# MCAS El Toro
# Installation Restoration Program

## Public Information Materials

## 7/29/98
## Restoration Advisory Board Meeting

## held at Irvine City Hall
## Irvine, CA

**Materials/Handouts Include:**

- RAB meeting agenda/Public notice – 7/29/98 RAB meeting.
- RAB Final Meeting Minutes – 6/24/98 RAB meeting *(Minutes approved at the 7/29/98 meeting.)*
- Presentation Handout – Issue: What if New Contamination is Found After Property Transfer?
- Presentation Handout – Public Comments, Proposed Plan for Closure of Inactive Landfills
- Presentation Handout – Status, Radiological Survey of Hangers 296 and 297
- Handout – Personal Radiation Dose Chart
- Handout - Radioactive Waste Fact Sheet, California Base Closure Environmental Committee, May 1994
- Handout – Guidance for Cleanup of Radioactivity on Closing Military Bases for Unrestricted Public Use of Property
- Presentation Handout – Perchlorate Detected in Shallow Groundwater
- Presentation Handout – Excerpts from RAB Meeting Minutes Pertaining to Ammonium Perchlorate
- Handout – Perchlorate Contamination in the Environment: Occurence
- Handout – Perchlorate Contamination in the Environment: Overview of Perchlorate Issues
- Handout – Perchlorate Contamination in the Environment: Analytical Methods
- Handout – Perchlorate Contamination in the Environment: Health Effects/Toxicology of Perchlorate
- Handout – Perchlorate Contamination in the Environment: Treatment Technologies
- Handout – Forums on Perchlorate to be Held on August 25 and August 27, 1998

# MCAS El Toro
# Restoration Advisory Board
# Meeting

***29 July 1998 6:30-9:00 PM***
***Irvine City Hall***
***Conference and Training Center***
***One Civic Center Plaza***
***Irvine***

## AGENDA

***REMINDER:*** ***Question and Answer (Q&A) Ground Rules***

- ***Q&A follows individual presentations.***
- ***Q&A time is included in the meeting segment and presentation timeframes.***
- ***After meeting adjournment, Navy and Marine Corps representatives are available to answer additional questions.***

### *Welcome/Introductions/Agenda Review (6:30-6:40)*

Joseph Joyce
*Marine Corps/Navy RAB Co-chair*

### *Old Business (6:40-7:00)*

Approval of 6/24/98 Minutes *(6:40-6:45)*

Greg Hurley
*RAB Community Co-chair*

Announcements *(6:45-7:00)*

Joseph Joyce & Greg Hurley

### *New Business (7:00-8:35)*

Regulatory Agency Comment Update *(7:00-7:15)*

Glenn Kistner, *U.S. EPA*; Tayseer Mahmoud, *Cal-EPA DTSC*; Patricia Hannon, *RWQCB*

Issue: What if New Contamination is Found After Property Transfer? *(7:15-7:25)*

Joseph Joyce or Andy Piszkin
*U.S. Navy/Southwest Division*

Present Public Comments - Landfill Proposed Plan *(7:25-7:45)*

Joseph Joyce

5 MINUTE BREAK *(7:45-7:50)*

Status - Radiological Survey *(7:50-8:20)*

Tamy Johniken
*U.S. Navy/Southwest Division*

Status – Perchlorate Detected in Shallow Groundwater *(8:20-8:35)*

Andy Piszkin

### *Meeting Summary (8:35-8:50)*

Greg Hurley

Meeting Evaluation

Future Topics and Meetings

### *Closing (8:50-9:00)*

Joseph Joyce & Greg Hurley

# MARINE CORPS AIR STATION EL TORO

# RESTORATION ADVISORY BOARD MEETING

## June 24, 1998

*MEETING MINUTES*

A Restoration Advisory Board (RAB) meeting for Marine Corps Air Station (MCAS) El Toro was held Wednesday, June 24, 1998 at the Irvine City Hall. The meeting began at 6:34 p.m. These minutes summarize the discussions and presentations from the meeting.

## WELCOME, INTRODUCTIONS, AGENDA REVIEW

Mr. Joseph Joyce, Marine Corps RAB Co-Chair, opened the meeting by introducing himself and welcoming everyone in attendance. He reminded the group to sign in and include their name and address on the sign-in sheet, so all in attendance will receive a copy of the meeting minutes and the next RAB meeting agenda. Joseph noted that (they) were unable to have some of the presentation materials available for the meeting, but said that the materials would be sent out along with the meeting minutes. Following self-introductions made by all in attendance, Mr. Joyce provided an overview of the meeting agenda. The Radiological Survey presentation was rescheduled for the next RAB meeting, July 29th, 1998. Mr. Joyce reminded the RAB that time is allotted at the end of each presentation specifically for questions and answers, and told the members to please hold all questions until the end of the presentation. He also said that information from the public meeting held June 18, 1998 was on display for the group to view during the break.

## OLD BUSINESS

### Review and Approval of March 25, 1997 Meeting Minutes

The RAB minutes from March 25, 1998 were approved without amendment. Mr. Hurley thanked Bob Coleman for doing a great job on the meeting minutes.

### Announcements

- Mr. Joyce stated that on Saturday, July 25, 1998, a site tour of MCAS El Toro for RAB members and other interested citizens would take place. He asked RAB members to fill out the sign-up sheets provided at the meeting to get an accurate head count to assure that enough vehicles would be available.

- Mr. Joyce thanked Marcia Rudolph, RAB member, for her work in support of the MCAS El Toro RAB and as a stakeholder that brings a community interest to the environmental cleanup program. He also thanked her for her recognition of the MCAS El Toro Project Team's efforts to support interests of the community.

- Mr. Hurley, RAB Community Co-Chair, announced that the OU-3 subcommittee, which focuses on the surface soil contamination at sites 7, 8, 11, 12, 14 and 16, no longer has a chairperson. If a RAB member is interested in fulfilling this role, please see Mr. Joyce or Mr. Hurley. He clarified that the chairperson must be a RAB member.

- In regard to RAB subcommittee meetings, Mr. Hurley said they are scheduled every other month on the last Wednesday of the month when RAB meetings are not held. (Subcommittee meetings and regular RAB meetings alternate each month.) The next RAB meeting is scheduled for July 29, 1998, while the next subcommittee meeting is scheduled for August 26, 1998 in this room (Conference and Training Center). However, Mr. Hurley said, a RAB subcommittee can meet anytime, at any location.

- As a reminder to RAB members, Mr. Joyce noted that the RAB meeting binders that are housed at the Heritage Park Regional Library were available to the RAB at tonight's meeting. These binders (4) contain all documents relating to the RAB, for example, previous meeting minutes, presentation materials, handouts, etc.

- Mr. Joyce reported that this week in San Diego, the MCAS El Toro BRAC Cleanup Team (BCT), composed of Glenn Kistner, U.S. EPA, Tayseer Mahmoud, Cal-EPA DTSC, and Mr. Joyce, is attending a BRAC Cleanup Team Conference sponsored by the Department of the Navy (DoN). The conference is for BCTs from bases throughout the country from all branches of the military and brings together base officials and regulatory agencies. The conference concentrates on emerging issues that have come to light during the base closure process. He said an issue, which also pertains to remediation MCAS El Toro landfills, was communicated from the senior management levels of the Department of Defense (DoD) and the DoN. These officials stated that the remedy selection process focus the limited cleanup dollars on remedies that are protective of human health and the environment. Although, there have been discussions pertaining to remedies which go further to support reuse; and these are currently taking place with the local redevelopment agencies. Mr. Joyce said he wanted to share this information in light of the comments on clean closure. He added that the DoD and DoN message regarding the focus on remedy selection was clearly delivered, reuse is also important but protection of human health and the environment is the priority.

- Mr. Joyce also said that the contract has been awarded for transfer of the soil vapor extraction (SVE) unit from Norton Air Force Base to MCAS El Toro. The SVE unit will be used to decontaminate the soil in the VOC Source Area (Site 24) and it is expected to arrive at the end of July or early August. Contaminated soil at Site 24 is the source of the three-mile plume of contaminated groundwater off-station. The use of SVE technology has been agreed upon by all of the regulatory agencies in the Record of Decision signed by the agencies in September 1997. In response to a question regarding the time line for the soil cleanup, Mr. Bernie Lindsey, Remedial Project Manager, from the Southwest Division Naval Facilities Engineering Command, explained that federal procedures for contracting and equipment acquisition must be complied with. Also, under the Federal

Facilities Agreement (FFA) a specific implementation procedure must be followed before soil remediation begins next spring. Steps in this process are as follows:

- The DoN produces a draft design (includes well placement, piping) for submittal to the agencies in mid-August.

- The agencies will have two months to review the draft design and submit comments to the DoN.

- During the next two-month period, DoN will review agency comments and incorporate comments and come to an agreement with the agencies on a design that meets needs of all groups concerned, and resubmit the final design to the agencies.

- The agencies will have 30 days to verify that the DoN incorporated the agencies' comments satisfactorily.

- The report becomes final 30 days later, and the design is expected to be finalized in mid-January 1999.

**NEW BUSINESS**

**Regulatory Agency Comment Update - Glenn Kistner, Project Manager, U.S. EPA**
**Tayseer Mahmoud, Project Manager, Cal-EPA DTSC**
**Patricia Hannon, Project Manager, RWQCB**

**Glenn Kistner, Project Manager, U.S. EPA**

Mr. Kistner provided two handouts. The U.S. EPA approved the OU-3A Draft Final Feasibility Study, and also approved modifications to the FFA schedule. The modifications to the schedule for OU-3A (Sites 7, 14, & 16) allow for a time extension of an additional seven months. The modifications to the schedule for OU-3 (Sites 8, 11, & 12) allow for a time extension of an additional six weeks.

**Tayseer Mahmoud, Project Manager, Cal-EPA DTSC**

Mr. Mahmoud stated that the DTSC reviewed and approved the Draft Final Soil Vapor Extraction System Design Work Plan for the system that is being transferred from Norton Air Force Base to MCAS El Toro. DTSC is satisfied that comments on the draft Work Plan submitted in March 1998 have been adequately addressed in the draft final document dated May 1998. In mid-August, the DoN will submit the actual design to DTSC for review and comment. Mr. Mahmoud said that even though such remedial action does not require federal, state, or local permits, DTSC requested that the DoN submit the Permit Equivalency Package to South Coast Air Quality Management District to insure that the design meets requirements for air emissions (Rules 1303 and 1401). Mr. Mahmoud concluded by telling the RAB that DTSC's letter of approval is available on the meeting sign-in table. He said that DTSC also approved the Draft Final Feasibility Study for OU-3. The approval letter was not made available because the approval occurred two months ago.

**Patricia Hannon, Project Manager, RWQCB**

Ms. Hannon said that she is currently reviewing the Design Work Plan Mr. Mahmoud referred to. She said she would also be reviewing Underground Storage Tank (UST) reports when she receives them. Mr. Joyce said that Ms. Hannon's name would be listed on the regulatory agency update portion of the meeting agenda for all future RAB meetings.

**Most Commonly Asked Questions - Environmental Cleanup at MCAS El Toro - Bernie Lindsey, Remedial Project Manager, Southwest Division Naval Facilities Engineering Command**

Mr. Joyce said that Marine Corps and Navy staff often receive questions via phone calls, at outreach presentations, and at public meetings regarding the cleanup program at MCAS El Toro. To provide RAB members and others with a clearer understanding of issues regarding the cleanup efforts at the Station, Mr. Lindsey presented some of the most commonly asked questions and responses to these questions.

1. **Question: If MCAS El Toro becomes an airport, will that require less environmental cleanup?**

**Answer:** No. This question has been asked several times. Mr. Lindsey reminded the RAB that 85% of the station is environmentally ready for transfer and that whatever reuse options are implemented at the Station properties after the Marine Corps leaves will not effect the current cleanup efforts. He said that landfill remedies do include restrictions on future land use at these sites.

Also, the BCT signed a Record of Decision in September 1997 for No Further Action at 11 Installation Restoration Program sites. The decision for no further action at these sites resulted from extensive study including conducting of a health risk assessment that is a requirement under federal law. The DoN assessed these sites under both residential and industrial reuse scenarios. This effort went above and beyond requirements since the Marine Corps was only required to evaluate such risks under the industrial scenario (reuse as an airport). The no further action determination was based on the results of the residential risk assessment. Mr. Lindsey reiterated that by applying the residential scenario for the risk assessment study, use of these sites as part of an airport was not considered.

2. **Question: Will a native soil cap protect the citizens of Orange County from contaminants present inside the landfills?**

**Answer: Yes.** Existing conditions with no landfill cover pose no unacceptable risk to people, so a cap of any kind placed on the landfill makes it that much more acceptable in regards to risk to human health.

3. **Question: Is the DoN/Marine Corps committed to cleanup at El Toro?**

**Answer:** Yes. The Marine Corps continues to be committed to implementing remedies that are protective of human health and the environment. The DoN has personnel with full time responsibilities that are dedicated solely to the cleanup of MCAS El Toro. This

includes SWDIV staff (RPMs) and extends to contractor support including CLEAN II/Bechtel.

4. **Question: What is all the controversy in the press regarding the Marine Corps' proposed remedy for the landfills and Cal-EPA DTSC?**

**Answer:** One of the agencies (DTSC) has a different opinion than the DoN regarding the enhancement of remedies to allow future land use. Earlier there was a reference to the BCT Conference and the DoD and DoN position on remedy selection; they are not going to spend funds beyond what they are required to under the federal law.

5. **Question: Do you have land mines in the landfills at MCAS El Toro?**

**Answer:** No. An extensive background check was done on the landfills; this included interviews with former employees who worked at the landfills. It was concluded that there is no reason to believe that ordinance, such as land mines, went into any of the landfill sites because the Station has a disposal ordnance range for such devices.

6. **Question: Does MCAS El Toro have radiation hazards that put the citizens of Orange County at risk?**

**Answer:** No.

**Question/Answer Discussion Session - Mr. Lindsey's Presentation**

**Q:** A RAB member asked if there was any explosive material at Site 1.
**A:** Mr. Lindsey explained that Site 1 is the Explosive Ordnance Disposal Range. It is at this location where the Marine Corps takes ordnance, from both the DoD and outside agencies, which is no longer usable and explodes and destroys it. The process the Marine Corps uses is designed to completely destroy all the explosive material. A search of the explosion area is made to retrieve material (metal, etc.) if any not disintegrated during the disposal.

**Q:** A meeting attendee asked if there is any radioactive material at the Station?
**A:** Mr. Joyce said, that currently DoD is conducting radiological surveys of Buildings 296 and 297 because of the radium paint used for some of the aircraft instruments. Mr. Joyce restated that a presentation regarding the radiological survey conducted at these locations would be presented at the next RAB meeting. He also reiterated, that with the information the DoD has to date, there is no health threat to the citizens of Orange Country from any of the operations at the Station.

**Q:** A meeting attendee questioned why it is better not to have a cover at Site 3 and at Site 5.
**A:** Mr. Lindsey clarified, that as the landfill sites currently exist, there are no landfill covers that were designed and engineered as landfill caps. After the field investigations, the risk assessment was conducted and it was determined, that based on existing conditions, there are no unacceptable risks to human health associated with the lack of covers at the landfill sites. He stated that placing covers over the landfill sites would be an improvement over the current conditions. Mr. Joyce added that the preferred alternative proposed by the Marine Corps' is a native soil cap that will enhance the existing conditions at the site. Mr. Lindsey reiterated that there is no threat at the surface of the landfills and the Marine Corps is

proposing the soil cover remedy for the landfills in order to satisfy state laws regarding groundwater protection.

