Investigation techniques in ground water

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Abstract

In this paper , I discuss and show the investigation techniques in ground water and the purpose of this research is to share with industry investigation techniques. In particular, the methodology ,the findings and lessons learned. These techniques have applications at several sites , These investigations include the groundwater monitoring system, the radiological source term assessment and the atomospheric deposition modeling that include processes assessments, video inspections , assessment of tritium migration through concrete, hydrostatic tracer tests,tritium/helium-3 residence times and tritium in soil

Key words/
Groundwater monitoring systems ,
Tritium migration ,Fluorescein , Vadionuclide ,Deuterium concentrations, Contamination

Introduction:

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Investigation techniques in ground water:

-**The purpose of this research is to share with industry and military the investigation techniques in particular , the methodology , the findings , and lessons learned These techniques have applications at several sites. These investigations include the groundwater monitoring systems , the radiological sources-term assessment and the atomospheric deposition odelin.**

Process assessments:

- Based on the radiological source term assessment a number of systems were identified as potential source for contamination of groundwater These systems were investigated in detail using document reviews staff interviews, system inspections and walk-downs. The documents reviewed included design manuals operations manuals ,inservice reports, system flow sheets, plams , significant event reports and previons . Investigative reports, information was also, obtained from operating experience (opex0 databases and discussions with several sites .The assessments were used to identify contamination risks and areas requiring further testing. They were also used as a reference base further investigations. The process assessments were considered a necessary , first step of the tritium in groundwater study (iigs) to faces the investigations and to ensure that no risks were left unidentified unassessed .

Video inspections:

-Video camera inspections were conducted on a number of sumps, foundation drains , a sewage pipe , vaults and catch basins. They

were used to identify the sewage line break to inconsistencies within drawing . To conduct the inspections , pipe cameras and push rods were used of particular , interest was a reactor building (RB) . Foundation drain that was investigated through the use of video inspections . Drawings showed this perforated pipe to discharge in the plant but the outlet could not be physically located . The risk existed that plant spills could enter this drain and enter the groundwater through the perforated pipe. Through the use of a push rod video camera and a tracer dye. The discharge point was found to be outside the plant in a sump that had no inputs.

Assessment of tritium migration through concrete

-Tritium migration through structural concrete was consider a possible cause of subsurface contamination to assess this risk, a contamination transport calculation was performed to assess tritium migration by diffusion and hydraulic flow in the reactor buildings. The study concentrated on developing a preliminary of the amount of tritium- contaminated water or vapour that could migrate through cracks and joints on the reactor building walls and dome , through the sumps and pits located in the floor slab , and during abnormal events(i.e. During retube or pressure tests). Potential pathways such as intact concrete. Concrete with through-wall micro cracks, and construction joints and water stops were evaluated . Stations supplied information on the building configuration, construction methods , probable defects source terms. Mathematical models were then used to estimate the possible migration through the concrete .Team evaluated the case where tritium diffused to the outer building surfaces. This diffusion was considered a risk as precipitation could then leach the tritium from the concrete which would raise the tritium level in the run off water and result in infiltration to the groundwater. The overage tritium concentration in the air, expressed as water activities inside the reactor building were calculated to be 1. 61 E8 Bq/L (4.4 E3 μ Ci/kg). Migration from diffusion of tritiated moist air could occur through crack and joints as well as through the concrete itself . The length of cracks and joints in the structural components were estimated by considering the effective pathways , taking into account the effects of aging on PRC joints and cracks. The transport flux calculations through the reactor building walls and dome were 3.278 and 9.819 Bq/s , respectively , when the flux was diluted with possible precipitation , the resulting concentration was 2.5E5 Bq/L (6.8 MCi /kg). Various sumps and pits in the reactor building often contain water and the risk existed that tritiated water would migrate from these locations . The hydrostatic head

