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Ms Cynthia B Gee
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Subject French Drain Inflows
881 Hillside
Operable Unit 1

Dear Ms Gee

This letter reviews the status of ground-water inflows to the 881 Hillside French Drain In particular, the letter addresses the following questions

1 What was the basis for the design inflow to the drain?

2 Why wasn t the project halted when no water was found in the geotechnical investigation?

3 Are the conditions as exposed in the excavation as expected?

4 Wher will the drain make water and how much will it make?

Each of these is discussed below

What was the basis for the design inflow to the drain?

There have been several estimates of design inflows to the drain since the concept was originally proposed in the feasibility study These estimates have been as follows

> Flow from the trench could be on the order of 100 gpm initially, but is expected to drop to less than 5 gpm within a few days Steady flow from the trench could be as low as 2 gpm (Rockwell 1988b)

> Flow from the trench could be on the order of 10 gpm initially but is expected to drop to less than 5 gpm

> within a few days The combined steady state flow from the trench and source well is estimated to be as low as 2 gpm (DOE 1990a)

The first estimate was prepared following analytical techniques presented on pages 41 through 43 of Lohman (1979) which can be used to predict discharge from a confined, homogeneous infinite aquifer subjected to an instantaneous and constant head change The 100 gpm initial flow can be expected one minute after 550 feet of drain are instantaneously subjected to 5 feet of drawdown (hydraulic conductivity of $1x10^{-4}$ cm/s and storage coefficient of 0 1) The predicted flow is less than 5 gpm after 16 hours as opposed to the few days conservatively reported in Rockwell (1988b) After two years, the flow is approximately 0 1 gpm

The second estimate was prepared following pages 214 through 217 of McWhorter and Sunada (1977), which is functionally equivalent to Lohman (1979) The hydraulic conductivity was assumed equal to $1x10^{-4}$ cm/s the saturated thickness and drawdown were assumed equal to 8 feet and the storage coefficient was assumed equal to 0 1 Applying these conditions to approximately 1,000 feet on the western end of the alignment and 100 feet downhill from IHSS 119 1 the following inflows were calculated

Time (days)	Unit Inflow (gpm/ft)	Total Inflow (gpm)
1	011	12
2	008	9
3	006	7
4	006	7
5	005	6
10	004	4
15	003	3
20	002	2

These analyses and the statements made in the reports based on them are very conservative The intent was to overstate the expected inflows so that the treatment plant would be of adequate capacity

Why wasn t the project halted after the geotech investigation?

In spite of rumors to the contrary, the geotechnical investigation (DOE 1990b) produced results which were generally confirmatory of previous investigations as follows

1 Soil thicknesses were generally consistent with the earlier investigations except that thicker soils were found near Station 6+00

2 Soil types were also generally consistent with the earlier investigations (slightly coarser to the east) Some to traces of gravel were noted in the soil borings as opposed to the gravels previously logged near IHSS 119 1

3 The presence of water was not directly observed (no piezometers were constructed) nor were saturated soils noted in the logs however, the laboratory moisture content determinations indicated potentially saturated conditions in eight of the borings

4 Packer test determinations of the hydraulic conductivity of the uppermost bedrock were somewhat higher than previously determined The geometric mean of sixty-seven packer test results is $2x10^{6}$ cm/s assuming values reported as less than a detection limit are equal to the detection limit the standard deviation is 1 9 orders of magnitude Earlier estimates of the average hydraulic conductivity were $7x10^{7}$ cm/s (Rockwell, 1988a) However, the DOE (1990b) results are thought to overestimate the true conductivity because of the averaging method

Thus there was no reason to halt the project after the geotechnical investigation because it generally confirmed the results of the earlier investigations

Are the conditions as exposed in the excavation as expected?

Construction of the drain through the area downhill from IHSS 119 1 has revealed geologic conditions to be as expected Most importantly, the presence of the gravel lenses encased in clay was confirmed However the structure clearly results from slumping of alluvial material rather than deposition, as was thought up to Rockwell (1988b) DOE (1990b) discussed the possibility that the soils had been disrupted by slumping

The lack of inflows from the soils is also consistent with our understanding of the ground-water system in the soils

> contamination does not appear to be migrating quickly or extensively (Rockwell, 1987)

> The flow of water in the surficial material is probably both slow and of small quantity because of the

discontinuous nature of the various materials and their low hydraulic conductivity (Rockwell, 1988a)

There is also no imminent hazard to the public health from SWMU 119 1 Although there are VOCs in the ground water near SWMU 119 1 it appears that the VOCs have not migrated to the Valley Fill Alluvium of Woman Creek or into bedrock sandstones of the Arapahoe Formation This apparently is the result of limited ground-water flow in the area (Rockwell, 1988b)

During the driest portions of the year evapo-transpiration can result in no flow in either the colluvium or the valley fill alluvium (DOE, 1990b)

In spite of the fact that there have been no inflows, very moist gravels were observed immediately on top of the bedrock near station 18+00 This is the area of deepest soils and is also the area downhill from IHSS 119 1 that the drain is intended to cut-off It is possible that these very moist soils will make a small amount of water to the drain after they are re-covered and the effects of evaporation are removed

In conclusion, conditions as exposed in the drain excavation are generally as anticipated First, most of the alignment downhill from IHSS 119 1 is dry (limited if any, saturation was expected away from the buried gravels beneath 119 1) Second, the buried gravels at the base of the soil that are probably the same gravels as those beneath IHSS 119 1 were found in the excavation and they were very moist Finally, total inflow to the trench during construction has been negligible, as expected

When will the drain make water and how much will it make?

The drain is expected to make water from the gravel downhill from IHSS 119 1 (Station 18+00) and from the saturated soils near IHSS 107 (Stations 6+00 through 8+00)

Station 18+00

Inflows at 18+00 are expected to be small Assuming a conductivity of $1x10^{4}$ cm/s a saturated thickness of one foot a saturated length along the drain of 15 feet and a gradient equal to the topographic gradient (0 13) the steady flow to the drain will be approximately 0 003 gpm A transient analysis following McWhorter and Sunada (1977) yields an inflow of 0 0004 gpm after one year

Stations 6+00 through 8+00

Based on DOE (1990b) inflows during construction can be expected between Stations 6+00 and 8+00 Assuming a conductivity of $4x10^{6}$ cm/s (well 2-87), a saturated thickness of 16 feet and a storage coefficient of 0 1, the following inflows can be predicted using McWhorter and Sunada (1977)

Time (days)	Inflow (gpm)
1	4
10	1
100	0 4
1,000	0 1
10,000	0 04

Thus, during construction, inflows on the order of 1 to 5 gpm can be expected For steady production, this section of the drain should make on the order of 0 1 to 1 gpm

The two sectiors of the drain that are expected to make water should begin to do so nearly immediately after construction However some time will be required for the water to move from the point of inflow to the sump Assuming that the velocity in the drain rock can be calculated using ground-water hydrology principles (conductivity of $1x10^{2}$ cm/s and effective porosity of 0 1), the following travel times are predicted

Source	Distance (feet)	Slope (%)	Velocity (ft/day)	Travel Time (days)
8+00	745	4	11	68
18+00	255	1	2 8	91

Thus, it is expected that fluids will be detectable in the sump on the order of 60 to 90 days after completion of construction

* * *

I trust that the above is complete enough for your needs please call if you have questions or need additional information

Sincerely
DOTY & ASSOCIATES

Benjamin P Doty P E

REFERENCES

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