Q: A RAB member asked why fencing was needed around those landfill sites if there is no current threat?
A: In response, Mr. Joyce said that in the ensuing period from the time the fence was proposed, there have been further discussions with the regulatory agencies that indicate that a fence is no longer required. The key is to restrict access to the area and there are many ways to do that. Currently, access is controlled because the sites are located on a military base. After closure of the base, in reference to the site proposed for golf course use, access would be restricted with green fees.

Mr. Joyce stated that as part of using a presumptive remedy for landfills, there have to be controls in place so that the remedy will not be impacted to the point where the protection of human health and the environment has been compromised. With that in mind, some restrictions are mandatory for long-term operation and maintenance to assure that the controls are in place and that the remedy continues to be protected. If there were no institutional controls in place and the remedy was tampered with, this tampering could cause the remedy to be less protective than the original design.

Q: A meeting attendee asked when the DoD speaks of long-term maintenance of the remedy for the landfills, how long is "long-term"?
A: Mr. Joyce stated that long-term operation and maintenance is 30 years from the time the remedy is put into place. He also noted that there are plans to have the regulatory agencies provide oversight for the DoD inspections of the long-term remedy to ensure that the remedy continues to be protective of human health and the environment. In addition, agency representatives will provide oversight during maintenance operations and the DoD will submit reports to the agencies for review and concurrence.

Mr. Andy Piszkin, SWDIV RPM, added that the long-term estimation of 30 years is an approximation. It may be less depending on what the maintenance report states. He reminded the RAB that the landfills have been inactive from anywhere between 18 to 40 years. Currently, the surface of the landfills does not pose a risk, so the general time frame allotted for long-term maintenance is 30 years. He noted that once the remedy is in place a 5-year review would be conducted. At the review, the agencies and the DoN will assess the requirements. Each remedy installed will have long-term operation and maintenance to assure that whatever remedy was selected and implemented remains to be protective.

Q: A RAB member asked, since there will be no fence around Site 5 and the golf course, will there be restrictions on foot traffic over the Site 5 cap on the golf course?
A: Mr. Joyce replied he does not foresee any restrictions on foot traffic. He noted that some communities have put parks with picnic tables and benches over landfills. The RAB member also asked if the regulators concur with the lack of foot traffic restrictions over the landfills? Mr. Kistner said that U.S. EPA would support access of that nature such as a park with foot traffic.

**Q:** A RAB member asked, whether the actions proposed for four landfill sites (2, 3, 5, and 17) are separate actions or one joint action with separate parts to them?
**A:** Mr. Kistner explained that each landfill will have its own cap but they will be grouped together in a single Record of Decision. Sites 2 and 17 will be transferred to the Department of Interior and become a park or wildlife habitat. Sites 3 and 5 will be transferred to a local reuse agency. Mr. Joyce clarified that although the landfill sites will be a part of one ROD, they will each have their own specific design with different characteristics that need to be accommodated. For example, the design for Site 2, because of its close proximity to Borrego Canyon Wash, will be quite different than the designs for the other landfills.

**Q:** Another RAB member asked what the cost differential is between a remedial action to clean close Sites 3 and 5 versus and the current presumptive remedy cap?
**A:** Mr. Joyce explained that clean closure is meant to take everything out of the landfill (dig it up) and move it. He said that it would be best to go back and look at figures previously presented and that could be done at the next RAB meeting. The cost differential for clean closure of Site 3 and the proposed remedy for Site 3 are a large differential, whereas for Site 5 clean closure versus the proposed remedy, the cost differential is much narrower. Dr. Chuck Bennett, RAB member, had this information on hand so he provided the costs figures previously presented. He said that for Site 5, the capping and monitoring is estimated at $4.4 million (current plan) and the consolidation approach is estimated at $7.4 million. For Site 3, the capping and monitoring is estimated at $7.8 million and clean closure is estimated at $27 million.

**Q:** A RAB member asked if Site 5 is still restricted in terms of irrigation?
**A:** He stated that there are studies which show that irrigation for a golf course will cause no significant infiltration and that the California Integrated Waste Management Board has said that if DoN will do more characterization, this Board would permit irrigation if the results were positive. The RAB member also mentioned that Integrated Waste Management Board (Peter Janicki) sent a letter to the Navy regarding this matter, but has not gotten a response.

Mr. Lindsey confirmed that current rate of infiltration at the landfill sites (without landfill covers) would be reduced by proposed native-soil caps. But, for any cap chosen, the DoN had to demonstrate that the cap is equivalent to the California prescriptive cap. Irrigating the Alternative 3 cap is not equivalent to the California prescriptive cap, therefore, that is why the DoN maintains that a restriction on irrigation is needed.

Mr. Hurley stated that he believes the landfill issues have been thoroughly covered in the RAB meetings and that the RAB has a comprehensive understanding of these issues. He said the RAB has produced a statement pertaining to the landfills that has been signed by six RAB members thus far. Mr. Hurley made the statement available for perusal at the RAB meeting. Mr. Hurley said he trusts that the RAB members will submit the statement as part of the public comment period record making it part of the decision process. He also requested that the Marine Corps provide a formal response.

**Q:** Mr. Hurley posed two specific questions he is asked quite frequently regarding the landfill sites concerning the CERFA (Community Environmental Response Facilitation Act)

properties, those properties that are being transferred and assumed to be clean. What happens if a developer uncovers contamination? What can be expected as far as a timeline for this remediation?
A: Mr. Joyce said that to date, the DoN has not discussed a timeline for remediation but they have clearly identified DoN policy: if an unforeseen condition exists and it is the DoN's responsible for any contamination that was a direct result of past Marine Corps activities, then the DoN is still liable and will come back and remediate the condition. The DoN is committed to this responsibility. As far as a timeline, Mr. Joyce said that if construction is taking place and a contamination problem arises, he does not know what the DoN's policy is regarding timelines. He assured he would investigate the question and provide an answer at the next RAB meeting. Mr. Hurley stressed that he would like a response because he has already received two phone calls from contractors.

Q: Mr. Hurley asked if contamination was found during construction and the company had to completely shut down the operation, who would be liable for the lost time/material costs? Would the DoN reimburse the contractor and the community for costs incurred as a result of having to shut down the job because of unexpected contamination findings?
A: Mr. Joyce said that this scenario is a legal matter that he would refer to attorneys who specialize in liability and reimbursable costs. He said he would follow up and present this information at the next RAB meeting.

Q: A RAB member wanted to clarify the statute of limitations for the DoN's liability if it can be determined that the contamination is a result of a Marine Corps activity? What would happen if there was a contamination problem where the origin or cause is ambiguous or cannot be determined? What is the standard that the Navy uses under those circumstances?
A: Mr. Kistner said, that in its current form, the CERCLA (the Federal Comprehensive Environmental Response and Liability Act) states that there is no statute of limitations. Mr. Joyce said that he couldn't try to address every potential scenario that might exist with the future redevelopment of the property. He emphasized that the scenarios would have to be dealt with on a case-by-case basis and be evaluated by using whatever information was available.

Mr. Lindsey reiterated that the purpose of conducting monitoring and maintenance of the protective remedy is to guarantee that the remedy is still in place and that conditions have not changed. If the DoN finds contamination or conditions change, then the DoN is responsible for those changes in site conditions.

Q: A meeting attendee asked why the site could be watered as part of a golf course, rained on, and walked on, but could not be irrigated?
A: Mr. Lindsey said that with the proposed remedy (native soil cap) there is a restriction on irrigation that does not allow additional water other than normal rainfall. The native soil cap is engineered as such that it restricts the flow of water infiltrating through the cap.

**Q: Another question was asked regarding the types of grass that would cover the site.**
A: Mr. Joyce said that there have discussions with the Orange County Local Redevelopment Authority (LRA) staff regarding different types of grass/vegetation for the site. Currently, it

has not been decided which type of grass/vegetation would be used. Those discussions will be continued if the proposed alternative is selected in the final ROD.

**Debrief - May 27, 1998 Reuse Plan Presentation/Town Hall Meeting (hosted by the Board of Supervisions) presented by Dr. Chuck Bennett, RAB member and Mr. Joseph Joyce**

Mr. Joyce said that there had been several requests from the RAB to have a presentation concerning the future reuse plans for MCAS El Toro. The RAB meeting scheduled for May 27, 1998 was postponed due to a concurrent presentation to the community regarding aviation and non-aviation alternatives for MCAS El Toro. The RAB meeting was rescheduled to allow RAB members the opportunity to attend the Board of Supervisors-sponsored meeting on future land use.

Dr. Chuck Bennett attended the Town Hall Meeting in Irvine and a similar meeting in Yorba Linda. According to Dr. Bennett, both meetings were nearly identical in terms of what they covered, and in audience response. The pro-airport group (Orange County LRA) presented and defended their options and reasons for choosing Plan C (retain John Wayne Airport and construct an international airport at MCAS El Toro). Their presentation was followed by a presentation from a group representing the Millennium Plan (El Toro Reuse Planning Authority). The major discussion point of the meeting was pro-airport versus non-aviation alternatives.

Dr. Bennett noted that critical issues from the RAB's standpoint include whether or not the two reuse parties are aware of the environmental activities currently occurring at the base with respect to the reuse plans. Dr. Bennett observed that both parties are reasonably aware of the landfills and how the landfills may impact future reuse. In regards to Site 5, reuse plans of both groups consider a golf course for that area.

He also noted that the RAB was well represented at the meeting; there were at least six RAB community members in attendance. Dr. Bennett believes RAB members and others attending RAB meetings are much more informed as to the environmental issues at MCAS El Toro than either of the groups who were making the future land use presentations. He said the RAB has an important function to help the groups be informed of the environmental issues at the base.

Mr. Joyce said that the Marine Corps is neutral in the debate pertaining to aviation versus non-aviation reuse. He maintained that the DoN's job is to ensure that the environmental cleanup program continues to move forward to allow the property to be reused in the future. The DoN is not involved at all in the debate, instead is strictly focusing on the environmental cleanup of El Toro. He mentioned that the DoD has briefed County staff, homeowner associations, and other interested parties in the community, etc. to help those groups understand the environmental conditions at El Toro.

A RAB member expressed concern about Site 24 and feels that people do not understand the implications of the issues here and the problems may not get taken care of. She asked if

there was any recognition of the fact that the groundwater cleanup at OU-2A (Site 24) may impact the reuse groups' ability to use some of the runway area? Dr. Bennett said he has observed in letters to the editor in newspapers that there is a growing awareness that many of the buildings at the Station cannot be used and that there will be certain changes needed to be to the runways to meet certain standards.

Mr. Joyce said that the above stated issues are discussed at various public meetings that focus on reuse at MCAS El Toro and are held at Orange County Hall of Justice. He offered to provide schedule information on upcoming reuse meetings for people who are interested in attending those meetings. Mr. Joyce reminded those in attendance at the RAB meeting that the focus here is environmental cleanup. He also encouraged the meeting participants to share information about the environmental cleanup and about the RAB with others. He suggested notifying himself or the BRAC Public Affairs Officer at the Station if you want to request a briefing on the environmental cleanup program for your group or community.

**Debrief - June 18, 1998 Landfill Proposed Plan Public Meeting - Mr. Bernie Lindsey**

Before Mr. Hurley introduced Mr. Lindsey to give his presentation, he noted that, as the RAB Community Co-chair he is not doing a very good job because the turnout for the public meeting was not very good. He feels the burden falls on the shoulders of him and the RAB members to generate more public interest. A meeting attendee suggested a phone tree be organized. He said that after the meeting, RAB members that are available should get together provide more suggestions for generating interest.

As pointed out by Mr. Joyce, Mr. Hurley's concerns pertain to an effort that goes beyond what the Marine Corps has already done in terms of advertising and generating public interest. There were announcements for the public meeting in both the *Orange County Register* and the *Los Angeles Times*. In addition, the Proposed Plan for MCAS El Toro, which advertised the date and time of the meeting along with the information to be presented at the meeting, was sent out to over 2,000 people. Moreover, the information for the public meeting was announced at the previous RAB meeting. Also, at the Town Hall Meeting, Gail Reavis, RAB member, told the audience about the June 18 public meeting. Mr. Joyce said that someone at the public meeting commented to him that the lack of large turnout might demonstrate that the public has confidence in Marine Corps' environmental cleanup program. Maybe that will challenge each and every RAB member here tonight to back to your community groups and share the information on the program and bring in members from the community.

A meeting attendee mentioned that she called Irvine City Hall to confirm the location and time of the RAB meeting, and was surprised when the City Staff could not provide the information. Mr. Hurley reminded all those in attendance that the RAB is a guest of the City of Irvine and they have been very gracious to provide this facility for us. The City of Irvine is unconnected with the RAB.

A RAB member asked if announcements were placed in local papers such as *The Irvine World News*? She noted that the *Orange County Register* and the *Los Angeles Times* place

the advertisements in undesirable locations within the newspaper. She feels the advertisement is not the problem, the placement of the advertisement is the problem. Mr. Joyce asked the RAB member to formalize her comment and submit it to the Marine Corps. According to Mr. Joyce, when the Marine Corps conducted interviews for the community relations plan, they asked each community member being interviewed what the best way to provide information to the community is. He stated that the most frequent responses were the "*Orange County Register*" and the "*Los Angeles Times*". He also mentioned that community interviews are to be conducted again.

Mr. Lindsey provided an overview of the public meeting that was held on June 18, 1998. The meeting presented the Proposed Plan for MCAS El Toro. The format of the meeting is such that tables with information displays are set up and are staffed by people from the DoN and the Marine Corps. With this format, attendee's sign-in, then they are greeted and given a brief description of the meeting format. Attendees are encouraged to start with the overview of the Station's history and mission, followed by a general overview of the clean up program. From this point, specific presentation/displays were available on the presumptive remedy approach, the remedial investigation, the feasibility studies, and the Proposed Plan. A court reporter was present for those in attendance to provide formal comments. The public had a chance to meet face-to-face with DoN staff who work everyday on the program. Six RAB members brought in their own expert who has dealt with landfill cleanup for approximately 20 years. Mr. Lindsey said he spent quite a while speaking with him at the remedial investigation table. He said that the landfill expert said that he was satisfied in the investigation effort conducted at the landfills. Mr. Lindsey reiterated that the format of the public meeting allowed members of the public to have one-on-one discussions with staff and to get their questions answered. In regards to attendance, Mr. Lindsey said that there were a total of 19 people in attendance (not including people from DoN and the agencies) eight of who were RAB members. Mr. Lindsey encouraged people attending the RAB meeting to take a closer look at the public meeting displays presented on the wall at the RAB meeting.

A RAB member commented that "getting the word out" regarding public meeting seems to be a common problem. He observed that the information goes out to parties who are highly motivated to participate. He acknowledged that is difficult to bring in people that are not knowledgeable on the issues. Another RAB member commented that he is a person who has a lot of experience doing volunteer work on community issues. He said, for example, for election campaigns he has handed flyers out and sat in front of supermarkets in an attempt to generate interest. He said from his experience, you have to understand that the majority of people just do not care and that is a sad commentary, and having 19 people or 30 or even 50 people attending a public meeting is a good turnout in this community.

