 inch topsoil layer. A typical storm drainage inlet (D.I.), that is connected to two typical concrete seepage pits, were installed to collect surface water and discharge it below grade. Specific procedures include routine inspections, routine maintenance, and contingency actions.

## 3.2 ROUTINE INSPECTIONS

The site will be inspected quarterly throughout the post-closure period in conjunction with the sampling events. The site will also be inspected following particularly heavy storm events, e.g. a 10-minute, 2-year frequency storm. After the two years has been completed inspection is to be performed when site groundwater sampling is conducted or at a minimum of once per year.

The site will be inspected for:

- visible debris, litter and waste;
- loss of vegetative cover;

- integrity of drainage system including:
  - clogging of swales and drop inlet covers;
  - sediment build-up;
  - pooling or ponding;
- integrity of groundwater monitoring wells (to be inspected during sampling);
- integrity of soil/Cap cover including:
  - erosion or settling of cover material;
  - animal borrows
  - woody vegetation.

A site inspection map, post-closure inspection checklist, well inspection checklist, and maintenance schedule are contained in Appendix D. The site plan is to be used to document problems and indicate areas that require attention.

## 3.3 ROUTINE MAINTENANCE

### 3.3.1 Soil Cover Maintenance

- Monitor site vegetation progress to annually confirm that the desired grass species have become established and that the desired ground cover is forming. Reseed and retreat local spots if the vegetation fails to become established by the end of the second growing season.
- Conduct annual ground inspections at the beginning of each summer to determine the status of woody plant species on the site surface.

- Mow the site surface once each year (no specific time), to control woody vegetation and promote short grass species.
- If woody plants are detected, remove the plants using one of the following methods:
    - For a small number of isolated individual plants, pull out the plants or cut them off at ground level by hand.
    - For more extensive areas involving hundreds of individual plants, remove the plants by mowing the area. Mowing should be deferred until after the grass cover has become firmly established and will not be damaged by mowing equipment.

Indications of erosion or other site maintenance problems detected during routine site inspections or following particularly heavy storm events will be corrected as soon as possible. Repairs of eroded areas will be made with materials and methods specified herein. If erosion of the topsoil layer is encountered, the repair action may include, but not be limited to, the following:

- Covering repaired areas with topsoil, as specified in the remedial construction Contract Documents (available at NYSDEC-Buffalo), to minimum thickness (min. 6 inches) and design grades; and
- reseeding and fertilizing in accordance with materials and application rates specified in Section 02220 Fill Materials, Topsoil, Seeding & Mulch of the Contract Documents (Appendix E).

If erosion is persistent in certain areas, alternate methods for maintaining soil and vegetative cover or erosion protection will be evaluated on a case-specific basis.

Spots barren of vegetation in the cap will be reseeded and fertilized as necessary.

Seed and fertilizer will be of the same type and quality as originally specified. Any undesirable species will be removed if their presence is suspected of deteriorating the integrity of the cap.

The need for cap repairs due to subsidence or settling will be determined based on an evaluation of whether the function of the cap in the affected area has been impaired. Should large areas appear to have settled or drainage is not occurring, a survey of the cover may be conducted to determine the extent and nature of the repairs. Bench marks, such as the monitoring wells, established during construction shall be used for the survey. Those areas where the function has been impaired will be repaired to ensure that the integrity of the site surface is maintained. Repair actions may include, but are not limited to:

- stripping and stockpiling topsoil from the affected area;
- regrading the affected area in accordance with the grading plan shown on the record drawings; and
- replacing topsoil, and reseeding and fertilizing to reestablish vegetative cover as described previously.

For animal control, follow these procedures:

- Conduct an annual site inspection for to look for woodchuck or other animal burrow or den entrances on the landfill. If den or burrow entrances are found, a program to trap, shoot, or otherwise remove the burrowing animal(s) will be implemented on a case-specific basis by the Department's Division of Natural Resources. Following removal of the burrowing animal(s), the entrances will be plugged and the bare areas will be reseeded and fertilized. Seed and fertilizer will be of the same type and quality as originally specified.

### 3.3.2 Maintenance of Site Structures

Maintenance activities will be performed as determined necessary based on routine inspections. During all maintenance activities, vehicle traffic crossing the site shall be kept to minimum so as not to rut the topsoil and damage the established grass cover.

### Drainage System Management

All elements of the drainage system including drainage swales, and drainage inlet will be maintained throughout the post-closure period. All elements will be inspected with sampling events as discussed in Section 3.2 or after severe rainfall events to verify the structures are intact and undisturbed, and that channels and discharge areas are free of obstructions which would impair the free flow of surface water run-off. In the event any of the structures are found to be damaged or incapable of conveying the design flows, repairs will be made as soon as practical. Any obstructions found in the swales will be immediately removed and channels regraded as necessary. Accumulated sediment will be removed from drainage structures as required to maintain required capacity and proper operation.

### Groundwater Monitoring Wells

Monitoring wells which are damaged such that representative ground water samples cannot be obtained will be repaired or replaced. Repair measures will be based on case-specific evaluation. Any well damaged beyond repair or rendered inoperative will be replaced with a new well of similar depth and construction. Detailed requirements for well installation and decommissioning are specified in Department Guidance documents (ie: 6 NYCRR Part 360) and Section 02670, Groundwater Monitoring Wells of the Contract Documents.

### Access Control

Their is currently no access restrictions to the site in the form of a gate or fencing. Barriers have been installed at the terminus of both Vine Street and Penn Street as a deterrent to prevent vehicular traffic from continuing on to the site. Request to repair these barriers should be made to the City of Olean, Public Works Department as needed.

# SECTION 4

# CONTINGENCY PLAN

## 4.1 INTRODUCTION

The objective of this contingency plan is to establish procedures for handling events which occur outside the scope of the routine maintenance. The contingency plan should be implemented following the identification of a site condition which is not covered by the routine maintenance plan. While it is highly unlikely that any condition would warrant implementation of this plan due to the simple nature of the site, it is none the less included for reference purposes.

Natural occurrences such as storms, drought and subsidence should be considered "expected occurrences" and are addressed under the routine maintenance program. Certain problems which cannot be reasonably expected to occur, such as earthquakes, are not addressed in this contingency plan.

The following problems are examples of occurrences which are not expected to occur, but may be discovered during a routine post-closure inspection:

- degradation of the soil cover integrity which may be a result of or indicated by:
    - soil erosion or other drainage problems; or
    - uncontrolled burrowing by pests.
- vegetative cover missing despite repeated efforts at revegetation;

The following guidelines are offered to determine when the contingency plan should be implemented and to determine possible corrective actions when responding to a contingency. All corrective actions, where appropriate, will be executed in a timely fashion after notifying the appropriate regulatory agencies.

## 4.2 FIRE

Fires at the site will be immediately reported to the local fire department. Appropriate response measures, including personnel safety, will be the responsibility of the fire department. Fires will be quenched according to approved fire department protocol. Damage to the surface drainage system or soil cover will be repaired where these systems have been compromised.

## 4.3 VANDALISM

Vandalism will be reported to the local law enforcement authorities. If vandals have gained entry to the site, appropriate measures may be taken to eliminate or restrict future access. Vandalism to monitoring wells will be repaired as appropriate on a case-specific basis.

Damage caused by off-road vehicles will be repaired where the damage is determined to have compromised the integrity of the soil cover or the function of the surface drainage system.

## 4.4 SEVERE EROSION AND COMPROMISE OF SOIL COVER INTEGRITY

Severe erosion of the soil cover, as well as the storm water management system will be repaired to original specifications. The cause of severe erosion will be investigated and remedial measures, if needed, will be developed and implemented accordingly.

## 4.5 UNAUTHORIZED DUMPING OR DISPOSAL

Unauthorized dumping or waste disposal will be reported to the NYSDEC and local enforcement officials. Appropriate measures will be taken to determine the waste characteristics, containment requirements and the necessary removal and disposal techniques. The waste will be removed and disposed of at an approved disposal facility, as appropriate. Efforts will be taken to eliminate further dumping and to restrict subsequent entry to the site. Persons found in the act of illegal dumping will be prosecuted according to the law and will be held responsible for all costs incurred in removing the waste.

## 4.6 QUALITY ASSURANCE/QUALITY CONTROL

To assure the performance of site inspection and maintenance, a reporting procedure has been established. A site inspection checklist is provided in Appendix C. The site inspection checklist was developed in accordance with the parameters identified in this section. The checklist will be completed after regularly scheduled site inspections and inspections following severe storms.

The monitoring and maintenance contractor and any future designated authority responsible for performing site inspections and supervising maintenance operations will be fully qualified (as determined by NYSDEC) to perform the work. The site inspection checklist and maintenance schedule will be completed under the supervision of a New York State licensed Professional Engineer. Maintenance and repair work shall conform to the requirements set forth in this Plan.

## EMERGENCY CONTACT LIST

| | |
|---|---|
| Olean Fire Department: | (716) 376-5677 or 911 |
| Olean Police Department | (716) 376-5685 or 911 |
| NYSDEC - Region 9 Office | (716) 851-7220 |
| NYSDEC - Albany Office | (518) 457-9280 |
| NYSDOH - Albany Office | 1-800-458-1158 |
| Cattaraugus County Department of Health | (716) 373-8050 |

# SECTION 5

# REPORTING AND RECORD KEEPING

## 5.1 INTRODUCTION

This section describes the reporting and record keeping that will be followed by the monitoring and maintenance contractor during the 30 year post-closure period. Groundwater data must be reported to NYSDEC on a quarterly basis. An annual report summarizing monitoring and maintenance activities will also be submitted to NYSDEC. Copies of the quarterly and annual reports will be sent to NYSDEC at each of the following locations:

Mr. Gerald Rider, P.E.
Chief, Operation, Maintenance & Support Section
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233-7010
(518) 457-0927

and

Mr. Peter Buechi, P.E.
Regional Hazardous Waste Engineer
New York State Department of Environmental
Conservation - Region 9
270 Michigan Avenue
Buffalo, New York 14203-2999

and

Dr. G. Anders Carlson

Director of Environmental Exposure

New York State Health of Department

2 University Place

Room 205

Albany, New York 12203-3399

## 5.2 QUARTERLY REPORTS

The quarterly report will include all of the quarterly groundwater data. The report outline will be based on the data reporting regulations in 6NYCRR Part 360-2.11(c)(4)(iv), including tables showing collection data, analytical results and applicable NYSDEC and NYSDOH standards and guidance values, a summary of contravention of water quality standards and a discussion of results.

## 5.3 ANNUAL REPORT

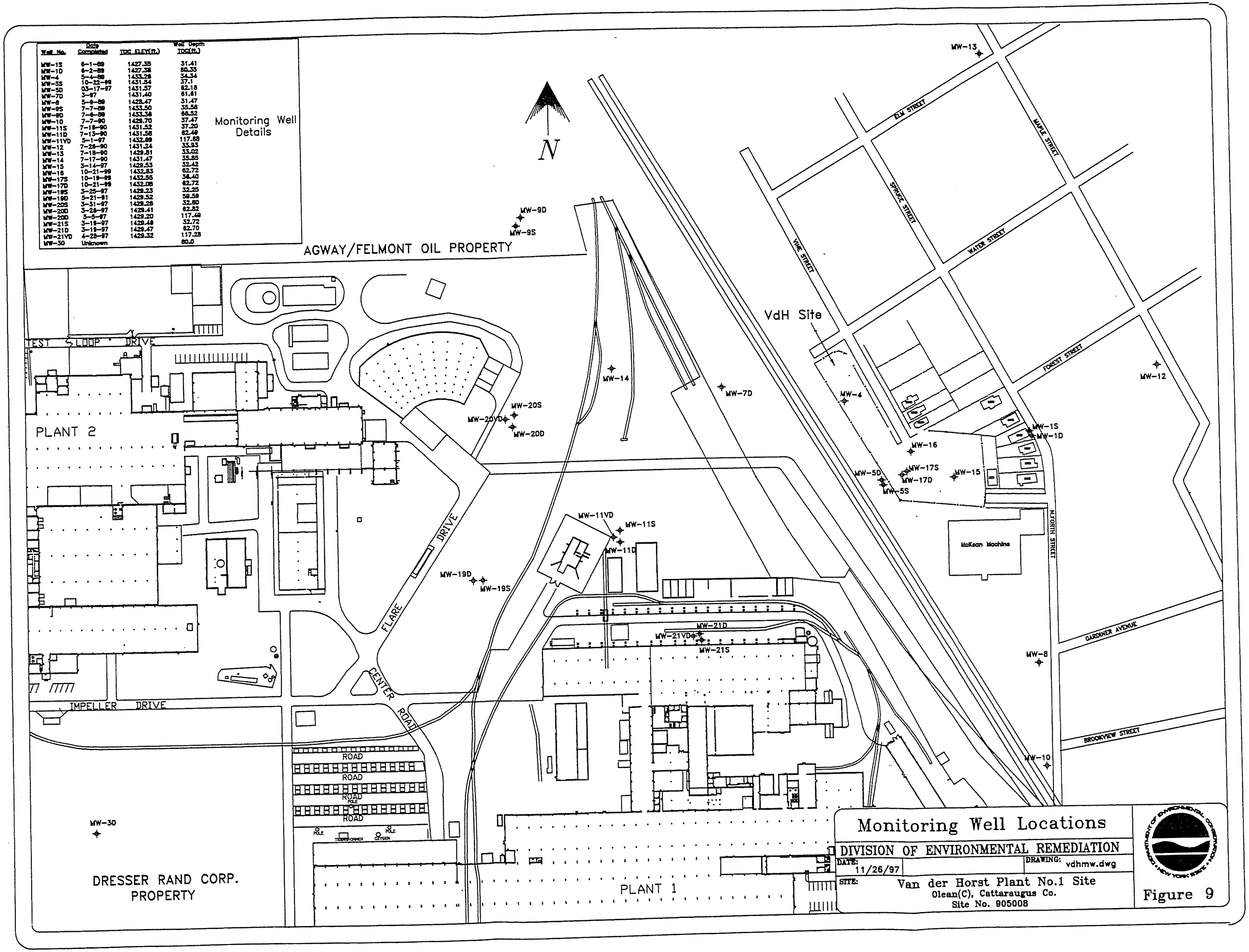
The annual report will contain a summary of water quality information from the quarterly reports with special note of any changes in water quality which have occurred throughout the year. The annual report will also summarize the inspection and maintenance activities on the cap and site structures for the year.

## 5.4 RECORD KEEPING

Records of data, drawings, and calculations concerning any work proposed or completed at the site are kept on permanent file by NYSDEC, Buffalo, New York. For example, wells will be monitored and data recorded on a data sheet. This and other investigative results are incorporated into reports that will be maintained by NYSDEC. Included in the reports are appendices with copies of data sheets, log books, and laboratory analysis results. A record of the cost for the monitoring and maintenance of the site should also be kept. The originals will be kept by NYSDEC or its contractor for performing maintenance and monitoring activities for at least five years.

# APPENDIX A

# RECORD DRAWINGS



Monitoring Well Details

| Well No. | Date Completed | TOC ELEV(ft.) | Well Depth TOC(ft.) |
|---|---|---|---|
| MW-1S | 6-1-89 | 1427.55 | 31.41 |
| MW-1D | 6-2-89 | 1427.38 | 60.35 |
| MW-4 | 5-4-89 | 1433.28 | 34.34 |
| MW-5S | 10-22-99 | 1431.84 | 37.1 |
| MW-5D | 03-17-97 | 1431.57 | 62.18 |
| MW-7D | 3-97 | 1431.40 | 61.61 |
| MW-8 | 5-9-89 | 1428.47 | 31.47 |
| MW-9S | 7-7-89 | 1433.50 | 35.58 |
| MW-9D | 7-6-89 | 1433.34 | 66.52 |
| MW-10 | 7-7-90 | 1428.70 | 37.47 |
| MW-11S | 7-18-90 | 1431.52 | 37.20 |
| MW-11D | 7-13-90 | 1431.58 | 62.49 |
| MW-11VD | 5-1-97 | 1432.89 | 117.68 |
| MW-12 | 7-28-90 | 1431.24 | 33.93 |
| MW-13 | 7-18-90 | 1429.81 | 33.02 |
| MW-14 | 7-17-90 | 1431.47 | 35.85 |
| MW-15 | 3-14-97 | 1429.53 | 32.42 |
| MW-16 | 10-21-99 | 1432.83 | 62.72 |
| MW-17S | 10-19-99 | 1432.55 | 38.40 |
| MW-17D | 10-21-99 | 1432.08 | 62.72 |
| MW-19S | 3-25-97 | 1429.23 | 32.25 |
| MW-19D | 3-21-91 | 1429.52 | 59.59 |
| MW-20S | 3-31-97 | 1429.28 | 32.80 |
| MW-20D | 3-28-97 | 1429.41 | 62.82 |
| MW-20D | 5-5-97 | 1429.20 | 117.49 |
| MW-21S | 3-19-97 | 1429.49 | 32.72 |
| MW-21D | 3-19-97 | 1429.47 | 62.70 |
| MW-21VD | 4-28-97 | 1429.32 | 117.28 |
| MW-30 | Unknown | | 80.0 |

# Monitoring Well Locations

DIVISION OF ENVIRONMENTAL REMEDIATION

DATE: 11/26/97

DRAWING: vdhmw.dwg

SITE: Van der Horst Plant No.1 Site
Olean(C), Cattaraugus Co.
Site No. 905008

Figure 9

VOLUMES

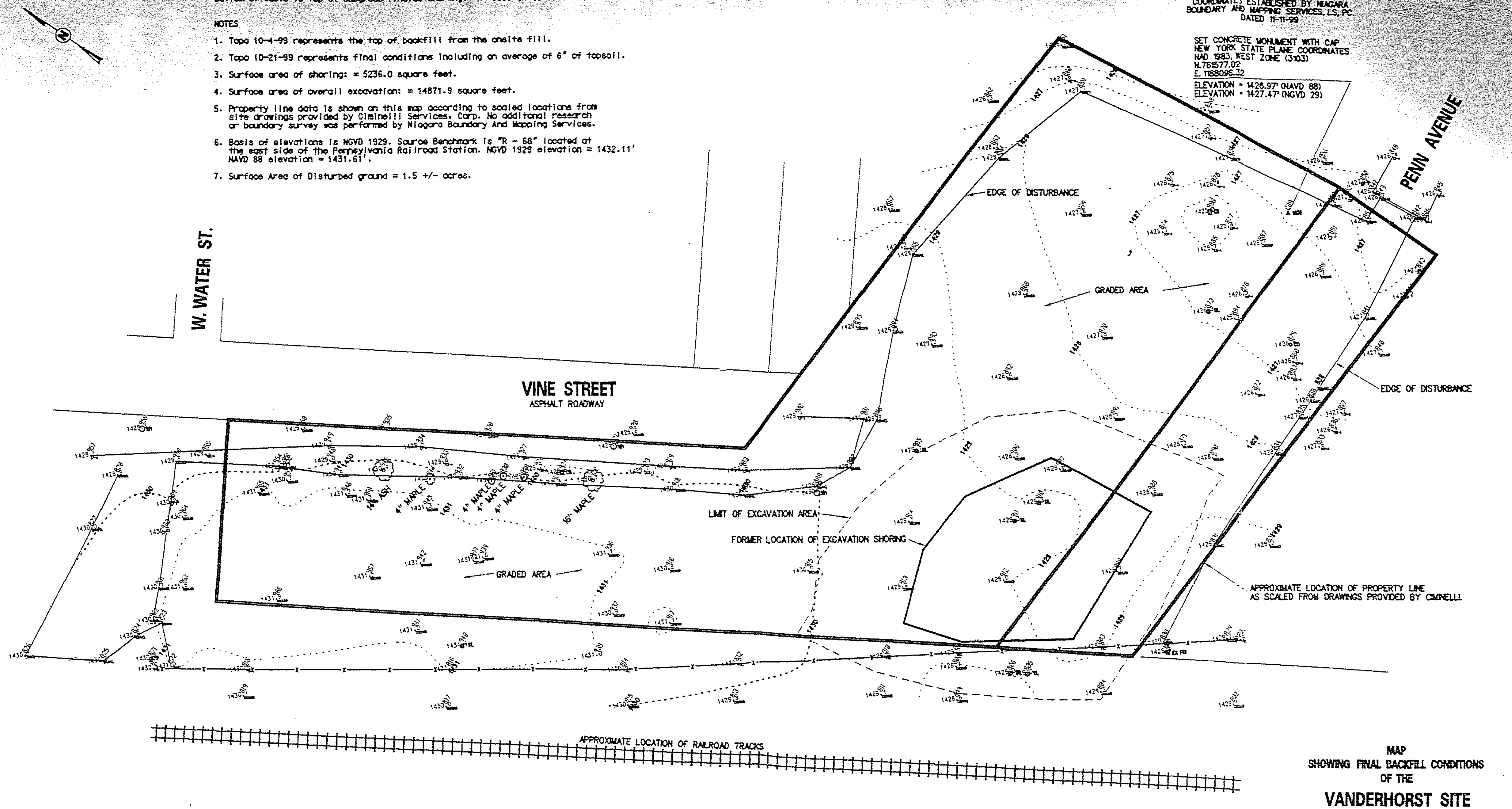
| | | |
|---|---|---|
| Off site fill (from topo 10-4-99 to subgrade) | 5344.5 | cu. Yds. |
| Total backfill from bottom of waste to top of shoring | 6199.0 | cu. Yds |
| Bottom of waste to top of subgrade (indide shoring) | 8098.6 | cu. Yds. |

NOTES

1. Topo 10-4-99 represents the top of backfill from the onsite fill.
2. Topo 10-21-99 represents final conditions including an average of 6" of topsoil.
3. Surface area of shoring: = 5236.0 square feet.
4. Surface area of overall excavation: = 14871.9 square feet.
5. Property line data is shown on this map according to scaled locations from site drawings provided by Ciminelli Services. Corp. No additonal research or boundary survey was performed by Niagara Boundary And Mapping Services.
6. Basis of elevations is NGVD 1929. Source Benchmark is "R – 68" located at the east side of the Pennsylvania Railroad Station. NGVD 1929 elevation = 1432.11' NAVD 88 elevation = 1431.61'.
7. Surface Area of Disturbed ground = 1.5 +/- acres.

COORDINATES ESTABLISHED BY NIAGARA BOUNDARY AND MAPPING SERVICES, LS, PC.
DATED 11-11-99

SET CONCRETE MONUMENT WITH CAP
NEW YORK STATE PLANE COORDINATES
NAD 1983, WEST ZONE (3103)
N.761577.02
E. 1188096.32
ELEVATION = 1426.97' (NAVD 88)
ELEVATION = 1427.47' (NGVD 29)



## MAP SHOWING FINAL BACKFILL CONDITIONS OF THE

## VANDERHORST SITE

PREPARED FOR: CIMINELLI SERVICES, INC.

