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TO PROPERLY EVALUATE THE EXTENT OF THE GROUNDWATER CONTAMINATION PROBLEM AT RMA, IT IS NECESSARY NOT ONLY TO IDENTIFY THE CONTAMINANTS, BUT ALSO THEIR POSSIBLE SOURCES. THE PRINCIPAL JUSTIFICATION FOR MONITORING WATER QUALITY, BOTH FROM ABOVE AND BELOW THE GROUND SURFACE, AT THE SOUTH BOUNDARY OF THE ARSENAL IS TO DETERMINE THE QUALITY OF THIS WATER BEFORE IT BECOMES PART OF THE RMA FLOW SYSTEM. THE WATER WAS ANALYZED FOR CL, SO4, NO3, F, NA, CA, DIMP, AND DCPD. THE SAMPLING POINTS ARE PART OF THE 360 DEGREE WATER MONITORING PROGRAM.

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1. INTRODUCTION

a. To properly evaluate the extent of the groundwater contamination problem at RMA, it is necessary not only to identify the contaminants, but also their possible sources. The principal justification for monitoring water quality, both from above and below the ground surface, at the south boundary of the Arsenal is to determine the quality of this water before it becomes part of the RMA flow system.

b. General Groundwater Flow - Groundwater flow at RMA is essentially south to north. Surface topography can be used with a fair level of confidence to predict the overall flow pattern of groundwater in a water-table aquifer such as that which occurs at RMA. This topographic pattern indicates the groundwater coming on Arsenal along the south boundary flows in a generally northwesterly direction, exiting the Arsenal along the northwest diagonal. It does not appear that any of this flow is directed toward the north boundary. However, the hydrogeologic maps prepared by Leonard Konikow (USGS Open-File Report 74-342) at a scale of 1:48,000 indicates that a small fraction of the flow from the south boundary is directed toward the north boundary. This flow appears to go under the Plants Area and Basin F and exits along the north boundary in Sections 23 and 24. More recent data compiled on groundwater flow in the northern part of the Arsenal, specifically Sections 23 and 24 and parts of Sections 22, 26 and 27, indicate that all the flow going past the north boundary originates from a small groundwater-flow system covering about three square miles of the northern part of the Arsenal.

2. WATER QUALITY

a. General

(1) Water coming on the Arsenal along the south boundary, both a surface drainage and groundwater flow, is monitored as part of the 360° Water-Monitoring Program. There are five surface drainage sampling points that are located directly on the south boundary of the Arsenal, these are 11 CCBD, 12 DCCD, 7 CCCD, 7 CDDC, and 8 CCCD. A sampling point along the southeast boundary, 8 ADDD, is used for measuring water quality as it enters the Arsenal via First Creek. Two sampling points, 7 BBBB and 8 AAAC, measure surface water quality downstream from points 8CCCD and 8 ADDD respectively. Sampling point 7 BBBB has been deleted from the 360° Water-Monitoring Program because the water quality at this point is either not significantly different or slightly degraded from the water that enters the Arsenal at 8 CCCD.

(2) Groundwater flow along the south boundary is monitored by wells 33, 34 35, 49 and 51. Wells 33, 34 and 35 are just north of the Montbello development and because of the geologic setting, should indicate any groundwater contamination that might occur and could be attributable to that development.

b. Surface Water Quality

(1) Water collected from the surface sampling points has been analyzed for chloride, sulfate, nitrate, fluoride, sodium, DIMP, DCPD, sulfides, sulfoxides and sulfones, In addition, the water has been tested for total hardness, which can be related to the amount of calcium in solution. Chloride, sulfate, fluoride, sodium, calcium, and to a limited extent, nitrate, are natural chemical constituents in water. It is only when concentration levels for these chemicals are unusually high that some sort of contamination as a result of human activity can be inferred. On the other hand, DIMP, DCPD, sulfones, sulfides and sulfoxides are associated with industrial activity; and their presence in water indicates contamination.

