STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

STAFF SUMMARY REPORT (Nicole Fry)
MEETING DATE: July 13, 2016

ITEM: **6**

SUBJECT: **Environmental Risk Assessment** – Status Report

CHRONOLOGY: February 2016 –Environmental Screening Levels (ESLs) Update in Executive Officer's Report

DISCUSSION: The purpose of this status report is to update the Board on how we assess risk at sites with contaminated soil and groundwater. An overview of our current risk assessment process and how it fits into the overall site cleanup process is provided in Appendix A.

RECOMMEN-DATION: This is an information item not requiring action by the Board.

Appendix A: Status Report

APPENDIX A

STATUS REPORT

Site Cleanup Risk Assessment

Overview of Site Cleanup Process

Once a site with soil and/or groundwater contamination has been identified, the first step in the site cleanup process is to conduct an investigation to fully characterize the site by sampling all media (groundwater, soil, soil gas, and indoor air) that may be impacted by contamination. Next, a risk assessment analysis is performed to determine if site receptors (human or ecological) are likely to be exposed to levels of contamination sufficient to result in adverse impacts (such as toxicity or nuisance). This usually involves the development of media-specific (groundwater, soil, soil gas, or indoor air) screening levels that define a sufficiently low contamination level where minimal risk of toxicity or nuisance is expected. The risk assessment process helps us to prioritize the risk posed by each site to human health or water quality, so we can focus our limited staff resources accordingly.

A cleanup plan is then prepared that assesses which cleanup strategy would best address the specific contamination and potential exposure at a given site. Cleanup levels are also set during preparation of the cleanup plan. Ideally, cleanup levels would be set at pre-release background concentration levels. However, in many cases cleanup to background is not technically or financially feasible. Instead, regulatory standards (such as maximum contaminant levels or MCLs) and the risk-based screening levels developed during the risk assessment are used to determine appropriate cleanup levels.

The cleanup plan is then implemented and monitoring is conducted to verify the effectiveness of the remedy. Once cleanup levels are met, the case is ready for closure. If cleanup levels have not been met, additional risk assessment may be conducted to evaluate if an alternate cleanup strategy is required. The process is often iterative, with additional investigation, risk assessment, or cleanup activities, as new information is gathered over the life of the cleanup.

There are two situations where case closure could occur before cleanup levels are met:

1. For sites where current beneficial uses are not impacted (e.g., groundwater not currently used), case closure can occur once it has been demonstrated that cleanup levels are likely to be achieved within a reasonable time frame; this ensures potential future beneficial uses are not impacted.
2. For sites where potential health risk could still exist (e.g., human health risk screening levels are exceeded), case closure can occur once mitigation measures are implemented to protect both current and potential future site receptors. Mitigation measures could include actions such as providing an alternate water supply or constructing vapor barriers to limit migration of contaminants to indoor air.

Receptors and Exposure Pathways

The basic question answered by a risk assessment is “does the site pose an unacceptable risk to human health or the environment?” To answer this, the risk assessment first determines which current and future receptors could be affected by site contamination depending on the use and location of a site. Both human (e.g., residents, commercial workers, or construction workers) and ecological (e.g., terrestrial or aquatic species) receptors are identified. Different receptors can be expected to engage in different site activities that will directly affect the amount of time spent onsite and the level of potential interaction with contaminated media. For example, residents could potentially spend most of their time near contamination at their residential property while commercial workers would probably only spend 40 hrs/week at their job. Further, it is more likely that a child could have a substantially higher contact with soil (playing outside) compared to a commercial worker in an office setting.

In order to assess the potential risk to site receptors, we next determine the amount of each contaminant and its proximity to each receptor. A risk only exists if receptors are exposed to sufficient quantities of the contamination. If contamination is in a location where we would not expect receptors to be exposed (incomplete exposure pathway), then we consider there to be little or no risk. This would be the case for sites with contaminated groundwater that is not currently used for municipal or domestic supply and does not discharge to a surface waterbody. Similarly, if contamination levels are sufficiently low, we would also consider there to be minimal risk even if receptors are exposed to site contamination.

For human receptors, there are three main exposure pathways addressed at contaminated sites:

1) Inhalation of contaminated air, water vapors, or soil particles;
2) Ingestion of contaminated soil or water; and
3) Dermal contact with contaminated soil or water.

Using these exposure pathways and receptor-specific exposure scenarios, a risk assessment will calculate the human health risk posed by contamination levels in each media (groundwater, soil, soil gas, or indoor air). Using those same exposure parameters, risk assessment will also define sufficiently low contamination levels where minimal risk is expected for each receptor. These levels are often referred to as screening levels. If contamination at the site exceeds these screening levels, a site is considered to pose an unacceptable risk to the receptor.

