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Mr. James R. Park
Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: Transmittal of Innovative Technology Remediation Demonstration Program (ITRD) Information, Tuba City, Arizona UMTRA Site

Dear Mr. Park:

I am writing pursuant to our telephone conversation regarding the on-going groundwater activities associated with our Tuba City, Arizona UMTRA Site. As we discussed, the DOE has formed an advisory group under the auspices of the Innovative Technology Remediation Demonstration Program (ITRD). This group is a consortium of EPA, National Laboratory, private industry, and stakeholder technical experts whose mission is to provide the project with recommendations on the most appropriate technologies for restoration activities associated with the mill tailings leachate in the groundwater at the above mentioned site.

I am sending you a brief write-up of the status of the group's progress to date. We hope to receive final recommendations by the end of this current fiscal year.

Upon receipt of the summary report, which will contain the group's recommendation, I will immediately transmit you a copy for your information.

Please call me at (970) 248-6037 if you have any questions or comments.

Sincerely,

Russel Edge

Russel Edge
Project Site Manager

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Enclosure

cc w/o enclosure:
R. M Plieness, DOE-GJO
GWTUB 3.2.3 File (record thru T. Pavlisick)

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EVALUATION OF INSITU GROUND WATER TREATMENT TECHNOLOGIES

Both active and passive insitu treatment technologies were identified and evaluated by the Advisory Group. Passive treatment technologies, such as insitu treatment walls, which contain materials such as zeolites, iron filings and co-metals, or microbial medium, have been shown to treat contaminated ground water as the contaminant plume flows through the treatment zone. Passive applications have the potential to significantly reduce remediation costs by eliminating the need for often expensive ground water pumping and surface treatment. Passive technologies have application where the ground water flow gradients are high and treatment wall installation costs are low. Active insitu technologies, such as electrokinetics or bioremediation, have the potential to more effectively reduce contaminant levels more quickly and less costly than traditional pump-and treat systems. The active and passive technologies identified and evaluated by the Advisory Group are discussed below. After reviewing these technologies, a one was identified for further detailed engineering evaluation and site specific treatment studies.

Permeable Treatment Walls

Permeable treatment walls have been studied as a method to lower both remediation operating and overall treatment costs for contaminated ground water. In this type of system, a material that can treat the contaminants of concern in the ground water is placed in the ground such that the ground water passes through the treatment zone. This affords contaminant capture and treatment without pumping. The application of this technology at a site depends on the site geology and hydrology, the contaminants of concern and their concentration levels, and the required cleanup levels. Several recent large-scale field applications of this technology has made this concept substantially more mature than even a few years ago.

At the Tuba City Site, the application of this technology had two major concerns. One was the ability to install a treatment wall in the sandstone aquifer and the second was the ability to remove all the contaminants of concern at the site, especially the sulfates. Several ideas were suggested and several types of treatment materials were evaluated for application in the treatment wall including; ion exchange resins, zero-valent iron, zeolites, and a microbial medium. Because of zeolite selectivity issues and problems of fouling ion exchange resins in areas of high total dissolved solids like at Tuba City, these were not the materials of choice in this application. Good laboratory and field data exists for sulfate, nitrate, and uranium removal using iron filings. The iron filings are effective for uranium and nitrate removal, but poor for sulfate removal. Based on this data, the Advisory Group suggested that a combination of organic material and iron filings would be effective as a treatment wall material and could address all the contaminants of concern in the ground water at Tuba City.

