AMMONIA TRANSPORT AND CONVERSION

MONITORING PROGRAM

A. Introduction

During the NRC environmental impact analysis of the Wyoming Mineral Corporation (WMC) Irigaray solution mining facility in Johnson County, Wyoming, it was agreed that WMC would conduct an experimental program at the original 517 field to determine the possible extent of post-mining and post-restoration ammonia migration and conversion. The 517 test site was mined in 1976 and a section of it was restored in 1977.

WMC has developed an experimental monitoring program which will satisfy the NRC requirements of Source Material License SUA-1341, (Docket 40-8502) Condition No. 38, "The licensee shall submit a plan for determining ammonia transport and conversion in the original section of the 517 test site before March 15, 1979."

The purpose of the proposed program is to evaluate:

1. The natural-groundwater-flow-induced transport of ammonia from both the restored as well as unrestored section of the 517 test site.

2. The potential for and extent of possible ammonia conversion to nitrate species in the pre- and post-restoration sections of the 5I7 test well fields.

B. Site Description of the 5I7 Test Area

The 5I7 test area consists of three 5-spot test patterns (cells) as shown in Figure 1. Two of the patterns (5I7 and 5I7-X) were drilled on approximately 40 foot spacings and one (5I7-S) was drilled on a 60 foot spacing. Each of these cells was tested using an ammonium bicarbonate solution mining lixiviant. Five monitor wells surround the test field. These wells were regularly monitored during the mining and restoration tests.

The general geology of the Wasatch formation where the 5I7 area minerology is deposited consists of interbedded sandstones, shales and coals. The Upper Irigaray Sandstone (UISS) is located at approximately 200 feet and has a thickness of about 100 feet. Mineralization distribution in the sandstone is complex and depends heavily on the relationship of the deposited roll fronts to the oxidized/reduced interfaces.

The hydrologic characteristics of the 5I7 test area were determined by a previously performed pump test. The results of this pump test indicate:

Transmissivity = 1000 gpd/ft
Storage coefficient = $1.85 \times 10^{-5}$ - $7.44 \times 10^{-4}$
Major axis hydraulic conductivity = 11.6 gpd/$ft^2$
Minor axis hydraulic conductivity = 6.7 gpd/$ft^2$

Direction of major axis = N35°W
Groundwater flow = 5-13 ft/yr
Porosity = 0.25

C. Objectives of Proposed Monitoring Program

The proposed monitoring program is designed to establish the effects of the natural hydrologic and geochemical environment on the post-mining and post-restoration groundwater in the 517 test field. Particularly, the phenomena of groundwater transport of residual lixiviant species and the potential for conversion of ammonia to other species will be examined.

The first objective of this program will be to address the question of the rate and extent of ammonia migration from the various portions of the test site area. This will be accomplished by taking into account the geo-hydrologic character of the mined and restored sections of the test field. It is expected that due to the slow movement of the groundwater (~10 ft/yr) and the high chemical exchange capacity of the clays in the ore body, the ammonium ion will not be transported from the test site over large distances.

While it is expected that a gradual increase in general water quality (conductivity) will occur in the south-east area of the test site due to the natural influx of fresh groundwater, it is not expected that this slow movement of groundwater will transport appreciable quantities of ammonium ion. In order to verify this expected phenomena, both the upstream as well as downstream areas

of the test site will be monitored. The proposed sampling and monitoring program is contained in the next section.

Because the restored section of the 5I7 test cell is surrounded to the south and east by unrestored mined areas, it is expected that the restored area will gradually decrease in groundwater quality due to the slow natural movement of groundwater from the unrestored areas to the south. The proposed sampling and monitoring program for this section of the 5I7 test site follows in the next section.

The second objective of the monitoring program is to evaluate the potential of in-situ ammonia conversion to nitrates or other nitrogen species. It is a well known phenomena that under the correct biological and chemical environments ammonium ion can be converted to nitrates and nitrites. For this conversion to take place, however, an aerobic environment is required to provide the necessary oxygen for the conversion. After mining has ceased, the underground environment is not conducive to oxygen retention due to the many oxygen consumption reactions that take place with the host mineralization. Thus, an anaerobic environment exists which would preclude the conversion of ammonia to nitrates. Additionally, in a post-restoration aquifer, anaerobic conditions will exist due to the influx of natural groundwaters into the mine zone. All of these factors will limit or entirely preclude the possibility of nitrate conversions in a post-mining or post-restoration environment.

It is likely that anaerobic biological reactions may occur in the aquifer after mining or restoration has been completed. These reactions could be quite beneficial in that direct conversions of any trace ammonia or nitrates to harmless nitrogen gas are possible. This conversion is well known to occur in oxygen depleted environments in the presence of denitrifying bacteria. Some evidence for the presence of the denitrifyers exists from biological evaluations of well confined aquifers. Although the process is biologically a slow process, this phenomena could give rise to gradual ammonia reductions with time to inert nitrogen gas.