Another RAB member asked if attendees at the public meeting submitted formal comments at each table? Mr. Lindsey explained that at each table it was made clear how to submit public comments and that every table/display at the meeting had signage with information on submitting public comments. There was a court reporter in attendance that transcribed public comments verbatim. At the public meeting, a form for submitting written comments was provided to all attendees when they were greeted. A box to place them in was also set up.

Mr. Joyce reminded all those in attendance at the RAB meeting that the public comment period is open until July 13, 1998 (postmarked no later than July 13), and that forms for submitting written comments are available at the information display set up at tonight's meeting. He said the DoN does not respond to each individual comment received, but will submit a Responsiveness Summary that will be documented in the Record of Decision. He added that similar comments are categorized in the Responsiveness Summary. A RAB member inquired as to the number of comments received at the public meeting? It was estimated that up to 10 people verbally commented to the court reporter, and two people placed completed comment forms in the comment box.

**Update - Department of Navy and Orange County Water District Negotiations - Andy Piszkin, Lead Remedial Project Manager for MCAS El Toro, Southwest Division Naval Facilities Engineering Command (SWDIV) and Roy Herndon, Project Manager, Orange County Water District (OCWD)**

Mr. Piszkin presented a background for the negotiations presently occurring between the DoN and the Orange County Water District (OCWD). The focal point of the discussions have been in partnering with OCWD, and more recently the Irvine Ranch Water District (IRWD) relative to their planned Irvine Desalter Project. To date there have been two meetings between DoN and OCWD. He said that the DoN, the Department of Justice/Navy Litigation Office, the Marine Corps, the Western Area Council Office (Marine Corps Attorneys), and SWDIV are confident they will make a decision on the joint project. This joint project is comprised of a local water supply project and a remedial action solution for the volatile organic compounds (VOCs) present in the groundwater both on-station and off-station. He said that, hopefully in the next couple of months, the parties would come to an initial decision leading to a signature on the agreement. Shortly thereafter, a Proposed Plan would be prepared. According to the Federal Facilities Agreement schedule, the Draft Proposed Plan is due to the agencies on August 24, 1998. This date may have to slip and that will be based on the next set of meetings between the DoN parties and OCWD officials.

Mr. Herndon, from the OCWD, advised that an updated presentation be given to the RAB to get them back up to speed on the water supply picture and the objectives for groundwater cleanup. He said that two years ago the parties were close to an agreement but such an agreement was not reached. Mr. Piszkin explained that the bankruptcy of Orange County was part of the issue but more importantly, all the options for the project had not been considered.

A question the DoN has heard numerous times is "Is contaminated water going to go into domestic water supply? Mr. Piszkin said that this would be a good opportunity for the DoN and OCWD to address this question. According to Mr. Herndon, the Irvine Desalter Project, which has been discussed for several years, is a water supply project in Irvine to supply water to the IRWD. Currently, the IRWD is not getting the amount of groundwater that they are entitled to pump from the area groundwater basin, formally called the Irvine Subbasin. Historically, the Irvine Subbasin has had a problem with nitrates and salts and it has a higher

salt concentration than the rest of the OCWD's major groundwater basins. OCWD has defined this area of the Irvine Subbasin (west of the Station boundary) as a possible location to put in a water supply project that would include a series of wells that pump water out of the ground followed by treatment to remove salts and nitrates. OCWD discovered TCE (trichloroethene, an industrial solvent) in the groundwater. TCE is a constituent in the groundwater that could be dealt with along with the salts and nitrates. Mr. Herndon stated that these compounds, from an engineering and technical standpoint, are very easy to eliminate from the water. The technology used is proven. OCWD is comfortable with making the groundwater cleanup and the water supply project the same endeavor. He said that the OCWD wants to provide a capable, reliable water supply for the City of Irvine and the customers of the Irvine Ranch Water District.

A meeting attendee asked about the amount of TCE found in the groundwater. Mr. Herndon said that TCE is measured in parts per billion (ppb) and that TCE present is above the ppb standards for drinking water. He also described the groundwater table in the area on-Station and off-Station and clarified where groundwater with TCE is located. The on-station water table starts about 100 feet below ground surface, and the solvents off-station are 200-400 feet below ground surface.

Mr. Herndon said that the water table in the Irvine community of Woodbridge is 10 to 15 feet below the ground surface but the TCE is not detected until approximately 200 feet below ground surface. The zone being targeted is the main aquifer that currently produces water for irrigation in Irvine. There is only one well that is used by the IRWD for irrigation purposes. OCWD's goal is to build a series of wells and connect them together in a central treatment system and make this a drinking supply project, not just an irrigation project. There is not an irrigation demand to use all of this water.

A RAB member asked if the DoN has included this project in its current budget. Mr. Piszkin said that this has been budgeted for several years.

## MEETING EVALUATION AND FUTURE TOPICS

**During the meeting evaluation RAB members provided the following comments:**

- Time management worked well, including holding questions and comments at the end of presentations
- much less "agitation", not confrontational
- need to make meetings more exciting

**Suggestions for future presentation topics include:**

- What can RAB members do to create more community interest?
- Status of funding for MCAS El Toro environmental cleanup programs.
- Public Affairs Office (PAO) briefing on community outreach
- Irvine Desalter Project
- Public Comments - Landfill Proposed Plan and Public Meeting
- Project schedule update

## CLOSING ANNOUNCEMENTS/FUTURE MEETING DATES

The next RAB meeting is scheduled for 6:30 to 9:00 p.m., Wednesday, July 29, 1998 at the Irvine City Hall, Conference and Training Center, One Civic Center Plaza, Irvine. The meeting was adjourned at approximately 8:30 p.m.

**Attachments:**

-Sign-in sheets.

**Handouts provided at the meeting and available at the Information Repository:**

- RAB meeting agenda/Public notice - 6/24/98 RAB meeting.
- RAB Final Meeting Minutes - 3/25/98 RAB meeting *(Minutes approved at the 6/24/98 meeting.)*
- Handout – MCAS El Toro RAB Member Tally, Community and Agency Members
- Handout – Sign-up sheet and Flyer, Site Tour for Saturday, July 25, 1998
- Handout – Executive Summary, BRAC Cleanup Plan, March 1998
- Handout – Underground Storage Tank Program Map, May 1998
- Handout – Installation Restoration Program Sites, Require Action and No Further Action, March 1998
- Handout – Where to Get More Information
- Handout – Navy and Marine Corps - Internet Access, Environmental Web Sites
- Handout – MCAS El Toro Mailing List Coupon
- Handout – U.S. EPA Presumptive Remedies: Policy and Procedures, Quick Reference Fact Sheet, September 1993
- Handout – U.S. EPA Presumptive Remedy for CERCLA Municipal Landfill Procedures, Quick Reference Fact Sheet, September 1993
- Handout – Orange County CIA Landfill Sites, Solid Waste Facility Inventory Report, May 1998
- Handout – Executive Summary Draft Final Remedial Investigation Report, OU-2B, Site 2, April 1997
- Handout – Executive Summary Draft Final Remedial Investigation Report, OU-2C, Site 3, April 1997
- Handout – Executive Summary Draft Final Remedial Investigation Report, OU-2C, Site 5, April 1997
- Handout – Executive Summary Draft Final Remedial Investigation Report, OU-2B, Site 17, April 1997
- Handout – Executive Summary Draft Final Feasibility Study Report, OU-2B, Site 2, September 1997
- Handout – Executive Summary Draft Final Feasibility Study Report, OU-2C, Site 3, September 1997
- Handout – Executive Summary Draft Final Feasibility Study Report, OU-2C, Site 5, September 1997
- Handout – Executive Summary Draft Final Feasibility Study Report, OU-2B, Site 17, September 1997
- Handout – Institutional Controls: What they are and how they are used, BRAC Environmental Program Fact Sheet, Spring 1997
- Handout – U.S. EPA, A Citizen's Guide to Natural Attenuation, Technology Fact Sheet, October 1996
- Handout – Responsibility for Additional Environmental Cleanup after Transfer of Real Property, DoD Base Reuse Implementation Manual, December 1997
- Handout – A Guide to Establishing Institutional Controls at Closing Military Installations, DoD, February 1998
- Handout – DoD – Environmental Base Realignment and Closure Web Site, Publications, June 1998
- Handout – Proposed Plan for Closure of Inactive Landfills at Marine Corps Air Station El Toro, May 1998
- Handout – MCAS El Toro Landfill Closure remedial alternatives and Cost Comparison (excerpt from May 1998 Proposed Plan
- Handout – MCAS El Toro Public Comment Form May 1998 Proposed Plan

- Handout – MCAS El Toro RAB Meetings, Presentations Pertaining to Landfills
- Handout – MCAS El Toro RAB Meetings Minutes, January 28, 1998 Meeting

Agency Comments - U.S. Environmental Protection Agency

- U.S. EPA Approval of Draft Final Phase II Feasibility Study (FS) OU-3A Sites 8, 11, and 12, MCAS El Toro, (letter dated June 22, 1998)
- U.S. EPA Approval of Changes to Federal Facility Agreement Schedule (FFA), MCAS El Toro, (letter dated June 23, 1998)

Agency Comments - Cal-EPA, Department of Toxic Substances Control

- Cal-EPA DTSC Comments on Draft Final Soil Vapor Extraction System Design, Site 24, Operable Unit 2A - Vadose Zone, MCAS El Toro (letter dated June 3, 1998).

***Copies of all past RAB meeting minutes and handouts are available at the MCAS El Toro Information Repository, located at the Heritage Park Regional Library in Irvine. The address is 14361 Yale Avenue, Irvine; the phone number is (714) 551-7151. Library hours are Monday through Thursday, 10 am to 9 p.m.; Friday and Saturday, 10 am to 5 p.m.; Sunday 12 p.m. to 5 p.m..***

***Navy and Marine Corps Internet Access - Environmental Web Sites***
*RAB meeting minutes are also located on the Navy's Southwest Division Environmental Web Page.*
**http://www.efdswest.navfac.navy.mil/pages/Envrnmtl.htm**

***Marine Corps Air Bases Western Area Web Site:***
*For more information on environmental cleanup activities at MCAS El Toro.*
**www.eltoro.USMC.mil**

***Department of Defense - Environmental BRAC Web Page***
*Contains information concerning presumptive remedies.*
**www.dtic.mil/environdod/envbrac.html**

***U.S. EPA Superfund Web Page***
*Has information regarding institutional controls.*
**www.epa.gov/superfund/index.html**

# MCAS El Toro Public Meeting
# June 18, 1998

## Attendance Breakdown

- Total attendance = 19 people
  - » RAB Members = 8
    - – Agency RAB Members = 2
    - – Community RAB Members = 6
  - » Community Members = 5
  - » Engineering/Environmental Consultants = 5
  - » News Media = 1

# MCAS El Toro Public Meeting
# June 18, 1998

- Attendance Total does not include:
  - » Navy and Marine Corps staff
  - » Staff from U.S. EPA, DTSC, RWQCB
  - » Navy contractors: CLEAN II or RAC
  - » Court Reporter

## MCAS El Toro, Environmental Cleanup Program, Most Commonly Asked Questions

Restoration Advisory Board Meeting

June 24, 1998

## If MCAS El Toro becomes an airport, will that require less environmental cleanup?

- No.
- 85% of Station land is environmentally ready for transfer
- Landfill remedy restrictions applicable to any future land use

## Will a native soil cap protect the citizens of Orange County from contaminants present inside the landfills?

- Yes.
- Landfill investigation Risk Assessment indicates acceptable risks under existing conditions

## Is the DoN/ Marine Corps committed to cleanup at MCAS El Toro?

- Yes.
- Marine Corps continues to be committed to implementing remedies that are protective of human health and the environment.

## What is all the controversy in the press regarding the Marine Corps proposed remedy for the landfills and CalEPA DTSC?

- DTSC believes DoN should spend funds to enhance the remedy beyond what is required to achieve protection of human health and the environment.

## Do you have landmines in the landfills at MCAS El Toro?

- No.

## Does MCAS El Toro have radiation hazards that put the citizens of Orange County at risk?

- No.

# MCAS EL TORO

## Issue: What If New Contamination Found After Property Transfer?

Restoration Advisory Board Meeting
29 July 1998

Andy Piszkin
c:\briefs\rab\nwchm987

1

## Protections

- Section 330 under National Defense Authorization Act for Fiscal Year 1994
- Section 120(h) under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- All Federal deeds or transfer documents include a clause granting the United States access to the property in any case in which a response or corrective action is found to be necessary after the date of such transfer.

2

closed or realigned or become scheduled for closure or realignment pursuant to the base closure law described in subparagraph (E)(ii)(II) after October 19, 1992, the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made not later than 18 months after the date by which a joint resolution disapproving the closure or realignment of the real property under section 2904(b) of such base closure law must be enacted, and such a joint resolution has not been enacted.

(iv) In the case of real property described in subparagraphs (E)(i)(II) on which operations are closed or realigned pursuant to a base closure law described in subparagraph (E)(ii)(III) or (E)(ii)(IV), the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made not later than 18 months after the date on which the real property is selected for closure or realignment pursuant to such a base closure law.

(D) In the case of the sale or other transfer of any parcel of real property identified under subparagraph (A), the deed entered into for the sale or transfer of such property by the United States to any other person or entity shall contain—

(i) a covenant warranting that any response action or corrective action found to be necessary after the date of such sale or transfer shall be conducted by the United States; and

(ii) a clause granting the United States access to the property in any case in which a response action or corrective action is found to be necessary after such date at such property, or such access is necessary to carry out a response action or corrective action on adjoining property.

(E)(i) This paragraph applies to—

(I) real property owned by the United States and on which the United States plans to terminate Federal Government operations, other than real property described in subclause (II); and

(II) real property that is or has been used as a military installation and on which the United States plans to close or realign military operations pursuant to a base closure law.

(ii) For purposes of this paragraph, the term "base closure law" includes the following:

(I) Title II of the Defense Authorization Amendments and Base Closure and Realignment Act (Public Law 100–526; 10 U.S.C. 2687 note).

(II) The Defense Base Closure and Realignment Act of 1990 (part A of title XXIX of Public Law 101–510; 10 U.S.C. 2687 note).

(III) Section 2687 of Title 10.

(IV) Any provision of law authorizing the closure or realignment of a military installation enacted on or after October 19, 1992.

(F) Nothing in this paragraph shall affect, preclude, or otherwise impair the termination of Federal Government operations on real property owned by the United States.

**(5) Notification of States regarding certain leases**

In the case of real property owned by the United States, on which any hazardous substance or any petroleum product or its derivatives (including aviation fuel and motor oil) was stored for one year or more, known to have been released, or disposed of, and on which the United States plans to terminate Federal Government operations, the head of the department, agency, or instrumentality of the United States with jurisdiction over the property shall notify the State in which the property is located of any lease entered into by the United States that will encumber the property beyond the date of termination of operations on the property. Such notification shall be made before entering into the lease and shall include the length of the lease, the name of person to whom the property is leased, and a description of the uses that will be allowed under the lease of the property and buildings and other structures on the property.