(NOT TO SCALE)

20' 0 20' 40'

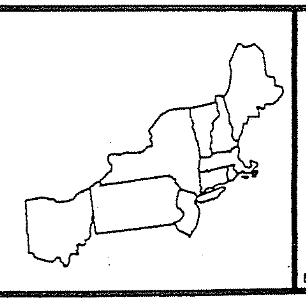
SCALE BAR
IN FEET

Niagara Boundary
And Mapping Services

4769 LOWER RIVER ROAD
LEWISTON, N.Y. 14092
(716) 754-2462

85 CENTRAL AVENUE
LANCASTER, NY 14086
(716) 685-8097

1185 EAST MAIN STREET
BRADFORD, PA. 16701
(814) 368-9526



THIS SURVEY IS CERTIFIED TO THE FOLLOWING PARTIES:

BY__________ LIC. NO.__________ DATE__________

"CERTIFICATIONS INDICATED HEREON SIGNIFY THAT THIS SURVEY WAS PREPARED IN ACCORDANCE WITH THE CODE OF PRACTICE FOR LAND SURVEYORS ADOPTED BY THE NEW YORK STATE ASSOCIATION OF PROFESSIONAL LAND SURVEYORS, AS AMENDED BY NIAGARA FRONTIER LAND SURVEYORS ASSOCIATION EFFECTIVE JANUARY 1, 1991. SAID CERTIFICATIONS SHALL RUN ONLY TO THE PARTY FOR WHOM THE SURVEY IS PERFORMED, AND IF REQUESTED ON THEIR BEHALF TO THE TITLE COMPANY, GOVERNMENTAL AGENCY AND LENDING INSTITUTION LISTED HEREON, AND TO THE SUCCESSORS AND/OR ASSIGNEES OF THE LENDING INSTITUTION. CERTIFICATIONS ARE NOT TRANSFERABLE TO ADDITIONAL INSTITUTIONS OR SUBSEQUENT OWNERS."

ABBREVIATIONS

EX. = EXISTING
MEAS. = MEASURED
REC. = RECORD
F.P. = FENCE POST
CONC. = CONCRETE
REP. = REPUTED
E. = EAST
N. = NORTH
W. = WEST
S. = SOUTH
L. = LIBER
P. = PAGE
R.O.W. = RIGHT OF WAY
A.K.A. = ALSO KNOWN AS

| LOT | SECTION | TOWNSHIP | RANGE |
|---|---|---|---|
| | | | |

| | |
|---|---|
| CITY | OLEAN |
| COUNTY | NIAGARA |
| STATE | NEW YORK |
| DATE | 10-21-99 |
| SCALE | 1" = 20' |
| JOB NO. | B535-99 |

NOTE: UNAUTHORIZED ALTERATION OR ADDITION TO THIS SURVEY MAP IS A VIOLATION OF SECTION 7209 PROVISION 2 OF THE NEW YORK STATE EDUCATION LAW.

NOTE: THIS SURVEY WAS PREPARED WITHOUT THE BENEFIT OF AN ABSTRACT OF TITLE AND IS SUBJECT TO ANY STATE OF FACTS THAT MAY BE REVEALED BY AN EXAMINATION OF SUCH.

"ONLY COPIES FROM THE ORIGINAL OF THIS SURVEY MARKED WITH AN ORIGINAL OF THE LAND SURVEYOR'S EMBOSSED SEAL SHALL BE CONSIDERED TO BE VALID TRUE COPIES."

THIS SURVEY WAS PREPARED FOR THE PARTIES AND PURPOSE INDICATED HEREON. ANY EXTENSION OF THE USE BEYOND THE PARTIES OR PURPOSE INDICATED IS EXPRESSLY FORBIDDEN WITHOUT WRITTEN RELEASE OR PERMISSION OF THE UNDERSIGNED.

[illegible]HOUPT, LIC. NO. 50349

| RESURVEYED | DATE |
|---|---|
| REVISED VOLUME | 12-15-99 |
| | |
| | |
| | |
| | |
| | |
| | |

SUBMAP REFERENCE:

CAD FILE NAME: B535-F.DGN

# APPENDIX B

# HEALTH AND SAFETY PLAN

# HEALTH AND SAFETY PLAN

## FOR

# POST CLOSURE MONITORING AND MAINTENANCE ACTIVITIES

## VAN DER HORST PLANT #1
## OLEAN, NEW YORK

SITE NO.905008

PREPARED BY:

NYSDEC - Region 9
Division of Environmental Remediation
270 Michigan Avenue
Buffalo, New York 14203-2999

April 2000

# TABLE OF CONTENTS

SECTION 1 - INTRODUCTION

SECTION 2 - RISK ANALYSIS

SECTION 3 - PERSONNEL PROTECTION AND MONITORING

SECTION 4 - WORK ZONES AND DECONTAMINATION

SECTION 5 - SAMPLE SHIPMENT

SECTION 6 - ACCIDENT PREVENTION AND CONTINGENCY PLAN

TABLES

# HEALTH AND SAFETY SUMMARY

## EMERGENCY CONTACTS

| | |
|---|---|
| Olean Fire Department: | (716) 376-5677 or 911 |
| Olean Police Department | (716) 376-5685 or 911 |
| NYSDEC - Region 9 Office | (716) 851-7220 |
| NYSDEC - Albany Office | (518) 457-7878 |
| NYSDOH - Albany Office | 1-800-458-1158 or (518)458-6309 |
| Cattaraugus County Department of Health | (716) 373-8050 |

## EMERGENCY PROCEDURES

Emergency procedures are described in Section 6.

## SITE SPECIFIC HAZARDS AND TRAINING

Site Specific Hazards and the History of the Site are described in Section 1.2.

The primary contaminants on the site are Trivalent ($Cr^{+3}$) and Hexavalent ($Cr^{+6}$) Chromium.

The Site Safety Officer will be responsible for providing site-specific training to all personnel that work at the site. This training will cover the following topics:

- Names of personnel responsible for site safety and health.
- Safety, health, and other hazards at the site.
- Proper use of personal protective equipment.
- Work practices by which the employee can minimize risk from hazards.
- Acute effects of compounds at the site.
- Decontamination procedures.

## GENERAL HEALTH AND SAFETY REQUIREMENTS

Personnel Protective Equipment

Level D protection will be worn for initial entry on-site and for all activities except as noted in Appendix F. Level D protection will consist of:

- Standard work clothes

- Steel-toe safety boots
- Safety glasses or goggles must be worn when splash hazard is present
- Nitrile outer gloves and PVC inner gloves must be worn during all sampling activities
- Hard hat (must be worn during all sampling activities)

## AIR MONITORING

No air monitoring will be required during the sampling activities. It should be noted that some wells have been reported to emit a slight hydrogen sulfide or petroleum odor during purging and sampling. Previous sampling at the site have detected only trace levels or non-detectable levels of either Volatile Organic or Semi Organic Compounds in groundwater at the site. The results of those sampling events can be reviewed in the Remedial Investigation Reports completed for the project.

# SECTION I
# INTRODUCTION

## 1.1 PURPOSE AND POLICY

The purpose of this safety plan is to establish personnel protection standards and mandatory safety practices and procedures. This plan assigns responsibilities, establishes standard operating procedures, and provides for contingencies that may arise while operations are being conducted at hazardous waste sites.

The provisions of the plan are mandatory for all on-site personnel. Any supplemental plans used by subcontractors shall conform to this plan as a minimum. All personnel who engage in project activities must be familiar with this plan, comply with its requirements, and sign the Plan Acceptance Form (Appendix B) prior to working on the site. The Plan Acceptance Form must be submitted to the Project Engineer which oversees the activities of this Site.

## 1.2 SITE DESCRIPTION

The Van Der Horst Corporation began chromium electroplating operations at Plant No. 1 in the early 1940s. There are two reported instances of subsurface process wastewater disposal at the plant site. One account has described a one-time dumping of iron-contaminated chromic acid into a shallow hole sometime during the early 1940s. Also, reference is made in the files of the County Health Department to an on-site wastewater disposal well, which was in operation until approximately 1952.

Since 1952, the process wastewater from the plant was discharged to the sewer system without any pretreatment. Until 1951, the plant used city water for its processes and other needs. In 1951, a 46-foot deep production well was installed on the Site. The County Health Department reported that this process supply well was found to be heavily contaminated with chromium by 1959. Use of this well was discontinued in 1960. In 1962, a new 91-foot deep process well was installed. Manufacturing operations at Plant No. 1 were ceased in July 1987.

In 1984, Plant No. 1 was listed on the NYSDEC Registry of Suspected Hazardous Waste Sites. In 1986, the Corporation received a proposed Order of Consent from the NYSDEC in reference to the facility's continued air releases through their stack emissions. In January 1987, the Corporation signed the Consent Order calling for a $5,000 fine and modifications to the emission control equipment.

In 1989, a summary abatement order was issued by NYSDEC to Van Der Horst Corporation stating that the physical conditions, due to chemical contamination at the Plant, constituted an imminent and substantial danger to public health and the environment. At the administrative hearing, held to review the case, substantial evidence was presented by the Van der Horst Corporation to prove that the company lacked financial resources to undertake remedial activities, thus making it necessary for the State to do so. Funds from the 1986 Environmental Quality Bond Act were subsequently used to investigate the site.

In 1989, another summary abatement order was issued requiring the immediate removal and disposal of large volumes of corrosive plating solutions and other hazardous substances which remained at Plant 1. The company responded with a proposed closure plan which fell short of requirements for closure, but did include financial statements which demonstrated that the company lacked financial resources to undertake the necessary activities for adequate closure. The NYSDEC requested USEPA to take action immediately because of the imminent threat posed by improperly stored chemicals inside the plant building. The chemicals inside the building were properly characterized, packaged, and removed. The removal action completed by USEPA eliminated the threat posed by the various chemicals and spent solutions which were improperly stored inside Plant No. 1.

In 1989, the NYSDEC contracted with ERM-Northeast to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Site. The RI for the Site was done in three phases. Phase 1 involved sampling and analyzing the surface and subsurface soil, ground water, and Olean Creek sediments. Soil samples from the backyards of the residences adjacent to the Site were also taken during the Phase I RI. The samples were analyzed for volatile, semi-volatile and metals. The major contaminants detected were:

- chromium, lead and arsenic in soil/sediment; and
- chromium, lead, and tetrachloroethylene in ground water.

These contaminants were determined to be associated with the past Plant activities.

The Phase III RI focused mainly on the investigation of the building interior at the Plant. Several monitoring wells and borings were drilled inside the building to collect and analyze ground water and subsurface soil samples. At several places inside the building, wipe and dust samples were collected for chemical analysis. The results of these analysis showed that the soil and ground water beneath the building are contaminated with chromium, lead, arsenic and a few volatile organic compounds. Some of the pipelines inside the building were found to have asbestos insulation.

The highest chromium concentration detected in Plant No. 1 surface soil was 585,000 parts per million (ppm).

In March 1992, a Record of Decision (ROD) was executed for Van Der Horst Corporation Plant No.1.

The selected remedy for the for Plant No. 1 site consists of:

1. Plant building decontamination.
2. Asbestos removal from the building and off-site disposal.
3. Plant building demolition and off-site disposal.
4. Olean Creek sediment removal.
5. Storm sewer cleaning and sediment removal.
6. Surface and subsurface soil removal, on-site solidification and placement.
7. Site restoration.
8. Possible ground water recovery, treatment, and discharge to the local POTW pending the results of groundwater monitoring following the removal of contaminated soil from the property.
9. Long-term ground water monitoring for 30 years.

Remedial tasks nos.1 through 3 were completed in September 1995. Remedial tasks nos. 4 through 7 were completed in October 1997. The Work described in this report covers additional remedial work that was initiated due to the discovery of an additional mass of highly contaminated subsurface soils during the previous phase of site work.

The Scope of Work for this Contract addressed the following remedial items for Plant No.1:

- Excavation and off-site disposal of approximately 4,700 cubic yards of on-site soils.
- Pumping and treating 3 million gallons of contaminated groundwater from the excavation prior to backfill.
- Backfill and restoration of excavated area.

## 1.3 PROJECT TEAM ORGANIZATION

The names of principal personnel associated with this project are:

- Project Manager: Michael J. Cruden (Albany)
- Project Engineer: Gregory P. Sutton (Buffalo)
- Site Safety Officer: David Szymanski
- Field Team Leader: David Szymanski

All personnel should be appropriately trained in first aid and hazardous waste safety procedures, including the operating and fitting of personal protective equipment, and are experienced with the field operations planned for the sites.

### 1.3.1 ON-SITE PERSONNEL AND RESPONSIBILITIES

#### PROJECT ENGINEER

Assumes total control over site activities. Reports to upper-level management (Project Manager). Has authority to direct response operations.

Responsibilities:

- Prepares and organizes the background review of the situation, the Work Plan, the Site Safety Plan, and the field team.
- Obtains permission for site access and coordinates activities with appropriate officials.
- Ensures that the Work Plan is completed and on schedule.
- Briefs the field teams on their specific assignments.
- Coordinates with the site health and safety officer to ensure that health and safety requirements are met.
- Prepares the final report and support files on the response activities.
- Serves as the liaison with public officials.

#### SITE SAFETY OFFICER

Advises the Project Engineer on all aspects of health and safety on site. Stops work if any operation threatens worker or public health or safety.

Responsibilities:

- Ensures that all necessary Health and Safety Equipment is available on-site. Ensures that all equipment is functional.
- Periodically inspects protective clothing and equipment.
- Ensures that protective clothing and equipment are properly stored and maintained.
- Controls entry and exit at the Access Control Points.

- Coordinates health and safety program activities with the Project Safety Officer.
- Confirms each team member's suitability for work based on a physician's recommendation.
- Monitors the work parties for signs of stress, such as cold exposure, heat stress, and fatigue.
- Implements the Site Safety Plan.
- Conducts periodic inspections to determine if the Site Safety Plan is being followed.
- Enforces the "buddy" system.
- Knows emergency procedures, evacuation routes, and the telephone numbers of the ambulance, local hospital, poison control center, fire department, and police department.
- Notifies, when necessary, local public emergency officials.
- Coordinates emergency medical care.
- Sets up decontamination lines and the decontamination solutions appropriate for the type of chemical contamination on the site.
- Controls the decontamination of all equipment, personnel, and samples from the contaminated areas.
- Assures proper disposal of contaminated clothing and materials.
- Ensures that all required equipment is available.
- Advises medical personnel of potential exposures and consequences.
- Notifies emergency response personnel by telephone or radio in the event of an emergency.

## FIELD TEAM LEADER

Advises the Project Manager on all aspects of health and safety on site. Stops work if any operation threatens worker or public health or safety. Responsible for field team operations and safety.

Responsibilities:

- Manages field operations.
- Executes the Work Plan and schedule.
- Enforces safety procedures.
- Coordinates with the Site Safety Officer in determining protection level.
- Enforces site control.
- Documents field activities and sample collection.
- Serves as a liaison with public officials.

# SECTION 2
# RISK ASSESSMENT

## 2.1 CHEMICAL HAZARDS

The chemical hazards associated with the site is presented in Appendix G.

## 2.2 RADIATION HAZARDS

No radiation hazards are known at the sites included in this project.

## 2.3 PHYSICAL HAZARDS

### 2.3.1 EXPLOSION

No explosive hazards are known to exist at this Site.

### 2.3.2 HEAT STRESS

The use of protective equipment may create heat stress. Monitoring of personnel wearing personal protective clothing should commence when the ambient temperature is 70°F or above. Table 2.1 presents the suggested frequency for such monitoring. Monitoring frequency should increase as ambient temperature increases or as slow recovery rates are observed. Heat stress monitoring should be performed by a person with a current first aid certification who is trained to recognize heat stress symptoms. For monitoring the body's recuperative abilities to excess heat, one or more of the following techniques will be used. Other methods for determining heat stress monitoring, such as the wet bulb globe temperature (WBGT) Index from American Conference of Governmental Industrial Hygienist (ACGIH) TLV Booklet can be used.

To monitor the worker, measure:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.
- If the heart rate exceeds 100 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
- If the heart rate still exceeds 100 beats per minute at the next rest period, shorten the following work cycle by one-third.
- Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
- If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.
- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following cycle by one-third.
- Do not permit a worker to wear a semipermeable or impermeable garment when oral temperature exceeds 100. 6°F (38.1°C).
- Prevention of Heat Stress - Proper training and preventative measures will aid in averting loss of worker productivity and serious illness. Heat stress prevention is particularly important because once a person suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat related illness. To avoid heat stress the following steps should be taken:
- Adjust work schedules.
- Modify work/rest schedules according to monitoring requirements. Mandate work slowdowns as needed.
- Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.

- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.

- Maintain worker's body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.d., eight fluid ounces (0.23 liters) of water must be ingested for approximately every eight ounces (0.23 kg) of weight lost. The normal thirst mechanism is not sensitive enough to ensure that enough water will be drunk to replace lost sweat. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

- Maintain water temperature 50° to 60°F (10° to 16.6°C).

- Provide small disposal cups that hold about four ounces (0.1 liter).

- Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.

- Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.

- Train workers to recognize the symptoms of heat related illness.

### 2.3.3 COLD-RELATED ILLNESS

If work on this project begins in the winter months, thermal injury due to cold exposure can become a problem for field personnel. Systemic cold exposure is referred to as hypothermia. Local cold exposure is generally called frostbite.

Hypothermia - Hypothermia is defined as a decrease in the patient core temperature below 96°F. The body temperature is normally maintained by a combination of central (brain and spinal cord) and peripheral (skin and muscle) activity. Interferences with any of these mechanisms can result in hypothermia, even in the absence of what normally is considered a "cold" ambient temperature. Symptoms of hypothermia include: shivering, apathy, listlessness, sleepiness, and unconsciousness.

Frostbite - Frostbite is both a general and medical term given to areas of local cold injury. Unlike systemic hypothermia, frostbite rarely occurs unless the ambient temperatures are less than freezing and usually less than 20°F. Symptoms of frostbite are: a sudden blanching or whitening of the skin; the skin has a waxy or white appearance and is firm to the touch; tissues are cold, pale, and solid.

Prevention of Cold-Related Illness - To prevent cold-related illness: Educate workers to recognize the symptoms of frostbite and hypothermia Identify and limit known risk factors: Assure the availability of enclosed, heated environment on or adjacent to the site.

Assure the availability of dry changes of clothing. Assure the availability of warm drinks.

Start (oral) temperature recording at the job site:

- At the Field Team Leader's discretion when suspicion is based on changes in a worker's performance or mental status.
- At a worker's request.
- As a screening measure, two times per shift, under unusually hazardous conditions (e.g., wind-chill less than 20°F, or wind-chill less than 30°F with precipitation).
- As a screening measure whenever any one worker on the site develops hypothermia.
- Any person developing moderate hypothermia (a core temperature of 92°F) cannot return to work for 48 hours.

# TABLE 2.1

## SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT AND ACCLIMATIZED WORK AREAS

| Adjusted Temperature[b] | Normal Work Ensemble | Impermeable Ensemble |
|---|---|---|
| 90°F (32.2°C) or above | After each 45 minutes of work | After each 15 minutes of work |
| 87.5-90°F (30.8-32.2°C) | After each 60 minutes of work | After each 30 minutes of work |
| 82.5-87.5°F (28.1-30.8°C) | After each 90 minutes of work | After each 60 minutes of work |
| 77.5-82.5°F (25.3 -28.1°C) | After each 120 minutes of work | After each 90 minutes of work |
| 72.5-77.5°F (22.5-25.3°C) | After each 150 minutes of work | After each 120 minutes of work |

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a For work levels of 250 kilocalories/hour.

b Calculate the adjusted air temperature (ta adj) by using this equation: ta adj OF = ta OF + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

c A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

# SECTION 3
# PERSONNEL PROTECTION AND MONITORING

## 3.1 MEDICAL SURVEILLANCE

Personnel involved in this operation must have undergone medical surveillance. Exams are to be conducted at 12-month intervals. The 12-month medical examination includes a complete medical and work history and a standard occupational physical, examination of all major organ systems, complete blood count with differential (CBC), and a SMAC/23 blood chemistry screen which includes calcium, phosphorous, glucose, uric acid, BUN, creatinine, albumin, SGPT, SGOT, LDH, globulin, A/G ratio, alkaline phosphatase, total protein, total bilirubin, triglyceride, cholesterol, and a creatinine/BUN ratio. Additionally a pulmonary function test will be performed by trained personnel to record Forced Vital Capacity (FVC) and Forced Expiratory Volume in second (FEVI.0). An audiogram and visual acuity measurement, including color perception, is provided The medical exam is performed under the direction of a licensed Occupational Health Physician. A medical certification as to the fitness or unfitness for employment on hazardous waste projects, or any restrictions on his/her utilization that may be indicated, is provided by the physician. This evaluation will be repeated as indicated by substandard performance or evidence of particular stress that is evident by injury or time loss illness on the part of any worker.

## 3.2 SITE-SPECIFIC TRAINING

The Site Health and Safety Officer will be responsible for developing a site specific occupational hazard training program and providing training to all NYSDEC personnel that are to work at the site. This training will consist of the following topics:

- Names of personnel responsible for site safety and health.
- Safety, health, and other hazards at the site.
- Proper use of personal protective equipment.
- Work practices by which the employee can minimize risk from hazards.
- Safe use of engineering controls and equipment on the site.
- Acute effects of compounds at the site.
- Decontamination procedures.

- Upon completion of site-specific training, workers will sign the Site-Specific Training Form.

## 3.3 MONITORING REQUIREMENTS

There is no specific health and safety monitoring associated or anticipated to be conducted during the routine maintenance and monitoring of the site.

## 3.4 PERSONNEL PROTECTIVE EQUIPMENT

### 3.4.1 LEVEL D

Level D protection will be worn for all on-site activities. Level D protection will consist of:

- Standard Work Clothes
- Safety boots with steel-toes
- Nitrile outer and PVC inner gloves (must be worn during all sampling activities)
- Hard hat (must be worn during drilling and excavation activities)
- Splash goggles or safety glasses (where splash hazard is present)

# SECTION 4
# WORK ZONES AND DECONTAMINATION

## 4.1 SITE WORK ZONES

To reduce the spread of hazardous materials by workers from the contaminated areas to the clean areas, work zones will be delineated at the site. The flow of personnel between the zones should be controlled. The establishment of the work zones will help ensure that personnel are properly protected against the hazards present where they are working, work activities and contamination are confined to the appropriate areas, and personnel can be located and evacuated in an emergency.

### 4.1.1 EXCLUSION ZONE

Exclusion zones will be established at the site for all sampling activities; unprotected onlookers should be located 50 feet upwind of sampling activities.

All personnel within the exclusion zone will be required to use the specified level of protection. No food, drink, or smoking will be allowed in the exclusion or decontamination zones. Contact lenses and cosmetics are not permitted on-site.

### 4.1.2 DECONTAMINATION ZONE

Should it be necessary to establish an exclusion zone, a decontamination zone will be utilized. This zone will be established between the exclusion zone and the support zone, and will include the personnel and equipment necessary for decontamination of equipment and personnel (discussed below). Personnel and equipment in the exclusion zone must pass through this zone before entering the support zone. This zone should always be located upwind of the exclusion zone.