The proposed monitoring program will observe both the potential presence and possible conversion of ammonia to nitrates or to $N_2$ gas.

D. Proposed 517 Site Transport Modeling Program

In addition to the chemical monitoring program outlined in Section E, a computer dispersion model analysis will be performed on the 517 test site. This model, currently under development, will enable the prediction of ammonia transport as a function of time and groundwater flow. It is expected that the analysis of this modeling will be available in the last quarter of 1979.

The model will be used to predict the natural-groundwater-flow-induced movement of ammonia in the presence of a clay ore body. Preliminary results from this model are capable of accurately predicting the clay interaction behavior of column tests and it is

expected that the field models will be capable of predicting the longtime effects of ammonia transport and dispersion.

E. Proposed Monitoring Program

The following proposed monitoring program is designed to obtain data on ammonia transport and conversion from the 5I7 test site consistent with the Irigaray NRC Source Material License SUA-1341, Condition 38. All well designations in the following program descriptions refer to Figure 1.

1. Initial Site Evaluation

(a) Groundwater Gradient

- Three sets of water level measurements will be taken over two weeks in wells M1, M2, M3, M4, M5 and 5I7-3, 7, 14 to establish the groundwater flow gradient.

(b) Initial Water Quality

- Initial water quality will be established for the monitor zone, restored test site area, mined area interior wells, and mined area exterior wells. These wells will be sampled according to the procedure outlined in Table 1.

2. Ammonia Migration and Conversion Monitoring

Wells have been selected in the 5I7 test pattern to show the effect and extent of groundwater movement on water quality and ammonia migration. These wells, in addition to being analyzed for water quality parameters will be analyzed for chemical conditions which would show potential for chemical or biological

ammonia conversion. The proposed well selection, sampling schedule and chemical analysis is shown in Table 1. It is recommended that pumped samples be minimized to reduce the effects of induced migrations on the analysis.

(a) Monitor Zone Wells

- Monitor zone wells (M wells) will be sampled to evaluate potential changes in water quality due to solution movement from the mined areas.
- Monitor zone wells will pump sampled quarterly and analyzed for species listed in Table 2 (normal excursion indicators).

(b) Restoration Area Wells

- Restoration wells (R wells) will be sampled quarterly by thief sampling. Pumped samples will be taken annually. Thief samples are recommended to reduce the effects of pumping-induced migrations of surrounding mining solutions into the restored area.
- R wells will be sampled and analyzed for a partial suite of elements including major cations and anions, ammonia, nitrates, and physical parameters such as pH, Eh, and conductivity.
- On an annual basis, R wells will be pump sampled.
- Well 5I7-6 will receive a full environmental analysis on an annual basis.

(c) Mined Area Interior Wells (I Wells)

- The unrestored cells 5I7-X and 5I7-S will be sampled to evaluate the change in water quality with time in a mine zone.
- Wells 5I7-9 and 5I7-14 will be thief sampled quarterly and pumped annually.
- There wells will be analyzed for all major cations and anions, ammonia, nitrates, pH, Eh, and conductivity.
- Well 5I7-14 will be analyzed for the full environmental suite annually.

(d) Mined Area Exterior Wells (E Wells)

- Since the natural flow of groundwater is to the northwest, a selection of wells to the southeast of the test pat[illegible] should show the influence of incoming fresh groundw[illegible]

- The E wells (5I7-7, 8, 12, 13) will be sampled quarterly to evaluate the effect of intrusion of fresh water on a mined zone.

- These wells will be analyzed for all major cations and anions, ammonia, nitrates, pH, Eh, and conductivity.

- Well 5I7-12 will be analyzed for the full environmental suite annually.

3. Data Analysis and Reporting

The data from this monitoring program will be analyzed and reported annually in the NRC Annual Report.

Table 1

Proposed Ammonia Migration and
Conversion Monitoring Program

| Migration & Conversion Sampling Program | Sampling | | | Analysis | | |
|---|---|---|---|---|---|---|
| | Initial Pumped | Routine Pumped | Routine Thief | Table 2 | Table 3 | Full Environmental Analysis (Initial & Annual) |
| . M Wells | x | Quarterly | -- | x | (Initial) | |
| . R Wells | x | Annual | Quarterly | | x | 5I7-6 |
| . I Wells | x | Annual | Quarterly | | x | 5I7-14 |
| . E Wells | x | Annual | Quarterly | | x | 5I7-12 |