Based on the site geology and ground water flow gradient, three permeable treatment wall options were considered. One option was a wall 2000 feet downgradient of the existing plume to a depth of 50-60 feet were the trenching technology exists to emplace a 1000' x 2' x 60' trench. Installation and treatment material costs were estimated by the EPA to be about $3 M. Unfortunately, at an expected plume advancement rate of about 50 feet per year, it would take over 100 years for the plume to pass through the treatment wall. Since there is no long term data on the effectiveness of any treatment materials for this long a period it would be difficult to ascertain whether the system would be effective for the duration needed. A second option was to put a wall closer to the existing plume, which would require the installation of a 2500 feet trench through about 40 feet of loose sand and 50-60 feet deep into the sandstone aquifer. The costs of this system using caisson technology for installation were estimated to be about $50 M. A third option considered was the creation of a fractured zone in the sandstone at the site using fracturing technology into which treatment material could be injected. Because the extent of the fractures could be difficult to determine, it would be difficult to determine exactly how effective this type of system may be. It was determined that this option would probably best be used as a polishing step, after some other process has removed the bulk of the contaminants.

None of the options identified appeared to provide a distinctive improvement in either the remediation schedule or costs relative to the baseline design. Therefore, the consensus was that treatment walls would be difficult to implement at this site as a primary treatment alternative.

Biological Treatment

Insitu biological treatment of contaminated ground water is more often being considered for remediation as the factors that control microbial degradation of contaminants become better understood and as numerous studies show their effectiveness for a wide range of contaminants. This technology is finding use throughout the world and has significant potential as a low cost remediation technology. For these reasons, we worked closely with the EPA's Kerr Environmental Laboratory to assess the applicability of this technology at Tuba City.

At this site, the efforts would require the application of nutrients to stimulate both denitrifying and sulfate reducing bacteria to reduce the sulfates and nitrates and immobilize the uranium in the ground water. Though there are applications where each of these contaminants has been treated separately biologically in aquifers, there is little field-scale data available on whether this can be done effectively for all three contaminants, especially sulfate removal. The sensitivity of the sulfate reducing bacteria to the type of nutrients injected suggests that sulfate reduction may be difficult to be control and adequately remove in this process. Some concerns were also raised that it was probable that the areas of high contaminant concentration would have to be reduced first before biological treatment could be effectively accomplished.

Another challenge identified is getting the proper nutrients to the microbes under the proper conditions at a site where the permeabilities are so low. This is expected to require an extensive injection system to apply the nutrients as well as a ground water extraction system to set up the circulation needed to move the nutrients through the aquifer. After technical review, it was determined that this type of system may be just as expensive at a standard pumping system. Another concern expressed was that the uranium was only immobilized and not removed in this process. After nutrient injection is stopped and oxidizing conditions are restored in the aquifer, there was concern that the uranium may be re solubilized. No long term data exists to address this concern.

The technical concerns with controlling this process in this aquifer to treat all the contaminants of concern suggested that the most promising option for application of biotreatment would be as component of a treatment wall. Since at this time treatment walls are not being further investigated as a primary treatment technology, biotreatment was also dropped from active consideration in insitu applications.

Recirculation Wells

This technology pumps ground water and reinjects it to set up a recirculation cell within the aquifer. The wells have a self contained treatment system. This allows the water to be treated within the well and reinjected to flush the contaminated material, which sets up a recirculation pattern so that the same water is treated over and over without continually drawing in non-contaminated ground water. In essence, the systems continuously flushes the local area around the well, increasing contaminant removal efficiency. Removal efficiencies of 90-95% have been reported in as little as eighteen months for some systems treating VOCs. A treatment or recirculation radius for the wells of as much as 80-100 feet have been seen.

Recently some vendors have applied these type of systems to treatment of ground water contaminated with heavy metals. After researching the status of these applications, it was determined that the systems as they presently exist treat the heavy metals on the surface and then reinject the ground water. This is therefore pump-and-treat with reinjection. Though the treatment cell concept is viable and is being pursued, these type of special systems offered no real advantages over existing technology as far as cost or performance and therefore were dropped from further consideration.

