INFORMATION SHEET

ORDER NO. R5-2010-XXXX
THE BOEING COMPANY
SIGMA COMPLEX IN-SITU GROUNDWATER BIOREMEDIATION PROJECT
INACTIVE RANCHO CORDOVA TEST SITE
SACRAMENTO COUNTY

Background

The Boeing Company (Boeing), along with Aerojet-General Corporation (Aerojet), as directed by the Central Valley Regional Water Quality Control Board (Regional Board) and the Department of Toxic Substances Control (DTSC), are initiating cleanup of groundwater beneath the Inactive Rancho Cordova Test Site (IRCTS). The IRCTS consists of approximately 4000 acres in eastern Sacramento County to the east of Sunrise Boulevard, south of White Rock Road, and north of Douglas Road. Past rocket testing operations and disposal practices by The McDonnell-Douglas Corporation and/or Aerojet, have caused the groundwater beneath the IRCTS to have become polluted with volatile organic contaminants (VOCs) and perchlorate. Several plumes of contaminants originate on the IRCTS with the largerst plume extending approximately 2.7 miles west of the IRCTS.

Groundwater beneath the IRCTS is contaminated by VOCs and perchlorate. The primary VOCs in the groundwater are trichloroethylene (TCE) and cis-1,2-Dichloroethylne (cis-1,2-DCE) at concentrations up to 710 micrograms per liter (µg/L) and 25 µg/l, respectively. Concentrations of perchlorate have been measured up to 32,000 µg/L. Boeing and Aerojet have completed an Engineering Evaluation/Cost Analysis (EE/CA) for the containment of the plume of perchlorate contaminated groundwater extending west from the IRCTS and across Mather Field. Boeing and Aerojet are in the process of constructing facilities to control the plume by extracting groundwater at the plume boundaries, treating the extracted water to remove the pollutants, and discharging the treated water. In addition, Aerojet and Boeing are evaluating alternatives for remediation of the contaminant plumes, both on and off of the IRCTS.

One of the alternatives being evaluated by Boeing and Aerojet for cleaning up the contaminated groundwater is in-situ bioremediation. This process uses a carbon substrate to provide food for the indigeneous bacteria to grow. The bacteria will, through reduction processes, remove perchlorate and, hopefullly, the VOCs. Aerojet has tested several variations of the in-situ biodegradation process on its own property and conducted a pilot test along the western edge of the IRCTS under Waste Discharge Requirements Order NO. R5-2003-0026. The process has shown significant success in reducing the perchlorate concentrations in the aquifer to below the detection limit of 4 µg/L (the current Action Level established by the California Department of Health Services). Reduction of the VOCs was not as successful without the addition of bacteria (KB-1) known to be able to reduce TCE to ethene and ethene. Boeing proposed to test the bioremediation concept at the Sigma Complex on the IRCTS as described below.

Bio-Barrier Pilot Project

Since 2007, The Boeing Company has operated an in-situ bio-barrier project under waste discharge requirements contained in Order No. R5-2007-0110. The objectives of the pilot project are to confirm the ability of the indigenous bacteria beneath the Sigma Complex on the IRCTS to biodegrade perchlorate to treatment goals through electron donor addition, quantify the rate and extent of perchlorate biodegradation by these indigenous bacteria; assess the impacts of the in-situ bioremediation process on secondary groundwater quality; assess the ability of the active containment system to provide the required level of hydraulic control for plume containment and treatment; identify design and operational factors that influence the successful performance of the in-situ bioremediation approach, and optimize system operation with respect to these factors, and generate performance, design and cost data that can be used for a full-scale system.

The pilot project targets groundwater in the uppermost water-bearing zone. This unconfined water bearing zone consists of sands and gravels extending from approximately 122-182 feet below ground surface. The groundwater is flowing west-southwest underneath the project area. The estimated groundwater velocity is 300 feet per year. One extraction well, one recharge well, and at least seven groundwater monitor well nests have been constructed for the project. The extraction well is located on the western edge with the recharge well upgradient of the perchlorate plume along the eastern edge. Groundwater monitor wells are positioned between the injection and extraction wells and downgradient from the injection well. Groundwater is extracted from the extraction well at up to a total of 120 gallons per minute (average flow is 90-95 gpm) and amended with an electron donor/carbon source and discharged back into the aquifer via the recharge well. The electron donor being used is acetic acid.