### 4.1.3 SUPPORT ZONE

The support zone will include the remaining areas of the job site. Break areas, operational direction and support facilities (to include supplies, equipment storage and maintenance areas) will be located in this area. No equipment or personnel will be permitted to enter the support zone from the exclusion zone without passing through the personnel or equipment decontamination station. Eating, smoking, and drinking will be allowed only in this area.

## 4.2 DECONTAMINATION

Generally, any water used in decontamination procedures will be disposed of onsite due to the low level of contaminants expected at the sites.

### 4.2.1 DECONTAMINATION OF PERSONNEL

Decontamination will not be necessary if only Level D protection is used. However, disposable gloves used during sampling activities should be removed and bagged; personnel should be encouraged to remove clothing and shower as soon as is practicable at the end of the day. All clothing should be machine-washed. All personnel will wash hands and face prior to eating and before and after using the restroom.

### 4.2.2 DECONTAMINATION OF FIELD EQUIPMENT

Field Equipment decontamination procedures are discussed in Section 2.3.4 of the Post Closure Monitoring and Maintenance Plan.

# SECTION 5
# SAMPLE SHIPMENT

## 5.1 ENVIRONMENTAL SAMPLES

Samples collected in this study will be classified as environmental samples. In general, environmental samples are collected from streams, ponds, or wells and are not expected to be grossly contaminated with high levels of hazardous materials.

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample". The sample tag will be legibly written and completed with an indelible pencil or waterproof ink. The information will also be recorded in a log book. As a minimum, it will include:

- Exact location of sample
- Time and date sample was collected
- Name of sampler witnesses (if necessary)
- Project codes, sample station number, and identifying code (if applicable)
- Type of sample (if known)
- Tag number (if sequential tag system is used)
- Laboratory number (if applicable)
- Any other pertinent information

Environmental samples will be packaged and shipped according to the following procedure:

1. Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal bag;
2. Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
3. Pack with enough noncombustible, absorbent, cushioning material to minimize the

possibility of the container breaking.

4. Seal large bag.

5. Seal or close outside container

The appropriate side of the container must be marked "This End Up" and arrows should be drawn accordingly. No DOT marking labeling is required. No DOT shipping papers are required. There are no DOT restrictions on mode of transportation.

# SECTION 6
# ACCIDENT PREVENTION CONTINGENCY PLAN

## 6.1 ACCIDENT PREVENTION

### 6.1.1 SITE-SPECIFIC TRAINING

All field personnel will receive health and safety training prior to the initiation of any site activities. The site-specific training form provided in Appendix B must be signed, dated, and returned to the Health and Safety Officer. On a day-to-day basis, individual personnel should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms in themselves and others that warn of hazardous conditions and exposures. Rapid recognition of dangerous situations can avert an emergency. Before daily work assignments, regular meeting should be held. Discussion should include:

- Tasks to be performed.
- Time constraints (e.g., rest breaks, cartridge changes).
- Hazards that may be encountered, including their effects, how to recognize symptoms or monitor them, concentration limits, or other danger signals.
- Emergency procedures.

## 6.2 CONTINGENCY PLAN

### 6.2.1 EMERGENCY PROCEDURES

In the event that an emergency develops on site, the procedures delineated herein are to be immediately followed. Emergency conditions are considered to exist if:

Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while on site.

A condition is discovered that suggests the existence of a situation more hazardous than anticipated.

General emergency procedures, and specific procedures for personal injury, chemical exposure and radiation exposure, are described below.

### 6.2.2 CHEMICAL EXPOSURE

If a member of the field crew demonstrates symptoms of chemical exposure the procedures outlined below should be followed:

- Another team member (buddy) should remove the individual from the immediate area of contamination. The buddy should communicate to the Field Team Leader (via voice and hand signals) of the chemical exposure. The Field Team Leader should contact the appropriate emergency response agency.
- Precautions should be taken to avoid exposure of other individuals to the chemical.
- If the chemical is on the individual's clothing, the chemical should be neutralized or removed if it is safe to do so.
- If the chemical has contacted the skin, the skin should be washed with copious amounts of water.
- In case of eye contact, an emergency eye wash should be used. Eyes should be washed for at least 15 minutes.
- All chemical exposure incidents must be reported in writing to the Office Health and Safety Representative. The Site Health and Safety Officer or Field Team Leader is responsible for completing the accident report (See Part 7 of this Section). In addition, chemical exposure incidents must be reported to the Facility Emergency Coordinator at AWPI.

### 6.2.3 PERSONAL INJURY

In case of personal injury at the site, the following procedures should be followed:

- Another team member (buddy) should signal the Field Team Leader that an injury has occurred.
- A field team member trained in first aid can administer treatment to an injured worker.
- The victim should then be transported to the nearest hospital or medical center. If necessary, an ambulance should be called to transport the victim.
- For less severe cases, the individual can be taken to the site dispensary.
- The Field Team Leader or Site Health and Safety Officer is responsible for making certain that an Accident Report Form is completed. This form is to be submitted to the Office Health and Safety Representative. Follow-up action should be taken to correct the situation that caused the accident.

### 6.2.4 EVACUATION PROCEDURES

The Field Team Leader will initiate evacuation procedure by signaling to leave the site.

All personnel in the work area should evacuate the area and meet in the common designated area.

All personnel suspected to be in or near the contract work area should be accounted for and the whereabouts or missing persons determined immediately.

Further instruction will then be given by the Field Team Leader.

### 6.2.5 PROCEDURES IMPLEMENTED IN THE EVENT OF A MAJOR FIRE, EXPLOSION, OR ON-SITE HEALTH EMERGENCY CRISIS

- Notify the paramedics and/or fire department, as necessary;
- Signal the evacuation procedure previously outlined and implement the entire procedure;
- Isolate the area;
- Stay upwind of any fire;
- Keep the area surrounding the problem source clear after the incident occurs;

- Complete accident report for and distribute to appropriate personnel.

A decision to notify local residents of emergency conditions at the site, will be made in consultation with local officials and the City of Olean Fire Department.

# APPENDIX C

# SAMPLING INFORMATION / FORMS

## TABLE C.1
## SUMMARY OF MONITORING WELL DATA- FIELD SHEET

**VAN DER HORST PLANT #1**
**GROUNDWATER SAMPLING**
**Date ________________**
**ANALYSIS FOR Cr**

| WELL NO. | SAMPLE I.D. | BOTTOM DEPTH TOC (FT.) | GW ELEV. TOC (FT.) | AMOUNT OF $H_2O$ (FT.) | WATER PURGED (GAL.) | TIME SAMPLED (DAY/HRS.) | TURBIDITY (ntu) | COMMENTS/ OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|
| MW-1s | 18891S | | | | | | | |
| MW-5s | 18895S | | | | | | | |
| MW-5d | 18895D | | | | | | | |
| MW-7d | 18897D | | | | | | | |
| MW-11s | 188911 | | | | | | | |
| MW-11d | 188913 | | | | | | | |
| MW-12s | 188912 | | | | | | | |
| MW-17s | 188917 | | | | | | | |
| MW-17d | 188907 | | | | | | | |
| MW-19d | 188919 | | | | | | | |
| MW-30d | 188930 | | | | | | | |

.5 GAL PER FT. WATER = 3 VOLUMES FOR A 2" I.D. MONITORING WELL

The purpose of the sampling was to perform routine long term groundwater monitoring at the site. The wells sampled were consistent with wells that had been previous sampled at he site. All wells were purged of a minimum of three volumes of groundwater on __________ prior to collection of the sample. The wells were purged using a Grundflo stainless steel submersible pump or disposable bailer until turbidity levels stabilized. Samples were collected using the Grundflo pump set the minimum volume so as to reduce turbulence in the well or with a disposable bailer. At the time of sample collection, a turbidity measurement was made and recorded on the sample sheet as noted above. Samples for Chromium(T) were collected in 500 ml plastic containers and preserved with $HNO_3$. All samples were transported to ________ laboratory on ___________ for analysis. A standard 28 day turn around was requested.

# TABLE C.2

## GROUNDWATER SAMPLE CONTAINERIZATION AND HOLDING TIMES

| Analysis | Bottle Type | Preservation | Holding Time |
|---|---|---|---|
| Aqueous Samples | | | |
| Metals | 1 liter plastic bottle | Nitric Acid to pH <2<br>cool to 4°C | 5 Days |

All samples to be preserved in ice during collection and transport.

# TABLE C.3

# GROUNDWATER SAMPLING EQUIPMENT

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## SAMPLING EQUIPMENT

- Personal safety equipment (hard hats, safety shoes, etc.)
- Sampling and analysis program
- Appropriate number (including spares) of sample bottles
- Water-level indicator (electric drop-line)
- Polyethylene ground cloth
- Aluminum Foil
- Distilled water
- Alconox detergent
- Disposable surgical gloves
- Disposable towels
- pH meter
- Conductivity meter
- Buckets (small: 5 gallon; large: 25 to 30 gallon)
- Teflon well bailer
- Nylon rope (individual lengths for each well)
- Stainless steel submersible pumps (Grundflo Redi-Flo® style recommended)
- Portable Generator (required for pump operation)
- Pump hoist (if needed)
- Flashlight

## SHIPPING AND PACKAGING EQUIPMENT

- Shipping labels
- Sufficient ice chests to hold all sample bottles, packing material and ice

## DOCUMENTATION EQUIPMENT

- Well Sampling Record
- Chain-of-Custody Forms
- Waterproof Pens
- Field Note Book

# Table C.4

## Historical Pre-Remediation Groundwater Monitoring Analysis

Trivalent Chromium (Cr+3) Concentrations

| | Phase I | Phase II | Phase III | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July 85 | Aug 90 | Aug 91 | Aug 95 | Sept. 95 | Dec. 95 | April 96 | Sept 96 | June 97 | Oct. 97 | Dec. 97 | Apr. 98 | Aug. 98 | Dec. 98 | Apr. 99 | Nov. 99 | 36584 |
| MW-1S | 10 | ND | | 10 | | | | | 3.4 | | | | | | | 3.6 | 3 |
| MW-1D | 10 | 18 | | 10 | | | | | 3.4 | | | | | | | | |
| MW-4s | 24 | 17 | | 10 | | | | | 3.4 | | | | | | | | |
| MW-5S | 8870 | 3920 | | 50 | | | 8560 | 1760 | 19.8 | 99.6 | 6440 | 22.3 | 561 | 1190 | 4660 | 15500 | 920 |
| MW-5D | 13400 | 55700 | | 580 | 536 | 1570 | 2110 | 9380 | 158 | 16.6 | 18.9 | 199 | 47.8 | 19.9 | 11.6 | 109 | 322 |
| MW-7D | 5600 | 5040 | | 610 | 430 | 1030 | 874 | 32.3 | 2180 | 1340 | 2060 | 1520 | 1190 | 1060 | 1030 | 1230 | 1220 |
| MW-8S | 10 | 29 | | 20 | | | | | 19.1 | | | | | | | | |
| MW-9S | 67 | 29 | | 30 | | | | | 3.4 | | | | | | | | |
| MW-9D | 10 | 132 | | 20 | | | | | 3.4 | | | | | | | | |
| MW-10S | | 13 | | 30 | | | | | 3.6 | | | | | | | | |
| MW-11S | | 10 | | 30 | | | | | 3.4 | 1 | 48.9 | 6.1 | 10.8 | 1790 | 1.7 | 79.8 | 19.6 |
| MW-11D | | 1030 | | 860 | 478 | 259 | 837 | 3920 | 8260 | 4960 | 2490 | 2090 | 2300 | 2 | 1560 | 1890 | 1360 |
| MW-11VD | | | | | | | | | 56.4 | 1.5 | 20.4 | 1.8 | 6.6 | 2.4 | | | |
| MW-12S | | 19 | | 30 | | | | | 3.4 | | | | | | | | |
| MW-13S | | 10 | | 30 | | | | | 3.4 | | | | | | | | |
| MW-14S | | 95 | | 40 | | | | | 3.4 | | | | | | | | |
| MW-15S | | | 846 | | | | | | 3.4 | 8 | 10.1 | 25.4 | 5.1 | 17.4 | | | |
| MW-16S | | | 4070 | | | | | | 2930 | 421 | 126 | 4410 | 2450 | 493 | 2220 | | 959 |
| MW-17S | | | 264000 | | | | | | 113000 | 170000 | 66900 | 8080 | 19800 | 55600 | 13200 | 1830 | 72.5 |
| MW-17D | | | | | | | | | 240000 | 170000 | 138000 | 129000 | 81500 | 43600 | 37100 | 19200 | 685 |
| MW-19D | | | 851 | 30 | | | 323 | 24 | 3880 | 14.4 | 631 | 4.6 | 216 | 9.4 | 28.2 | 106 | 199 |
| MW-19S | | | | | | | | | 463 | | | | | | | | |
| MW-30D | | | | 40 | 5.7 | 9.6 | 66.9 | 5.6 | 3.4 | 1 | 7.9 | 1.2 | 1.1 | 7.8 | 5 | 10.2 | 5.2 |
| MW-20S | | | | | | | | | 125 | 1 | 9.2 | 1 | 1 | 8.4 | | | |
| MW-20D | | | | | | | | | 3.4 | 1 | 29.8 | 2.3 | 2.4 | 6.7 | | | 53.8 |
| MW-20VD | | | | | | | | | 3.4 | 1 | 14.6 | 2.3 | 1.2 | 2 | | | |
| MW-21S | | | | | | | | | 8 | 1 | 9.6 | 1 | 1.5 | 2 | | | |
| MW-21D | | | | | | | | | 3.4 | 1 | 13 | 2.2 | 1.7 | 3.2 | | | 57.5 |
| MW-21VD | | | | | | | | | 3.4 | 1 | 9.8 | 4.4 | 1.9 | 2 | | | |

Hexavalent Chromium (Cr+6) Concentrations

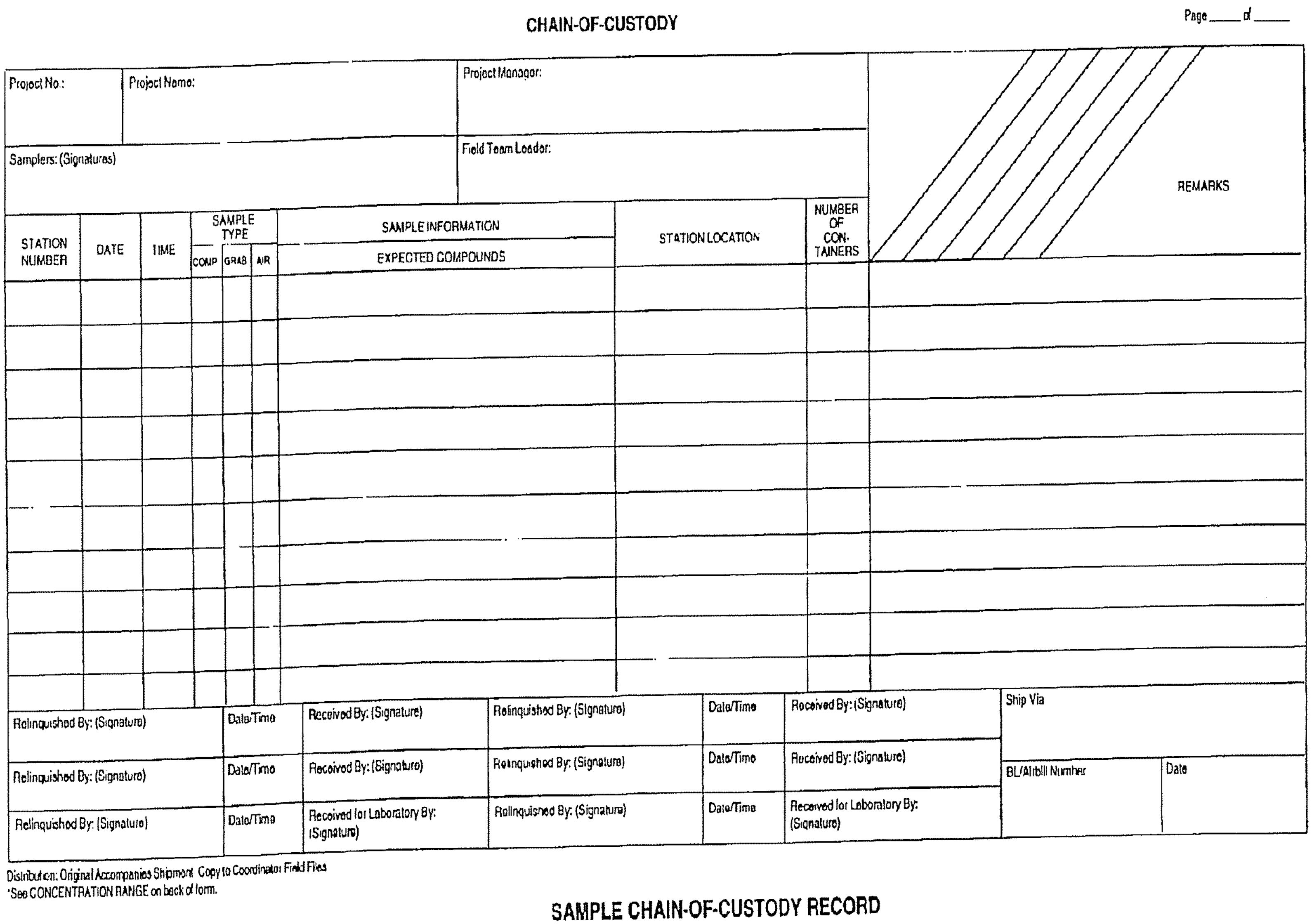
| | Phase I | Phase II | Phase III | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July 85 | Aug 90 | Aug 91 | Aug 95 | Sept. 95 | Dec. 95 | April 96 | Sept 96 | June 97 | Oct. 97 | Dec. 97 | Apr. 98 | Aug. 98 | Dec. 98 | Apr. 99 | Nov. 99 |
| MW-1S | 50 | 11 | | ND | | | | | 10 | | | | | | | ND |
| MW-1D | 45 | ND | | ND | | | | | 11 | | | | | | | |
| MW-4s | 66 | 15 | | 16 | | | | | 10 | | | | | | | |
| MW-5S | 4100 | 7580 | | ND | | | 8130 | NA | 34 | 22.8 | 1190 | 2.9 | 175 | 472 | 639 | ND |
| MW-5D | 4140 | 35900 | | 678 | 489 | 1100 | 2450 | NA | 72 | 3.2 | 2.6 | 9.1 | 8.4 | 2.4 | 12 | ND |
| MW-7D | 1700 | 6300 | | 391 | 366 | 949 | 912 | NA | 1900 | 237 | 394 | 254 | 271 | 235 | 187 | ND |
| MW-8S | 104 | 26 | | ND | | | | | 19 | | | | | | | |
| MW-9S | 31 | 16 | | ND | | | | | 46 | | | | | | | |
| MW-9D | 57 | 70 | | ND | | | | | 13 | | | | | | | |
| MW-10S | | ND | | ND | | | | | 10 | | | | | | | |
| MW-11S | | ND | | ND | | | | | 10 | 0.74 | 9 | 0.97 | 0.26 | 414 | 1.2 | ND |
| MW-11D | | 1030 | | 519 | 391 | 234 | 898 | NA | 7990 | 938 | 476 | 376 | 536 | 0.6 | 250 | ND |
| MW-11VD | | | | | | | | | 53 | 0.91 | 1.8 | 0.6 | 1.2 | 5.7 | | |
| MW-12S | | ND | | ND | | | | | 30 | | | | | | | |
| MW-13S | | ND | | 21 | | | | | 10 | | | | | | | |
| MW-14S | | ND | | ND | | | | | 12 | | | | | | | |
| MW-15S | | | 17 | | | | | | 10 | 1.9 | 1.6 | 3.4 | 10.5 | 2.4 | | |
| MW-16S | | | 18 | | | | | | 107 | 50 | 13.8 | 717 | 496 | 52 | 330 | |
| MW-17S | | | 167000 | | | | | | 86800 | 32000 | 11200 | 1210 | 5910 | 5180 | 1750 | ND |
| MW-17D | | | | | | | | | 67800 | 26900 | 3000 | 22400 | 16800 | 8910 | 7730 | ND |
| MW-19D | | | 56 | ND | | | 201 | NA | 10 | 3.7 | 91.4 | 0.7 | 32.6 | 1.8 | 1.9 | ND |
| MW-19S | | | | | | | | | 16 | | | | | | | |
| MW-30D | | | | ND | 11.9 | 9.3 | 10 | NA | 10 | 0.55 | 1.2 | 0.69 | 1.4 | 0.41 | 0.78 | ND |
| MW-20S | | | | | | | | | 10 | 0.3 | 1 | 0.44 | 0.42 | 0.4 | | |
| MW-20D | | | | | | | | | 11 | 0.22 | 1.2 | 0.65 | 0.35 | 0.89 | | |
| MW-20VD | | | | | | | | | 10 | 0.36 | 0.8 | 0.69 | 0.2 | 0.4 | | |
| MW-21S | | | | | | | | | 10 | 0.55 | 1.1 | 0.97 | 0.2 | 0.4 | | |
| MW-21D | | | | | | | | | 10 | 1.3 | 1.4 | 0.69 | 0.2 | 1 | | |
| MW-21VD | | | | | | | | | 10 | 4.7 | 1.5 | 1.5 | 0.2 | 0.4 | | |