Chemical Fixation

Chemical fixation a process of injecting low concentrations of chemicals such as; carbon dioxide, sodium dithionate, polysulfide, or hydrogen sulfide several types of materials to form reducing conditions around an injection well such that uranium can be precipitated out of the water and the sulfates and nitrates can be abiotically destroyed. Additionally, other materials, like colloidal iron was suggested for injection, which would settle out and form a similar reducing zone around an injection well. The advantages to this process is that all the treatment of the ground water would be insitu and very little water would have to be

pumped. Except for the colloidal iron, each of these chemicals has been used successfully in field applications to drive aquifers to reducing conditions and are commercially available. The three major issues about the application of these chemicals were; the rate at which the contaminant reduction would occur, and the permanence of the precipitated uranium once oxidizing conditions of the aquifer were reestablished. Like the insitu bioremediaiton application, a significant number of both extraction and injection wells would be needed to accomplish full treatment of the aquifer. Since no clear cost or schedule advantage could be identified for the use of these technologies, they were dropped from further consideration.

Chemical Flushing

Soil flushing with surfactants in the case of DNAPLs is being actively pursued by both the EPA and DOE. Chemical flushing using lixiviants is a process that has been used successfully for over twenty years by the mining industry to remove heavy metals and is know as solution mining. In these applications, either oxidants or complexing agents are used to remove commercially valuable amounts of heavy metals out of formations. The major issues are controlling the flushing of the aquifer, increasing the mobility of the bound uranium, and the reduction in overall remediation that might be accomplished with this technology. DOE EM-50 is supporting research in this area and has efforts with solution mining companies to try and apply this technology to remediation efforts. Based on a review of the status of this technology, it appears that the technology is able to remove uranium to drinking water standards and could accelerate remediation by accelerating the removal of uranium and the other contaminants from the aquifer through the use of a complexing agent like citrate. The Advisory Group proposed that a treatability study and a possible small field evaluation be conducted at the site in conjunction with EM-50 to fully evaluate the technology cost savings and optimum implementation concept.

Electrokinetics

This technology uses electrical current to move charged particles through subsurface soil or an aquifer. The technology has been used extensively over the past 50 years to dewater clays for the construction industry. The application to treatment of contaminated soils and ground water has been recently investigated. In the process, positive and negative electrodes are placed in the soil to move charged contaminants through the aquifer to a collection point where they could be removed and treated. The technology has been recently used for movement of a variety of charged species including nutrients, VOCs, and heavy metals through the soil and ground water.

Applications considered at this site included movement of the metals, nitrates, and sulfates directly through this low permeability aquifer for collection and treatment. Laboratory experimental data suggests that this process can reduce by an order of magnitude the amount of water that has to be treated. At this site, two options were looked at for application of this technology, one was treatment of the whole area, and the second was as a treatment wall. Evaluations of the costs associated with treatment of the whole area

suggested that application at this site would exceed $50 M. Application of the technology in the form of a treatment wall was significantly less and would cost approximately $15 M.

A few technical issues were identified for use at the site. One was the need to use acetate or acetic acid, vinegar, as an ion exchange fluid. Since the indigenous bacteria can easily use this as a food source this did not seem to be a big problem. The second issue was treatment of the concentrated solution, which might make the use of standard treatment technologies more difficult. Since a clear cost or schedule advantage could not be directly identified, this technology was suggested to be reviewed later if other technologies fail to be identified with more distinct cost and schedule advantages.

Dilution/Natural Attenuation

This process is successfully being used at a few mining sites in the country. The concept is to reduce the concentration of contaminants by pumping in uncontaminated water into the contaminated zone to dilute the high contaminant concentration areas. This is continued until the contaminant levels are low enough to met regulatory requirements or that natural attenuation can take over. At sites that have available process water or where uncontaminated water is easily available, this application has some advantages is accepted by the appropriate regulatory agencies. For application at this site, the issue of purchasing water rights on what is disputed could cause significant problems. Also, some type of large pumping system would be needed to obtain the non-contaminated water. Because of the political issues and the fact that pumping costs could still be high and no cost advantages could be identified, this concept was not pursued further.