(2) Water quality determinations made between Apr 75 and Nov 76 have shown that no DCPD, sulfones, sulfides, or sulfoxides occur in surface water entering the Arsenal. DIMP has not been identified above the detectable level of less than 0.5 parts per billion, except for isolated measurements 1.9 ppb + 1.0 ppb at points 8 AAAC and 8 ADDD. This measurements could be attributable to either analytical error or distribution by airborne means from Arsenal activity.

(3) Table 1 shows the average chemical constituents for each of the surface sampling points described above. The analyses indicate that there is no significant contamination of surface water flowing onto the Arsenal. Comparing these analyses to U.S. Public Health drinking water standards (Table 2), it can be seen that from the basis of the nonorganic constituents, the surface water almost meets these standards, and is above average to normal quality for surface water.

(4) In evaluating surface water quality in a setting such as RMA, caution must be exercised. Many of the sampling points only contain water at intermittent times during the year. Extended dry periods followed by precipitation or extended rainy periods significantly affect water quality because of concentration and dilution effects. As a result, surface water quality from these sampling points should be used quardedly when attempting to evaluate possible contamination problems.

c. Groundwater Quality

(1) Because of the problems encountered in evaluating changes in surface water quality, evaluating possible contamination problems using analyses of groundwater is a much more meaningful basis for evaluation. This is particularly true for a setting such as that which occurs at RMA. For the most part, the principal groundwater aquifer in the vicinity of the Arsenal is near the surface. It is isolated from lower aquifer zones by several tens of feet of very low permeability shale and mudstone. This shallow groundwater system is much less subject to the temporary fluctuations which affect surface water drainage, and differences or changes in water quality can be easier to explain.

(2) Wells 33, 34, 35, 49, and 51 have been periodically analyzed for the same chemical constituents as the surface water, with the exception of sulfide, sulfoxide, and sulfone. Chloride, sulfate, calcium, sodium, fluoride, and to a limited extent, nitrate are common constituents of groundwater. Unusually high concentrations of any of these ions may indicate contamination from an industrial or domestic source. Fluoride, for example, is associated with the manufacture of GB nerve agent. Chlorides are common waste products of human activity. Nitrate can naturally occur in groundwater in concentrations between 0.1 and 10 parts per million. However, nitrate is most often present in groundwater (especially in shallow groundwater) as a result of agricultural practices and sewage disposal.

(3) For the most part, the water quality in each of these wells (as shown in Table 3) meets or only slightly exceeds drinking water standards (Table 2). In comparison to groundwater in general, this water is above average in quality.

(4) Well 51 is of particular interest because of the relatively high NO_3 values. This level of nitrate concentration in the groundwater is well above the levels normally expected to naturally occur. The location of well 51 is such that the sewage lagoon which serves the mobile home park on the southeast corner of the Arsenal is approximately one-third mile directly east of that well. The topographic and apparent hydrologic setting is such that flow is from the lagoon towards the Arsenal. It is reasonable then to attribute the high nitrates in the groundwater in the vicinity of well 51 to that sewage lagoon. However, nitrates have not been identified as a problem in the northern part of the Arsenal.

(5) Nitrate content in wells 34, 35, and 49 also suggest possible contamination. Well 34 is in somewhat of a low area along the south boundary. Surface drainage tending to collect there could infiltrate into the groundwater system. A possible source could be

from drainage in the vicinity of Montbellow where nitrate-type lawn fertilizers are undoubtedly used. Well 35 is in the picnic area, around which human activity takes place that could provide a source for nitrates. Wells 34 and 35 possibly reflect the migration of nitrate from the direction of well 51. However, in that part of the Arsenal, it is essentially northwestward; and this latter possibility is considered unlikely. The somewhat high nitrate levels in well 49 also indicate contamination. If the inferred direction of groundwater flow is correct, then it is unlikely that the nitrate source is from the vicinity of Commerce City. The analyses for this well show a high nitrate concentration of 15.4 ppm in Dec 75, decreasing to less than 4 ppm by Apr 76. This would suggest a somewhat limited source, such as animal activity within the vicinity of the well.