# Table C.5
# Monitoring Well Construction Details

Summary of Monitoring Well Construction Data
Van der Horst Plant #1
Olean(C), Cattaraugus County
Site No. 905008

| Monitoring Well No. | Date Completed | Ground Surface Elevation (ft) | Monitoring Point Elevation (TOC)(ft) | Depth Of Boring (ft) | Bottom of Boring Elevation (ft) | Screened Interval Depth (ft) | Screened Interval Elevation (ft) | Sand Pack Depth (ft) | Sand Pack Elevation (ft) |
|---|---|---|---|---|---|---|---|---|---|
| MW-1S | 6/1/89 | 1427.76 | 1427.35 | 31 | 1396.76 | 15.0-30.0 | 1412.76-1397.76 | 12.6-31.0 | 1415.16-1396.76 |
| MW- 1D | 6/2/89 | 1427.73 | 1427.38 | 60 | 1367.73 | 50.0-55.0 | 1377.73-1372.73 | 51.0-60.0 | 1377.73-1367.73 |
| MW-4 | 5/4/89 | 1430.92 | 1433.26 | 32 | 1398.92 | 16.0-31.0 | 1414.92-1399.92 | 14.9-32.0 | 1416.02-1396.92 |
| MW-5S | 10/22/99 | 1428.74 | 1431.84 | 35 | 1394.38 | 19.0-34.0 | 1409.74-1394.74 | 18.0-35.0 | 1410.74-1393.74 |
| MW-5D | 3/13/97 | 1429.39 | 1431.57 | 63 | 1369.39 | 50.0-60.0 | 1379.39-1369.39 | 47.0-63.0 | 1382.39-1369.39 |
| MW-7D | 3/97 | 1428.97 | 1431.40 | 60 | 1372.44 | 44.0-59.0 | Not Available | 43.0-59.0 | Not Available |
| MW-8 | 5/9/89 | 1429.00 | 1428.47 | 32 | 1397.92 | 16.0-31.0 | 1413.00-1398.00 | 13.4-32.0 | 1415.60-1397.00 |
| MW-9S | 7/7/89 | 1429.92 | 1433.50 | 32 | 1397.92 | 15.0-30.0 | 1414.92-1399.92 | 12.0-32.0 | 1417.92-1397.92 |
| MW-9D | 7/6/89 | 1429.84 | 1433.36 | 63 | 1366.84 | 55.0-60.0 | 1374.84-1369.84 | 53.0-63.0 | 1376.84-1366.84 |
| MW-10 | 7/7/90 | 1427.23 | 1429.70 | 35 | 1392.23 | 14.0-34.0 | 1413.23-1393.23 | 12.9-35.0 | 1414.33-1392.23 |
| MW-11S | 7/16/90 | 1428.92 | 1431.52 | 34.6 | 1394.32 | 18.6-33.6 | 1408.32-1393.32 | 18.5-34.6 | 1410.42-1394.32 |
| MW-1 1D | 7/13/90 | 1429.09 | 1431.58 | 60 | 1369.09 | 54.0-59.0 | 1373.09-1368.09 | 49.0-60.0 | 1380.09-1369.09 |
| MW-11VD | 5/1/97 | 1430.01 | 1432.69 | 115 | 1315.1 | 90.0-115.0 | 1340.10-1315.10 | 87.0-115.0 | 1343.10-1315.1 |
| MW- 12 | 7/26/90 | 1431.31 | 1431.24 | 34 | 1397.31 | 18.0-33.0 | 1413.31-1396.31 | 15.2-34.0 | 1416.11-1397.31 |
| MW- 13 | 7/18/90 | 1429.79 | 1429.81 | 33 | 1396.79 | 15.0-32.0 | 1412.79-1395.79 | 15.0-33.0 | 1414.79-1396.79 |
| MW- 14 | 7/17/90 | 1429.62 | 1431.47 | 34 | 1395.62 | 18.0-33.0 | 1411.62-1396.62 | 17.0-34.0 | 1413.62-1395.62 |
| MW-15 | 3/14/97 | 1427.11 | 1429.53 | 30 | 1397.11 | 15.0-30.0 | 1412.11-1397.11 | 12.0-30.0 | 1415.11-1397.11 |
| MW-16 | 10/21/99 | 1429.72 | 1432.83 | 32 | 1397.72 | 16.0-31.0 | 1413.72-1398.72 | 15.0-32.0 | 1414.72-1397.72 |
| MW-17S | 10/19/99 | 1429.15 | 1432.55 | 34 | 1395.15 | 17.0-33.0 | 1411.15-1396.15 | 17.0-34.0 | 1412.15-1395.15 |
| MW-17D | 10/21/99 | 1429.36 | 1432.08 | 61 | 1368.36 | 54.0-60.0 | 1375.36-1369.36 | 53.0-61.0 | 1376.36-1368.36 |
| MW-19S | 3/25/97 | 1426.98 | 1429.23 | 30 | 1396.98 | 15.0-30.0 | 1411.98-1396.98 | 12.0-30.0 | 1414.98-1396.98 |
| MW-19D | 5/21/91 | 1426.93 | 1429.52 | 57 | 1369.93 | 46.0-56.0 | 1380.93-1370.93 | 42.5-57.0 | 1384.43-1369.93 |
| MW-20S | 3/31/97 | 1426.66 | 1429.26 | 30 | 1396.66 | 15.0-30.0 | 1411.66-1396.66 | 12.0-30.0 | 1414.66-1396.66 |
| MW-20D | 3/26/97 | 1426.59 | 1429.41 | 60 | 1366.59 | 50.0-60.0 | 1376.59-1366.59 | 47.0-60.0 | 1379.59-1366.59 |
| MW-20VD | 5/5/97 | 1426.71 | 1429.20 | 115 | 1311.71 | 105.0-115.0 | 1301.71-1311.71 | 102.0-115.0 | 1334.71-1311.71 |
| MW-21S | 3/19/97 | 1426.77 | 1429.49 | 30 | 1396.77 | 15.0-30.0 | 1411.77-1396.77 | 12.0-30.0 | 1414.77-1396.77 |
| MW-21D | 3/19/97 | 1426.77 | 1429.47 | 60 | 1366.77 | 50.0-60.0 | 1376.77-1366.77 | 47.0-60.0 | 1379.77-1366.77 |
| MW-21VD | 4/28/97 | 1427.04 | 1429.32 | 115 | 1312.04 | 105.0-115.0 | 1332.04-1312.04 | 102.0-115.0 | 1335.04-1312.04 |
| MW-30 | Unknown |  |  | 60 |  | 45.0-60.0 |  | 42.0-60.0 |  |

## Figure C.1
## Sample Chain of Custody Record



CHAIN-OF-CUSTODY

Page____ of ____

| | | | |
|---|---|---|---|
| Project No.: | Project Name: | Project Manager: | |
| Samplers: (Signatures) | | Field Team Leader: | |

| STATION NUMBER | DATE | TIME | SAMPLE TYPE | | | SAMPLE INFORMATION | STATION LOCATION | NUMBER OF CON-TAINERS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | COMP | GRAB | AIR | EXPECTED COMPOUNDS | | | |
| | | | | | | | | | |
| | | | | | | | | | |
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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Relinquished By: (Signature) | Date/Time | Received By: (Signature) | Relinquished By: (Signature) | Date/Time | Received By: (Signature) | Ship Via | |
| Relinquished By: (Signature) | Date/Time | Received By: (Signature) | Relinquished By: (Signature) | Date/Time | Received By: (Signature) | BL/Airbill Number | Date |
| Relinquished By: (Signature) | Date/Time | Received for Laboratory By: (Signature) | Relinquished By: (Signature) | Date/Time | Received for Laboratory By: (Signature) | | |

Distribution: Original Accompanies Shipment Copy to Coordinator Field Files
*See CONCENTRATION RANGE on back of form.

SAMPLE CHAIN-OF-CUSTODY RECORD

# APPENDIX D

# INSPECTION AND MAINTENANCE REPORT FORMS

# TABLE D.1
# QUARTERLY SITE INSPECTION CHECKLIST

## QUARTERLY INSPECTION AND MAINTENANCE CHECKLIST
## VAN DER HORST PLANT #1 SITE
## NYSDEC SITE NO. 9-05-008

**Inspector:**__________________________

**Weather:** _________________________

**Date:**

**Temperature:** _______

| Area | Item | Action | Comments |
|---|---|---|---|
| Surface Soils | Subsidence/ponding | Delineate, fill, and revegetate. | |
| | Erosion/gullies | Determine cause, grade, and vegetate. | |
| | Surface soil stability | Check for erosion, | |
| | Vegetation | Check for areas of weak/no vegetation, revegetate. | |
| | | Mow annually (ea. fall). | |
| | | Remove scrubs and trees from cover system and drainage ways. | |
| | Vectors | Check for burrows and backfill with clean soil. | |
| Stormwater system | Ditches and swales | Check for pooling, erosion, excessive vegetation, and weak vegetation. | |
| | Drainage Inlets | Check for blockage and general condition. | |
| | | Check excessive build up of sediment | |
| Groundwater monitoring system | Sampling wells | Check condition of caps, locks, surface seals, and markings. Lubricate locks. | |

# TABLE D.2

## Soil Cover
## Stormwater System
## Monitoring Wells
## Facility Access

**SITE MAINTENANCE ITEMS**
**VAN DER HORST PLANT #1 SITE**
**NYSDEC SITE NO. 9-05-008**

| Inspection Area | Item Noted | Action | Preventive Maintenance |
|---|---|---|---|
| 1.Subsidence/ponding | a. Formation of small depressions in cover ground surface | • Fill area with clean common fill to surrounding grade.<br>• Re-establish vegetation layer. | • Quarterly inspection |
| | b. Formation of large depressions in cover ground surface | • Fill area with clean common fill to surrounding grade.<br>• Re-establish vegetation layer.<br>• Conduct subsurface investigation if problem persists. | |

# SITE MAINTENANCE ITEMS
# VAN DER HORST PLANT #1 SITE
# NYSDEC SITE NO. 9-05-008

| | | | |
|---|---|---|---|
| 2. Erosion | a. Formation of erosion gullies | • Grade gully with clean common fill to smooth v-shaped cross sections and reestablish vegetation cover. | • Quarterly inspection |
| | b. Chronic gully formation | • Smooth gully sides and install Geotextile filter fabric or erosion control matting. Backfill gully to original grade with NYSDOT medium stone fill (NYSDOT Specification Section 620). | • Ensure vehicles on cover keep wheels perpendicular to slope (i.e., mowing tractors, inspection vehicles, etc.) to prevent ruts. |
| 3. Vegetation | a. Lack of vegetation | • Prepare area for vegetation establishment by fertilizing and placement of topsoil.<br>• Apply seed - fescue and ryegrass varieties - either by hydro seeding or manual application.<br>• Cover seed with mulch to allow establishment of roots and to minimize seed loss.<br>• Reseeding should preferably occur in late August through October or April through June. | • Quarterly inspection<br>• Annual fertilization and liming if necessary |
| | b. Excessive vegetation | • Mowing - preferably during dry periods to prevent damage to topsoil. | • Annual mowing (vary cutting pattern to avoid causing ruts) |

## SITE MAINTENANCE ITEMS
## VAN DER HORST PLANT #1 SITE
## NYSDEC SITE NO. 9-05-008

| | | | |
|---|---|---|---|
| | c. Chronically weak and vulnerable vegetation | • Perform soil analyses to identify nutrient deficiencies, pH.<br>• Evaluation of soil water-holding properties and drainage.<br>• Application of required nutrients.<br>• Physical removal of vegetation and root system.<br>• Repair topsoil after root system removal.<br>• Fertilization of soil and reseed. | • Quarterly inspection |
| | d. Undesirable species or scrubs on cover | • If uncontrollable, judicious application of herbicides may be necessary. | • Annual mowing |
| | e. Scrubs or trees obstructing roads or inspection routes | | • Semi-annual mowing |
| 6. Vectors | a. Large population of burrowing animals | • Backfill burrows with clean soil. Reseed affected area(s).<br>• Capture animals in traps if problem becomes chronic. Remove animals to distant location or release. | • Quarterly inspections |

## STORM WATER SYSTEM MAINTENANCE ITEMS
## VAN DER HORST PLANT #1 SITE
## NYSDEC SITE NO. 9-05-008

| Inspection Area | Item Noted | Action | Preventive Maintenance |
|---|---|---|---|
| 1. Ditches and swales | a. Pooling | • Regrade, revegetate/repair, reinspect after 30 days. | • Inspect quarterly |
| | b. Erosion | • Regrade, revegetate/repair, reinspect after 30 days. | |
| | c. Excessive vegetation, woody plants | • Mow area | • Annual mowing |
| | d. Weak vegetation | • Test soil, refertilize, adjust pH (if necessary), reseed, mulch; reinspect after 30 days. | |
| 2. Drainage Swales | a. Blocked/restricted | • Remove blockage. | • Inspect quarterly |
| | b. Culvert damaged | • Assess damage, replace if warranted. | |
| | c. Erosion | • Regrade area, revegetate/repair, reinspect after 30 days. | |

# GROUNDWATER MONITORING SYSTEM MAINTENANCE ITEMS
## DER HORST PLANT #1 SITE
## NYSDEC SITE NO. 9-05-008

| Inspection Area | Item Noted | Action | Preventive Maintenance |
|---|---|---|---|
| 1. Caps | a. Cracked or broken | • Replace. | • Check quarterly |
| 2. Locks | a. Will not open | • Break open and replace. | • Lubricate quarterly |
| | b. Rusted | | |
| | c. Different key for each well | • Replace with the same lock number. | |
| 3. Surface seals | a. Cracked | • Re-grout. | • Inspect quarterly |
| 4. Markings | a. None<br>b. Mislabeled | • Remark. | |
| 5. Water level (semiannually) | a. Dry | • DEC/DOH to determine if redrilling to a greater depth is warranted. | • Check during sampling |
| | b. Silted in or blocked | • DEC/DOH to determine if redrilling is warranted.<br>• Abandon in-place and/or install new well. | |

# APPENDIX E

# TOPSOIL, SEEDING AND MULCH SPECIFICATIONS

# TOPSOIL, SEEDING AND MULCH SPECIFICATIONS

## TOPSOIL AND SOIL SUPPLEMENTS

A. Topsoil shall be friable sandy loam, free of subsoil, stones larger than 1 inch diameter, roots, grass, excessive amounts of weeds, and foreign matter. It shall be a loam typical of locality, meeting the following gradation:

1. 100 percent passing the No. 4 sieve.

2. Between 20 percent and 65 percent passing the No. 200 sieve.

B. Fertilizer shall contain total nitrogen, available phosphoric acid, and soluble potash in the ratio 10-10-10. Each bag of fertilizer shall bear the manufacturers guaranteed statement of analysis.

C. Limestone shall be ground limestone having a minimum total neutralizing value of 88% calcium carbonate equivalence. A minimum 90% shall pass No. 20 sieve and a minimum of 60% shall pass the No. 100 sieve.

D. Mulch shall be shredded stalks of oat, wheat, rye, or other approved crop air dried and free from noxious weeks, mold, or objectionable material.

## Preparation for Placing Topsoil

A. Ensure that subgrade backfilling activities are complete and ready to receive topsoil.

B. Eliminate uneven areas and low spots in subsoil. Remove debris, roots, branches, and stones, in excess of ½ inch in size.

C. Provide topsoil material to location of placement.

D. Allow topsoil to dry at the source prior to transportation

E. Scarify subgrade to a depth of 3 inches where topsoil is designated for placement. Scarify in areas where equipment has compacted subsoil.

## Placing Topsoil

A. Place 6 inches of topsoil in designated areas to lines and grades shown on the plans

B. Use relatively dry topsoil and place during dry weather.

C. Finely grade the topsoil, eliminating rough or low areas, maintain levels, profiles, and contours of subgrade.

D. Remove stones greater than 1 inch, roots, grass, weeds, debris, and foreign material while spreading.

E. Lightly compact or roll placed topsoil.

F. Remove surplus backfill and topsoil from Site.

## Topsoil Testing

Test topsoil for sand and clay content.

## SEEDING

### Grass Seed

Seed shall be labeled in accordance with USDA Rules and Regulations under the Federal Seed Act and applicable State seed laws. Seed shall be furnished in sealed bags or containers bearing the date of the last germination, which date shall be within a period of six (6) months prior to commencement of planting operations. Seeding material shall be inspected upon arrival at the job site, and unacceptable material shall be removed from the job site. Seed shall be from same or previous year's crop; each variety of seed shall have a purity of not less than 85 percent, a percentage of germination not less than 90 percent, shall have a weed content of not more than 1 percent and contain no noxious weeds. The seed mixture shall consist of the following proportions or approved equal.

| Common Name | By Weight | % By Weight | % Germination |
|---|---|---|---|
| Fine Fescue | 65 | 90 | 90 |
| Kentucky Bluegrass | 20 | 90 | 90 |
| Perennial Ryegrass | 15 | 90 | 90 |

### Placement of Seed

A. Distribute fertilizer and limestone (as required) evenly over the surface of the soil in areas to be seeded as shown on the Plans or as directed by the Engineer, lime the topsoil to a pH of 6.0 and fertilize with 600 pounds of fertilizer per acre (14 pounds per 1,000 square feet). Any application method that will ensure an even distribution will be acceptable. When hydraulic application is used, the minimum rate of water shall be 500 gallons per acre.

B. Sow seeds at the rate of 2 pounds per 1,000 square feet in two operations of equal amounts, and at right angles to each other. The seed shall be sown at the rate of 1 pound per thousand square feet in each operation.

C. Lightly rake or drag the entire seeded area after sowing the seed. The area shall then be rolled with a 200-pound roller.

D. Contractor may hydroseed required areas, providing that a pre-germinated hydroseed mix is used, which includes all fertilizer and mulch specified in this section.

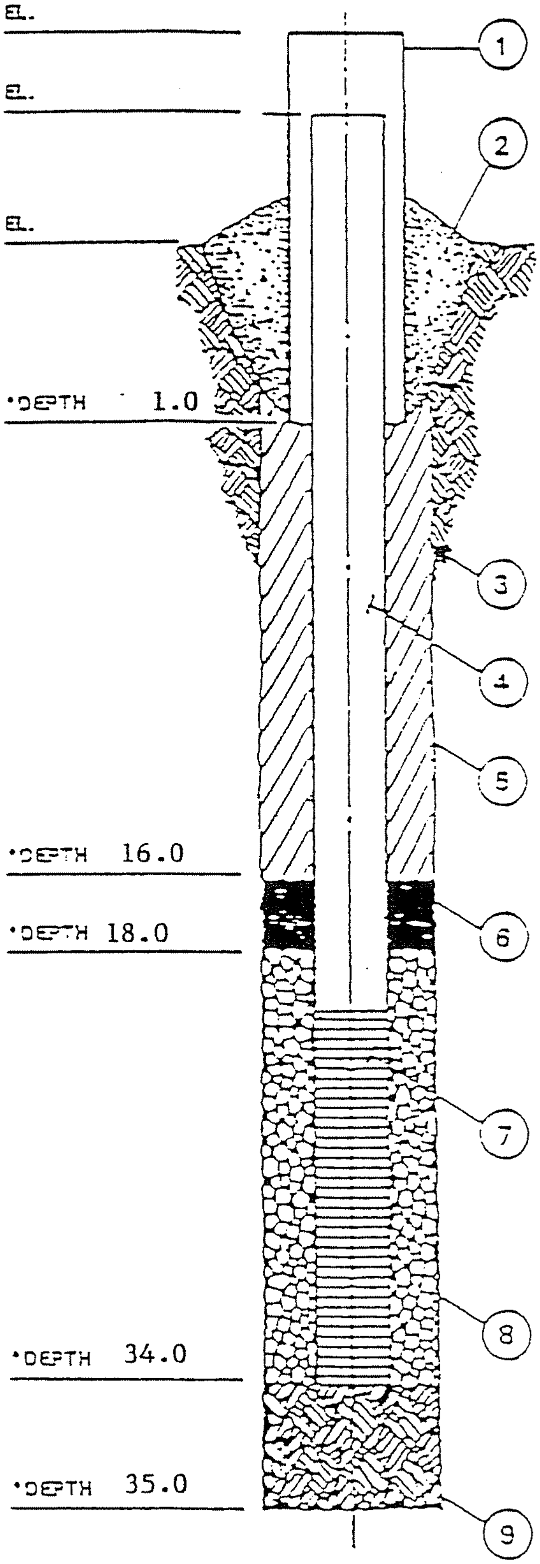
**Mulching**

The Contractor shall mulch at a rate of 2 tons per acre (90-1 00 pounds per 1,000 square feet) and water with a fine spray until a uniform moisture depth of 1 inch has been obtained after all raking and rolling operations are completed.

# APPENDIX F

# MONITORING WELL LOGS/CONSTRUCTION DIAGRAMS

# MONITORING WELL COMPLETION REPORT



•DEPTH IN FEET BELOW GRADE

WELL NO. Railroad Well MW-5S

PROJECT NO. 99-02057

DATE INSTALLED 10/22/99

PROJECT VANDERHORST PLANT #1

OLEAN, NY

1. PROTECTIVE CASING I.D. (INCHES) 4"
2. SURFACE SEAL TYPE SAKRETE
3. BOREHOLE DIAMETER (INCHES) 8"
4. RISER PIPE
   TYPE PVC
   I.D. (INCHES) 2"
   LENGTH (FEET) 21'
   JOINT TYPE THREAD FLUSH
5. BACKFILL
   TYPE BENTONITE GROUT
   INSTALLATION TREMIE
6. TYPE OF SEAL BENTONITE CHIP
7. SCREEN
   TYPE PVC CONTINUOUS WRAP
   I.D. (INCHES) 2"
   SLOT SIZE (INCHES) 20
   LENGTH 15'
8. SCREEN FILTER TYPE SILICA SAND #0
9. BACKFILL TYPE Silica Sand #0

NOTE: APPROXIMATELY 2" OF SILICA SAND #00 INSTALLED ON TOP OF BENTONITE SEAL TO PREVENT GROUT FROM LEACHING INTO SANDPAK

MAXIM TECHNOLOGIES INC

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>RO-01463-001 | WELL NUMBER<br>PW5d |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference PW5d

Town and City Olean

County and State Cattaraugus, NY

Installation Date (s) 3-13-97

Drilling Method Canterra CT 350 with 4.25" HSA

Drilling Contractor K. Marcellus

Drilling Fluid NA

Development Technique (s) / Dates

NA

Fluid Loss During Drilling (gals) NA

Water Removed During Development (gals)

NA - NA

Static Depth to Water Date NA

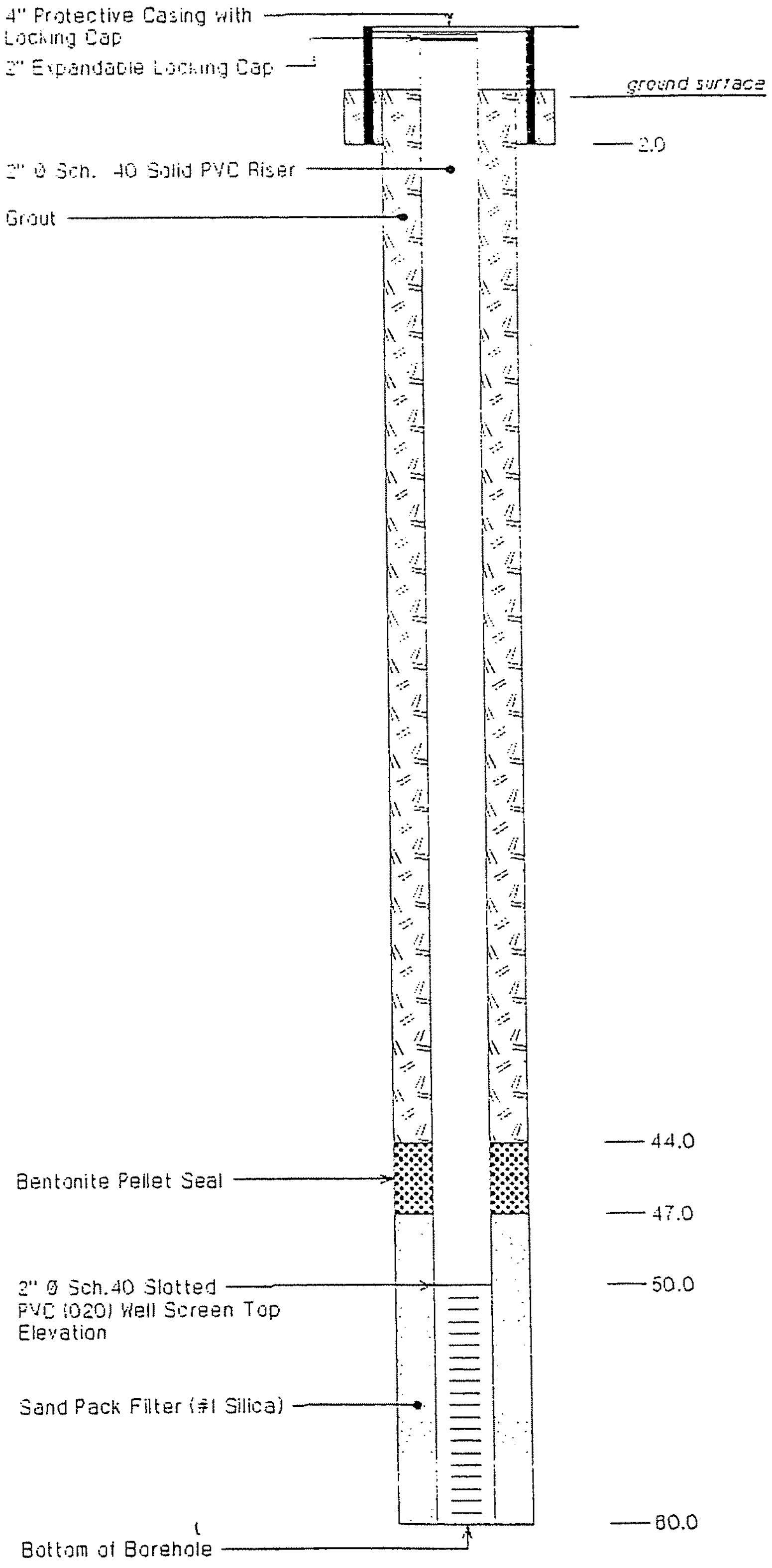
Static Depth to Water (feet) NA

Well Purpose Monitoring ground water.