**(i) Obligations under Solid Waste Disposal Act**

Nothing in this section shall affect or impair the obligation of any department, agency, or instrumentality of the United States to comply with any requirement of the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] (including corrective action requirements).

**(j) National security**

**(1) Site specific Presidential orders**

The President may issue such orders regarding response actions at any specified site or facility of the Department of Energy or the Department of Defense as may be necessary to protect the national security interests of the United States at that site or facility. Such orders may include, where necessary to protect such interests, an exemption from any requirement contained in this subchapter or under title III of the Superfund Amendments and Reauthorization Act of 1986 [42 U.S.C.A. § 11001 et seq.] with respect to the site or facility concerned. The President shall notify the Congress within 30 days of the issuance of an order under this paragraph providing for any such exemption. Such notification shall include a statement of the reasons for the granting of the exemption. An exemption under this paragraph shall be for a specified period which may not exceed one year. Additional exemptions may be granted, each upon the President's issuance of a new order under this paragraph for the site or facility concerned. Each such additional exemption shall be for a specified period which may not exceed one year. It is the intention of the Congress that whenever an exemption is issued

# Public Comments

## MCAS El Toro Proposed Plan
## Closure of Inactive Landfills

July 29, 1998

MCAS El Toro RAB Meeting

# Purpose of this Presentation

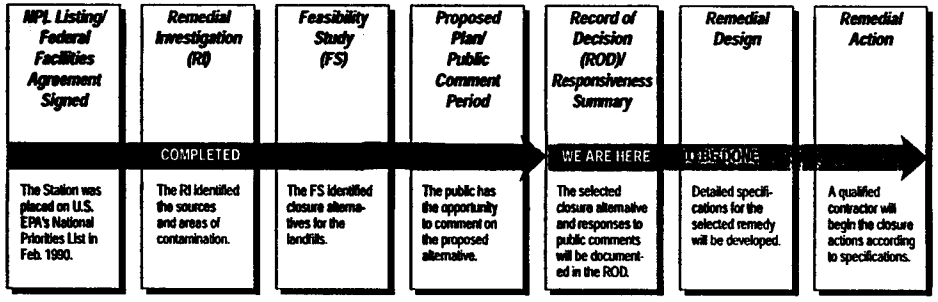
- Recap public comment period and role of public comments in decision-making.
- Inform RAB members of the types of public comments submitted.
- Describe the process for responding to public comments.
- Update on current status of post-public comment period.



# Public Comment Period

**60-day public comment period:**
**May 15 - July 13, 1998**

**MCAS El Toro Installation Restoration Program Process Landfill Closures – Sites 2, 3, 5, and 17**




# Public Comments and Community Acceptance

- Each alternative undergoes detailed evaluation and analysis, using evaluation criteria developed by U.S. EPA (nine criteria)
- "Community Acceptance" comprises part of the U.S. EPA's "modifying criteria" used in making final decisions on remedial actions.
- Public comments on RI/FS Reports, Proposed Plan, and DoN's preferred remedy and other proposed alternatives are considered under "Community Acceptance" criteria.



# Public Comments Submitted

- Public comments received from both individuals and agencies/organizations
- Total "public comments" submitted = 19
- "Comments" ranged from:
  - one page letter stressing a single point
  - report format, 60 pages in length discussing numerous issues

## Format of Comments Submitted

**Total Submitted = 19**

- Public Meeting Oral Comments = 8 (Court Reporter Transcript)
- Public Meeting Written Comments = 2 (Comment Form)
- Letters General Public = 3
- Letters Local Agencies/Organizations = 6



## Categories of Public Comments

- Presumptive Remedy Approach
- Agree with DoN's Preferred Remedy
- Disagree with DoN's Preferred Remedy
- Clean Closure
- Institutional Controls, Property Restrictions
- Responsibility for Cleanup After Property Transfer
- Reuse Guidance and Policies
- LRA's Preferred Remedy



## Responding to Public Comments

- Categorize comments
- Evaluate comments
- Develop written responses for Responsiveness Summary portion of Record of Decision
- Process involves participation of BRAC Environmental Coordinator, Marine Corps BRAC Office, Marine Corps Headquarters Staff, SWDIV Management, RPMs and Legal Staff

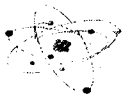


## What's Next ?

- Complete evaluation of all public comments.
- Cooperative effort by BCT members to make final decision for Sites 2, 3, 5 and 17.
- Marine Corps completes Record of Decision and Responsiveness Summary with review and oversight by BCT.
- BCT signs Record of Decision, anticipated in spring 1999.

## Marine Corps Air Station El Toro

## Radiological Survey of Hangers 296 and 297



**July 1998**

1

## MCAS El Toro Radiological Background

- Aircraft maintenance was carried out in Hangers 296 and 297 over a period of many years.
- 1944 building plans for Hanger 296 show a Radium Paint Room on the second floor mezzanine area, northeast corner.

2

## MCAS El Toro Radiological Background

- Radium paint was applied to luminescent dials, signs, and some aircraft parts in Hanger 296.
- Orange County Health Care Agency sent May 1997 letter to DTSC asking for more investigation into the radium painting at MCAS El Toro.

3

## MCAS El Toro Radiological Background

- Radiological Survey of Hangers 296 and 297 is being completed.

4

## What is Background Radioactivity?

- Naturally occurring
- Always present
- Varies widely from location to location
- Need to distinguish between natural and manmade

5

## Radioactivity in Everyday Life

- Radium-226 (Ra-226)
  - brazil nuts, soil, brick, granite, ceramics, concrete
- Potassium-40(K-40)
  - bananas, salt substitute, chemical fire extinguishers
- Uranium-238 (U-238)
  - soil, asphalt, brick, ceramics, concrete
- Thorium-232 (Th-232)
  - soil, optical devices, aircraft parts
- Others
  - smoke detectors, tobacco products, and residual fallout

6

## Radiation Terminology

- mr/yr = millirem per year
- 1 millirem is a small amount of radiation
- the average U.S. resident receives about 300 millirem per year from background sources; residents in Denver receive at least 50% more. California is close to average.
- chest X-rays give an effective dose of about 8 millirem each
- average dose from medical and consumer products (except tobacco) is 63 millirem per year; X-rays, TV sets, airplane flights
- radiation exposure received from medical and consumer products etc. is in addition to the 300 mr/yr background average

7

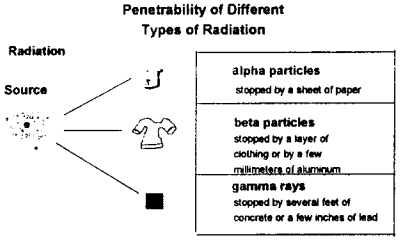
## Background Sources of Radiation

| Source | Average mr/yr* | Remarks |
|---|---|---|
| Cosmic Radiation | 29 | Depends on altitude |
| Terrestrial sources | 32 | Rocks, soil, bldg. materials |
| Natural sources in humans | 39 | K-40, C-14, Ra-226 and others |
| Radon gas | 200 | Varies greatly |
| Annual Totals | 300 | ( 2/3 from radon) |

*The biological effect of absorbed radiation is expressed in rems or millirems.

8

## Types of Radiation alpha - beta - gamma




9

## Type of Radiation Emitted

- Radium-226, Thorium-232, Uranium-238
  - » emits alpha, beta and gamma radiation
- Potassium-40
  - » emits beta and gamma radiation

10

## Radiological Units of Measure

cpm = counts per minute
dpm = disintegrations per minute
curie = large quantity of radioactivity
uCi = micro-curie, one-millionth of a curie
pCi = pico-curie, one-millionth of a micro-curie
pCi = 2.22 dpm
$100cm^2$ = a square about 4 inches on a side
millirem =one thousandth of a rem (0.001), small amount of radiation
mr/yr =millirem per year

11

## Surface Contamination Action Levels

| Radionuclide | Surface Contam. average ($dpm/100\ cm^2$) (Note) | Removable Surface Cont. ($dpm/100\ cm^2$) | Gamma Scintillation (vs. Bkgrd) | Radioactivity Concentration (pCi/gm) |
|---|---|---|---|---|
| Th-232 | 1000 | 200 | < 2X | 50 |
| U-238 | 5000 | 1000 | < 2X | 45 |
| Cs-137 | 5000 | 1000 | < 2X | 10 |
| Ra-226 | 100 | 20 | < 2X | 5 |
| Sr-90 | 1000 | 200 | N/A | N/A |

Note: Maximum limit is 3X Average

Limits from Reg. Guide 1.86 (Nuc. Reg. Comm.) And submitted to State and Fed. EPA.

Investigation limits recommended by and submitted to State and Fed. EPA

12

## Radiological Survey of Hangers 296

- Radium Paint Room (2nd floor north mezzanine)
  - » Radium-226 detected with an alpha meter at 47 dpm alphas on the surface.
  - » Removed 10 ft section of interior wall.
  - » Area remediated to below action level (20 dpm).
- Cast Iron Drain Piping
  - » Radium-226 detected with a gamma meter at 16,000 cpm gammas inside the drain pipe.
  - » Removed 80 ft of piping under north mezzanine.
  - » Remaining drain pipe is below action level (8,000 cpm).
- No other contamination detected in Hanger 296.

13

## Radiological Survey of Hangers 297

- No contamination detected in Hanger 297.

14

## Next Steps

- Dispose of waste generated during the remediation of Hanger 296.
- Finalize report on the radiological survey and remediation of Hanger 296 and the survey of Hanger 297.
- Conduct a Historical Radiological Assessment (HRA) at MCAS El Toro.

15

**"Personal Radiation Dose Charts" are available in quantity at special prices.**

The American Nuclear Society is a not-for-profit scientific and educational organization devoted to the advancement of science and engineering as related to nuclear energy. This chart is produced and distributed as part of the ANS public information program. The Society consists of more than 15,000 individual members and nearly 200 organization members in the U.S. and many other countries.


For further information, contact:

**American Nuclear Society**
Public Communications Department
555 North Kensington Avenue
La Grange Park, Illinois 60525
U.S.A.
708/579-8265


3/50M

# PERSONAL RADIATION DOSE CHART

We are all exposed to radiation all the time... from the stars, from food from water. But HOW MUCH? and from WHAT? A person living in the U.S. receives an average dose of about 360 mrems per year from all radiation sources.

American Nuclear Society

# PERSONAL RADIATION DOSE

We live in a radioactive world—always have. Radiation is all around us as a part of our natural environment. It is measured in terms of millirems (mrems). The annual average dose per person from all sources is about 360 mrems, but it is not uncommon for any of us to receive far more than that in a given year (largely due to medical procedures we may have done). As an example, international standards allow up to 5,000 mrems a year exposure for those who work with and around radioactive material.

| | Common Sources of Radiation | Your Average Annual Dose (mrems)* |
|---|---|---|
| **Where you live** | Cosmic radiation at sea level (from outer space) | 26 |
| | For your elevation (in feet) - add this number of millirems: | |
| | up to 1000 ft.= 2; 1-2000 ft.= 5; 2-3000 ft.= 9; 3-4000 ft.= 15; 4-5000 ft.= 21; 5-6000 ft.= 29; 6-7000 ft.= 40; 7-8000 ft.= 53; 8-9000 ft.= 70 | |
| | Elevation of some U.S. cities (in feet): Atlanta 1050; Chicago 595; Dallas 435; Denver 5280; Las Vegas 2000; Minneapolis 815; Pittsburgh 1200; St. Louis 455; Salt Lake City 4400, Spokane 1890. | |
| | Terrestrial (from the ground): | |
| | If you live in states that border the Gulf or Atlantic Coasts (from Texas east, and then north) add 23 | |
| | If you live in the Colorado Plateau Area (around Denver) ..... add 90 | |
| | If you live in Middle America (rest of the U.S.) ..... add 46 | |
| | House construction: | |
| | If you live in a stone, brick or concrete building ..... add 7 | |
| **What you eat and drink** | Internal radiation (in your body): | |
| | From food and water - U.S. average | 40 |
| | From air (radon) - U.S. average | 200 |
| **How you live** | Weapons test fallout (less than 1)** | 1 |
| | Jet plane travel: | |
| | For each 1000 miles you travel ..... add 1 | |
| | If you have porcelain crowns or false teeth* ..... add 0.07 | |
| | If you use gas lantern mantles when camping ..... add 0.003 | |
| | **If you wear a luminous wristwatch (LCD) ..... add 0.06** | |
| | **If you use luggage inspection at airport (using typical X-ray machines) ..... add 0.002** | |
| | **If you watch TV (value is less than 1) ..... add 1**** | |
| | **If you use a video display terminal (less than 0.1) ..... add 1**** | |
| | **If you have a smoke detector ..... add 0.008** | |
| | **If you wear a plutonium-powered cardiac pacemaker ..... add 100** | |
| | **If you have had medical exposures:*** ** | |
| | **Diagnostic X-rays (e.g., upper and lower gastrointestinal, chest X-rays) - U.S. average ..... add 40** | |
| | **If you have had nuclear medical procedures (e.g., thyroid scans) - U.S.average ..... add 14** | |
| | **If you live within 50 miles of a nuclear power plant (pressurized water reactor) - U.S. average add 0.009** | |
| | If you live within 50 miles of a coal-fired electrical utility plant ..... add 0.03 | |
| | **My total annual mrems dose** | |



*Some of the radiation sources listed in this chart result in an exposure to only part of the body. For example, false teeth result in a radiation dose to the mouth. The annual dose numbers given here represent the "effective dose" to the whole body.

**The value is less than 1, but adding a value of 1 would be conservative.

***These are yearly average doses. If you have had many such procedures, your dose would be much greater.

Primary sources for this information are National Council on Radiation Protection and Measurements Reports: #92 Public Radiation Exposure from Nuclear Power Generation in the United States (1987); #93 Ionizing Radiation Exposure of the Population of the United States (1987); #94 Exposure of the Population in the United States and Canada from Natural Background Radiation (1987); #95 Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources (1987); and #100 Exposure of the U.S. Population from Diagnostic Medical Radiation (1989).

