Form 2

Information for the following six areas is provided.

(1) Accumulation of contaminated water (Storage Tanks, etc.)

ANABET

ANABET is an analytical technique for non-gamma-emitting radionuclides developed by members of the team over twenty years ago (**AN**alysis of **A**lpha and **BET**a radionuclides). Since that time the technique has been further developed in conjunction with other parties such as Clemson University in South Carolina, USA and Electric Power Research Institute in USA. The principle of operation is that samples to be analysed are prepared and then separated by high performance liquid chromatography (hplc). The eluted solution from the hplc column passes through a solid scintillation detector, which detects "peaks" due to radioactive isotopes of the individual chemicals elements eluted. Because the detector response is specific to the element, there is no need to undergo other chemical separations or to wait for secular equilibrium. The technique would be particularly useful for quick (less than 1 hour), routine analysis of ^{90}Sr.

Other information (technology readiness level, challenges, information related to patents, etc.)
An early reference to ANABET can be found at: http://www.wmsym.org/archives/1990/V2/46.pdf

An example of the technique being used to analyse for ^{90}Sr is given in:
http://www.deepdyve.com/lp/springer-journals/separation-of-strontium-90-and-yttrium-90-in-the-presence-of-thorium-5xmNegE2u9

(2) Treatment of contaminated water (Tritium, etc.)

Tritium Concentration Technologies (CECE)

Matom/Bradtec has expertise in tritium concentration technologies and have reviewed them for the US Department of Energy in relation to treatment of groundwater. However, this review was completed many years ago and all the technologies we reviewed are already listed (and hence known about) by IRID. Our view is that CECE is likely to be one of the most effective technologies applicable to treating currently accumulated water for discharge, and there is already experience of this technology at Fugen NPP.

Tritium removal by any technology is likely to be very expensive and at the levels present in the large volumes of contaminated water held on site, the radiotoxicity due to tritium is very, very low. It is likely therefore to be far more effective to make an acceptable safety case to release this water (after removal of other radionuclides by the ALPS system and other available practical measures). To be acceptable, this safety case will need to address many aspects such as deciding on a strategy for how, where and when to discharge the treated water to minimize any residual radiological impact. In addition, there are precedent cases in other countries where tritium in groundwater has been detected, but after careful consideration it has been determined that the most effective solution to the problem is to leave it alone and (including, where appropriate, continuing to track it by monitoring procedures) rather than attempting further treatment. Our experience and expertise in this area would support IRID in making a good and defensible case for the discharge of the water without further treatment to remove tritium.

(3) Removal of radioactive materials from the seawater in the harbour

Seeded Filtration

Matom/Bradtec has considerable experience (but no specific patented technology) concerning the technique of “seeded filtration”. This technique involves making very small adjustments to the chemistry of the water (for examples small adjustments in pH – e.g. just a fraction of a pH unit), and/or addition of selective absorbers (“seeds”) for particular radionuclides at parts per million level. These procedures can effectively convert dissolved radioactivity to the form of solids for removal by subsequent filtration procedures. The optimum regime of seeded filtration needs to be designed and tested for the specific water chemistry to be treated. If the kinetics of absorption are appropriately managed the addition to the adjusting chemicals and seeds can take place either “in-pipe” in advance of the filtration, or in a small mixing vessel in advance of the filtration unit. Provided that the seeded filtration system is appropriately designed, large volumes of water can be treated with minimal plant and equipment needs and with minimal radioactive waste generated. This solution may be particularly useful for the treatment of water in the harbour. The approach is particularly applicable for the removal of caesium and strontium, but is not suitable for removal of tritium.

Matom/Bradtec can design and test an optimum seeded filtration system to meet IRID’s performance and waste management requirements, but this system must be based upon the precise chemical conditions in the water to be treated and as such would be a bespoke solution where IP would lie with the funding body.

(4) Management of contaminated water inside the buildings

Selective Ion Exchange

Matom/Bradtec has over thirty years of experience of selective ion exchange applications for removal of radioactivity from contaminated water. Through projects on Magnox Dissolution in the UK the group has had extensive contact with Tim Milner of Energy Solutions who has played a major role in the design of the “ALPS” system. The group can undoubtedly contribute to the effective operation and performance enhancement of the ALPS plant and can add downstream waste solidification technology to the cleanup toolkit.

Resin regeneration

In the case of organic ion exchange resins used for water treatment on site it is possible to carry out a controlled regeneration to recover the resin for re-use and to present the entrained radioactivity in a form which can be treated and immobilised in a passively safe grout matrix for disposal. This regeneration process yields two primary benefits to the site:

- Significant drop in secondary wastes through resin re-use over storage for further treatment.
- Activity is immobilised and a percentage of the water used in the process is also treated in that it is used for the hydraulic cure of the cementitious grout.

This process offers the site a major advantage in that it can demonstrate to both the public and regulators that they are actively managing their more onerous waste streams and beginning the process of rendering the wastes safe for final sentencing as opposed to leaving a legacy for future generations to deal with.

(5) Management measures to block groundwater from flowing into the site

Expertise/Consultancy/Advise on Groundwater Barriers / Channelling Options

The emplacement of any groundwater retardation, or redirection approach, needs to be efficient, cost effective and fir for purpose. Members of our team are significantly experienced in the areas of both Hydrology and Hydrogeology, with specific experience of applying this in the nuclear context, both in terms of modelling, contamination transfer and flow (both radiological and non-radiological) and aqueous retardation approaches to minimizing flows.

Recent experience of related nature has been gained by Matom/Bradtec in respect to mitigating the potential of both radiological and non-radiological contaminants to flow from operational and decommissioning station sites to that of a new build site. The approaches considered included grout curtains, low permeability clay/bentonite barriers, jet grouting utilising hydrophobic substrates and liquid nitrogen fed ice curtains amongst others.

Initial thoughts include: The impermeable walls should comprise two parallel lines of cement/bentonite grout separated by 5m to 10m and extending down into the lower ‘muddy layer’ to around O.P.-10m. Each line of grout should be formed using the tube-a’-manchette method. Every 100m a line of grout should be injected across the walls to create a series of contained boxes in the ground. Piezometers and groundwater sampling boreholes can then be installed within each box, and inside and outside each box, with ongoing monitoring to determine whether further grouting is required in any particular length of the wall. Monitoring can be automated with telemetry to minimize human interaction. Access platforms for drilling and grouting equipment will be required on steeply sloping ground and this can comprise tubular steel scaffolding, or similar, or earth fill according to local condition and variations in slope gradient.

(6) Understanding the groundwater flow

Expert Hydrological and Hydro-geological Modelling and Advice

Matom/Bradtec is an experienced and professional expert in the fields of Hydrology and Hydrogeology, having undertaken hydrological investigations and modelling both in the UK and internationally. These have included significant sized projects such as the design of a Purification Plant and Waste Management Solution at Tabuk WTW, in the Kingdom of Saudi Arabia (KSA). This included consideration of the deep aquifer flow of radiologically (NORM in origin) contaminated drinking waters as well as the identification of the various options, under Saudi Arabian legislation and practices, applicable for use in the treatment of Naturally Occurring Radioactive Materials (NORM) contaminated groundwater, and provision of specialist advice on the applicable methods for the management of any waste purification media produced during water processing.

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