Remarks

Prepared By D. Stamp

Date Prepared 2-13-98



| WELL CONSTRUCTION LOG | PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>R0-01463-001 | WELL NUMBER<br>PW11vd |
|---|---|---|---|---|
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured☐Surveyed ☒Estimated | | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference *PW11vd*

Town and City *Olean*

County and State *Cattaraugus, NY*

Installation Date (s) *5-1-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*

Drilling Contractor *K. Marcellus*

Drilling Fluid *NA*

Development Technique (s) / Dates

*NA*

Fluid Loss During Drilling (gals) *NA*

Water Removed During Development (gals)

*NA - NA*

Static Depth to Water Date *NA*

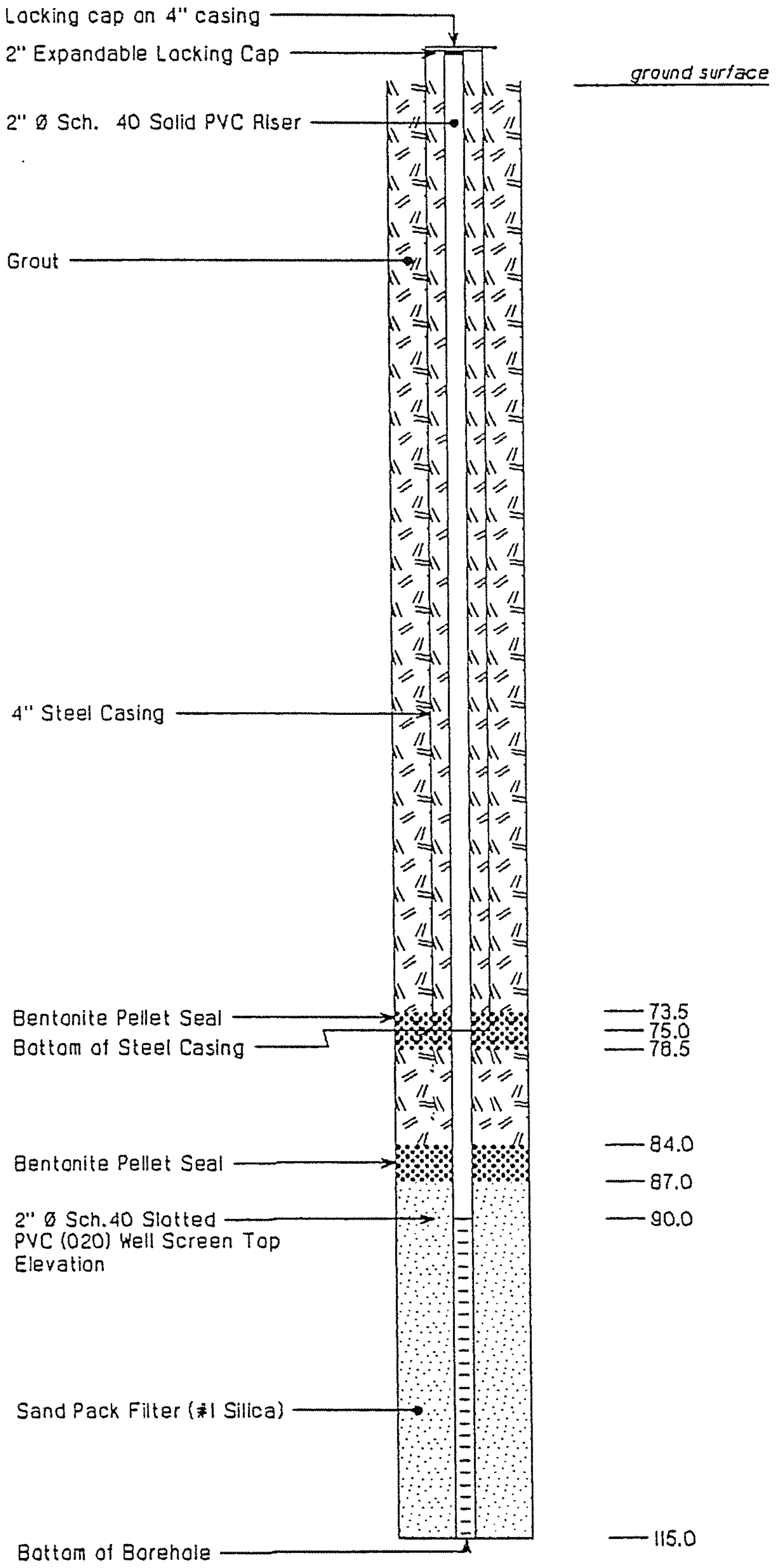
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*

Date Prepared *2-13-98*



MARCOR Remediation Inc.

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>R0-01463-001 | WELL NUMBER<br>PW15 |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured☐Surveyed ☒Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference *PW15*

Town and City *Olean*

County and State *Cattaraugus, NY*

Installation Date (s) *3-14-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*

Drilling Contractor *K. Marcellus*

Drilling Fluid *NA*

Development Technique (s) / Dates

*NA*

Fluid Loss During Drilling (gals) *NA*

Water Removed During Development (gals)

*NA - NA*

Static Depth to Water Date *NA*

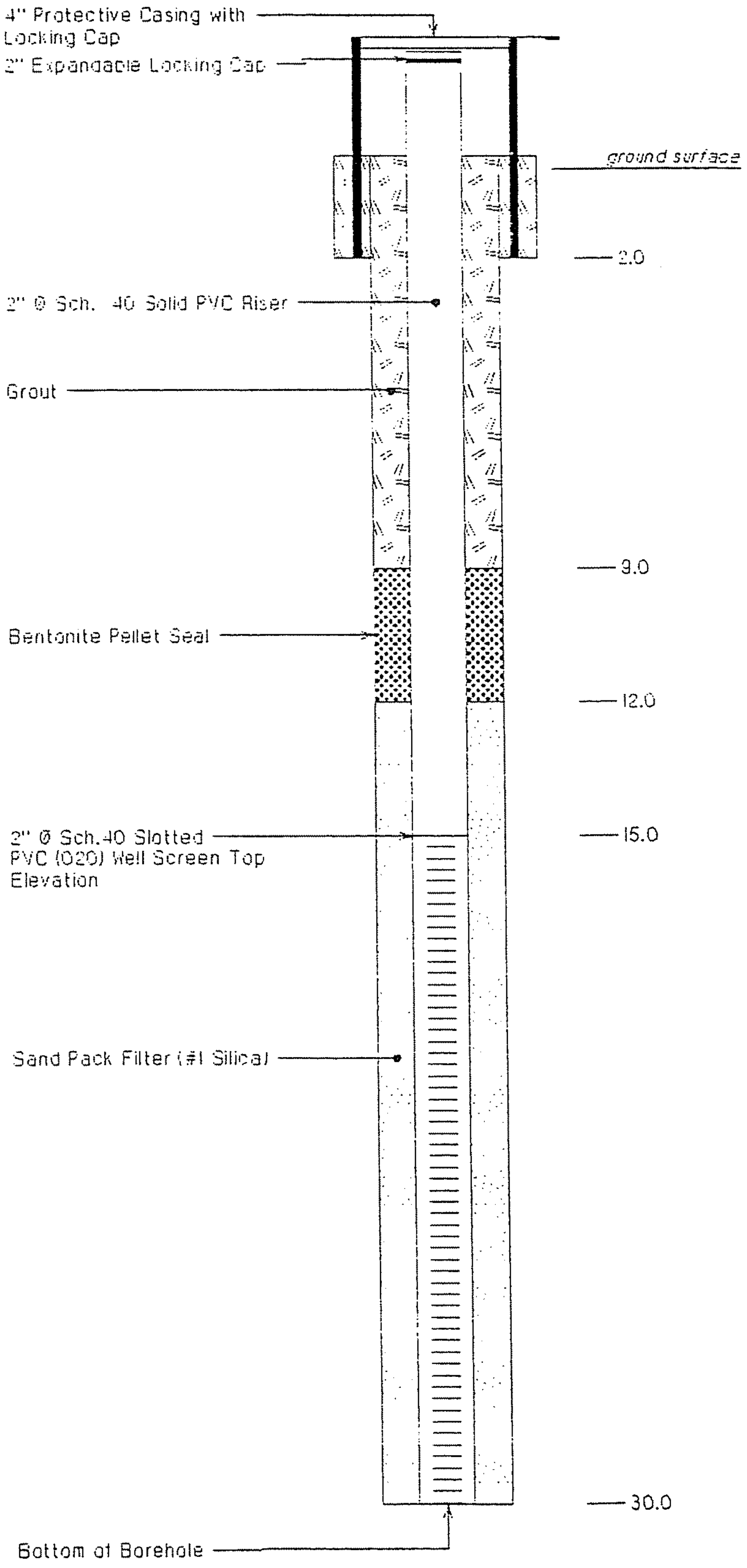
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*

Date Prepared *2-13-98*



MARCOR Remediation Inc.

# MONITORING WELL COMPLETION REPORT

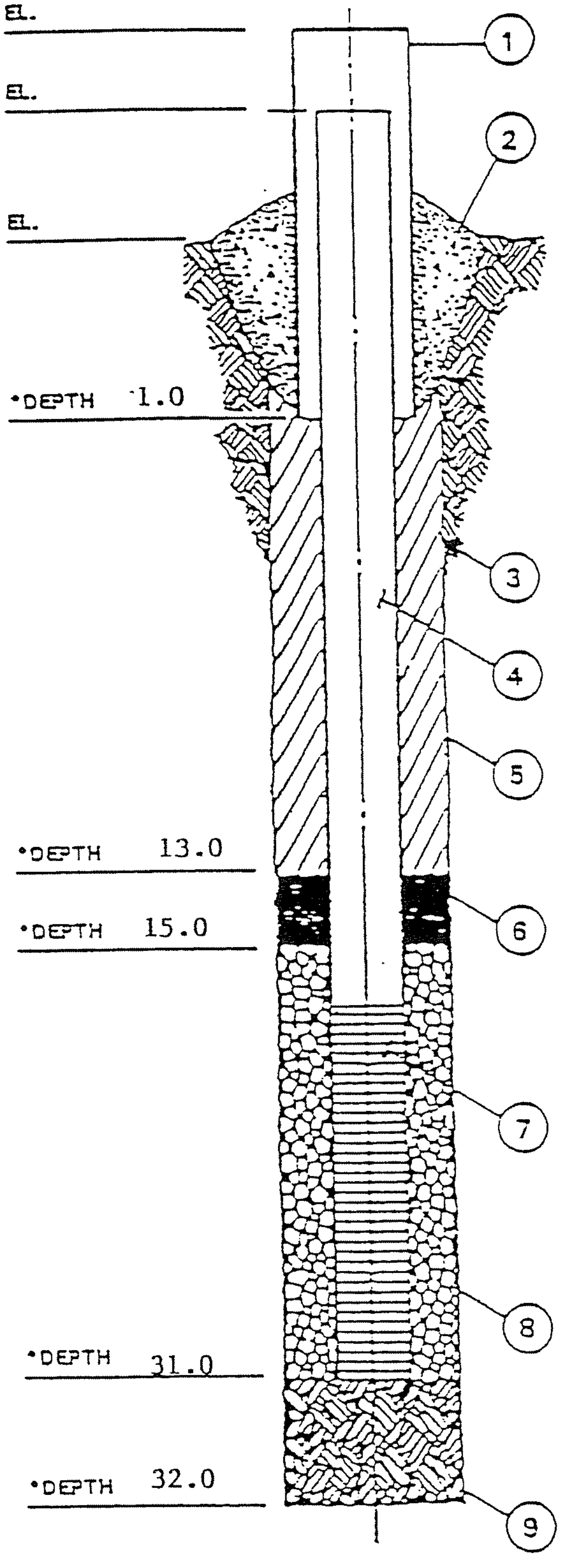
WELL NO. 16S (F03)

PROJECT NO. 99-02057

DATE INSTALLED 10/21/99

PROJECT VANDERHORST PLANT #1

OLEAN, NY



1. PROTECTIVE CASING I.D. (INCHES) 4"
2. SURFACE SEAL TYPE SAKRETE
3. BOREHOLE DIAMETER (INCHES) 8"
4. RISER PIPE
   - TYPE PVC
   - I.D. (INCHES) 2"
   - LENGTH (FEET) 19'
   - JOINT TYPE THREAD FLUSH
5. BACKFILL
   - TYPE BENTONITE GROUT
   - INSTALLATION TREMIE
6. TYPE OF SEAL BENTONITE CHIP
7. SCREEN
   - TYPE PVC CONTINUOUS WRAP
   - I.D. (INCHES) 2"
   - SLOT SIZE (INCHES) 20
   - LENGTH 15
8. SCREEN FILTER TYPE SILICA SAND #0
9. BACKFILL TYPE Silica Sand #0

*DEPTH IN FEET BELOW GRADE

MAXIM
TECHNOLOGIES INC

NOTE: APPROXIMATELY 2" OF SILICA SAND #00 INSTALLED ON TOP OF BENTONITE SEAL TO PREVENT GROUT FROM LEACHING INTO SANDPAK

# MONITORING WELL COMPLETION REPORT

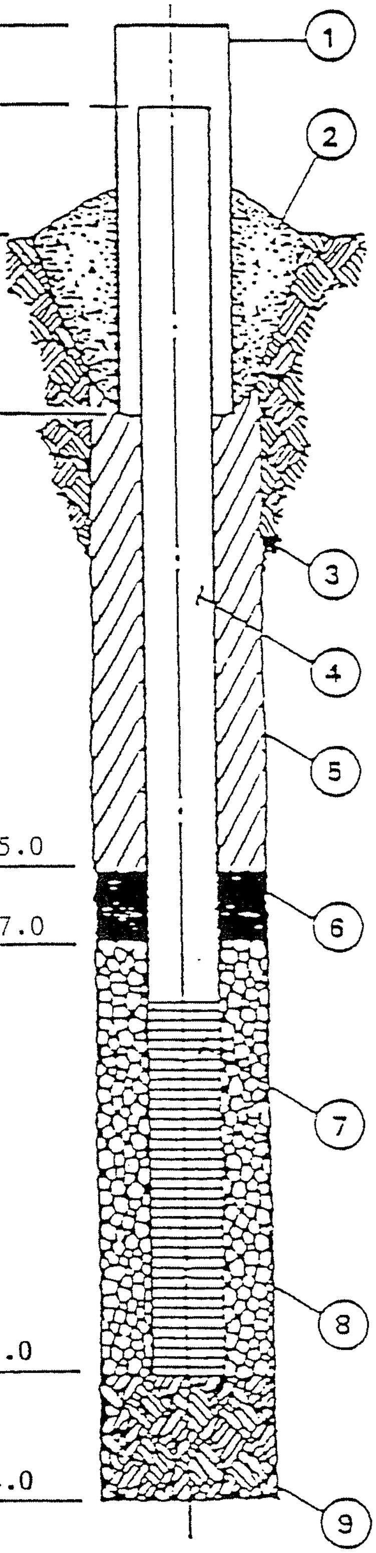
WELL NO. 17 S (F01)

PROJECT NO. 99-02057

DATE INSTALLED 10/19/99

PROJECT VANDERHORST PLANT #1

OLEAN, NY



EL.

EL.

EL.

•DEPTH 1.0

•DEPTH 15.0

•DEPTH 17.0

•DEPTH 33.0

•DEPTH 34.0

•DEPTH IN FEET BELOW GRADE

1. PROTECTIVE CASING I.D. (INCHES) 4"
2. SURFACE SEAL TYPE SAKRETE
3. BOREHOLE DIAMETER (INCHES) 8"
4. RISER PIPE
   - TYPE PVC
   - I.D. (INCHES) 2"
   - LENGTH (FEET) 21'
   - JOINT TYPE THREAD FLUSH
5. BACKFILL
   - TYPE BENTONITE GROUT
   - INSTALLATION TREMIE
6. TYPE OF SEAL BENTONITE CHIP
7. SCREEN
   - TYPE PVC CONTINUOUS WRAP
   - I.D. (INCHES) 2"
   - SLOT SIZE (INCHES) 20
   - LENGTH 15'
8. SCREEN FILTER TYPE SILICA SAND #0
9. BACKFILL TYPE SILICA SAND # 0

MAXIM
TECHNOLOGIES INC

NOTE: APPROXIMATELY 2" OF SILICA SAND #00 INSTALLED ON TOP OF BENTONITE SEAL TO PREVENT GROUT FROM LEACHING INTO SANDPAK

# MONITORING WELL COMPLETION REPORT

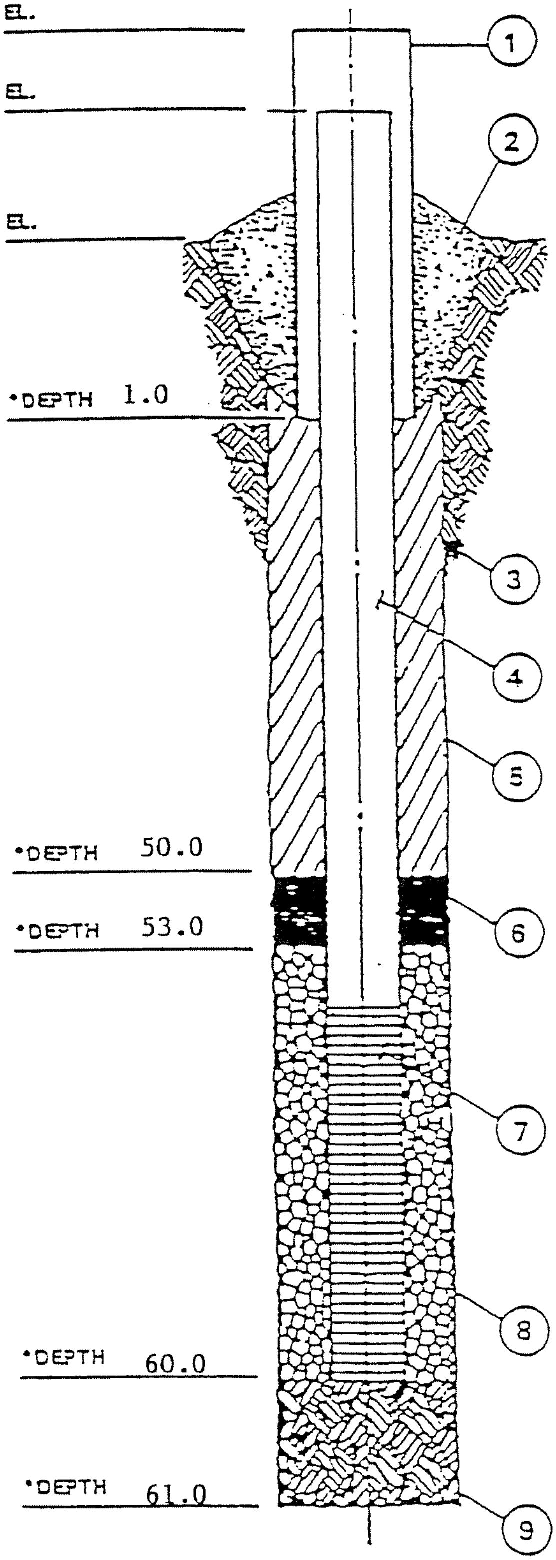
WELL NO. 17D (F02)

PROJECT NO. 99-02057

DATE INSTALLED 10/21/99

PROJECT VANDERHORST PLANT #1

OLEAN, NY



1. PROTECTIVE CASING I.D. (INCHES) 4"
2. SURFACE SEAL TYPE SAKRETE
3. BOREHOLE DIAMETER (INCHES) 8"
4. RISER PIPE
   - TYPE PVC
   - I.D. (INCHES) 2"
   - LENGTH (FEET) 58'
   - JOINT TYPE THREAD FLUSH
5. BACKFILL
   - TYPE BENTONITE GROUT
   - INSTALLATION TREMIE
6. TYPE OF SEAL BENTONITE CHIP
7. SCREEN
   - TYPE PVC CONTINUOUS WRAP
   - I.D. (INCHES) 2"
   - SLOT SIZE (INCHES) 20
   - LENGTH 5
8. SCREEN FILTER TYPE SILICA SAND #0
9. BACKFILL TYPE Running Sands
   ( NYSDEC Notified On-Site)

•DEPTH IN FEET BELOW GRADE

NOTE: APPROXIMATELY 2" OF SILICA SAND #00 INSTALLED ON TOP OF BENTONITE SEAL TO PREVENT GROUT FROM LEACHING INTO SANDPAK

MAXIM
TECHNOLOGIES INC

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>RO-01463-001 | WELL NUMBER<br>PW19s |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference PW19s

Town and City Olean

County and State Cattaraugus, NY

Installation Date (s) 3-25-97

Drilling Method Canterra CT 350 with 4.25" HSA

Drilling Contractor K. Marcellus

Drilling Fluid NA

Development Technique (s) / Dates

NA

Fluid Loss During Drilling (gals) NA

Water Removed During Development (gals)