created from water in the sumps would allow tritiated water to permeate into the concrete as well as migrate through cracks and joints by hydraulic flow. To evaluate this risk a model was deployed to estimate the water flow rate and the tritium flow rate from the reactor building sumps. The model assumed a typical crack width of 0.1 mm , which from a structural point of view , is not considered to be a significant crack for concrete water-retaining structures. The findings from the model indicated that the greatest potential from the model indicated that the greatest potential for tritium leakage through concrete was at the moderator purification room sump. At an assumed crack width of 0.1 mm , a tritium flow rate of 1.3E9 Bq/day (0.035 Ci/day) was calculated. This sump however only received water on a periodic basis the east fuelling machine room sump was also considered to be a significant historical risk with a calculated flux of 59E10 Bq/day (1.6 Ci/ day) However , this sump was retrofitted with a steel liner in the mid 1980 s.

Hydrostatic tracer tests :

- Sumps in the active Drainage , system were considered to be a significant risk of groundwater contamination as they often contain liquids for extended periods of time and leaks could go undetected tracer tests and hydrostatic pressure tests were conducted on several reactor Auxilliary Bay (RAB) and reactor building sumps to evaluate the potential for leakage to the environment . Tests essentially consisted of filling the sumps to floor level or above with tracer water (a fluorescein or bronide solution) and monitoring the change in water level over time. Sampling was also conducted on adjacent monitoring wells and foundation drains to identify the tracer in ground water . Two challenges existed in conducting the tracer tests: The selection of an environmentally safe and detectable tracer for use in the reactor building : and the design of a hydrostatic pressure test to measure small leakage rates. Tracer tests were conducted at two locations within the reactor building fluorescein was an initial choice due to its conservative nature and small particle size This tracer was used in other studies onsite and therefor other options were assessed. Tritium , Bromide , and Oxygen-17 were likely condidates but , ater evaluation , non of these were able to replace fluorescein. Tritium , a common and effective tracer , could not be used as the groundwater was contaminated with this radionuclide Bromide was also considered but discounted as it had the potential to create corrosise halides . An isotope of Oxygen (Oxygen-17) was considered but was found to be too costly considering the quantities required to increase

concentrations significantly above background . A novel method of conducting hydrostatic pressure tests was developed as possible sources could not be ruled out without a rigorous test. A detection limit of <0.3 L/day was required to discount a potential source of contamination. Due to the surface area of the sump a leak at that rate would cause a head drop of 1 cm in 28 days . This was considered too slow and open to error from measurement or evaporation . To increase measurement sensitivity , a 10 cm C4 manometer and a rent were fitted to the sump manhole cover. The sump was filled with tracer solution . The manhole sealed to the sump and the manometer filled above the floor level. This configuration allowed for a detection limit of leakage better that 0.3/day and proved successful in measuring very low leakage rates.

Tritium / Helium -3 residence times and tritium age dating:

- Tritium undergoes beta decay with a half-life (t.5) of 12.43 years to produce helium -3 . Which converts to helium-4 . In recent years , it has been demonstrated that combined measurements of the ground water concentration of tritium , helium-3 , helium-4 , and neon can , under appropriate conditions , provide reliable values of the groundwater residence time tritium and helium analyses were used to determine the relative age of the groundwater to assess sources and to aid in understanding the groundwater flow system . Samples were collected for tritium /helium-3 analysis from 12 wells in the area of unit 1 Samples were collected using diffusion samplers, suspended in the wells below the water table. After about one week , the samples were also collected from the same wells for analysis of tritium and deuterium. The sample from the well with the highest tritium concentrations could be analyzed for helium-3 due to the high levels of helium-3 ,also the values obtained could not be considered absolute residence times due to the high concentrations, the possibility of helium-3 migration , the possible effects of more than one source and possible changes in groundwater flow conditions. Tritium/ helium-3 residence times were calculated to be between 0.1 and 14 years for six of the samples groundwater with the lowest tritium concentrations and having deuterium concentrations similar to natural background levels (.... 144 ppm) had the shortest calculated tritium /helium-3 residence times of 0.9 years and less. The results were generally consistent with the interpretation of groundwater flow in the area of the samples. The analysis was usefull in confirming existing groundwater flow information but was less useful in identifying

the source of contamination or delineating the extent of contamination as development in this area continues , helium-3 analysis could provide a valuable tool in groundwater investigations of this nature.