M Wells = Monitor wells; M1-M5
R Wells = Restoration wells; 5I7-3, 3A, 2A, 6A, 6
I Wells = Mined area interior wells; 5I7-9, 14
E Wells = Mined area exterior wells; 5I7-7, 8, 12, 13

Table 2

Chemical Analysis: Monitor Wells:

$U_3O_8$, $NH_4^+$, $Cl^-$, Total alkalinity, Conductivity

Table 3

Chemical Analysis: Ammonia Migration and Conversion Wells

Major Cations: $Na^+$, $Ca^{++}$, $Mg^{++}$

Major Anions: $HCO_3^-$, $Cl^-$, $SO_4^=$

Conversion Parameters: $NH_4^+$, $NO_3^-$, Eh

Misc. Parameters: $U_3O_8$, pH, Conductivity

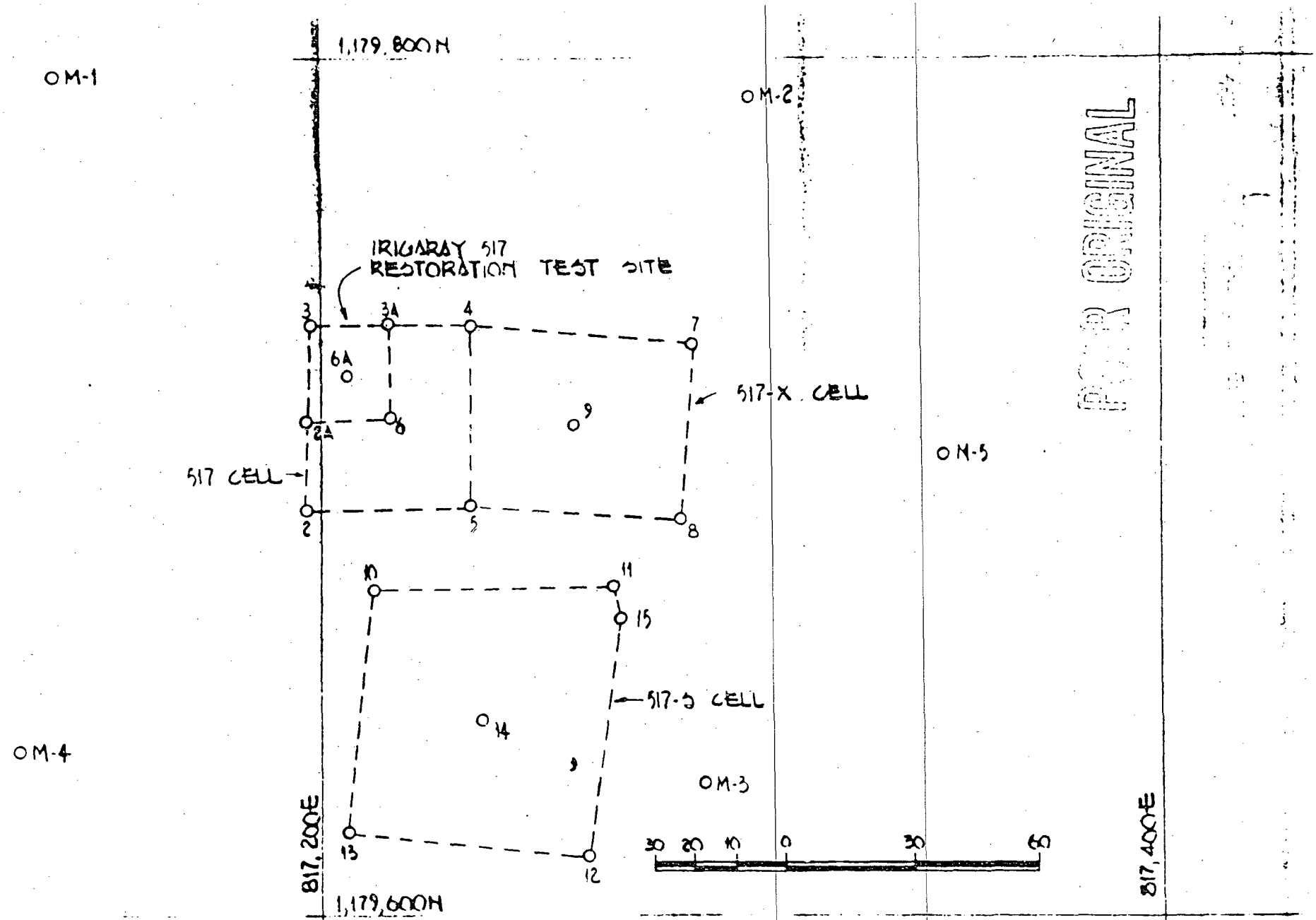




FIG. 1: 517 TEST SITE: AMMONIA MONITORING PROGRAM