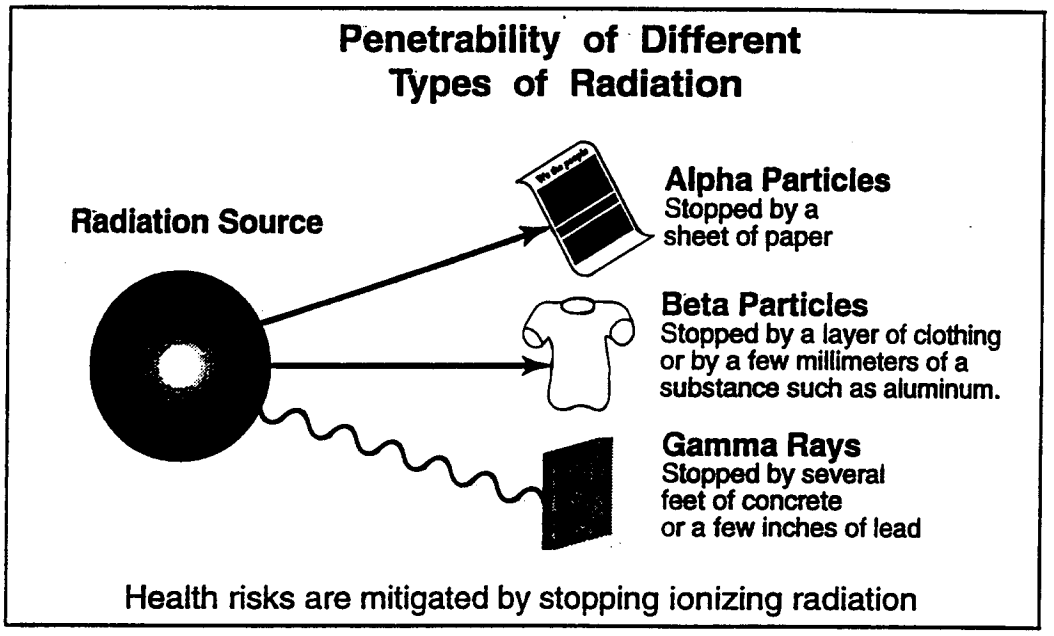
**Note: Boldface items are man-made radiation; others are naturally occurring.**

# RADIOACTIVE WASTE

CALIFORNIA BASE CLOSURE ENVIRONMENTAL COMMITTEE

*Radioactive and Mixed Waste Process Action Team* *May 1994*

Many activities that have occurred at military installations over the years have involved radioactive materials, and in the past, disposal practices at some installations have resulted in environmental contamination. Such practices, which were legal and considered proper in the past, occurred in some cases because the potential risks of radioactive contamination from releases of small amounts of radioactive material were not known, and because procedures for handling radioactive materials were not in place. To identify the magnitude of potential radioactive contamination problems and to work toward a solution, the California Base Closure Environmental Committee (CBCEC) formed the Radioactive and Mixed Waste Process Action Team (RMWPAT). The RMWPAT prepared this fact sheet to explain what radioactive waste is, to describe the types of radioactive contamination that may be found at military installations in California, and to explain what is being done to clean up the contamination.




## WHAT IS RADIOACTIVE WASTE?

Radioactive waste is simply any radioactive material that is no longer usable. **Radioactive material** is any material that spontaneously emits **ionizing radiation**, which is radiation that has enough energy to produce ionization in its passage through a substance. When ionizing radiation passes through human tissue it can cause cellular damage. This ionizing radiation consists predominantly of three forms: alpha particles, beta particles, or gamma rays. Each presents its own health risks. **Alpha particles** (helium nuclei) are the largest particle form of radiation, and their size makes them the most easily blocked by shielding (they can only travel a few inches through the air). Radionuclides that emit alpha particles are hazardous primarily through inhalation and subsequent deposition in the body, often in skeletal tissue. For example, the environmental hazards of naturally occurring radon gas are caused by alpha particles. **Beta particles** are electrons, far smaller than alpha particles. Beta-emitting nuclides are hazardous primarily as a result of internal irradiation following ingestion or inhalation, since they are also easily shielded like alpha particles. **Gamma radiation**, on the other hand, easily penetrates into the human body, potentially causing cellular damage even if it is not ingested. Gamma radiation is similar to the x-rays taken at a doctor's office. Although alpha, beta, and gamma radiation enter the body in different ways, all can potentially cause cellular damage.

Radioactivity is measured in different units than other environmental contaminants. The concentration of radioactive material in the environment is measured by the **activity**, or number of disintegrations per unit time in a given volume or weight of the environmental medium. Levels of radioactivity are expressed in curies (Ci) or becquerels (Bq). One becquerel equals one nuclear transformation or decay per second, and one curie equals $3.7 \times 10^{10}$ Bq.

The biological effect of absorbed radiation is expressed in rems or millirems. The **rem** for a particular radioactive emission is defined as the product of the absorbed dose of ionizing radiation (measured in **rads**) and a quality factor. A **millirem** is one thousandth (0.001) of a rem. The **quality factor** takes into account the different types of biological

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effects radiation has on humans. For example, one rad of beta or gamma radiation (quality factor=1) equals one rem, but the same amount of absorbed alpha radiation energy (quality =20) will equal 20 rems, reflecting the greater biologi- arm delivered by the heavier, highly charged alpha particles.

Another important factor in determining the risk of radioactive materials is the physical half-life of a radionuclide. **Half life** measures how long it takes for one-half the radioactivity to decay or disappear, thus indicating how long a particular material will be potentially harmful. Half lives of different nuclides vary widely, from fractions of a second to billions of years. Some radioactive elements decay into other radioactive elements (see insert box).

## WHAT ARE THE TYPES OF RADIOACTIVE WASTE?

The Atomic Energy Act (AEA) and the Nuclear Waste Policy Act (NWPA) provide the federal definitions and regulatory framework for control of radioactive materials and radioactive waste. Radioactive waste is characterized as either high-level or low-level. **High-level waste** is typically associated with nuclear reactor fuel. **Low-level waste**, which includes all radioactive waste except nuclear fuel, is not defined by the amount of radiation released, and may in fact emit large amounts of ionizing radiation. **Transuranic waste** i set of both high- and low-level waste, and consists of a aterial contaminated with radioactive material that has an atomic number higher than uranium (such as plutonium, americium, and curium).

The State of California has a more encompassing definition of radioactive waste. California Radioactive Waste includes all AEA and NWPA radioactive wastes but also includes wastes that contain naturally occurring and accelerator produced radioactive materials (NARM). The acronym "NORM" is often used to refer to naturally occurring radioactive materials. NARM, and therefore NORM, wastes are not regulated under the AEA or NWPA. Radium used in self-luminous dials is an example of a NORM found on military installations. Particle accelerators used by some research laboratories and hospitals may have produced wastes containing NARM.

When radioactive and hazardous wastes are found blended together, the regulations governing both radioactive and hazardous components apply. **Mixed waste** is defined by the U.S. Environmental Protection Agency (EPA) as any AEA radioactive material that is contaminated with a **hazardous waste** as defined by the Resource Conservation and Recov- t (RCRA). But since California defines radioactive and ous waste differently than the federal government, the also has a different definition of radiation and hazardous wastes together (see insert box). **Combined waste**, a waste category defined by the CBCEC's RMWPAT, is any blend of California radioactive and California hazardous wastes, and although it may not meet the criteria for federally defined mixed waste, state regulations still apply.

## WHAT TYPES OF RADIOACTIVE MATERIALS ARE FOUND AT MILITARY INSTALLATIONS?

The Department of Defense (DoD) has used over 2,800 different kinds of instruments and articles containing radioactive materials. The vast majority of the items present little risk individually; however, many of these items are (were)

### THE BREAKDOWN OF RADIOACTIVE MATERIALS: AN EXAMPLE

The following chart shows the breakdown of radioactive materials from naturally occurring Uranium 238 to the stable element Lead 206. The numbers to the right tell how long the half life of each material is, and the symbols on the left show what type of radiation is emitted during the decay process (α=Alpha particles, β=Beta particles, and γ=Gamma rays).

**Uranium - 238**
α,γ ▼ (BILLIONS OF YEARS)
**Thorium - 234**
β,γ ▼ 24 DAYS
**Protactinium - 234**
β,γ ▼ 1.2 MINUTES
**Uranium - 234**
α,γ ▼ 247,000 YEARS
**Thorium - 230**
α,γ ▼ 80,000 YEARS
**Radium - 226**
α,γ ▼ 1,622 YEARS
**Radon - 222**
α ▼ 3.8 DAYS
**Polonium - 218**
α,β ▼ 3 MINUTES
**Lead - 214**
β,γ ▼ 27 MINUTES
**Bismuth - 214**
α,β,γ ▼ 20 MINUTES
**Polonium - 214**
α ▼ LESS THAN A SECOND
**Lead - 210**
β,γ ▼ 22 YEARS
**Bismuth - 210**
α,β ▼ 5 DAYS
**Polonium - 210**
α,γ ▼ 138 DAYS
**Lead - 206**

shipped to bases in large numbers and could potentially present a serious health threat if collectively released into the environment. Additionally, some items if disassembled or broken can allow leakage of the radioactive material and present an internal contamination threat (ingestion or inhalation) and an environmental hazard. Examples of radiation often found at military bases include the following: radium dials, gauges, and illuminators (by far the most common radioactive material found); depleted uranium used in armor, armor-piercing munitions, and aircraft counterweights; tritium used in illuminators (for example, self-illuminating exit signs); carbon 14 and tritium used at hospital facilities; and thorium used in lenses, glass, and in mag-thorium (magnesium) metal used for machine, aircraft, and rocket parts.

## WHO IS IN CHARGE OF CLEANING UP RADIOACTIVE WASTE AT MILITARY INSTALLATIONS AND WHAT CLEANUP STANDARDS MUST BE MET?

The possession and use of radioactive materials at military bases is controlled by a licensing or permitting program implemented by the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy, or by special radiologic agencies within the military. In some cases, the internal regulation of radioactive materials was due to national security issues associated with weapons systems, and information release was complicated by the security requirements surrounding such equipment. These historical security measures can often create difficulties in assessing whether releases occurred at military installations.

The California Department of Health Services Radiologic Health Branch is responsible for enforcing radiation control regulations in California. Specific cleanup levels for sites contaminated with radioactive materials are under development by EPA, the NRC, and the state. EPA regulations will apply to a wide range of site types, while NRC regulations will apply only to the decommissioning of NRC-licensed facilities. The agencies are coordinating their efforts to produce consistent regulations, and cleanup of radioactive contamination at closing military bases has begun or will begin in the near future in expectation of the EPA and NRC regulations. Cleanup requirements and acceptance criteria may have to be established on a case-by-case basis prior to the anticipated EPA and NRC regulations to support accelerated base closure schedules.

DoD or other appropriate agencies are responsible for identifying, characterizing, and cleaning up radioactive contamination at military bases just as they are responsible for cleaning up hazardous waste. DoD has committed to cleaning up both federal and California wastes to meet all applicable federal and state cleanup standards. In no cases are California's cleanup standards less strict than applicable federal standards. DoD will clean up all contaminated bases in California to the strictest applicable standards.

Cleanup standards at closing bases may be derived from several different statutes or regulations. For example, California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits a discharge or release of carcinogens, including radionuclides, unless the resulting exposure poses no significant lifetime risk, which is defined as one excess cancer per 100,000 people (or **$10^{-5}$ risk**). If an individual's exposure exceeds this level, "clear and reasonable warning" must be given.

At Superfund sites, EPA often establishes cleanup goals for known or suspected carcinogens based on a concentration level that represents an additional lifetime cancer risk of between $10^{-4}$ and $10^{-6}$. **$10^{-4}$ risk** corresponds to one extra case of cancer per 10,000 people exposed, and **$10^{-6}$ risk** one extra case per million people exposed. The National Council on Radiation Protection and Measurements reports that natural background radiation exposure results in an estimated lifetime cancer risk of about $10^{-2}$ (one death per hundred per-

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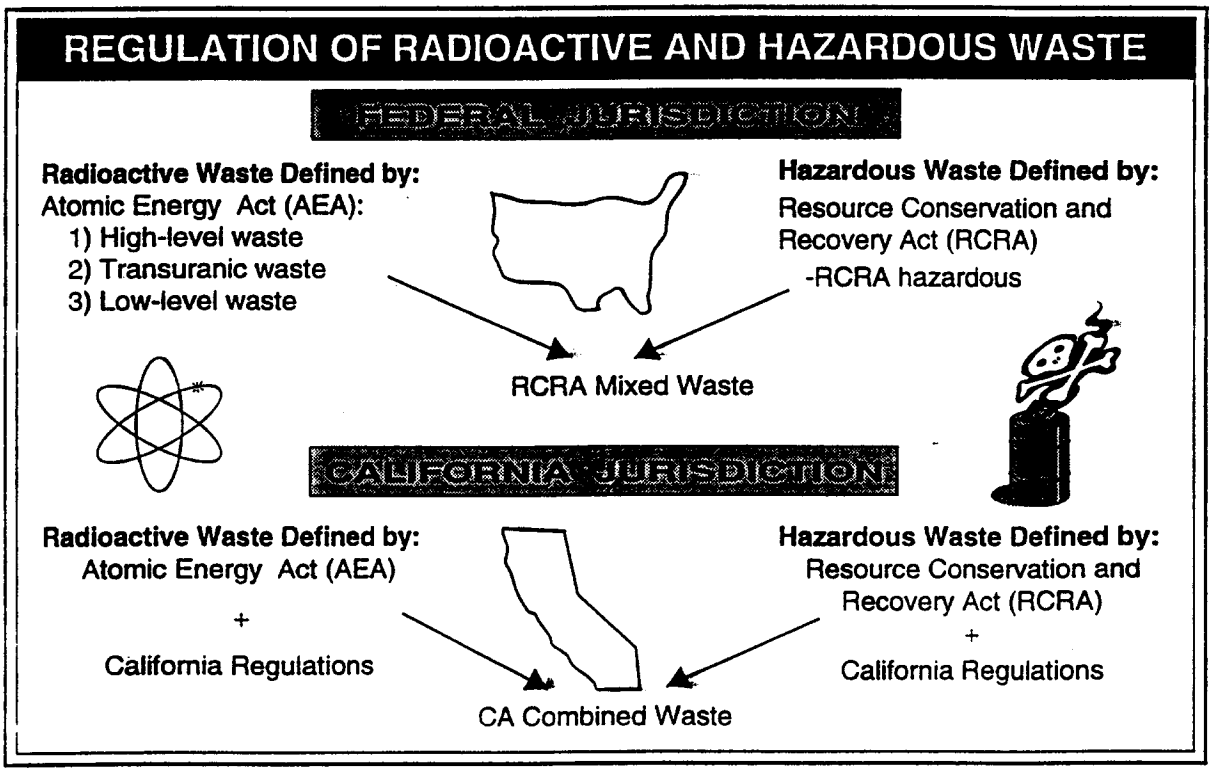

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sons). Natural background radiation varies widely around the 300 millirem/year average. With the relatively high risk associated with natural background radiation, it is often dif[illegible] to differentiate the small increment of additional risk fr[illegible]t associated with background.

## HOW WILL THE PRESENCE OF RADIOACTIVE MATERIALS IMPACT BASE REUSE?

If radioactive contamination is present at closing military installations, it will affect base reuse in a fashion similar to residual chemical contamination. Slightly contaminated parcels may have reuse restrictions placed on them. For example, a site may be deemed suitable for industrial activity but not for a school. More seriously contaminated areas may be made unavailable for reuse until appropriate remediation has taken place. In these cases, the restrictions may be written into the land deeds to ensure appropriate use in the future. If residual contamination at closing military bases results in exposures that exceed a $10^{-5}$ lifetime cancer risk level, the entity to whom the land is transferred will have to comply with all applicable regulations (which may include obtaining a radioactive material license). The entity may be subject to enforcement action if the regulations are not met.