Development of Human Health Risk-Based Screening Levels

The first step in the development of human health risk-based screening levels is to identify the different types of health risks that need to be addressed. Typically, two distinct health risks associated with exposure to toxic chemicals are considered: 1) the risk of developing cancer, and 2) the risk of developing any other non-cancer-related illness. Next, the specific amount of risk that is considered acceptable needs to be determined for both cancer- and non-cancer-based risks. For non-cancer, the maximum acceptable risk amount is set at the highest concentration where there are no observed adverse effects. However, for cancer there is no concentration of a cancer-causing chemical where no risk of developing cancer exists. Therefore, there is a range of maximum cancer risk levels that have historically been considered acceptable by regulators: 1 in a million (10^{-6}) to 1 in 10,000 (10^{-4}) chances of developing cancer over a lifetime. In most situations, cancer risk should not exceed 10^{-6}. This risk range is only used in situations where cleanup to a 10^{-6} cancer risk level is not feasible. We typically do not use the upper end of the risk range and only accept screening levels (or risk-based cleanup goals) with risk at or below 1 in 100,000 (10^{-5}) chances of cancer for sites that cannot cleanup to levels below the desired 10^{-6} risk level.

Environmental Screening Levels (ESLs)

The Water Board's Environmental Screening Levels (ESLs) are a set of generic screening levels for several common contaminants that we have developed to facilitate the risk assessment process at our cleanup sites. The ESLs are particularly helpful for quickly and cost effectively assessing risks in situations where a full risk assessment is too time consuming or costly. We have several different ESLs that address risk for a few common receptors assuming exposure parameters based on some common site conditions. Therefore, different ESLs can be selected for use at specific sites depending on applicable site conditions and receptors. However, it is impossible to develop generic scenarios that can be applied to every single site. Thus, for sites with receptors or conditions not considered in the ESLs, a site-specific risk assessment may still be necessary.

The ESLs are also designed to consider more than just toxicity risks. For example, we have ESLs for different media that protect against taste (water) or odor (water, soil, and soil gas) nuisance. In

addition, several different regulatory standards are used to develop some of the ESLs. This can be seen for several of the aquatic toxicity-based ESLs that were developed using California Toxics Rule Criteria. Lastly, there are ESLs that assess the likelihood of contamination transport onsite (e.g., soil contamination leaching to groundwater or groundwater contamination volatilizing and moving into indoor air). This becomes particularly helpful when assessing whether contamination transport could lead to receptor exposure.

The most recent major update of our ESLs occurred in February 2016 and those ESL values are compiled in an Excel Workbook that is available on the Water Board's website along with the accompanying ESLs User's Guide (www.waterboards.ca.gov/sanfranciscobay/esl.shtml).

Current Risk Assessment Issues

The February 2016 ESL update addresses two significant risk assessment issues: the toxicity of petroleum breakdown products (metabolites) and the toxicity of chlorinated solvents. These issues are particularly important since the majority of cleanup sites in our region contain petroleum, chlorinated solvents, or both.

Toxicity of Petroleum Metabolites

Background: Petroleum products are a mixture of hundreds to thousands of distinct chemicals (mainly hydrocarbons). However, only a small number of petroleum chemicals have been sufficiently studied to understand their toxicity (such as benzene, ethylbenzene, and naphthalene). For risk assessments, typically only the well-studied petroleum chemicals are individually identified and measured. The rest of the petroleum chemicals are measured together and reported as the "total petroleum hydrocarbons" (TPH) concentration.

Our ESLs include human health risk-based levels for these well-studied petroleum chemicals and for four distinct TPH mixtures: gasoline (TPHg), diesel (TPHd), motor oil (TPHmo), and Stoddard solvent (TPHss). These TPH-mixture ESLs are based on toxicity values calculated using U.S. EPA's fractionation approach where the chemicals within each TPH mixture are separated into a few groups (aka fractions) based on their chemical properties (i.e., how they act in soil and water). Toxicity values are assigned to each fraction using a surrogate approach consistent with U.S. EPA methods for mixture risk assessment. For the TPH-mixture ESLs, these fraction toxicity values are combined to calculate the total toxicity based on each fraction's proportion in a particular TPH mixture.

Toxicity of Petroleum Metabolites: The TPH-mixture ESLs do not take into account the toxicity of petroleum contamination, as it naturally breaks downs in the environment. It is generally believed that petroleum hydrocarbons get systematically oxidized and broken down into successively smaller chemicals, eventually becoming mainly carbon dioxide and water. This has led to the idea that petroleum products become less toxic as they break down. However, thousands of chemicals are produced during the breakdown processes, and they can persist in the environment for extended periods of time before complete breakdown is achieved. Moreover, breakthroughs in analytical chemistry technologies over the last decade are now allowing researchers to better evaluate these breakdown products and pathways, and the findings indicate that this breakdown is neither as simple nor as complete as previously believed. In addition, published research documenting adverse effects of petroleum metabolites on both human and ecological receptors has shown that petroleum metabolites clearly pose a toxicity risk.