EVALUATION OF EX SITU GROUND WATER TREATMENT TECHNOLOGIES

A set of technologies reviewed by the Advisory Group were several alternatives to treating pumped ground water. These were considered since some of the possible innovative technologies being considered though enhancing the baseline pump-and-treat system would still require treatment of some ground water. The technologies reviewed included; biological reactors, advanced membrane separation and filtration processes, various absorptive processes, iron filings technologies, and phytoremediation options. The systems reviewed were based on treating water with high levels of uranium, sulfates, and nitrates more cost effectively. After reviewing the identified technologies, the Advisory Group identified a few technologies with the potential to improve ground water remediation and further review. Most are mature enough for application, but will require site specific treatability study data to determine the expected cost effectiveness for application at Tuba City.

New Ion Exchange Materials and Engineered Zeolites

Ion exchange is part of the baseline ground water treatment system design and the technology is well understood. We investigated some of the newer more selective ion exchange materials being developed specifically for metals removal. The materials being developed are still very expensive and continue to have problems with ground water with high total dissolved solid concentrations.

Though the basic research on engineered zeolites type has been very promising, little date exists to date of any full field applications where long term effectiveness and cost effectiveness can be ascertained.

The other problem with both of technologies is the waste disposal issue caused by concentration of the uranium. The amount of uranium concentrated could significantly affect disposal costs. Since there was not a clear advantage of these technologies, they were not considered further.

Zero-valent Iron Reactors

Iron filings have been shown to be effective in the removal of both nitrates and metals, especially uranium. Several small scale pilot systems are in operation as above ground reactors that have shown very good results. Unfortunately, iron filings have not been shown to be very effective for sulfate removal. For the treatment of the additional sulfate at the site, organic substrates would probably have to be added to the iron filings to get sulfate removal. The biggest technical issue with this type of system is the kinetics of an iron filings reactor and the required removal levels. The kinetics of a reactor need to be evaluated to determine overall size and cost of the filings. The Advisory Group has suggested that these studies be completed so that an expected treatment cost can be

calculated and to see if there would be any associated cost advantage by using this technology.

Bioreactors

Several types of bioreactors were considered. One approach is to use biological processes to remove all the contaminants including the sulfates, nitrates, and uranium in one reactor such as discussed above. Other options are to try and optimize a biological reactor for use on a specific contaminant. For example, the baseline design uses a continuous biological batch reactor to help with the removal of sulfate. The best application depends on the overall cost effectiveness of the combination of processes and other factors such as waste generation, etc. The advantages of biological reactors often is their simple operation and low operating costs.

Research data is being gathered on the application of this technology at a site like Tuba City, but unfortunately the technology is just getting to the commercial stage. With little full-scale data on these bioreactor systems, the technology maybe somewhat immature for application at this site. The Advisory Group has suggested that treatabillty data be generated to evaluate the kinetics and effectiveness of these systems for application at Tuba City, in order to identify any cost advantages that might be realized.

Nanofiltration and Advanced Membrane Separation Systems

Both of these technologies are mature and have been used for removal of metals and high dissolved solids from water. The technologies are generally considered to be very costly. Our review looked at recent advancements to see if the cost effectiveness of these systems had improved. The biggest problems from the Tuba City standpoint is that the systems generate a concentrated brine that still must be treated or disposed, either though distillation or evaporation. Since the costs of these technologies has not been significantly reduced, both technologies were dropped from further consideration.

Phytoremediation

Recently, a significant amount or research has been conducted on the uptake of heavy metals by plants. The results have been very encouraging for the uptake of uranium by plants grown both hydroponically or through straight plant uptake. The application of the pumped water to raise crops and the use of plants to filter the water were evaluated for this site. Two technical issues were raised with application for agriculture. One was that the high dissolved solids in the expected ground water made the water marginal as an irrigation water source, and second was that agriculture is a consumptive use of the resource. The advantages of using the water for agricultural use was that it might not require any treatment and that an income stream could be generated to offset the costs of the remediation effort. Since the expected water quality was marginal, it was determined that some form of treatment would be required prior to irrigation, reducing some of the benefits for land application.