## FOR MORE INFORMATION

The following references provide more detailed information on the subjects mentioned in this fact sheet:

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California Base Closure Environmental Committee
Radioactive and Mixed Waste Process Action Team

P.O. Box 944212
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Attn: Leslie Laudon



*In[illegible]. Environmental cleanup of radioactive waste at closing military installations*

April 5, 1994

# GUIDANCE FOR CLEANUP OF RADIOACTIVITY ON CLOSING MILITARY BASES FOR UNRESTRICTED PUBLIC USE OF PROPERTY

**Environmental Management Branch**
**Division of Drinking Water and Environmental Management**

**Radiological Health Branch**
**Division of Food, Drug and Radiation Safety**

**California Department of Health Services**
**601 North 7th Street**
**P.O. Box 942732**
**Sacramento, CA 94234-7320**

## 1. INTRODUCTION

1.1. This document presents guidance to assist interested parties in the evaluation of levels of environmental radioactivity on closing military bases and resulting radiation exposures to the general population. It provides direction on managing potential risks of cancer from radionuclides in the environment for purposes of site cleanup and decontamination associated with the cleanup of closing military bases so that the property can be utilized by the public. Reducing radiation exposure levels and minimizing cancer risks to the levels set forth in this discussion will be protective against other adverse health effects of radiation (*e.g.*, reproductive and developmental effects) that would be associated with environmental radioactive contamination.

1.2 The Department of Health Services (DHS) views it appropriate to maintain consistency with existing health-based standards whenever those standards exist. Hence, DHS believes that its drinking water standards for radionuclides are appropriate cleanup levels for water, as are the radon action level for indoor air, and the federal Environmental Protection Agency's (EPA's) standards for cleanup of residual radium in soil.

## 2. CLEANUP OF RADIOACTIVE SITES—BASIC PRINCIPLES

**2.1.** Documentation of the history of use, storage and disposal of radioactive material on the site should be complete.

**2.1.1.** A site characterization document for the site should identify all past and current use, storage and disposal of radioactive material.

**2.1.1.1.** The site characterization for radioactive material should begin with a review of the general and specific licenses from the US Nuclear Regulatory Commission (US NRC) and Department of Defense (DOD) permits for radioactive material on the site, and reports required pursuant to those licenses and permits.

**2.1.1.2.** The site characterization should include reviews of written histories and documents, and oral histories or interviews with current and past employees—including current and past base radiation safety officers—and others who would have historical insights into past activities using radioactive material.

**2.1.1.3.** The various military service branches within DOD have organizations that need to be contacted for consultation about characterization of the site, and for documentation of the historic use, storage, and disposal of radioactive material at the base in question. These include:

- The Air Force's Radioisotope Committee and Armstrong Laboratory at Brooks Air Force Base in Texas.
- The Army's Environmental Hygiene Agency at the Aberdeen Proving Ground, Maryland.
- The Army Corps of Engineers in Omaha, Nebraska.
- The Navy's Radiological Affairs Support Office in Yorktown, Virginia.

**2.2.** Cleanup of discrete radioactive items.

**2.2.1.** With the exception of standard commercial smoke detectors installed in buildings, all discrete items that are radioactive and known to be present should be removed. This includes, but is not limited to, (a) radioactive sources, (b) gauges, dials, knobs and other material painted with or containing radium or other radionuclides, (c) radionuclides in electronic equipment and instrumentation, and (d) materials containing depleted uranium. Examples of sources of radioactivity on military bases are presented in Table 2-1.

**2.2.2.** If radioactive items cannot be removed, unrestricted public use would not be an option for the property in question. The nature of restrictions to be placed on the property, as well as the future use of the site, would require deliberations by concerned parties.

**2.3.** Cleanup of diffuse radioactive contamination.

**2.3.1.** Radioactive contamination on the property that is diffuse should be removed to levels that would minimize the cancer risk to the exposed population, consistent with the guidance that follows in this document.

**2.3.2.** If diffuse radioactive contamination cannot be removed to levels that would minimize the cancer risk to the exposed population, unrestricted public use would not be an option for the property in question.

## Table 2-1. Examples of sources of radioactivity on military bases.

The Department of the Army's Corps of Engineers distributed to its regional commands a memorandum (dated December 8, 1993) addressing awareness of radioactive materials used at DOD facilities. That memorandum pointed out that the DOD has issued over 2800 different types of instruments and articles containing radioactive materials, and that radioactive contamination may exist in materials in base supply warehouses, or in shops used for the manufacture, repair or maintenance of such articles. The memorandum also points out that "during the 1940s, 1950s, and 1960s, on-base burial, sometimes in radioactive waste disposal cells and often in on-base landfills, was a reasonable and acceptable disposal technique." That memo plus other information from DOD point out a number of sources of radioactivity that may be found on military bases:

a. Radium dials, gauges, and illuminators were used extensively in military applications, and represent the most common and the greatest radioactive health and environmental hazard found on bases. Examples include luminous dials on a variety of components used in navigation and communication, and on watch dials, weapons sights, and compasses. To illustrate this point, about half a million deck markers (each with about 20 microcuries of radium-226 or strontium-90) were made for and used by the Navy in 1952. The decommissioning of the Battleships Iowa, Missouri, and New Jersey resulted in the removal of about 1,200 radium-226 components from each vessel. As another example, the equipment utilized for mobile ground control approach (GCA) radar systems contained extensive amounts of radium-226 in readily accessible components such as knobs, dials, and gauges. Some of this GCA equipment had a component that contained up to 5,000 microcuries of radium-226.

b. Depleted uranium used in armor and armor piercing ordnance, as well as in shipping containers for use in sealed source radiography.

c. Tritium as a source of illumination, especially for exit signs.

d. Thorium as a component in lenses to enhance the optical quality, and in magnesium-thorium metal used for machinery, aircraft and rocket parts, plus welding rods used in thick metal welding.

e. Hospital and research facilities used tritium and carbon-14 in liquid scintillation counting. Liquid scintillation counting fluids contain xylene or toluene which are hazardous wastes.

f. Washdown areas for contaminated equipment (*e.g.*, aircraft and ships) used in association with or in monitoring above-ground nuclear weapons tests.

g. Calibration sources for radiation survey instruments.

h. Hospital sources used in diagnostic techniques and for radiation therapy procedures, plus sources used in research facilities.

i. Sources used in radiography.

j. Gauges used to measure the level, thickness, or the density of an object of interest.

k. Sources known as commodities which are used extensively as components for weapons systems and within navigation and communication equipment.

l. Low-level radioactive waste from reactor and primary plant maintenance and repair, weapons processing, and associated with some of the sources mentioned above.

# 3. CHEMICAL CARCINOGEN EXPOSURES—REGULATORY PERSPECTIVE

**3.1.** Carcinogenic chemical substances that are released into the environment are regulated for the protection of public health to strict standards in non-occupational settings. Regulatory levels are established to limit the cancer risk. Cancer risk is expressed in terms of "excess" cancer cases, that is, those that exceed the cancer cases that would normally occur in a given population (i.e., about 25 to 30%).

**3.1.1.** The lower end of the range (one excess case of cancer in a population of 1,000,000 people exposed for a 70-year lifetime, the so-called "$10^{-6}$" risk) is the usual regulatory goal, though costs and technical feasibility may lead to the higher end of the range (one excess case of cancer in an exposed population of 10,000 people exposed for a 70-year lifetime (the "$10^{-4}$" risk).

**3.1.1.1.** Human exposures to chemical carcinogens that would result in lifetime cancer risks below the $10^{-6}$ risk are often referred to as posing a *"de minimis"* risk, and are usually do not receive much regulatory attention, although public health agencies often seek to reduce exposures that result in risks of this magnitude, as well.

**3.1.1.2.** Human exposures to chemical carcinogens that would result in lifetime cancer risks greater than one excess case of cancer in an population of 100,000 people (the $10^{-5}$ risk), if allowed by regulatory agencies, could be required to be accompanied by warnings or notices to the exposed population. For example, see California Health and Safety Code §25249.5, *et seq.* or §44300, *et seq.*

**3.1.1.3.** Risks of $10^{-4}$ may be allowed by federal and state regulatory agencies if there is an offsetting public health benefit (*e.g.*, the cancer risk from exposure to byproducts of drinking water chlorination), or if the costs of cleanup to a lower risk level are considered excessive, when compared to the benefit.

**3.1.1.4.** Human exposures to chemical carcinogens that would result in cancer risks to the general population (non-occupational exposures) greater than the $10^{-4}$ risk level are generally not allowed by federal and state regulatory agencies.

**3.2.** The US EPA's Guidance *for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final* (October 1988), has as a step in the evaluation process, a determination as to "[w]hether the remediation goals for all carcinogens of concern . . . provides protection within the risk range of $10^{-4}$ to $10^{-7}$." (page 4-15). The lower end of this range is a lifetime cancer risk of one excess case of cancer per 10,000,000 people.

In *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim* (December 1991), the US EPA states that "action is generally warranted at a site when the cumulative carcinogenic risk is greater than $10^{-4}$. . . ," and that preliminary remediation goals are "not needed for any chemicals in a medium with a cumulative cancer risk of less than $10^{-6}$." When the cancer risk for a medium is "within the range of $10^{-6}$ to $10^{-4}$, a decision about whether or not to take action is a site-specific determination." (page 15).

**3.3.** The DOD's Base Realignment and Closure (BRAC) Cleanup Plan Guidebook (Fall, 1993) identifies "areas of contamination below action levels" for carcinogens (page 4-52) as areas that "risk estimates completed for contamination do not do the following:"

- Exceed $10^{-6}$ for any carcinogenic hazardous substance or petroleum constituent detected in any medium.
- Exceed $10^{-6}$ for all carcinogenic hazardous substances and petroleum constituents, taken together, in any exposure pathway.
- Exceed $10^{-4}$ for all carcinogenic hazardous substances and petroleum constituents accumulated across all pathways.

**3.3.1.** The DOD BRAC Cleanup Plan Guidebook states: "At present, sites exhibiting a cancer risk of $10^{-4}$ or greater are considered unacceptable, and require action to protect human health. Sites with cancer risks below $10^{-6}$ are considered acceptable, and are likely candidates for NFA [no further action]. Sites exhibiting risks between these two values require the exercise of considerable professional judgment on a site-by-site basis. . . . The classification of the carcinogens, and the likelihood of the exposure assumptions and the future land use scenarios should be considered in site-specific interpretations of the risk estimate. The result will facilitate the identification of site-specific solutions and actions that are appropriate for each site to protect human health and the environment. However, consistency across a given installation is desirable and a general consistent installation-wide approach to cost/benefit analysis of remedial alternatives will facilitate application of risk management policies." (page 4-71).

**3.3.2.** The DOD continues: "Examples [of sites that require special consideration] are sites . . . where a proven human (class A) carcinogen is present, resulting in lower acceptable risk estimates." (page 4-71).

**3.3.2.1.** The US EPA has designated all radionuclides to be Class A carcinogens, "based on their property of emitting ionizing radiation and on the extensive weight of epidemiological evidence of radiation-induced cancer in humans." (US EPA, *Risk Assessment Guidance for*

*Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim,* December 1991, page 33.)

## 4. RADIATION EXPOSURES—CANCER RISK AND EXPOSURE LIMITS

**4.1.** Radiation standards are established or recommended by a number of agencies, including the US EPA, the NRC, the National Academy of Sciences/National Research Council (NAS/NRC), the National Council for Radiation Protection and Measurements (NCRP), the International Council for Radiological Protection (ICRP), and the California Department of Health Services (DHS). These groups utilize a linear dose/effect relationship for the estimate of radiation effects, extrapolating to low exposures from the high exposures that are associated with human radiogenic cancer.

**4.1.1.** Lifetime cancer risk from radiation exposure is estimated in the NAS/NRC's *Health Effects of Exposure to Low Levels of Ionizing Radiation*, BEIR V (Table 4.4, Page 176, NAS/NRC, 1990) to be 520 and 600 excess cancer deaths per 100,000 for males and females, respectively, for a continuous exposure of 1 milligray per year (100 millirads per year). From these values, an estimated lifetime risk of $6 \times 10^{-5}$ per mrad/yr results. Hence, 0.016 mrad/yr would yield a lifetime cancer risk of $1 \times 10^{-6}$, and 1.6 mrad/yr would yield a lifetime cancer risk of $1 \times 10^{-4}$.

**4.1.2.** The NRC, in its 1990 Below Regulatory Concern Policy Statement, based on reports by the United Nations Scientific Committee on the Effects of Atomic Radiation and ICRP, cited an annual cancer risk of $5 \times 10^{-7}$ per mrem/yr, or a lifetime (70-yr) risk of $3.5 \times 10^{-5}$. From this risk, an exposure of 0.028 mrem/yr would result in a lifetime cancer risk of $1 \times 10^{-6}$, and 2.8 mrem/yr would result in a lifetime cancer risk of $1 \times 10^{-4}$. The estimates of cancer risk per exposure are helpful for purposes of this guidance. In 1993, NRC abandoned its Below Regulatory Concern Policy Statements.

**4.1.3.** The NCRP, in *Limitation of Exposure to Ionizing Radiation*, (Table 7.1, Report No. 116, 1993) presents estimates of $5 \times 10^{-2}$ excess fatal cancers per sievert (100 rem) and $1 \times 10^{-2}$ excess non-fatal cancers per sievert, based on NCRP and ICRP reports. These can be summed to equal $6 \times 10^{-2}$ per sievert, or $6 \times 10^{-2}$ per 100 rem, or, with a linear assumption, $6 \times 10^{-7}$ per mrem. From this, an annual exposure of 1 mrem each year for 70 yr would result in a lifetime risk of $4.2 \times 10^{-5}$ excess cases of cancer. From this, an annual exposure of 0.024 mrem would result in a lifetime cancer risk of $1 \times 10^{-6}$, and 2.4 mrem would result in a lifetime cancer risk of $1 \times 10^{-4}$.

**4.2.** Based upon the doses and risk estimates presented above, lifetime cancer risks can be approximated for various lifetime annual radiation exposures, as presented in Table 4-1.

**4.2.1.** The current radiation standard for workers is 5,000 mrem/yr .

4.2.2. Current federal and state standards for members of the general public include 100 mrem/yr for members from all radiation sources, 25 mrem/yr from nuclear power operations or radioactive waste, 10 mrem/yr from airborne radionuclide emissions, 4 mrem/yr from radionuclides in drinking water.

**Table 4-1. Lifetime (70-year) cancer risks and corresponding annual radiation exposures.** For purposes of conversion among risk levels, the exposure/risk relationship is assumed to be linear.

| Lifetime cancer risk | Annual radiation exposure (mrem/yr) |
|---|---|
| $10^{-2}$ | 200 |
| $10^{-3}$ | 20 |
| $10^{-4}$ | 2 |
| $10^{-5}$ | 0.2 |
| $10^{-6}$ | 0.02 |

4.2.2.1. Current standards are for federal operations (*i.e.*, Department of Energy facilities), or for permitted operations that are regulated by federal or state agencies (*i.e.*, US NRC, US EPA, or the California DHS).

4.2.2.1.1. As described by the NRC in 1992, its criteria for acceptable levels of radioactive contamination associated with cleanup are inconsistent and not binding on NRC licensees.

4.4.2.2. Standards related to the cleanup of radioactive contamination and restoration of sites are under development by the US NRC and the US EPA. The NRC's proposed regulations are to be available in spring of 1994, and EPA's, later in 1994.

4.4.2.3. Existing California law (California Health and Safety Code §25249.5, *et seq.*) requires warnings for exposure to radionuclides and may limit discharges of radioactivity to sources of drinking water if lifetime cancer risks exceed $10^{-5}$.

# 5. BENEFITS OF A COMMON APPROACH TO REGULATING ENVIRONMENTAL CARCINOGENICITY

**5.1.** A uniform, risk-based approach to dealing with radioactive materials and with chemical carcinogens would enable regulators and the public to ensure that environmental cleanup is targeting the exposures that pose the greatest carcinogenic risk.