NA - NA

Static Depth to Water Date NA

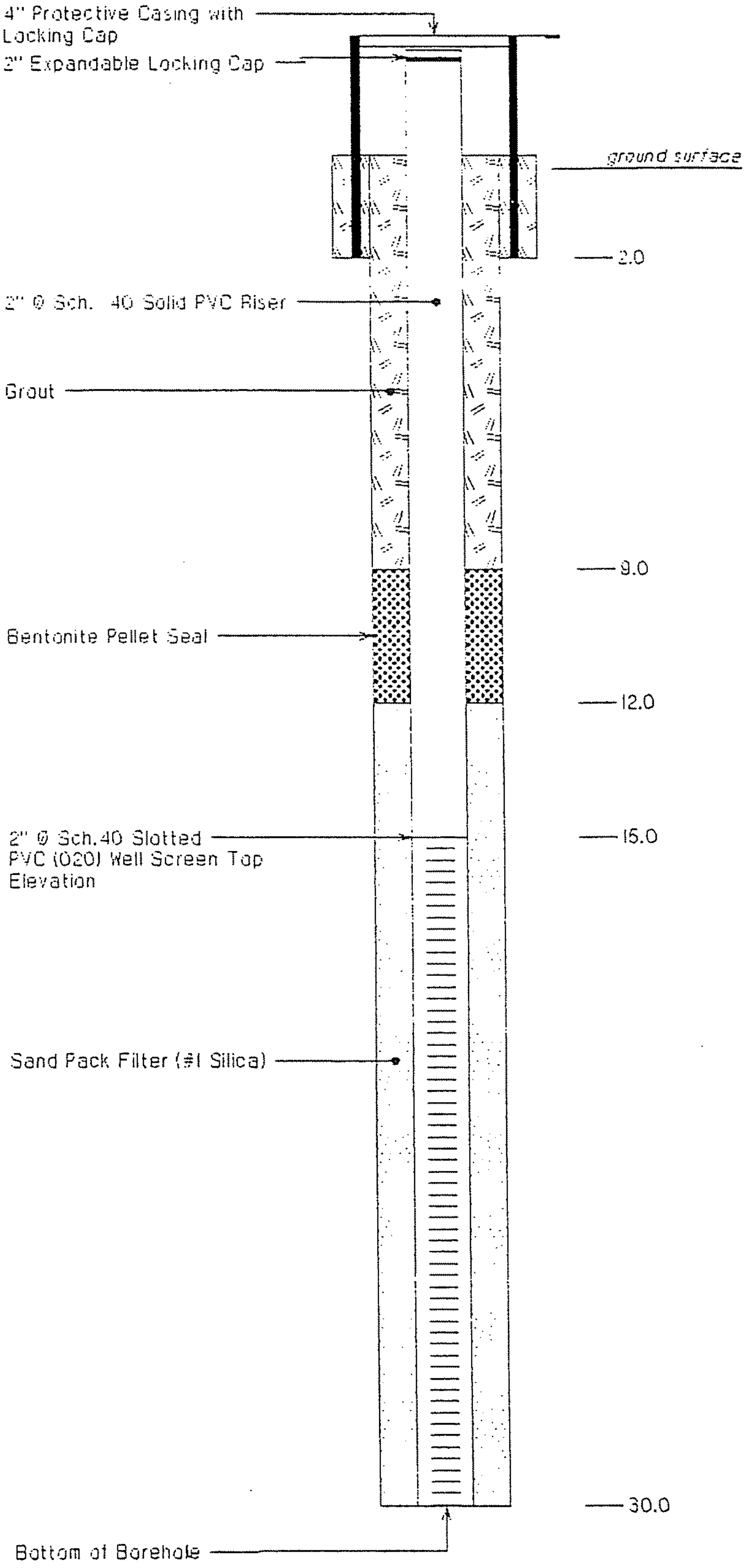
Static Depth to Water (feet) NA

Well Purpose Monitoring ground water.

Remarks

Prepared By D. Stamp

Date Prepared 2-13-98



MARCOR Remediation Inc.

| | | | |
|---|---|---|---|
| **WELL CONSTRUCTION LOG** | PROJECT<br>All State Olean Drilling | PROJECT NUMBER<br>R0-01463-001 | WELL NUMBER<br>PW20s |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference PW20s

Town and City Olean

County and State Cattaraugus, NY

Installation Date (s) 3-31-97

Drilling Method Canterra CT 350 with 4.25" HSA

Drilling Contractor K. Marcellus

Drilling Fluid NA

Development Technique (s) / Dates

NA

Fluid Loss During Drilling (gals) NA

Water Removed During Development (gals)

NA - NA

Static Depth to Water Date NA

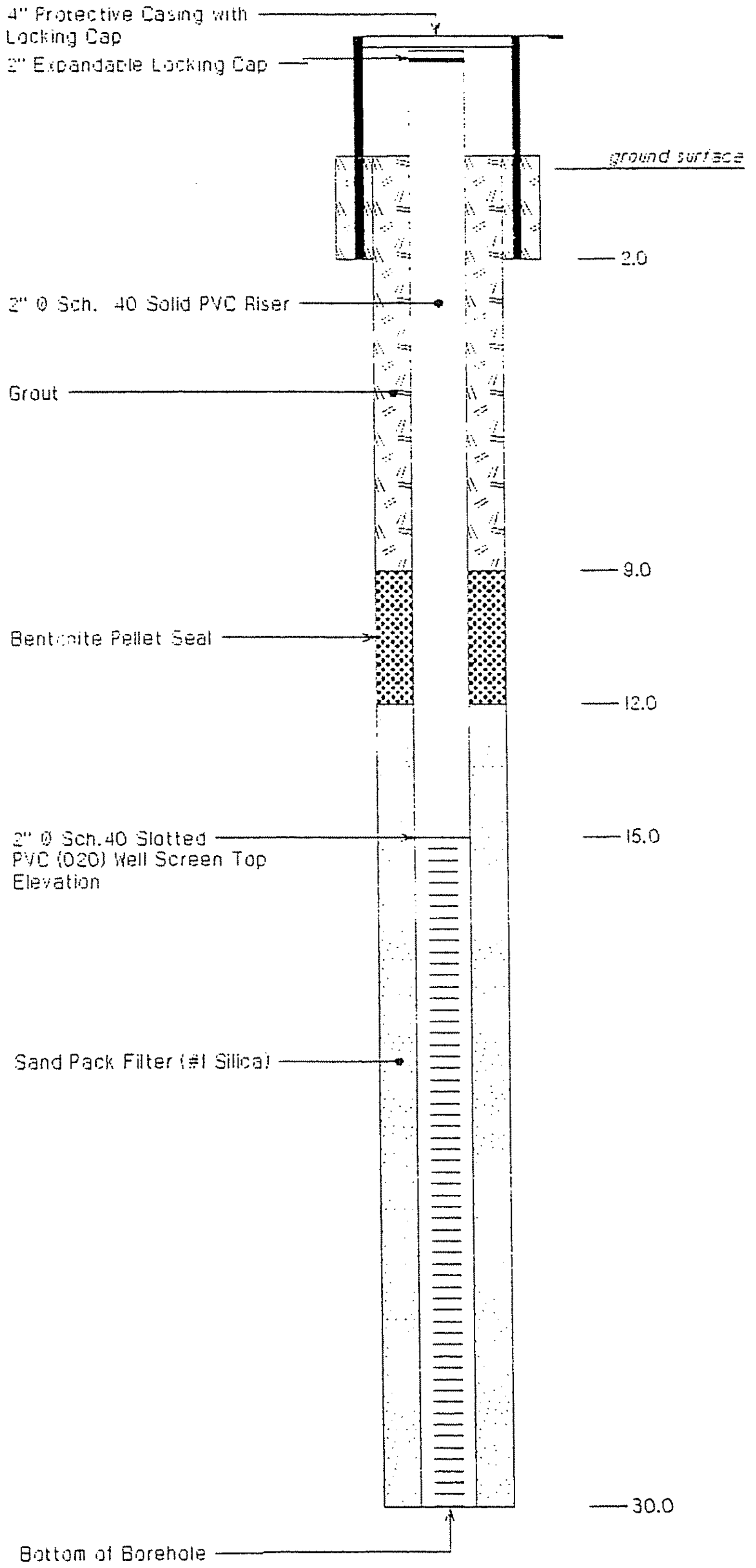
Static Depth to Water (feet) NA

Well Purpose Monitoring ground water.

Remarks

Prepared By D. Stamp

Date Prepared 2-13-98



# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>R0-01463-001 | WELL NUMBER<br>PW20d |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference PW20d
Town and City Olean
County and State Cattaraugus, NY

Installation Date (s) 3-28-97

Drilling Method Canterra CT 350 with 4.25" HSA
Drilling Contractor K. Marcellus
Drilling Fluid NA

Development Technique (s) / Dates
NA

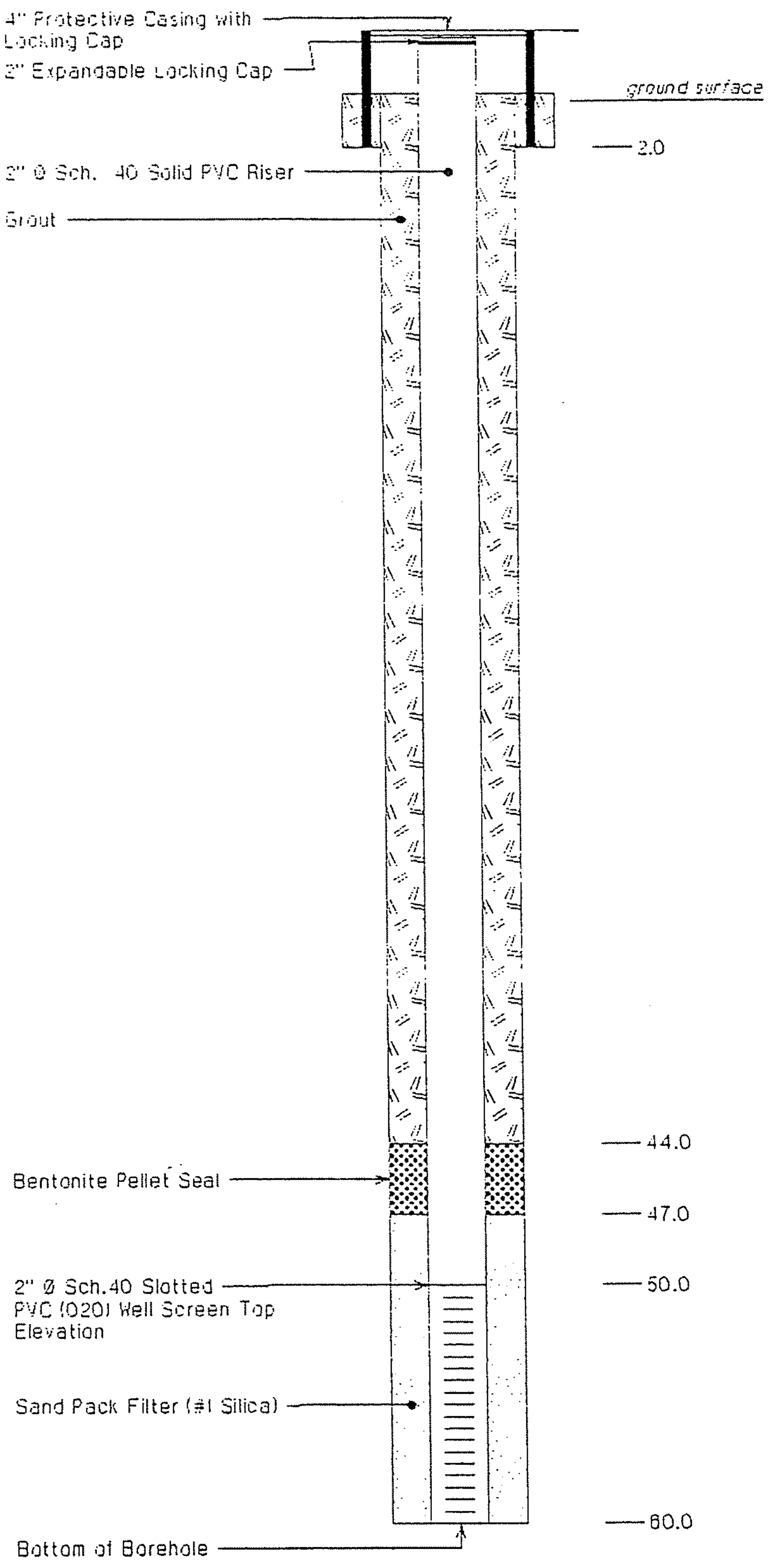
Fluid Loss During Drilling (gals) NA
Water Removed During Development (gals)
NA - NA

Static Depth to Water Date NA
Static Depth to Water (feet) NA

Well Purpose Monitoring ground water.

Remarks

Prepared By D. Stamp
Date Prepared 2-13-98



MARCOR Remediation Inc.

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| | PROJECT<br>All State Olean Drilling | PROJECT NUMBER<br>RO-01463-001 | WELL NUMBER<br>PW20vd |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference *PW20vd*
Town and City *Olean*
County and State *Cattaraugus, NY*

Installation Date (s) *5-5-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*
Drilling Contractor *K. Marcellus*
Drilling Fluid *NA*

Development Technique (s) / Dates
*NA*

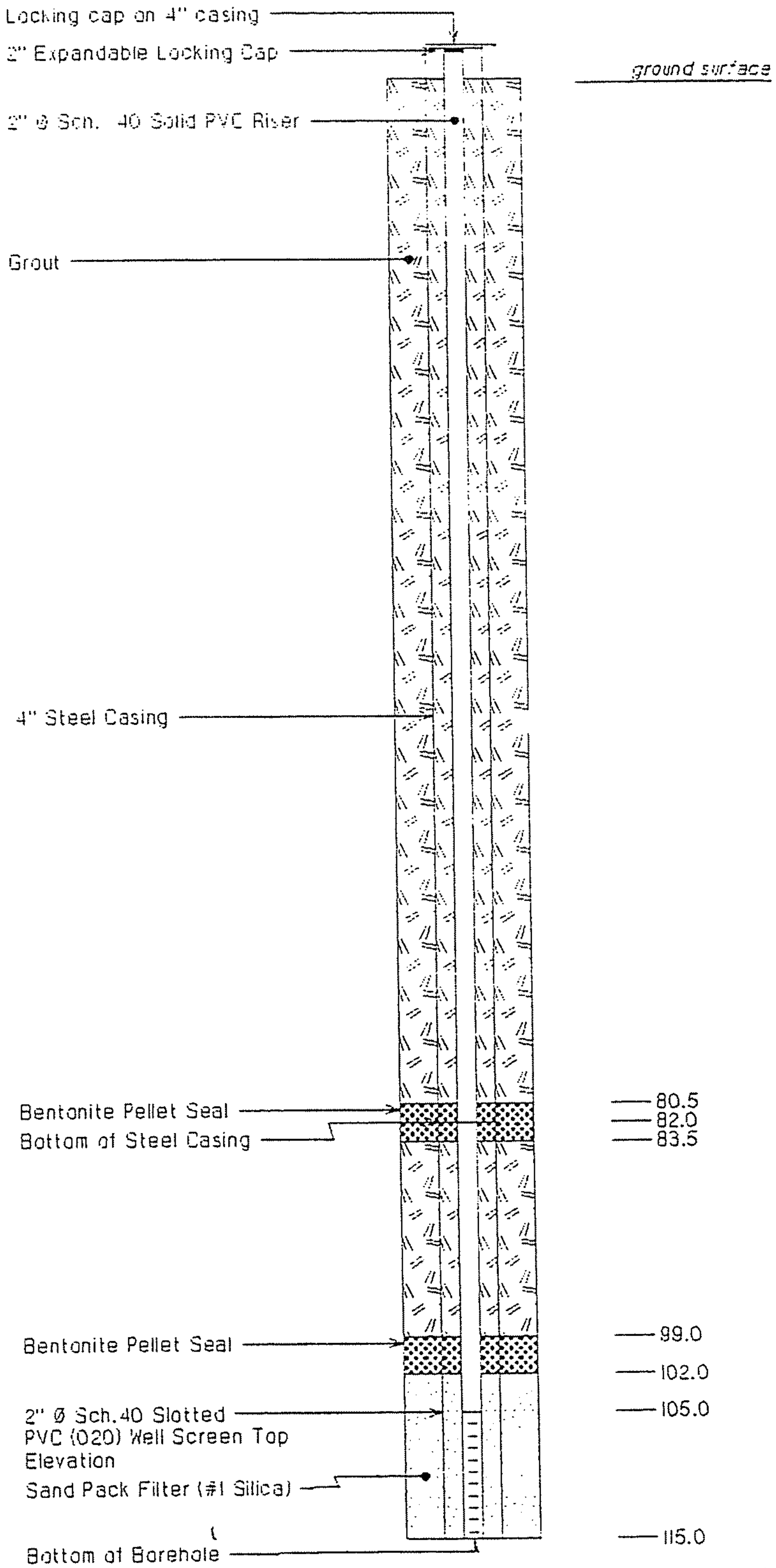
Fluid Loss During Drilling (gals) *NA*
Water Removed During Development (gals)
*NA - NA*

Static Depth to Water Date *NA*
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*
Date Prepared *2-13-98*



MARCOR Remediation Inc.

| | | | |
|---|---|---|---|
| WELL CONSTRUCTION LOG | PROJECT<br>All State Olean Drilling | PROJECT NUMBER<br>RO-01463-001 | WELL NUMBER<br>PW21s |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference *PW21s*
Town and City *Olean*
County and State *Cattaraugus, NY*

Installation Date (s) *3-19-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*
Drilling Contractor *K. Marcellus*
Drilling Fluid *NA*

Development Technique (s) / Dates
*NA*

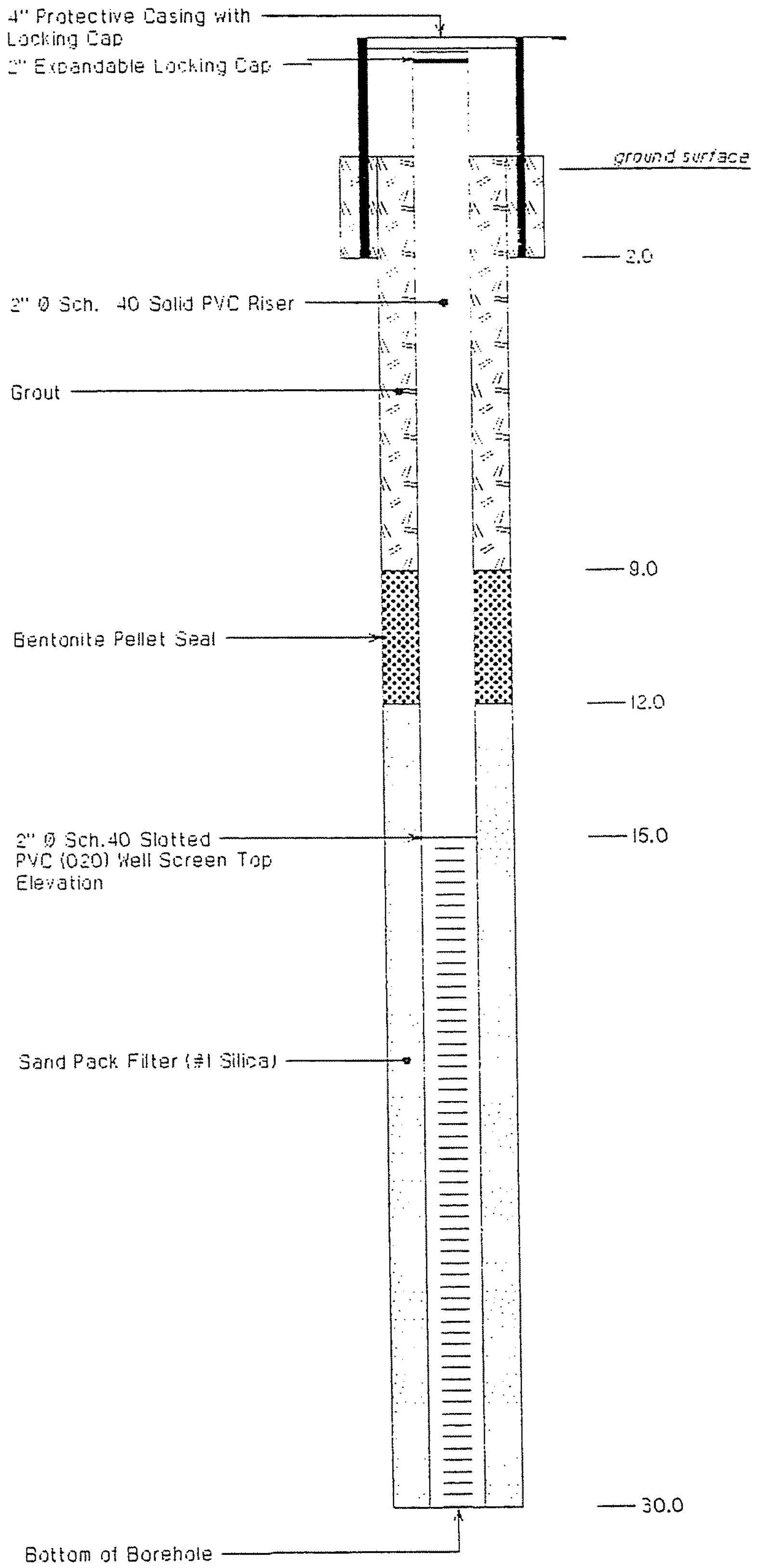
Fluid Loss During Drilling (gals) *NA*
Water Removed During Development (gals)
*NA - NA*

Static Depth to Water Date *NA*
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*
Date Prepared *2-13-98*



MARCOR Remediation Inc.