The electron donor stimulates the growth of bacteria in a small portion of saturated subsurface to degrade the perchlorate into chloride and oxygen atoms. It is hoped that the TCE will be degraded by the bacteria to ethene and thence to carbon dioxide. Nitrate concentrations are also being reduced by the bacteria. The electron donor dosage is balanced with the amount of electron receptor (oxygen, nitrate, perchlorate, and sulfate) present in the extracted groundwater. This minimizes the potential adverse impacts on groundwater quality.

Based on past evaluations on the IRCTS and the Aerojet facility, the estimated half-life for reduction of perchlorate is approximately 1 day. Thus, to reduce perchlorate concentrations from 4100 µg/L to less than 4 µg/L will take 10 days wihin the reactive zone. With an average groundwater velocity of approximately 3 feet/day, the perchlorate would be expected to be removed within thirty feet of the recharge well. However, the groundwater velocity at the recharge well will be greater than that of the aquifer in general. At the Aerojet facility, the reduction took place within 25 to 75 feet of the recharge well. The data from the operation of the bio-barrier shows that perchlorate is consumed within 100 feet, and likely much less than that.

The area downgradient from the test area is degraded by perchlorate for a distance of over two miles. Boeing and Aerojet are in the process of constructing a cleanup action to halt the downgradient migration of the perchlorate plume. This cleanup is being undertaken pursuant to Cleanup and Abatement Order No. 97-012. Thus, waters beneath and downgradient from the test area covered under this permit, are included in a cleanup action that will be construction completed in the near future.

Operational Changes

Boeing has requested that a portion of the extracted groundwater be allowed to infiltrate through the perchlorate source area in the vadose zone upgradient and within the capture are of the extraction well. This is proposed in order to enhance the cleanup of the vadose zone. Initially, 5 gpm from the extraction well would be treated to remove the perchlorate and TCE prior to application to land. The remaining flow would continue to be amended with acetic acid and injected into the treatment zone to maintain the bio barrier.

TCE would be removed by passing the water through vessels filled with granular activated carbon. The perchlorate will be removed by a bioremediation process that has undergone successful column testing at the Aerojet site. The treatment system is similar to ones being constructed by Aerojet for operation at the Propellant Burn Area on the IRCTS and operated under Order NO. R5-2010-0069. The extracted groundwater is passed through granular activated carbon (GAC) vessels to remove VOCs and then through a modular biotreatment cell (MBC) to remove perchlorate. The MBC consists of either a tank filled with crushed rock and the addition of a carbon substrate such as acetic acid or glycerol, or the tank will be filled with a mixture of elemental sulfur granules and crushed walnut shells. The crushed rock/walnut shells serve as a media to support the growth of indigenous bacteria. The sulfur or carbon donor stimulate the bacterial growth which in turn will breakdown the perchlorate in a manner similar to that achieved by the exisiting in-situ system.

In column studies, Aerojet has shown sulfer and limestone capable of providing an environment to allow bacteria to sufficiently degrade perchlorate to concentrations less than 4 µg/L. There is the potential for sulfate to be produced in the reducing environment witihin the perchlorate treatment tank. Monitoring for sulfate is required and an effluent limitation of 75 mg/L has been established, well below the Secondary Drinking Water Standard of 250 mg/L. Background concentrations at the project site are approximately 50 mg/L.

The ex-situ treatment system will be designed to utilize the entire flow from the extraction well in the event that it is determined that the in-situ biobarrier should be eliminated and all of the perchlorate will be removed by the ex-situ MBC.