**5.2.** A uniform approach would enable radioactive materials on closing military bases to be addressed in the same manner as chemical carcinogens (see Section 3.2, above).

**5.2.1.** Such an approach allows comparisons of sites based on cancer risk, no matter whether concerns are radiation-related, chemical-related, or both.

**5.2.2.** Such an approach provides a basis prioritization of sites based on cancer risk, for purposes of resource utilization.

**5.2.3.** Such an approach provides for consistency in dealing with carcinogenic substances, since the focus is on the risk, and not the source of the risk (e.g., radiation vs. chemical).

**5.2.4.** In determining the overall health risk to the public from environmental exposures, the total cancer risk from radioactive and non-radioactive materials should be considered in the evaluative process.

**5.3.** Currently, the regulation of radiation exposures to minimize cancer risk, when compared with the regulation of exposures to carcinogenic chemical contaminants and expressed in terms of permitted lifetime risk, is generally less restrictive (see Table 5-1).

**5.4.** The establishment of standards to limit radiation exposures to the same cancer risk level used in the regulation of chemical exposures would require that the standards be between 0.02 millirem per year and 2 millirems per year.

**5.4.1.** These limits would be applied to environmental contamination that results in radioactivity ingested or inhaled by a person and from external irradiation from that contamination (*e.g.*, air, water, and ingested soil, and external exposures from contaminated soil).

**5.4.2.** Exposures would be in excess of background levels of radioactivity in water, soil, and air, as discussed in below.

**Table 5-1. Comparison of lifetime cancer risks and annual radiation exposures, with notes on selected standards.[1]**

| Chemical standard | LIFETIME CANCER RISK or ANNUAL RADIATION EXPOSURE | Radiation standard |
|---|---|---|
| | **10,000 mrem/yr** | |
| | **$10^{-1}$** | Workplace limit (5,000 mrem/yr) |
| Cancer risk at occupational limit—vinyl bromide | **1,000 mrem/yr** | |
| Cancer risk at occupational limit—p-toluidine | **$10^{-2}$** | |
| | **100 mrem/yr** | NRC/DOE limit—all sources (100 mrem/yr) |
| Cancer risk at occupational limit for several chemicals (acrylamide, amitrole, carbon tetrachloride, chloroform, o-toluidine) | **$10^{-3}$** | EPA action level for radon in indoor air (4 pCi/l)<br>EPA limit—Nuclear Power Operations (25 mrem/<br>NRC limit—Radioactive Waste (25 mrem/yr) |
| | **10 mrem/yr** | EPA limit—Air (10 mrem/yr)<br>EPA limit—Drinking Water (4 mrem/yr) |
| Upper limit—public (non-occupational) exposures to chemical carcinogens (e.g. trihalomethanes as byproducts of drinking water disinfection) | **$10^{-4}$**<br>**1 mrem/yr** | NCRP Negligible individual dose (1 mrem/yr) |
| California Proposition 65 standard[2]; Air "Toxic Hot Spots" notification requirement | **$10^{-5}$**<br>**0.1 mrem/yr** | |
| *"De minimis"* level for exposures to chemical carcinogens--usually not regulated below this level (e.g., California Recommended Public Health Levels for drinking water) | **$10^{-6}$**<br>**0.01 mrem/yr** | |
| | **$10^{-7}$** | |

[1]Lifetime cancer risk for radiation exposures is estimated to be $4.2 \times 10^{-5}$ excess cases of cancer for an annual exposure of 1 mrem each year for 70 years. For chemical carcinogens, cancer risk is estimated by methods utilized by the US EPA and other federal regulatory agencies, and by State of California regulatory agencies. The methods are generally consistent, though for certain chemicals, the specific risk may differ among different federal and state agencies. Radiation standards from US EPA, *Issues Paper on Radiation Site Cleanup Regulations*, EPA 402-R-93-084, September 1993. Cancer risks from occupational exposures are taken from the US Occupational Safety and Health Administration's Final Rule on Air Contaminants 29 CFR Part 1910, Section 15, "Substances for which limits are based on avoidance of cancer," *Federal Register* 54: 2668 (1989).

[2]Includes radionuclides.

## 6. BACKGROUND RADIATION CONSIDERATIONS

**6.1.** Radiation from natural sources in the environment results in external and internal radiation exposures to people. This is usually around 300 mrem/yr. Long-lived fission products deposited as world-wide fallout from historic above-ground testing of nuclear weapons also contribute to the global environmental radioactivity burden and to ambient background radiation.

**6.2.** Recommended cleanup levels are exclusive of location-specific ambient background radioactivity. For purposes of this document, "ambient" includes radioactivity from global fallout associated with above-ground nuclear weapons testing, and radioactivity from natural origins within (1) building materials such as bricks and aggregate, and (2) fertilizers.

**6.3.** Resulting cancer risks are those that result from radiation exposures in excess of background exposures.

**6.4.** Cleanup of a particular radionuclide need not be to levels below its background concentration for a given site or medium.

**6.5.** Determination of background radiation levels is an important part of the site characterization process, when embarking on a cleanup of a radionuclide contaminated site.

## 7. DETERMINATION OF RADIONUCLIDE CONCENTRATION LIMITS AND EXTERNAL RADIATION EXPOSURES

**7.1.** The following default assumptions should be used in determining exposures to radionuclide contaminated soil, water, or air, unless scientifically more appropriate values can be justified:

**7.1.1.** Drinking water consumption: 2 liters per day.

**7.1.2.** Air inhalation: 20 cubic meters per day.

**7.1.3.** Soil ingestion: 0.1 gram per day.

**7.1.4.** Lifespan: 70 years (25,500 days).

**7.1.5.** Residence time on soil: 70 years.

**7.2.** In determining radiation exposures, the dosimetric monitoring, documentation and calculations should be clearly shown and references should be appropriately identified. Any method or methods that are utilized in the determination of radiation exposure and dose calculation should follow the hierarchy of methods set forth in Section 8.

**7.3.** Dose calculations and risk should be based on the tissue or organ of concern—that is, the tissue or organ that received the greatest committed dose equivalent per unit of radioactivity intake. Where there is no specific target tissue or organ, the total body should be the tissue or organ of concern, and the total effective dose equivalent should be used.

# 8. METHODS OF ANALYSIS FOR RADIONUCLIDES IN ENVIRONMENTAL MEDIA AND EXTERNAL RADIATION EXPOSURES

**8.1.** "Method of analysis" or "methods of analysis" refer to the method or methods of detection of radiation exposure or detection and calculation of radiation exposure or of a radionuclide in a particular environmental medium, including but not limited to, water, air, soil, or food.

**8.1.1.** Included herein are methods and procedures concerning the number of samples and the frequency and site of sampling that are appropriate for the monitoring of radioactivity in environmental media or external radiation exposures.

**8.1.2.** The calculations of dose, dose equivalence, or other expressions of absorption of deposited energy associated with the interaction of ionizing radiation with biological cells, tissues, organs, etc., are also considered to be within the realm of 'method of analysis."

**8.2.** In performing an analysis to determine external radiation exposures of a contaminated site, or background external radiation exposures, generally accepted standards and practice, including, but not limited to, radiation monitoring, location and frequency of sampling, equipment, collection of data, statistical analysis, interpretation of results, modeling and dose calculations should be observed.

**8.3** In performing an analysis to determine the concentration of a given radionuclide in a given environmental medium, or the background concentration of that radionuclide in that medium, generally accepted standards and practice, including, but not limited to, location and frequency of sampling, sample collection, numbers of samples , sample storage, and preparation, radiochemical analysis, statistical analysis, interpretation of results, modeling and dose calculations should be observed.

**8.4.** Complete written documentation should be maintained for all procedures, including but not limited to, frequency and location of sampling, types of dosimeters and instrumentation used, sample collection, sample handling and chain of custody, storage, and preparation, analyses, and dose calculations.

**8.5.** The following is the hierarchy that is to be utilized in establishing the method or methods of analysis to be used for the evaluation of environmental radioactivity, for purposes of describing radioactive contamination and for establishing background radiation levels.

**8.5.1.** If the California DHS has adopted or employs a method of analysis for external radiation exposures or for a radionuclide in a specific medium, that method is the appropriate method of analysis. If more than one method of analysis has been adopted or is employed by DHS, each may be used as a method of analysis.

**8.5.1.1** The DHS's Radiologic Health Branch's Policy Memorandum "Clearance Inspection and Survey", Policy No. IPM-88-2, effective September 15, 1991, identifies the procedure to verify that a facility in which licensed materials were used has been decontaminated to acceptable levels and to assure that the facility will not present a radiation hazard to future occupants.

**8.5.2.** If DHS has not adopted or does not employ a method of analysis, a method of analysis for external radiation exposures or for a radionuclide in a specific medium adopted or employed by another state or local agency (*e.g.*, the Department of Toxic Substances Control, the Air Resources Board, a local air pollution control district, the State Water Resources Control Board or a Regional Water Quality Control Board) is the appropriate method of analysis. If more than one method of analysis has been adopted or is employed by another state or local agency, each may be used as a method of analysis.

**8.5.3.** If no state or local agency has adopted or employs a method of analysis, a method of analysis for external radiation exposures or for a radionuclide in a specific medium adopted or employed by a federal regulatory agency (*e.g.*, the US EPA, or the US NRC) is the appropriate method of analysis. If more than one method of analysis has been adopted or is employed by a federal regulatory agency, each may be utilized as a method of analysis.

**8.5.3.1.** The DOD BRAC Cleanup Guide (page 4-55) directs BRAC Cleanup Teams to review data in accordance with the outline given in section 5 of the US EPA guidance document *Guidance for Data Usability in Risk Assessment.*

**8.5.3.2.** The document *Residual Radioactive Contamination from Decommissioning, Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent, Final Report,* by W. E. Kennedy, Jr., and D. L. Strange, NUREG/CR-5512, PNL-7994, Vol. 1, October 1992 (reprinted January 1993), provides generic and site-specific estimates of radiation dose for exposures to residual radioactivity after facilities decommissioning. It was prepared for the NRC's Office of Regulatory Applications.

**8.5.4.** If no regulatory agency has adopted or employs a method of analysis, a method of analysis for external radiation exposures or for a radionuclide in a specific medium that is generally accepted by the scientific community—as evidenced by its publication in compilations by professional and scientific associations or societies, in peer-reviewed technical journals published by such associations or societies, or in technical documents prepared for government regulatory agencies—is the appropriate method of analysis. If more than one method of analysis has been generally accepted by the scientific community, each may be utilized as a method of analysis.

## 9. USE OF DRINKING WATER STANDARDS AS LIMITS OF RADIATION EXPOSURE

**9.1.** Whenever a source of drinking water is contaminated with a radionuclide, cleanup of an area should be to a concentration resulting in a cancer risk level lower than $10^{-6}$ to $10^{-4}$, except as noted below.

**9.1.1.** Whenever a source of drinking water is contaminated with a radionuclide for which a specific drinking water maximum contaminant level (MCL) exists, cleanup need not be more restrictive than the MCL for that radionuclide for purposes of protecting public health.

**9.1.1.1.** California drinking water MCLs exist for the following radionuclides:

- Hydrogen-3 (The California MCL is 20,000 pCi/l)
- Strontium-90 (8 pCi/l)
- Radium-226 and radium-228, combined (5 pCi/l)
- Natural uranium (20 pCi/l—based on chemical toxicity)

**9.1.2.** Discharges or releases of radioactivity into sources of drinking water may be subject to other regulation and enforcement and should be limited accordingly.

## 10. USE OF CURRENT ACTION LEVEL FOR RADON IN INDOOR AIR

**10.1** The action level of 4 picocuries of radon per liter of air applies to residential indoor air, consistent with State and federal law.

## 11. USE OF FEDERAL STANDARDS FOR RADIUM IN SOILS

**11.1** The Uranium Mill Tailings Radiation Control Act (UMTRCA) and regulations in 40 CFR 192 provide guidance for the cleanup of Department of Energy uranium mill tailing sites for unrestricted use. They state that a site must achieve a concentration of less than 5 pCi of radium per gram above the typical background level for the top 15 centimeters of soil. At depths greater than 15 cm, however, the maximum concentration of radium can be up to 15 pCi/g.

**11.1.1.** These standards are appropriate for use in situations involving radium contaminated soils, in the absence of other federal guidance. However, they do not apply to soil contaminated by spills or disposal of radium paint, or to radium-containing dials, knobs and gauges that are present in soil.

**11.2** Section 11.1 notwithstanding, the NRC and EPA are developing guidance documents for the cleanup of residual radioactivity for property intended for unrestricted use.

## 12. HEALTH RISKS FROM URANIUM

**12.1** In evaluating the human health concerns from uranium exposures, the risks associated with uranium's chemical toxicity (principally to the kidneys) may exceed the risks related to its radioactivity. Hence, each endpoint should be evaluated as cleanup options are being considered.

## 13. CALCULATIONS OF RADIATION EXPOSURES THAT RESULT FROM SELECTED RADIONUCLIDES IN WATER, AIR AND INGESTED SOIL

**13.1.** Comparison of concentrations of selected radionuclides in water, air and soil with various cancer risk levels ($10^{-6}$, $10^{-5}$, or $10^{-4}$ lifetime cancer risk).

**13.1.1.** Table 13-1.1 presents various intake levels of selected radionuclides and the corresponding lifetime cancer risk from ingested contaminated water. Intakes from water to yield the various lifetime cancer risks are calculated from US EPA's Health Effects Assessment Summary (January 1992). The risk per pCi from US EPA is converted to pCi ingested for a specific cancer risk, divided by (365 days/yr x 70 yr =) 25,550 days, for a daily intake. This value is divided by 2 liters per day to yield corresponding radionuclide concentrations in ingested water.

**Table 13-1.1. Concentrations of specific radionuclides in drinking water that would yield various lifetime cancer risks.** The drinking water consumption rate is two liters per day for 70 years.

| Radionuclide | Lifetime Cancer Risk: $10^{-6}$ (pCi/l) | $10^{-5}$ (pCi/l) | $10^{-4}$ (pCi/l) |
|---|---|---|---|
| Hydrogen-3 | 370 | 3,700 | 37,000 |
| Carbon-14 | 22 | 220 | 2,200 |
| Cobalt-60 | 1.3 | 13 | 130. |
| Strontium-90 | 6 | 60 | 600 |
| Iodine-131 | 0.55 | 5.5 | 55 |
| Cesium-137 | 0.7 | 7 | 70 |
| Radium-226 | 0.16 | 1.6 | 16 |
| Uranium-238 | 1.3 | 13 | 130 |
| Plutonium-239 | 0.085 | 0.85 | 8.5 |

**13.1.2.** Table 13-1.2 presents various intake levels of selected radionuclides and the corresponding lifetime cancer risk from inhaling contaminated air. Intakes from air to yield the various lifetime cancer risks are calculated from US EPA's Health Effects Assessment Summary (January 1992). The risk per pCi from US EPA is converted to pCi inhaled for a specific cancer risk, divided by (365 days/yr x 70 yr =) 25,550 days, for a daily intake. This value is divided by 20 cubic meters per day to yield corresponding radionuclide concentrations in inhaled air.