(6) The sulfate content in well 33 is extremely high in comparison to the other wells along the south boundary. The topographic setting in the vicinity of this well is a low area, flanked by a topographic high along the northern side. The setting in the vicinity of well 33 is such that this low area could be a local groundwater discharge zone -- at least on a seasonal basis. Groundwater in discharge zones is commonly much more mineralized than water in other parts of the groundwater flow system.

d. Other Chemical Studies - Calgon Corporation analyzed water from wells 33, 34, 35, and 51. The water was analyzed using GC-mass spectra methods. Several organic compounds were identified; however, the identified spectral lines were a rather poor fit with the known organic compounds. Further mass spectral work needs to be done in this respect.

3. PLANNED INVESTIGATIONS

a. FY 77 Program - The five wells and seven of the eight surface points described above are part of the 360° Water-Monitoring Program. Water samples are collected from each of these points on a quarterly basis. To date, mass spectral analyses have not been included but will be added to ensure the quality of water is maintained. Close monitoring of water quality from these sampling points during FY 77 will highlight any changes that might occur and be used to develop a more comprehensive study along the south boundary.

b. Post FY 77 Program

(1) In order to develop a complete hydrogeologic model of the RMA groundwater-flow system, more subsurface investigations will need to be directed to the south boundary. Of specific interest is the extent of nitrate contamination from the off-post sewage lagoon and the significance of the high sulfate concentrations in the vicinity of well 33. Distribution of the aquifer materials and configuration of the bedrock surface will need to be known in much greater detail than is presently available.

(2) The initial investigation planned would involve installation of a series of three or four wells, each in the vicinity of wells 51 and 33 to evaluate the distribution of nitrate and sulfate respectively.

(3) Additional drilling is required along the southern part of the Arsenal to identify the geologic setting of the part of the Arsenal as part of evaluating the groundwater-flow system for the entire Arsenal.

(4) Just when a definite investigative program can be implemented in the southern part of the Arsenal depends largely on the progress made along the northwest and west boundary, as well as in the basin areas. It is unlikely that, at present manpower, equipment, and funding levels, that such a program could begin before late FY 78. However, should the close monitoring of water quality during FY 77 indicate a need to assess potential contamination problems sooner, a change in priorities would be dictated. Any studies that may have begun in the basin areas would be postponed, and all efforts would be directed to the south boundary. This investigation would then begin in early FY 78.

TABLE 1
SAMPLING POINT

Chemical Constituent	7 BBBB	7 CCCD	7 CDDC	8 AAAC	8 ADDD	8 CCCD	11 CCBD	12 DCCD
Cl	38	71	67	200	72	37	40	57
SO_4	73	231	224	390	138	44	51	141
NO_3	0.29	3.5	3.8	2.0	1.4	0.2	0.2	1.1
Fl	0.69	1.47	1.47	1.05	0.83	0.75	0.95	1.10
Na	33	78	101	125	118	34	26	44
Ca	70	139	134	268	103	52	63	93
DIMP	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
DCPD	0	0	0	0	0	0	0	0
Sulfoxide	0	0	0	0	0	0	0	0
Sulfide	0	0	0	0	0	0	0	0
Sulfone	0	0	0	0	0	0	0	0

Average concentrations of selected chemical constituents in surface water collected along the south boundary of RMA between Apr 75 and Nov 76. All values shown in parts per million, except for DIMP, which is in parts per billion.

TABLE 2
U. S. PUBLIC HEALTH STANDARDS FOR DRINKING WATER

Ion	Recommended Limit (ppm)
Cl	250
SO_4	250
NO_3	45
Fl	1 (may vary between 0.8 and 1.7, depending on temperature)

TABLE 3
SAMPLING POINT

Chemical Constituent	Well No. 33	34	35	49	51
Cl	34	34	52	78	60
SO_4	1,618	63	132	332	43
NO_3	0.6	3.5	7.0	5.4	22.9
Fl	2.98	0.69	0.57	0.44	0.96
Na	312	44	68	100	60
Ca	441	67	139	185	112
DIMP	< 0.5	<0.5	<0.5	1.15	<0.5
DCPD	0	0	0	0	0

Average concentration of selected chemical constituents in groundwater from wells near the south boundary of RMA (based on data collected between Nov 75 and Nov 76). All concentrations in parts per million, except for DIMP, which is given in parts per billion.