Recommendations: At this time, we recommend that petroleum metabolites be treated as having similar toxicity to the parent petroleum mixtures when assessing sites that meet two criteria: (1) a large TPH mass remains in soil, and (2) the site is located near a receptor such as a surface water body or a supply well. At such sites, samples used for determining the full extent of petroleum contamination

and assessing potential risks should be analyzed without silica gel cleanup (a procedure that removes the metabolites prior to analysis so that only the parent petroleum hydrocarbons are detected).

Toxicity of Chlorinated Solvents

Background: Widespread, historic use of tetrachloroethene (PCE) and trichloroethene (TCE) throughout the Bay Area as degreasing agents has led to significant environmental contamination. These chlorinated solvents are heavier than water and thus tend to sink deeper and travel further into the ground compared with petroleum, which is lighter than water and floats. As chlorinated solvents travel through the porous subsurface, they pass through coarse soil zones and are adsorbed in clay layers. This leads to a complex pattern of soil and groundwater contamination that is challenging to fully assess. In addition, groundwater plumes of PCE and TCE can be quite extensive both laterally and vertically. Chlorinated solvents in soil and groundwater will readily volatize, generating contaminated soil gas that can then impact indoor air through vapor intrusion into buildings. Overall, chlorinated solvent contamination is particularly mobile and can pose risks from exposure to soil, groundwater, and indoor air.

Approach for Vapor Intrusion Evaluation: The vapor intrusion exposure pathway has proven to be the main risk driver at many of our cleanup sites contaminated with PCE and TCE. The current scientific understanding of vapor intrusion mechanisms as well as the technology and methodology for assessing vapor intrusion are still evolving. Therefore, we have adopted a "multiple lines of evidence" approach for risk assessment. This approach highlights the need for a complete understanding of site conditions based on multiple types of data and a good understanding of the limitations of each type of data. For example, the spatial variability of soil gas concentrations below a building makes any one soil gas sample unreliable for making a risk determination. In addition, even if the soil gas below a building is well characterized, the results might not reveal preferential pathways (such as poorly sealed utility conduits) or unusual ventilation features. Therefore, we recommend assessment of building characteristics and the collection of indoor air samples taken concurrently with soil gas samples when there is a significant soil or groundwater source near a building.

TCE Short-Term Toxicity: This issue has become even more urgent over the last few years due to our growing awareness of the unique short-term toxicity posed by TCE to developing fetuses. For most chemicals, the exposure concentrations leading to acute toxicity (caused by short chemical exposures of less than 24 hours) are orders of magnitude larger than the concentrations necessary to cause chronic toxicity (from long-term exposures over many years). Therefore, to protect for both long- and short-term toxicity, our ESLs are calculated using the lower chronic toxicity levels that assume long exposure periods (e.g., 30 years for residents). Thus, even if contamination were above the ESLs, it would be years before there were significant risks to human health, providing time for remediation activities to reduce contamination below the ESLs. This is not the case for TCE, which is extremely toxic to developing fetuses. The fetal heart forms over a short period during the first trimester of pregnancy. The concentration of TCE where fetal heart malformation can occur from short-term exposure to a pregnant woman is only slightly higher than the concentration that can cause cancer over a period of many years. Thus, if TCE contamination in indoor air is above its ESL, there is very little time for TCE concentrations to be reduced before fetal harm could occur. For sites with TCE in indoor air at concentrations greater than the ESL, we now require quick sampling of indoor air and implementation of mitigation measures that ensure exposure pathways are cut off until contamination levels are reduced below risk levels.

Next Steps

Based on our evolving understanding of risk, we now realize there may be some cleanup sites in our region that need to reopened because the potential risks from petroleum metabolites or chlorinated solvents were not adequately assessed before closure. Ideally, we would go back through data at the time of closure from sites with petroleum or chlorinated solvent releases and assess whether those cases should be reopened. Currently, we have not done this for all of our closed cases. We are reassessing cases on a site-specific basis, typically upon request during a property transfer.

We expect that the ESLs and our overall risk assessment process will continue to get updated as the science used to understand the fate, transport, and toxicity of environmental contamination continues to evolve. It is important that Water Board staff stay aware of the latest scientific advances so that we can provide proper oversight of contaminated sites.

Staff will be providing a followup status report to the Board later this year that will address the risk management process used at our cleanup sites.