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>R0-01463-001 | WELL NUMBER<br>PW21d |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.56' |

Soil Boring Cross-Reference *PW21d*

Town and City *Olean*

County and State *Cattaraugus, NY*

Installation Date (s) *3-19-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*

Drilling Contractor *K. Marcellus*

Drilling Fluid *NA*

Development Technique (s) / Dates

*NA*

Fluid Loss During Drilling (gals) *NA*

Water Removed During Development (gals)

*NA - NA*

Static Depth to Water Date *NA*

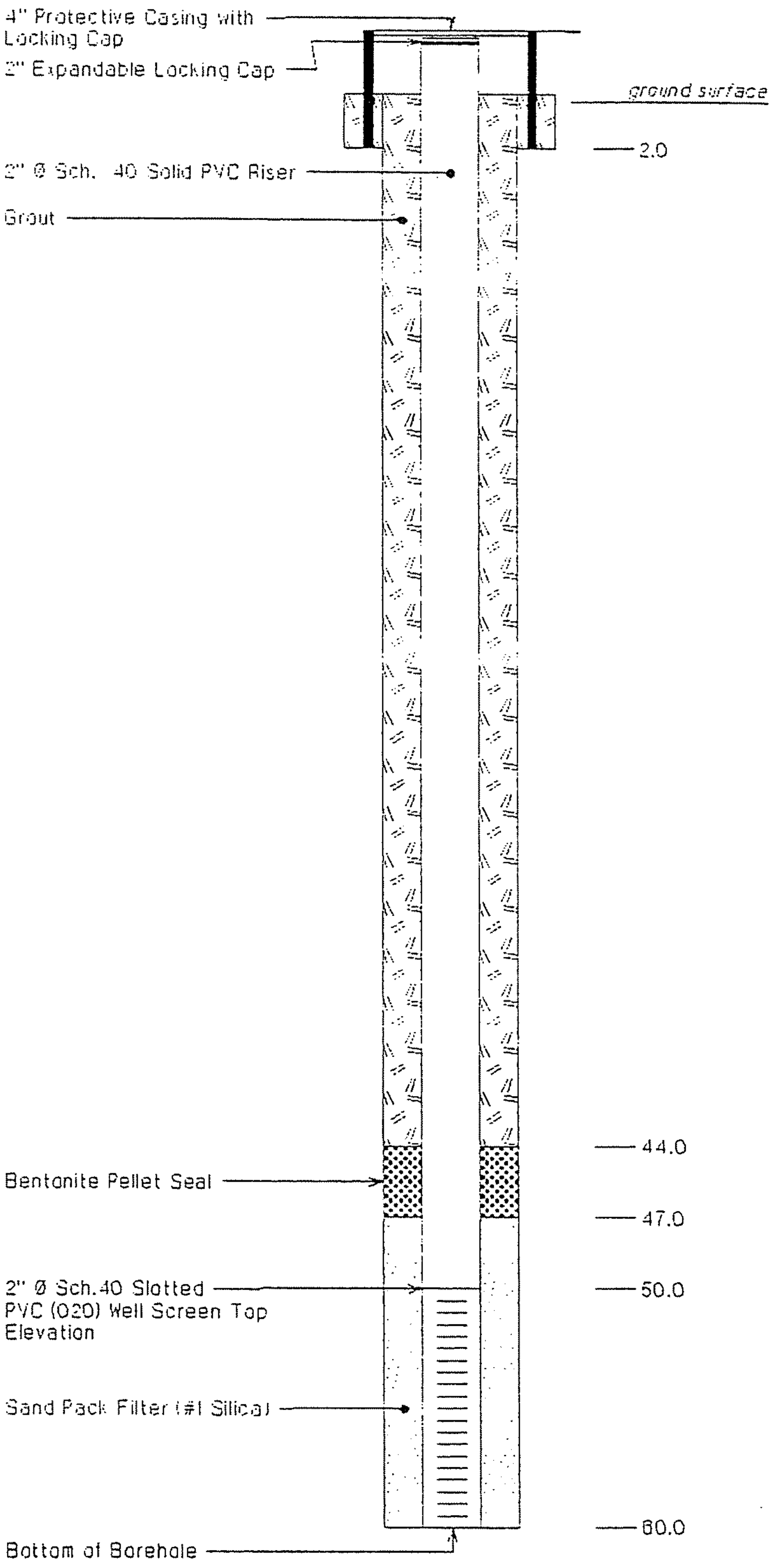
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*

Date Prepared *2-13-98*



MARCOR Remediation Inc.

# WELL CONSTRUCTION LOG

| | | | |
|---|---|---|---|
| PROJECT<br>All State Olean Drilling | | PROJECT NUMBER<br>RO-01463-001 | WELL NUMBER<br>PW21vd |
| SITE<br>Olean, NY | COORDINATES | GROUND SURFACE ELEVATION<br>Not Measured ☐ Surveyed ☒ Estimated | CASING STICKUP<br>2.66' |

Soil Boring Cross-Reference *PW21vd*
Town and City *Olean*
County and State *Cattaraugus, NY*

Installation Date (s) *4-28-97*

Drilling Method *Canterra CT 350 with 4.25" HSA*
Drilling Contractor *K. Marcelius*
Drilling Fluid *NA*

Development Technique (s) / Dates
*NA*

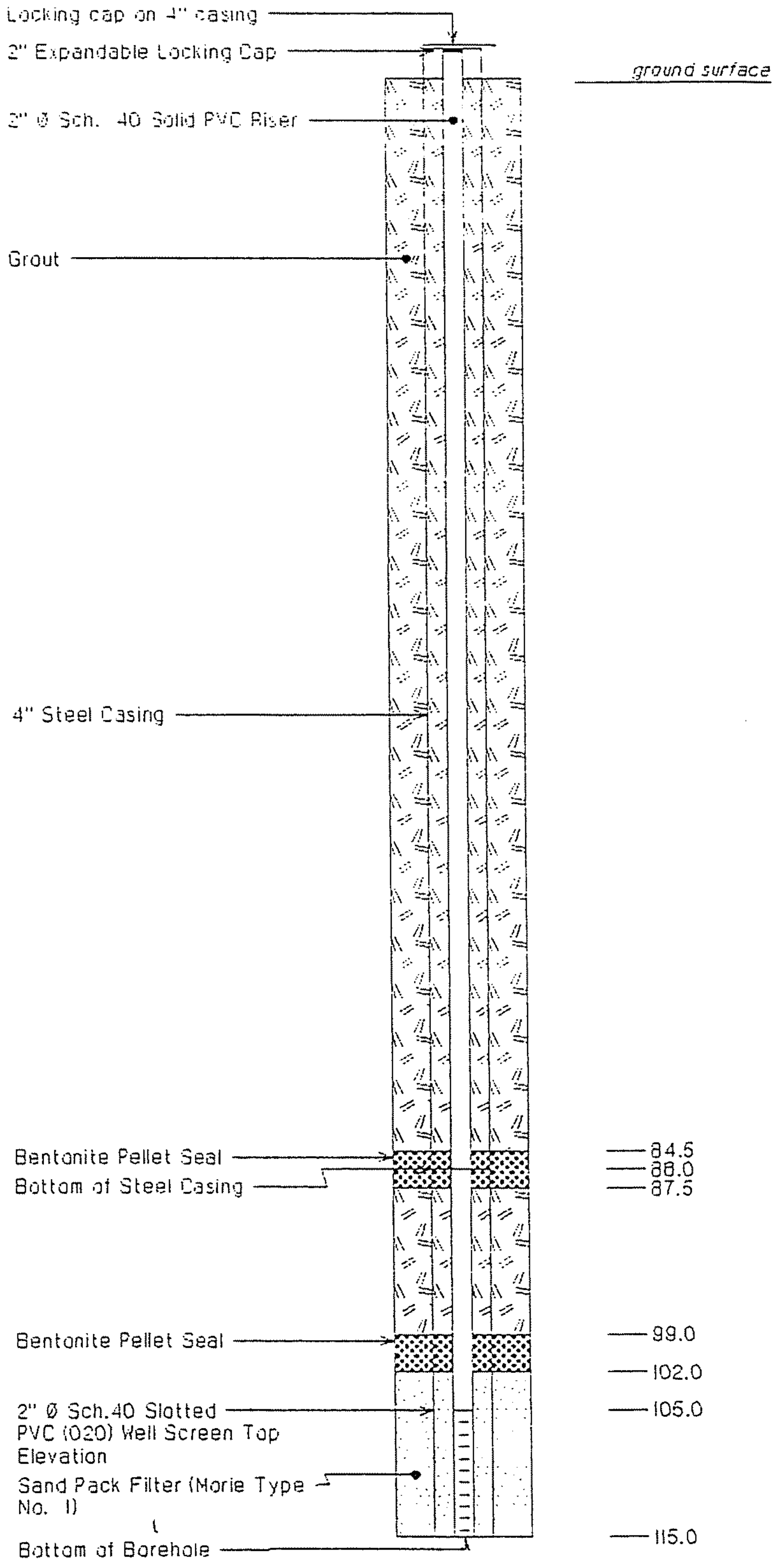
Fluid Loss During Drilling (gals) *NA*
Water Removed During Development (gals)
*NA - NA*

Static Depth to Water Date *NA*
Static Depth to Water (feet) *NA*

Well Purpose *Monitoring ground water.*

Remarks

Prepared By *D. Stamp*
Date Prepared *2-13-98*



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# APPENDIX G

# CHEMICAL HAZARDS

# Patty's Industrial Hygiene and Toxicology

THIRD REVISED EDITION
In Three Volumes

Volume 1
GENERAL PRINCIPLES

Volume 2A
TOXICOLOGY

Volume 3
THEORY AND RATIONALE
OF INDUSTRIAL HYGIENE
PRACTICE

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384. G. Maycock et al., *Nature*, **188**, 355 (1960).
385. *Natl. Bur. Stand. Handbook*, 69.

## 9 CHROMIUM, Cr

### 9.1 Source and Production (1, 2)

Elemental Cr does not exist naturally, but is found combined in the mineral chromite, $FeOCr_2O_3$, the most important source. Never found pure, conforming to the formula, chromite contains impurities of Mg and Al with interstitial impurities of metal silicates. High grade ore usually contains 48 percent $Cr_2O_3$, with a Cr/Fe ratio of about 3 : 1.

U.S. domestic mine production of chromite ceased in 1961, when the last Defense Production Act contract was phased out, but the United States continues to be one of the world's leading chromite consumers, producing Cr alloys, refractories, and chemicals. World production of chromite, totaling almost 8 million short tons in 1974, was derived from more than 20 countries worldwide, with the Soviet Union and Republic of South Africa leading all others by large margins. Chromite concentrates are readily produced by flotation with $C_{16}$ or $C_{18}$ amines after comminution of the ore to 120 $\mu$m size. Sodium lignin sulfonate is used to suppress the gangue.

Chromium is produced in the form of an iron alloy, ferrochromium, by the reduction of chromite ores with carbon or silicon in an electric furnace. Ferrochromium is also produced from chromite by a silicothermic reaction in the presence of a suitable oxidizing agent, such as calcium chromate, $CaCrO_4$, sodium nitrate, $NaNO_3$, or manganese dioxide, $MnO_2$. The latter reaction is exothermic. The silicothermic reaction is generally employed to produce ferrochromium of controlled low carbon content (0.03 to 0.1 percent C), although low carbon ferrochromium is also produced in quantity by the reduction and removal of the carbon of normal high carbon ferrochrome in a vacuum furnace by iron oxide, chromic oxide, or silica. The ferrochromium produced by this method is usually of very low carbon content (0.01 to 0.03 percent).

Chromium metal may be produced also by the exothermic reduction of chemically produced $Cr_2O_3$, using powdered aluminum as the reductant. Since the use of aluminum powder is associated with explosive hazards and with considerable losses of Cr, molten aluminum is poured at a lower temperature into a melt of $Cr_2O_3$–44 wt. percent CaO. With vigorous stirring nearly 94 percent of the Cr is recovered. The metal quality is good. Chromium metal is also produced on a commercial scale by electrolysis of an ammonium chromium–alum solution, prepared either from Cr ore or from high carbon ferrochromium.

Chromium metal is produced in more limited quantities by the thermal dissociation of $CrI_2$ in contact with a suitable heated deposition surface under vacuum conditions (the Van Arkel–de Boer process). This is the purest form of Cr presently available. A high purity product is also produced on a commercial scale by the hydrogen reduction of oxide in electrolytic Cr.

Table 29.9.1. Physical and Chemical Properties of Cr and Some of its Compounds

| Form of Cr | At. or Mol. Wt. | Sp. Gr. | M.P. (°C) | B.P. (°C) | Solubility |
|---|---|---|---|---|---|
| Chromium (Cr) | 52.01 | 7.20 (28°C) | 1157 ± 20 | 2672 | Insol. hot or cold $H_2O$; sol. HCl, dil. $H_2SO_4$; insol. $HNO_3$ |
| Chromic oxide (chromium sesquioxide ($Cr_2O_3$) | 152.02 | 5.21 | 2435 | 4000 | Insol. hot or cold $H_2O$; insol. acids, alcohol, alkalies |
| Chromium trioxide, "chromic acid" ($CrO_3$) | 100.01 | 2.70 | 196 | Dec. | 1.6 kg/liter (15°C), 2.067 kg/liter (100°C); sol. ether, alcohol, $H_2SO_4$ |
| Chromic chloride ($CrCl_3$) | 158.35 | 2.76 (15°C) | ~1150 subl. | 1300 | Insol. cold, sl sol. hot $H_2O$; insol. alcohol, acetone, MeOH, ether |
| Chromous chloride ($CrCl_2$) | 122.92 | 2.75 | 824 | | V. sol. cold or hot $H_2O$; sl. sol. alcohol; insol. ether |
| Chromium carbide ($Cr_3C_2$) | 180.02 | 6.68 | 1890 | 3800 | Insol. cold, hot $H_2O$ |
| Sodium chromate ($Na_2CrO_4$) | 162 | 2.71 | — | — | 873 g/liter (30°C); sol. MeOH; sl. sol. EtOH |
| Potassium dichromate ($K_2Cr_2O_7$) | 294.19 | 2.676 (25°C) | Triclin. monoclin. 241.6–>398 | Dec. 500 | 49 g/liter cold $H_2O$, 1.02 kg/liter hot $H_2O$; insol. alcohol |

Chromium exhibits a valence of 2+, 3+, and 6+ in its compounds. Chromium is a blue-white hard metal that is not oxidized in moist air and, even when heated, oxidizes to only a slight extent. In an atmosphere of $CO_2$, it oxidizes to $Cr_2O_3$; in HCl, to $CrCl_2$. Chromium combines directly with N, C, Si, and B. A passive form of the metal is conferred by oxidizing acids, attributable to a film of $Cr_2O_3$.

Bivalent Cr compounds are basic, the trivalent compounds amphoteric, and the hexavalent compounds acidic. The chromate ion in acidic solution is a powerful oxidizing agent. $Cr^{2+}$ compounds closely resemble $Fe^{2+}$ compounds; $Cr^{3+}$ compounds resemble those of $Al^{3+}$. Chromium forms a series of isopoly acids and salts ($K_2CrO_4$, $K_2Cr_2O_7$, $K_2Cr_3O_{10}$, $K_2Cr_4O_{13}$); a group of chrome alums (e.g., $NH_4Cr(SO_4)_2 \cdot 12H_2O$); and complex ammines (e.g., $[Cr(NH_3)_6]Cl_3 \cdot H_2O$), in which Cr is trivalent.

## 9.4 Analytic Determination

Samples of air containing Cr compounds may be collected in an impinger using a *N* NaOH solution. Upon addition of KI and acidification, the liberated $I_2$ is titrated with standardized $Na_2S_2O_3$ for a determination of $Cr^{6+}$. Microgram quantities may be determined colorimetrically by diphenylcarbazide following permanganate oxidation. The procedure is applicable to samples of air, water, and urine, with good recovery and a sensitivity of 0.03 μg of Cr in 25 ml (390). A modification has been recommended of the Saltzman method of Abell and Carlberg (391). Total particulate Cr in air can also be determined by atomic absorption spectrometry, as recommended by the Physical and Chemical Analysis Branch of NIOSH (63). The method has a sensitivity of about 0.1 μg/ml and the linear range extends to about 4 μg/ml when the nitrous oxide–acetylene flame is used. The range in air, accordingly, is from 0.01 g/m³ to greater than 0.4 μg/m³ when the recommended volumes of 100 liter air and 10 ml of solution are used.

Tissues have been analyzed for water- and acid-soluble Cr by a modified carbazide test (392) and for acid-insoluble Cr (chromite) by the method of Cahnmann (393). Procedures exist for the separation and analysis of soluble $Cr^{6+}$ and soluble total Cr in Portland cement, and for the determination of total Cr (394).

## 9.5 Physiologic Response

The physiological responses to Cr and its compounds are wide and varied, because associated with each of the three Cr valencies, 2+, 3+, and 6+, are different toxicologic potentials. Further, within each valency group, toxicity varies according to solubility. Thus whereas chromic acid, $CrO_3$, in which Cr is 6+, is highly corrosive and toxic, $Cr^{2+}$ and $Cr^{3+}$ salts, including $Cr_2O_3$, are ascribed a far lower order of toxicity; and Na chromate, $Na_2CrO_4$, a highly soluble Cr compound, in which Cr is also hexavalent, also has a low order of toxicity, but the corresponding insoluble chromates of Ca, Pb, and Zn are suspect, human lung carcinogens. By comparison, the physiological response of univalent elements is more regular and uniform.

The principal toxicologic reaction sites from industrial exposures are the skin (various forms of dermatitis, ulcers of the upper respiratory tract, nasal inflammation, and perforation of the septa), the larynx (inflammation and ulceration), and the lung (inflammation and bronchogenic carcinoma). The liver (enlargement) and the gastrointestinal tract (inflammation and ulceration) have been less commonly involved and only after many years of exposure, as was keratosis of the lips, gingiva, and palate. All responses occurred at Cr levels well above those recommended at the time (0.1 mg/m$^3$ as $CrO_3$), from $Cr^{6+}$ substances, and after long exposures.

### 9.5.1 Acute Toxicity

The industrial importance of the chromates, $Cr^{6+}$, has naturally led to greater amounts of toxicity data than for Cr compounds of lower valency, $Cr^{2+}$ and $Cr^{3+}$. But even here, strict comparison of data between compounds is impossible because of the piecemeal nature of the investigations, different species and routes of administration having been used on otherwise comparable compounds.

From information compiled in the NIOSH Registry (171) the acute toxicities of K and Na chromates and dichromates obtained variously from six laboratory animal species and by five routes are roughly of the same order of magnitude. These soluble chromates are of very low toxicity by mouth (of the order of 1500 mg/kg) and of intermediate toxicity by cutaneous application (from ca. 200 to 350 mg/kg), but highly toxic by subcutaneous, intraperitoneal, or intramuscular injection (from ca. 10 to 50 mg/kg), depending on the species.

The insoluble chromates of Ca, Pb, and Zn, as determined in the mouse, rat, and guinea pig, varied from a mouse intravenous $LD_{LO}$ of 30 mg/kg for basic Zn chromate, to 400 mg/kg for an intraperitoneal $LD_{50}$ for the guinea pig for Pb chromate (171).

A more detailed study of percutaneous and intraperitoneal toxicity of Na chromate and dichromate in guinea pigs, reported by Wahlberg (395), showed both chromates to be more toxic by intraperitoneal administration (7-day mortality, 100 percent from 140 and 80 mg doses for di- and monochromate, respectively, versus 60 and 20 percent mortality by cutaneous application.

In comparison, chromous ($Cr^{2+}$) and chromic ($Cr^{3+}$ salts had lower acute toxicities than those of $Cr^{6+}$ (171); again, oral toxicity was far less than that from other parenteral routes; for example, oral rat $LD_{50}$ for $CrCl_3$ of 1870 mg/kg versus 400 mg/kg for intravenous $LD_{LO}$ for the mouse. The acute toxicities, obtained from various species and routes, of $Cr^{2+}$ acetate, chloride, chromic fluoride, nitrate, oxide, and sulfate, Cr hexacarbonyl, and chromic acid ($CrO_3$) are given in Reference 171. Unfortunately, little acute toxicity for many of the Cr compounds appears to have been determined.

High doses of chromates given subcutaneously to rabbits and guinea pigs damage the kidneys with the production of albumin and casts (396), and inhalation of chromic acid dust by rabbits resulted in pulmonary hyperemia and inflammation (397).

In man, a case of acute K dichromate poisoning was characterized by an enlarged, tender liver with measurable amounts of Cr in the urine (398). The use of chromic acid for the treatment of warts and cauterization of hemorrhoids has resulted in several cases of Cr poisoning. A fatal case of nephritis has been reported (399) following treatment of carcinoma of the face with chromic acid crystals. Anuria rapidly developed, and death occurred in 30 days. The kidneys showed extensive lesions, particularly in the convoluted tubules, and blood chemistry showed very elevated levels of urea, inorganic phosphates, amino acids, and creatinine.

### 9.5.2 Chronic Toxicity

The chromic $Cr^{3+}$ compounds $Cr_3(PO_4)_2$ and basic Cr carbonate, $Cr_2O(CO_3)_2$, were shown by Akatsuka and Fairhall (400) to have a very low order of toxicity by inhalation and by ingestion compared with $Cr^{6+}$ compounds. Two cats exposed for 30 to 60 min/day for a total of 40.6 and 81.2 hr during a 4-month period to basic Zn chromic carbonate showed no evidence of acute or chronic toxicity, respectively, in spite of lung sections showing pinhead size patches of green Cr discoloration. At an average exposure concentration of 58.3 mg Cr/m$^3$, the estimated Cr inhaled was 115 and 223 mg Cr during the exposure period. The lack of measurable amounts of Cr in tissues other than the lungs tended to substantiate the lack of toxicity, and the 16 and 19 percent of the estimated inhaled dose retained in the lungs was apparently inert.

Ten cats daily ingesting levels of Cr phosphate of from 50 to 1000 mg/cat, amounting to 3.75 to 83 g total intake, also showed no adverse health effects, and of 12 tissues analyzed for Cr, only bone, urine, and blood showed more than the 2 to 17 $\mu$g Cr/50 g tissue sample (400). Thus a sharp distinction can be drawn between the toxicity of $Cr^{3+}$ and $Cr^{6+}$ inorganic salts.

In contrast, guinea pigs inhaling chromic acid mist from Cr-plating baths, in which Cr is hexavalent, for 0.5 to 3 hr daily during a 45-day period developed lesions of the mucosa and submucosa of the respiratory tract, as well as changes in the spleen and kidney (401). Also, sintered $CrO_3$ and $CaCrO_4$ produced cancers, mainly sarcomas, when introduced in pellet form into the thigh muscle and pleural cavity of rats (402). But neither $BaCrO_4$ nor basic KZn chromate, intratracheally injected into rats, resulted in carcinoma of the lungs; nor did a "mixed" chromate dust inhaled by rats and mice 4 hr daily throughout a major part of their lifetime (403), or irradiated $^{51}$Cr metal as an implant for 18 months in rats (404).

Tests of oral toxicity of four Pb-containing chrome pigments in worldwide use have been made in 90-day studies in dogs and rats (405). Molybdate orange, medium chrome yellow, primrose chrome yellow, and light chrome yellow (compositions given in Table 29.9.2) were fed for 90 days mixed separately in stock diets at extremely high levels of 2000, 5000, and 20,000 ppm for the purpose of comparing the toxicities with that of a standard basic Pb carbonate, white Pb. All pigments exerted effects at each level that were qualitatively similar, but medium chrome yellow, which had the lowest content of acid-soluble Pb, was less toxic. The toxicities could not be related quantitatively to their Cr or Pb content, or to acid-soluble Pb. In relative species response, dogs showed greater mortality; only the 2000 ppm level showed none for each of the pigments, whereas rat mortality occurred only at the 20,000 ppm level, and then only in association with the stress of bleeding; female deaths exceeded male by more than tenfold. Mortality response in dogs was probably a reflection of Cr tissue content, for the Cr in liver, kidney, brain, and bone of the dogs for all four pigments was two orders of magnitude greater in liver and kidney and one order of magnitude in brain and bone than in the rat. However, tissue Pb content of kidneys and bone of rats exceeded that of dogs, often by two- to fivefold or more, whereas that of liver was less by ten- to twentyfold; the brain showed comparable values (1 $\mu g/g$ or less). These varying tissue Cr and Pb contents may explain the general finding of inability to relate toxicity quantitatively to the Cr and Pb content of the pigments. Despite these lesser amounts of tissue Cr, rats showed more marked changes in hematologic variables (mean corpuscular volume, mean corpuscular hemoglobin) for all pigments, and histopathology of the kidney showed some tubular changes in dogs at all levels as did the majority of the rats. Noteworthy is the comparison of the toxicity of the white Pb positive control (for composition, see Table 29.9.2); toxic responses of the chrome pigments were considerably less severe and later in appearance, indicating a capacity of $Cr^{6+}$ to reduce Pb toxicity.