Deuterium analysis:

- Deuterium and tritium analyses were used to calculate tritium concentration at 100% deuterium concentration. This was done to determine if the tritium could be related to process water. The moderator system typically contains 3.7 E 11 to 7. 4 E 11 Bq/L (10 tp 20 Ci /kg) of tritium at 100% deuterium while the primary heat transport system contains less than 3.7E10 Bq/L (<1 Ci/kg) of tritium at 100% deuterium. The background deuterium concentration was assumed to be the concentrated samples. For samples for which the tritium concentration is less than 2 E4 Bq/L (0.54 μ Ci/kg). The deuterium concentrations averaged 143.1 ppm with a standard deviation of 2.5 ppm for 13 measurements . The deuterium background concentration onsite was therefor assumed to lie with the range of 140.6 and 145.6 ppm Assuming the deuterium found in the samples results from a two -components mixture of heavy water and uncontaminated water with deuterium concentrations of 140.6, 143.1 and 145.6 ppm. The resulting tritium concentrations at 100% deuterium were calculated . For example , a well with tritium activity of 1.5 E 11 Bq/L and a deuterium concentration of 464.2 ppm was calculated to have a tritium activity at 100% deuterium of 4.7E11 to 4.6 E11 Bq/l (12.7 to 12.4 Ci/kg). The results clearly showed the source of this tritium in groundwater to be from the moderator system rather than the primary heat transport system. This example also, shows that at high tritium and deuterium levels , the calculation is not sensitive to the background deuterium assumed. The calculation is sensitive to the assumed background deuterium concentration at lower levels of deuterium. For example , one sample contained 2.3E5 Bq/L (6.2 μ Ci /kg) tritium and 144.3 ppm deuterium. The tritium at 100% deuterium was calculated to range from 1.9E11 to - 1.8 E11 Bq/L (5.2 to -48 Ci/kg). Although the calculations were sensitive at low levels of deuterium , the analyses met its objectives and served to conclude the source of the contamination.

Tritium in soil:

The vertical extent of tritium in groundwater was assessed through the use of wells at various depths and by the analysis of tritium in soil . In particular , the tritium in soil provided valuable and detailed data on the vertical tritium profiles . This information was used to delineate contamination and assess

sources of contamination. The tritium in soil analysis was conducted either by centrifugal extraction of the water in the soil and analysis of the water or by adding a known mass of soil into a known volume of water and analyzing the tritium in the resulting mixture in adding , the moisture content of the soil was analyzed where possible. The results were reported as tritium per kg of soil and since tritium is contained only in a liquid phase and not in the soil , the moisture content was used to convert the soil concentration to a tritium in soil water concentration . For example tritium in soil at 2.6E5 Bq/L (6.9 * Ci/kg) of soil at a moisture content of 4.3 percent by weight equals 6.0 E 6 Bq/L (160 μ Ci/kg) in water For some of the samples , soil was not analyzed and therefore this value was assumed based on data in the surrounding wells. It was found that the calculation is relatively insensitive to change in moisture content . Tritium versus depth profiles were plotted and in most of the profiles , the tritium concentrations dropped to less than about 20 percent of the peak concentrations by a depth of about 6.1 m to 7.6 m (20 to 25 ft) below surface. From the tritium profiles , The thickness of the tritium plume was found to be on the order of about 3.0 to 4.6 m (10 to 15 ft). In most cases, the tritium found in the soil pore water was at low tritium concentration at depths of about 4.6 m (25 ft) below surface .The tritium in soil pore water was found to correlate well with the tritium in groundwater data from monitoring wells. The data indicated that the source of the contamination was near the surface. Providing additional evidence to support the conculsions derived from leak testing.

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