The biggest problem with hydroponic applications was the removal and uptake of sulfur. Both plants and algae were identified that could uptake the uranium and nitrates, but sulfate removal is very difficult. The view of the Advisory Group was that phytoremediation would be difficult to implement cost effectively at this site because of the problems with sulfates.

EVALUATION OF ENABLING OR ENHANCEMENT TECHNOLOGIES

Several concepts and technologies were reviewed that have the potential to expedite the application of the baseline pump-and-treat system or replace the system with a more cost effective extraction system. Several new methodologies and concepts were evaluated including; hydraulic isolation, development of treatment cells through reinjection, fracturing to increase yield and reinjection rates, and multiport injection systems. The application and cost effectiveness of each of these systems are discussed below.

Multiport Injection

Multiport injection systems have been identified as simple ways to inject nutrients or chemicals to facilitate insitu processes such as chemical fixation, chemical flushing, or bioremediation. The system has been used successfully in soils and the system was reviewed for application here to enhance the application of several possible technologies. In review of the technology, it was determined that the present systems are not compatible with the sandstone formations at this site. For that reason, the system was dropped from further consideration.

Hydraulic Isolation

This concept uses impermeable barriers near the plume to isolate the contaminants. The barriers can be either behind the plume to keep upgradinet ground water from entering the contaminated zone or can be used to completely encase the contaminant plume to prevent further migration. The costs associated with this concept because of the size of the plume and the fact that the aquifer is sandstone made this option prohibitive.

Water Reinjection/Reinfiltration

The baseline case includes water reinfiltration to support flushing of the contaminants from underneath the disposal cell. Additional concepts were evaluated analytically to study the effect of additional reinjection of any treated water to create recirculation cells and accelerate cleanup. The modeling results showed significant reductions in the time needed to maintain a flushing action of several pore volumes of the aquifer. These results appear very encouraging and suggest that options using reinjection should be looked at very closely to evaluate cost effectiveness. The Advisory Group is working with the Grand Junction Office to conduct additional modeling of the suggested concepts.

Horizontal Wells

Horizontal wells were reviewed for several applications. In one application, you could replace many of the baseline vertical wells with a few horizontal wells to reduce operating and installation costs and enhance overall effectiveness of the ground water recovery system. A second application reviewed was as a way to either pump water from beneath the disposal cell or to inject water underneath the land fill. Review of the costs and

capabilities to construct the required wells in sandstone for lengths of up to 2000 feet were investigated. The data obtained shows that several companies across the country have the capability to construct such systems. Preliminary modeling of the effectiveness of the horizontal wells showed significant advantages in reducing overall operating periods and costs. Additional modeling is being pursued in order to identify an optimized remediation concept for Tuba City.

Fracturing

Several methods were looked at to increase the permeability of the sandstone aquifer at the site to potentially increase well yields and radiuses of influence to help reduce the number of wells needed. The Advisory Group looked at several types of fracturing including explosive, hydraulic, and pneumatic. At this site, explosive fracturing seemed the most appropriate option application. This technology has been used at several hard rock sites and has been shown to increase permeabilities and well yields by two to three orders of magnitude. A thorough review of this technology by the Advisory Group showed substantial promise of the technology for application at Tuba City. At installation costs of about $150/ft, very large fracture zones can be cost effectively installed at the site, which make the benefits obtained from the system very cost effective. Modeling of installation of these types of systems showed tremendous benefits to ground water recovery and reinjection, providing significantly reduced overall remediation times at the site. The application of this technology is being pursued with treatability and possible small site field studies.

STATUS OF INNOVATIVE TECHNOLOGY ASSESSMENTS AND IMPLEMENTATION EFFORTS AT TUBA CITY

Based on the technologies identified and reviewed, several are being further considered for possible field-scale application at Tuba City. These studies being conducted will continue through the summer of 1997. Each of the studies and modeling will be completed by the end of September. Based on these results, final engineering evaluations will be completed on the various options under investigation. These costs and the expected reduction in remediation schedules for each option will be reviewed by the Advisory Group and final recommendations made to DOE.