Soluble chromates, as opposed to the insoluble chromates just cited, at approximately 100 to 1000 times lower concentration, however, are well tolerated by both man and animals. Orally, hexavalent (and trivalent) Cr proved nontoxic to rats when given in drinking water for 1 year at levels from 0.45 to 25 ppm (406), and a Long Island, New York family has been reported (407) to have drunk water for several years from a well contaminated with 1 to 25 ppm chromate without known effects (408). On the other hand, an investigator is reported to have become nauseated when drinking 10 ppm of bichromate ($Cr_2O_7^{2-}$), but found 3.5 ppm tolerable (409).

### 9.5.3 Metabolism

Baetjer et al. studied the metabolism of Na chromate, K dichromate, and chromic chloride hexahydrate in guinea pigs for 140 days in the case of chromates and 60 days for the chromic compound, after intratracheal injection of 200 $\mu g$ Cr (410). The water-soluble chromates were cleared very rapidly from the lungs; only about 15 percent Cr remained in the lungs 10 min after injection; 20 percent was found in the blood at this time and another 5 percent in the three tissues analyzed (liver, kidneys, spleen), although small amounts were deposited in other soft tissues, and some may have been deposited in the gastrointestinal tract through cilia action. After 24 hr about 13 percent of the dose had been eliminated in the urine; 11 percent remained in the lungs, 8 percent in the red blood cells, 1 percent in the plasma, and about 4 and 3 percent in the liver and kidneys. Small amounts of Cr were deposited in muscle, adrenals, and skin, but essentially none in the bones, even after 90 days. Chromium in all tissues, except lung and spleen, gradually decreased to very low levels or disappeared altogether by 140 days. Chromium reached a peak in the spleen in 30 days, after which it declined, owing to uptake of disintegrating Cr-bearing red cells. Chromium was still present in the lungs and spleen even after 140 days, however. The metabolism was the same whether Na or K dichromate was administered.

**Table 29.9.2. Composition of Lead-Containing Chrome Pigments**

| | |
|---|---|
| Molybdate orange (MO) | 61.6% Pb; 3.7% Mo; 12.3% Cr; acid-soluble Pb, 4.7% |
| Medium chrome yellow (MCY) | 62.3% Pb; 14.6% Cr; acid-soluble Pb, 2.6% |
| Primrose chrome yellow (PCY) | 64.3% Pb; 10.6% Cr; acid-soluble Pb, 9.3% |
| Light chrome yellow (LCY) | 63.2% Pb; 10.6% Cr; acid-soluble Pb, 5.4% |
| White lead (WL) (control) | 81.9% Pb; acid-soluble Pb, 81% |

With $CrCl_3$, however, Cr metabolism was different; 10 min after injection, 69 percent of the dose remained in the lungs, and only 4 percent was found in the blood and the three other tissues that were analyzed. By 24 hr, 45 percent was still in the lungs, 6 percent was excreted in the urine, and only a very small percent was found in the other tissues. The spleen was the only tissue that showed accumulation and that occurred during the first 48 hr. The Cr that reached the blood was found in greater amounts in the plasma than in the cells, thus differing from the distribution of the chromates. Lung retention of $Cr^{3+}$ also differed; at the end of 30 days, 30 percent of $Cr^{3+}$ was still in the lungs compared with 2.4 percent of $Cr^{6+}$, and at 60 days, the comparable retentions are 12 and 1.6 percent.

Distribution of Cr in rats fed $Cr^{6+}$ in drinking water at various low levels (0.45 to 11 ppm) for 1 year showed highest amounts in spleen, then bone, kidney, and liver. All ppm $Cr^{6+}$ in the drinking water resulted in closely similar values for both males and females in the spleen at 1 year. At 25 ppm $Cr^{3+}$ in the water, the amount retained was about $\frac{1}{5}$ to $\frac{1}{10}$ that of $Cr^{6+}$ (406).

Mean urinary Cr value of white U.S. chromate workers in 1950, when exposures greatly exceeded the TLV 0.1 $\mu g/m^3$, was 43 $\mu g$/liter, for black workers 71 $\mu g$/liter. White workers from this group had a lung cancer rate 14 times the expected number, and blacks had 80 times the expected number. Mean value for blood Cr of white males was 4 $\mu g$ percent; for black males it was 6 $\mu g$ percent; 12 percent of the samples showed values of 10 $\mu g$ percent or greater (386).

As far as can be judged from the environmental data reported, comparable urinary and blood Cr values were found by Mancuso (411) in 90 chromate workers with known exposures to predominantly chromate or chromite, measured as "soluble" and "insoluble" Cr. Urinary Cr values among production and maintenance workers averaged 51 $\mu g$/liter, ranging as high as 380 for the production workers and 130 for the maintenance men. Blood Cr values determined in these workers tended to range below 10 percent of the urine values during exposure; 74 days after exposure, blood values tended to exceed 10 percent. Workers mainly exposed to chromate dusts develop higher blood and urine Cr levels than those having contact mainly with chromite dust. The important fact was noted that workers almost exclusively exposed to chromite had measurable amounts of Cr in both blood and urine 25 months after the last exposure (blood, 1 to 16 $\mu g$ percent vs. 2.5 $\mu g$ percent for normal adults) (412). Without measured amounts in a control population, it is doubtful, as the author claims, that Cr was in excess of normal in those workers 1 to 8 years after exposure (blood, 1.4 to 10 $\mu g$/percent; urine, 2 to 50 $\mu g$/liter).

Distribution and retention of Cr in body tissues of chromate workers was made by Baetjer et al. (410) to determine if tissue burden was related to bronchogenic carcinoma. From analyses of soluble and insoluble Cr in the lung and acid-soluble Cr in the respiratory tract including the bronchi of 11 chromate workers with carcinoma, five without, and two nonexposed controls, no such relation could be found, presumably because of the great variability of the contributing factors: (1) the very considerable differences in the lengths of exposure (2 to 42 years); (2) great variation in the latent period between the end of exposure and tissue analysis (2 weeks to 23 years); (3) the differing types and degrees of exposures that were only roughly known; and (4) the lack of smoking histories. Perhaps the most impressive finding was the high concentration of soluble Cr 23 years after exposure had ended (295 $\mu g$ Cr/10 g dry lung tissue compared with values of 1510 and 1270 $\mu g$ at latent periods of 1.5 and 4 years, in all three cases "heavy" Cr exposures with bronchogenic carcinoma.

From the foregoing metabolic data, blood and urinary Cr levels do not have practical usefulness as biologic indicators either of exposure or of body burden. Limited use possibly could be found for urinary Cr levels as indicators of very recent exposure to soluble chromates, but even here, unless exposure is well in excess of the recommended air standard, and control urinary Cr values are at hand, questionable results might be obtained. Urinary Cr as a measure of body burden from chromite (or other insoluble chromic compounds) could be useful, but for lack of appropriate, dose–response data, results could be of doubtful interpretation.

### 9.5.4 Mechanism

Chromium has been shown by Rollinson et al. (413) to interact with a variety of biologic substances, many of them critical to the proper functioning of the body. Among them are low molecular weight substances such as found in red blood cells, which form the basis for the solubility of $Cr^{3+}$ in body tissues. The following biologically important ligands have been shown to keep Cr in a diffusible form: pyrophosphate, methionine, serine, glycine, leucine, lysine, proline. The great affinity of Cr for pyrophosphate is of special interest because a number of pyrophosphate derivatives are of critical biologic importance.

Chromium has been shown also to react with proteins, but only as $Cr^{3+}$, with which it reacts slowly to form very stable complexes, as in chrome leather tanning. Chromates must be reduced to react. In confirmation of this, Grogan and Oppenheimer (414) found $Cr^{3+}$ to develop a strong bond with human plasma proteins at physiological pH, whereas that with $Cr^{6+}$ was quite weak. Further, Samitz and Katz (415) found that $K_2Cr_2O_7$ ($Cr^{6+}$) was reduced to $Cr^{3+}$ by abdominal skin.

Because enzymes are proteins, there is a natural affinity of Cr for certain enzymes; the enzyme, phosphoglucomutase, has a requirement for Cr for its activity (416). Chromium catalyzes the succinate, cytochrome C reductase system (417), favorably influences plant growth, and affects many other biologic reactions (418). Chromium also stimulates the conversion of acetate to $CO_2$, cholesterol, and fatty acids by rat liver in concentrations of $5 \times 10^{-5}M$ (419). Chromium inhibits as well as stimulates enzymatic reactions depending on concentration; for example, $Cr^{6+}$ has been shown by Dixon et al. (420) to inhibit at relatively high concentrations benzopyrene hydroxylase, an enzyme having an important role in the development of asbestos cancer.

The interaction of Cr with nucleic acids investigated by Wacker and Vallee (421) represents one of the most important contributions to our knowledge of the biologic role of Cr. The highest Cr concentrations ever reported (260 to 1080 ppm) were found in a beef liver fraction containing 70 percent ribonucleic acid and 30 percent protein, and a purified fraction contained 50 to 137 ppm Cr. RNA from other animal sources varied from 400 ppm in horse kidney to 18 ppm in calf pancreas, and the ratio between total metals and RNA-phosphorus was remarkably constant. Experimentally, $Cr^{3+}$, but not $Cr^{6+}$, precipitated pure RNA and DNA from solution at pH7 (422) but both valence forms denatured albumins at high concentration (2 percent) and at low pH (5.4) (423).

Another important, naturally occurring substance is the glucose tolerance factor, a dietary ingredient required for normal glucose metabolism, which contains $Cr^{3+}$ as its active ingredient, discovered by Schwartz and Mertz (424).

The complexation of proteins by Cr probably indicates the mechanism of its toxic action in dermatitis and sensitization, its combination with nucleic acids RNA and DNA, and its relation to cancer; its capacity to precipitate protein probably accounts for the highly acidic and corrosive action of "chromic acid," chrome ulcers, and perforation of nasal septa.

For a more detailed discussion of the mechanism of Cr action see Mertz (425).

### 9.5.5 Industrial Experience and Epidemiology

Industrial experience in the United States, Great Britain, and Europe of workers exposed to Cr substances has embraced a host of serious effects from (1) those industries using chromic acid anhydride or alkali metal salts of chromic acid, (2) the chromate–bichromate producing industry, (3) the chrome pigment producing industry, (4) the Cr alloy industry, and (5) the cement industry. Associated with the first have been reports of allergic contact dermatitis, skin ulcers, nasal membrane inflammation and ulceration, nasal septal perforation, rhinitis, nosebleed, liver damage, pulmonary congestion and edema, epigastric pain, erosion and discoloration of the teeth, and nephritis. Prominent among the chromate producing industry has been, in addition, an excessive incidence of lung cancer, and a suspicion of it in the pigment producing industry. In the chrome alloy industry, a single incident of pulmonary fibrosis has been reported, and in the cement industry, allergic hypersensitivity to Cr contributing to "cement dermatitis." All the effects have been from hexavalent Cr forms, except lung cancer, in which evidence for trivalent Cr has also been adduced. Beginning in 1827 by Cummin, in Great Britain, and in 1885 by Pye, who described "chrome holes," literally scores of reports of these industrial injuries have been repeatedly reported, all presumably from exposures in excess of the recommended limits. Because of their voluminous nature, only the more recent or definitive reports on each effect that contain references to previous reports are given.

**Skin Effects.** Dermatologic lesions, consisting of ulcers from contact with chromic acid or Na and K chromates, contact type dermatitis from the primary irritant, and sensitization from chromic acid and its salts, which are described in detail in the U.S. Public Health Service survey of the early 1950s (386), had already been reported by McCord and others in the 1930s and before. The ulcer, which occurs more readily if there is a break in the skin, is round, nonspreading, and deeply penetrating, with a clean-cut central crater whose base is covered with exudate or a tenacious crust. Once developed it is slow to heal, and if exposure continues it may persist for many months. The healing process usually leads to scar formation. In the six chromate plants surveyed, about 46 percent (300) white workers and 62 percent (151) blacks had ulcers or scars, and the percentage of scars and nearly healed and active lesions was about the same in both groups (84, 5, 12 percent).

Although skin ulceration continued to be reported in chromate and electroplating workers as late as the 1970s (426, 427), in those employed 1 year or less, no incidents of ulceration occurred in one of three plants surveyed in 1973 by Markel and Lucas (428) despite employment for much longer periods of time; 15 were employed 8 years or more, seven between 4 and 8 years, four between 1 and 4 years, and only six less than 1 year. Differences in personal hygiene practices were considered responsible.

Chromate dermatitis has been reported frequently since it was reported in 1944 among workers in the aircraft industry (429), for example, in 1951 among diesel railroad employees who handled chromate solutions as rust inhibitor (430); in 1959 among lithographers (431); in 1963 among automobile assemblers in Great Britain (432); in 1963 and 1964 among welders with Cr hypersensitivity (433, 434); and in 1963 handling chromate paints (435) and in 1954 and 1974 from cement (436, 437) in a few individuals with allergic chromate hypersensitivity. Cement workers who have green tattoo areas (from $Cr^{3+}$) get a lymphocytic reaction of delayed hypersensitivity along with a simultaneous cement dermatitis, as determined, oddly, by chromate ($Cr^{6+}$) patch tests (438). Fumes from welding Cr-containing stainless steel, or certain Cr-containing welding rods (E11018, E70S-3, E70T-1) (439) can trigger a severe eczematous eruption on the palms of the hand of a Cr-sensitive individual (434). Dermatologists do not understand the absence of Cr dermatitis among chromate workers who have chrome ulcers (428), and present-day improved work practices have for the most part eliminated Cr dermatitis seen in many of the industries listed above.

**Nose, Throat, and Sinuses.** At least a dozen reports, mostly from the United States (440), show nasal membrane inflammation and ulceration, nasal septal perforation, and chronic rhinitis, laryngitis, and pharyngitis to be a common finding among chromate workers and those exposed to chromic acid mist alike. Mancuso (411) in an intensive medical study of 97 chromate workers in a plant population of 226, reported in 1951 that 63 percent showed perforations of the nasal septum, 86.6 percent had chronic chemical rhinitis, and 42.3 percent pharyngitis. Clinical changes in the larynx, including polyps and hoarseness, were present in 23 percent of those examined, and sinuses of 89 workers had polyps or cysts in 8 percent. There was a direct relation of sinus involvement to soluble chromates, but is should be noted that it is not possible to relate nasal septal perforation to ambient Cr levels because of the common practice of nose picking to remove encrustations. It should be noted also that there were no instances found of cancer of the affected parts, although carcinoma of the lung was found at this time (1951).

Very similar incidences of these lesions were reported in the 1953 survey made by the U.S. Public Health Service of 897 workers, both white and black, in six chromate plants (386). At this time there was no evidence that chromic acid and its salts led to chrome sensitization (441).

Despite the widespread knowledge of the seriousness of the findings in both these studies, which led to the rebuilding of the chromate producing plants with improved controls, reports of similar Cr injuries appeared as late as 1965 in the United States in the chrome plating of auto parts, (442) and among electroplaters in Brazil in 1974 (443). In both instances, exposures were well above the recommended TLV.

**Lung Cancer.** The Cr lesion that is currently giving the greatest concern to industry and health agencies alike is bronchogenic carcinoma. Attention was first drawn to its appearance in seven chromate producing plants in the United States by Machle and Gregorius (444). These investigators were employed by the chromate industry after it was learned that lung cancers were appearing in the chrome pigment plants in Germany (445). Because this study had some shortcomings, Baetjer (446) brought further attention to the problem when she found from hospital records that the lung cancer rate was higher among chromate workers than in hospital control groups. This, and a more intensive study by Mancuso and Hueper (447) of one of the plants studied by Machle and Gregorius, initiated the comprehensive study by the U.S. Public Health Service of six chromate plants comprising 897 workers (386). This study revealed that there were 28.9 times as many deaths from lung cancer in the male chromate workers between 1940 and 1948 than would have been expected on the basis of average death rate for the United States for that period.

Mancuso has redetermined the lung cancer death rates, after 37 to 43 years, of chromate workers that had been employed from 1931 to 1937 in a plant that began operations in 1931–1932 (448). Of a total of 332 workers, 52 percent or 173 had died by 1974. Of the 173, 41, or 23.7 percent, had died of lung cancer (62.1 percent of all cancers). The latent period was found to cluster around 27 to 36 years, indicating Cr to be not a very potent carcinogen. Mancuso was able further to ascertain with greater assurance than in the past that (1) both soluble and insoluble Cr forms are involved in eliciting lung cancer. This conclusion was reached on the basis of a clear demonstration of a dose–response relation for both soluble and insoluble forms, made possible by his determination of the relative amounts of the two forms in the workers' exposure in his previous report (411). (2) No cancer deaths occurred from exposures to the insoluble forms at levels less than 0.25 mg/(m$^3$)(year); three deaths resulted from the soluble forms at this level, however; and no deaths resulted from total Cr at levels below 0.50 mg/(m$^3$)(year). In each, the number of deaths increased as the level of Cr increased. Because no smoking histories were available, the first study having been made before the association with lung cancer was realized, it must be assumed that smoking habits were the same in each group.

Attention at long last has been focused on the carcinogenic potential of chrome pigments. First suspected in Germany in 1943 from Pb and $ZnCrO_4$, it was not until the mid 1950s that two reports of very preliminary nature, appeared, one from Norway (449) and one from the United States (450). Four cases of cancer, three of the bronchus and one of the pancreas, were reported from a small cohort of 24 workers employed in three Norwegian plants, and exposed at various times since 1948 to $PbCrO_4$ or $ZnCrO_4$, and sometimes to both (449). Because of the small number in the study cohort (total employment 133 from 1948 to 1972), the relatively short exposure time (six exposed for 4 years, four for 5 years, and 14 for more than 5 years), and the small number and types of cancer, and in light of the long latent period for Cr cancers found by Mancuso, the study reveals no information as to whether Pb or Zn chromates are carcinogenic together or singly. Moreover, one worker with bronchogenic carcinoma was a heavy smoker.

An epidemiologic study of three chrome pigment plants in three states in the United States, sponsored by the Dry Color Manufacturers' Association, was somewhat more revealing (450). The cohort analysis included 548 male workers, among whom 53 deaths had occurred before December 31, 1974. For two plants with only $PbCrO_4$ exposure, a threefold excess of lung cancer was found (SMR 313.7 vs. 100 expected). For workers hired before 1960 and who had worked for at least 10 years, the SMR was 236.4. Employees of the plant with both Pb and Zn chromate exposure, hired before 1960, had an SMR of 237.1. Five deaths due to stomach cancer were also found, apparently from swallowing inhaled chromate dust or from excessive mouth breathing. Because of the small number of cancer deaths, it is still not possible to declare either Pb or Zn chromate carcinogens, and certainly not potent ones, because in nearly one-half of the samples, time-weighted average Cr concentrations exceeded the recommended TLV.

**Systemic Effects.** In addition to the gastric cancers just cited, decrease or loss of taste and smell with gastrointestinal ulcers or hypertrophic gastritis have been reported by several observers, including Mancuso (411). Mancuso also found some blood changes, including leukocytosis or leukopenia, monocytosis, and eosinophilia. Liver injury has been recorded rarely.

A single report of progressive pulmonary fibrosis in a small number of workers in a plant producing chrome alloys, low carbon ferrochrome alloys, and ferrosilicon appeared in 1962 (451). No subsequent report on the subject has since appeared. It is possible, as a result of this finding, that exposures have since been reduced. Air levels of total dust ranged from 0.4 to 445 mg/m$^3$. The fibrosis was believed not to be due to silica because the quartz content of the dust was commonly below 2 percent and no crystalline silica was found in the lung. The disease was characterized by recurring bouts of acute pneumonitis, with cough, wheezing, anorexia, loss of weight, increased sedimentation rate, linear and nodular fibrosis, and ventilatory impairment.

## 9.6 Hygienic Standards of Permissible Exposure

The TLV Committee of the American Conference of Governmental Industrial Hygienists has recommended a limit of 0.05 mg/m$^3$ as Cr as a time-weighted average for chromic acid ($CrO_3$) and chromates; of 0.5 mg/m$^3$ as Cr for soluble chromic and chromous salts; of 1 mg/m$^3$ for Cr metal; and a classification of Ala for certain insoluble metal chromates, Pb, Zn, and Ca, which are suspected of carcinogenic potential for man (452).

NIOSH has recommended to OSHA a limit of 0.05 mg/m$^3$ as $CrO_3$ as a time-weighted average exposure for an 8-hr workday, 40-hr work week, and a ceiling concentration of 0.1 mg/m$^3$ as $CrO_3$ as determined by a sampling time of 15 min (453); for $Cr^{6+}$ of carcinogenic potential, a limit of 0.001 mg Cr/m$^3$ in the breathing zone; and for noncarcinogenic $Cr^{6+}$, a limit of 0.025 mg Cr/m$^3$ as a time-weighted average for a 10-hr workday, 40-hr work week, and a ceiling of 0.050 mg/m$^3$ (440).

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## 10 COBALT, Co

### 10.1 Source and Production (1, 2)

Cobalt is a relatively rare element, composing only 0.001 percent of the earth's crust, as compared with 0.02 percent Ni. Important minerals are the arsenides, sulfides, and oxidized forms. The principal arsenides of Co are smaltite ($CoAs_2$), safflorite ($CoAs_2$), skuterudite ($CoAs_3$), and cobaltite (CoAsS). The principal sulfide minerals are carrolite ($CuCo_2S_4$) and linnaeite ($Co_3S_4$). The principal oxide minerals are asbolite (an impure mixture of Mn and other oxides), neterogenite (a hydrated oxide usually containing Cu and occasionally Ni and Fe), sphaerocobaltite ($CoCO_3$), and erythrite ($3CoO \cdot As_2O_5 \cdot 8H_2O$). A number of other less known materials of Co exist but in insufficient quantity to be mined.

No domestic (U.S.) production of Co occurred in 1974, although developments for production were underway, but imports for consumption totaled almost 16 million pounds, and total domestic consumption totaled about 19 million pounds, the excess coming from U.S. government stockpiles. World sources of metal and oxide were chiefly from Zaire, Belgium-Luxembourg, Norway, and Finland, in that order, Zaire furnishing 58 percent of the world supply.

Practically all Co produced is a by- or coproduct of other metals, chiefly Cu; accord-