Basin Plan, Beneficial Uses, and Regulatory Considerations

Surface water drainage from the project area is to Morrison Creek, tributary to the Sacramento River. The *Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region, Fourth Edition* (Basin Plan), designates beneficial uses, establishes

water quality objectives, and contains implementation plans and policies for all waters of the Basin. Beneficial uses often determine the water quality objectives that apply to a water body. For example, waters designated as municipal and domestic supply must meet the maximum contaminant levels (MCLs) for drinking waters. The Basin Plan sets forth the applicable beneficial uses (industrial, agricultural, and domestic supply in this instance) of groundwater, procedure for application of water quality objectives, and the process for and factors to consider in allocating waste assimilation capacity.

Antidegradation

The antidegradation directives of Section 13000 of the California Water Code require that waters of the State that are better in quality than established water quality objectives be maintained "consistent with the maximum benefit to the people of the State." Waters can be of high quality for some constituents or beneficial uses and not others. Policies and procedures for complying with this directive are set forth in the Basin Plan (including by reference State Water Board Resolution No. 68-16, "Statement of Policy With Respect to Maintaining High Quality Waters in California," or "Antidegradation" Policy).

Resolution 68-16 is applied on a case-by-case, constituent-by-constituent basis in determining whether a certain degree of degradation can be justified. It is incumbent upon the Discharger to provide technical information for the Board to evaluate that fully characterizes:

- All waste constituents to be discharged;
- The background quality of the uppermost layer of the uppermost aquifer;
- The background quality of other waters that may be affected;
- The underlying hydrogeologic conditions;
- Waste treatment and control measures;
- How treatment and control measures are justified as best practicable treatment and control;
- The extent the discharge will impact the quality of each aquifer; and
- The expected degradation to water quality objectives.

In allowing a discharge, the Board must comply with CWC section 13263 in setting appropriate conditions. The Board is required, relative to the groundwater that may be affected by the discharge, to implement the Basin Plan and consider the beneficial uses to be protected along with the water quality objectives essential for that purpose. The Board need not authorize the full utilization of the waste assimilation capacity of the groundwater (CWC 13263(b)) and must consider other waste discharges and factors that affect that capacity.

As stated above, groundwater will be extracted, amended with a carbon source and recharged back to the aquifer. The biological activity will reduce the concentrations of VOCs and perchlorate and the carbon source will be completely consumed in the process. Groundwater quality will be monitored to assess the impacts due to the project. The groundwater flowing from

the project area will be captured by the extraction system being installed by Aerojet and Boeing. Any residual pollutants remaining from the pilot project will be captured and removed by that extraction system. No degradation should occur as a result of the discharge.

Title 27

Title 27, CCR, section 20380 et seq. ("Title 27"), contains regulations to address certain discharges to land. Title 27 establishes a waste classification system, specifies siting and construction standards for containment of classified waste, requires extensive monitoring of groundwater and the unsaturated zone for any indication of failure of containment, and specifies closure and post-closure maintenance requirements. Generally, no degradation of groundwater quality by any waste constituent is acceptable. The proposed discharge will not degrade groundwater quality.

Proposed Order Terms and Conditions

Discharge Prohibitions and Specifications

The proposed Order establishes a discharge flow limit of 360,000 gallons per day. The proposed Order's discharge specifications for the electron donor are designed to minimize residual salts and to maintain all beneficial uses of the groundwater.

Monitoring Requirements

Section 13267 of the CWC authorizes the Board to require monitoring and technical reports as necessary to investigate the impact of a waste discharge on waters of the state. In recent years there has been increased emphasis on obtaining all necessary information, assuring the information is timely as well as representative and accurate, and thereby improving accountability of any discharger for meeting the conditions of discharge. Section 13268 of the CWC authorizes assessment civil administrative liability where appropriate.

This Order requires effluent and groundwater monitoring requirements, including flow rates. In order to adequately characterize its discharge, Boeing is required to monitor for VOCs, perchlorate, electron donor, dissolved metals, dissolved oxygen, total dissolved solids and pH.

AMM:10/18/10