**Table 13-1.2. Concentrations of specific radionuclides in air that would yield various lifetime cancer risks.** The inhalation rate is 20 cubic meters of air per day for 70 years.

| Lifetime Cancer Risk: | $10^{-6}$ | $10^{-5}$ | $10^{-4}$ |
|---|---|---|---|
| Radionuclide | ($pCi/m^3$) | ($pCi/m^3$) | ($pCi/m^3$) |
| Hydrogen-3 | 26 | 260 | 2,600 |
| Carbon-14 | 320 | 3,200 | 32,000 |
| Cobalt-60 | 0.01 | 0.1 | 1 |
| Strontium-90 | 0.04 | 0.4 | 4 |
| Iodine-131 | 0.08 | 0.8 | 8 |
| Cesium-137 | 0.11 | 1.1 | 11 |
| Radium-226 | 0.00065 | 0.0065 | 0.065 |
| Uranium-238 | 0.00008 | 0.0008 | 0.008 |
| Plutonium-239 | 0.00005 | 0.0005 | 0.005 |

**13.1.3.** Table 13-1.3 presents various intake levels of selected radionuclides and the corresponding lifetime cancer risk from ingested soil. Intakes from soil to yield the various lifetime cancer risks are calculated from US EPA's Health Effects Assessment Summary (January 1992). The risk per pCi from US EPA is converted to pCi ingested for a specific cancer risk, divided by (365 days/yr x 70 yr =) 25,550 days, for a daily intake. This value is divided by 0.1 gram per day, to yield corresponding radionuclide concentrations in ingested soil.

**Table 13-1.3. Concentrations of specific radionuclides in ingested soil that would yield various lifetime cancer risks.** The ingestion rate is 0.1 gram of soil ingested per day for 70 years.

| Radionuclide | Lifetime Cancer Risk: $10^{-6}$ (pCi/g of soil) | $10^{-5}$ (pCi/g of soil) | $10^{-4}$ (pCi/g of soil) |
|---|---|---|---|
| Hydrogen-3 | 7,400 | 74,000 | 740,000 |
| Carbon-14 | 430 | 4,300 | 43,000 |
| Cobalt-60 | 26 | 260 | 2,600 |
| Strontium-90 | 120 | 1,200 | 12,000 |
| Iodine-131 | 11 | 110 | 1,100 |
| Cesium-137 | 14 | 140 | 1,400 |
| Radium-226 | 3.2 | 32 | 320 |
| Radium-228 | 3.9 | 39 | 390 |
| Uranium-238 | 25 | 250 | 2,500 |
| Plutonium-239 | 0.17 | 1.7 | 17 |

## 14. CALCULATIONS OF EXTERNAL RADIATION EXPOSURES RESULTING FROM RADIONUCLIDES IN SOIL

**14.1.** Radionuclides in soil, besides presenting an opportunity for human exposure via the pathway of soil ingestion, can also result in human exposures from external radiation, owing to emissions related to their radiologic decay. Table 14-1 presents various concentrations of selected radionuclides and the corresponding lifetime cancer risk from external exposures ($10^{-6}$, $10^{-5}$, or $10^{-4}$ lifetime cancer risk).

**Table 14-1. Lifetime cancer risks from external exposures to radionuclides in soil.** Lifetime cancer risks from radionuclides in soil are calculated from US EPA's Health Effects Assessment Summary (January 1992). The annual risk per pCi/g from US EPA is converted to lifetime risk by dividing the annual risk by 70 years.

| Radionuclide | Lifetime Cancer Risk: $10^{-6}$ (pCi/g of soil) | $10^{-5}$ (pCi/g of soil) | $10^{-4}$ (pCi/g of soil) |
|---|---|---|---|
| Hydrogen-3 | -- | -- | -- |
| Carbon-14 | -- | -- | -- |
| Cobalt-60 | 0.002 | 0.02 | 0.2 |
| Strontium-90 | -- | -- | -- |
| Iodine-131 | 0.01 | 0.1 | 1 |
| Cesium-137* | 0.007 | 0.07 | 0.7 |
| Radium-226* | 0.002 | 0.02 | 0.2 |
| Radium-228* | 0.005 | 0.05 | 0.5 |
| Uranium-238* | 0.4 | 4 | 40 |
| Plutonium-239 | 840 | 8,400 | 84,000 |

*includes risks from radioactive decay chain products

# 15. SUMMARY

**15.1.** For closing military bases, the following should occur:

**15.1.1.** A complete history of the use, storage, and disposal of radioactive material should be documented. Where information is lacking, the discussion should identify the extent in information gaps.

**15.1.2.** Known discrete radioactive items should be removed.

**15.1.3.** Diffuse radioactive contamination should be removed to a level that minimizes the risk of exposure to people.

**15.2.** Cleanup levels can rely upon appropriate existing standards for water, air, and soil.

**15.2.1** Cleanup of radioactivity in water need not be more restrictive than drinking water MCLs for radionuclides.

**15.2.2** Radon in indoor air need not be considered of concern at concentrations below the federal and state radon action levels of 4 pCi radon per liter of air.

**15.2.3.** In the absence of federal regulation, cleanup of radium in soil need not be more restrictive than 5 pCi/g for the top 15 cm of soil, consistent with EPA rules for cleanup of uranium mill tailings.

**15.3.** For areas that are intended to have unrestricted use upon release to the public, exposures from radionuclide contamination associated with radionuclides other than those identified in 15.2, should not result in a cancer risk in excess of $10^{-6}$ to $10^{-4}$, and should be consistent with the cancer risks resulting from residual chemical carcinogens.

**15.3.1.** The corresponding limit on the cancer risk for areas that are intended to be unrestricted upon release to the public corresponds to the annual radiation exposures of from about 0.02 to 2 millirems per year.

**15.3.2.** The annual radiation exposure of from 0.02 to 2 millirems per year for areas that are intended to be unrestricted upon release to the public is in excess of background radiation exposures.

**15.3.3.** Pursuant to existing California law, exposures that result in cancer risks greater than $10^{-5}$ may require the property owner to provide warnings to the public.

**15.4.** The method or methods of analysis for external radiation exposures and for external ambient background radiation exposures should be scientifically appropriate, and consistent with existing regulations or guidelines.

**15.5.** The method or methods of analysis for a radionuclide in a specific medium and for the ambient background concentration of a radionuclide in that medium should be scientifically appropriate, and consistent with existing regulations or guidelines.

**15.6.** For exposures from radionuclide contamination associated with radionuclides other than those identified in 15.2, the following applies: If the $10^{-6}$ to $10^{-4}$ cancer risk limit corresponds to a radiation exposure that is below background radiation exposures, cleanup should be to the level of non-detection (*i.e.*, to background levels).

**15.6.1.** If the cancer risk limit corresponds to a radiation exposure that is below background radiation exposures, then an external radiation exposure from radioactive contamination that is greater than background, using appropriate radiation monitoring and statistical methodologies, exceeds the limit. This finding should prompt further cleanup and reevaluation of whether the property is to be released for unrestricted use.

**15.6.2.** If the cancer risk limit corresponds to a concentration of radionuclide contamination in a given medium that is below the background concentration of that radionuclide in that medium, then a concentration of the radionuclide in a medium that is greater than its background concentration in that medium, using the appropriate method of analysis including appropriate statistical methods, exceeds the limit. This finding should prompt further cleanup and reevaluation of whether the property is to be released for unrestricted use.

## 16. REFERENCES

California Code of Regulations Title 22 Chapter 3. Safe Drinking Water and Toxic Enforcement Act of 1986, §12000 *et seq.* List of substances subject to the Act and implementing regulations.

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# MCAS EL TORO
# Perchlorate Detected in Shallow Groundwater

Restoration Advisory Board Meeting
29 July 1998

Andy Piszkin
c:\briefs\rab\perch987

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# What is Perchlorate?

- Perchlorate ($ClO_4^-$)
  - » Man-made inorganic salt
  - » First production 1894, mass production 1940s
- Uses
  - » Solid rock fuel (90%), explosives, & other
- Fate, Transport, Toxicity
  - » May persist in environment for decades
  - » Highly mobile in groundwater
  - » DHS considers 18ug/L (ppb) protective
- Reverse Osmosis an Effective Remediation

2

# Perchlorate Detected in Shallow Groundwater

- OCWD Testing Results (preliminary)
  - » December 1997, MCAS-3 monitor well
  - » Non-detect & 8ppb at 164' bgs, 4ppb at 224'
- El Toro Testing Results (not reproducible)
  - » Spring 1998, 28 hydropunch samples collected
  - » Southwest of VOC source area
  - » 2 samples above detection limit of 10ppb
  - » Highest detection of 23ppb near well TIC-55
    - (sample diluted due to matrix interference)
  - » Depth of detected samples: 127' to 181' bgs
  - » No discernable concentration trends

3

# Investigation Plans

- Sample 50 Groundwater Monitoring Ports
  - » Explosive Ordnance Disposal Range
  - » Landfills
  - » Regional groundwater
  - » VOC source area
- Quality Assurance & Control
  - » Coordinate with USEPA experts
  - » US EPA laboratory control samples
- Report Findings (Fall 1998)
  - » Analyze for Concentration & Spatial Patterns

4

# EXCERPTS FROM MCAS EL TORO RAB MEETING MINUTES

# PERTAINING TO AMMONIUM PERCHLORATE

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## MARINE CORPS AIR STATION EL TORO

## RESTORATION ADVISORY BOARD MEETING

**August 6, 1997**

*REVISED MEETING MINUTES*

FROM PAGE 4 –

Another question was whether there are ammonium perchlorate concerns at MCAS El Toro. The concern over ammonium perchlorate was raised because the technology to detect this chemical at toxic levels has recently become available. Mr. Joyce said it was not a chemical of concern during the remedial investigation because there was no indication that rockets (attached to aircraft to assist in take-off) were ever tested or used at the Station. Ammonium perchlorate is a fuel component in solid fuel rockets. Based on this concern raised at the RAB meeting, potential use of ammonium perchlorate at MCAS El Toro will be reexamined and that information will be provided at the next RAB meeting.

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## MARINE CORPS AIR STATION EL TORO

## RESTORATION ADVISORY BOARD MEETING

**September 24, 1997**

*MEETING MINUTES*

FROM PAGE 2 --

**Rocket Propelled Ordnance - Capt. Matt Morgan, BRAC Public Affairs Officer, MCAS El Toro**

Capt. Matt Morgan's presentation regarding rocket propelled ordinance provided clarification of a concern first raised at the August 6, 1997 RAB meeting. The concern centered on the

use and disposal of rocket propelled munitions at MCAS El Toro and the chemical ammonium perchlorate, a substance used in the solid rocket fuel of these weapon systems. Capt. Morgan explained that rocket propelled munitions are stored in magazines at the Station. These munitions meet hazardous materials (HAZMAT) handling and storage requirements and are accompanied with Material Safety Data Sheets (MSDSs) with detailed information and instructions. He further explained that this ordnance, when used for training operations, is attached to various aircraft at MCAS El Toro. When aircraft return to the Station they are no longer carrying these munitions.

Concerning the disposal of rocket propelled munitions at the Station, Capt. Morgan said, that to the best of his knowledge, no rocket propelled munitions have ever been disposed of at the Station's Explosive Ordnance Disposal (EOD) Range, also referred to as Installation Restoration Program Site 1. The order of detonation for these munitions is too high to be disposed of at MCAS El Toro, therefore, ordnance disposal of this type is conducted at Naval Air Facility El Centro, Camp Pendleton, and other bases suited to handle such activities. If some unusual circumstances occur and an aircraft that is carrying these munitions has to return to MCAS El Toro, and the aircraft cannot make it to Camp Pendleton, the ordnance is disposed of out at sea in a specially designated area.

# PERCHLORATE CONTAMINATION IN THE ENVIRONMENT

Occurrence

## Introduction

Nearly all of the sources of perchlorate in the environment discovered to date were identified following the recent (March, 1997) development of the methodology to detect dilute concentrations by the California Department of Health Services (DHS). Within six months of this analytical advance, perchlorate was found at various manufacturing sites and in some wells and drinking water supplies of communities in California, Nevada, and Utah. At this time, there has not been a systematic national survey of perchlorate occurrence. Only a relatively small number of water supplies have been monitored using the more sensitive method, primarily in the western States, with a few sample results now available in other regions of the US. As more laboratories across the country adopt improved analytical methods, it is likely that other sources will be identified.

Identification of the magnitude and extent of perchlorate occurrence in the environment is important in assessing the routes of exposure to humans and determining the different types of organisms and ecosystems that may be affected. Further search for possible sources of perchlorate contamination is essential for alerting States and communities and to assess the need to develop national policies or regulations.

## Where Perchlorate Contamination Occurs

The majority of locations where perchlorate has been detected in groundwater are in California, associated with twelve facilities which have manufactured or tested solid rocket fuels for the military or National Aeronautics and Space Administration (NASA). Seven National Priority List sites (federal Superfund sites) in California are affected by these releases. Two facilities which manufactured ammonium perchlorate near Henderson, Nevada, were found to have released perchlorate to groundwater. Perchlorate from the Henderson area has entered the surface water and has been detected at low levels (4 to 16 ppb) in Lake Mead and the Colorado River. This water is used as a drinking water supply for more than 1 million people in Nevada, over 10 million in southern California and more than a million in Arizona. Native American Tribes and other communities along the Colorado River rely on the water for irrigation and recreation.

Perchlorate entered a private water supply well in Utah from contamination on the property of a rocket motor manufacturer near Magna, west of Salt Lake City. A storm drain from a perchlorate-handling area of the Longhorn Army Ammunition Plant in northeast Texas was

discovered discharging detectable levels of perchlorate to Caddo Lake.
The concentrations reported in wells and surface water vary widely. At one facility near Henderson NV, perchlorate in groundwater monitoring wells was measured as high as 0.37% (37 million parts per billion). Water suppliers in northern and southern California have detected perchlorate in 110 public water supply wells, with 33 of these having perchlorate greater than 18 ppb, which is the current action level in California. The highest level of perchlorate reported in any water supply well was 280 ppb with few others greater than 100 ppb.

The American Water Works Service Company recently completed sampling and analysis of 425 drinking water supply wells in 16 States. Of theses, 7 wells (1.6%) were found with perchlorate above 4ppb, with the highest level at 6.4ppb. The wells testing positive for perchlorate were located in CA, IN, IA, and PA. Drinking water wells in the following States had no detections of perchlorate: AZ, CT, IL, MD, MA, MI, MO, NJ, NM, NY, OH, and WV.

Information on other potential sites across the country is being gathered from the Department of Defense (DoD) and NASA searches and from U.S. Environmental Protection Agency (EPA) information requests made to perchlorate manufacturers. About 90% of the perchlorate produced by major US manufacturers has been shipped for use as a rocket fuel oxidizer, with most of the remainder used in explosives. Initial records indicate that perchlorate has been shipped to facilities in 37 States. EPA has notified State, Tribal and local governments when it has evidence of perchlorate manufacture and use in their jurisdictions. The American Water Works Association Research Foundation (AWWARF) is coordinating a survey to characterize possible perchlorate contamination of drinking water sources in areas of high risk. EPA will build upon these survey data and other information in order to discover potential sources and evaluate threats to water resources.

## Questions for Discussion

1. How might various State and federal agencies enhance coordination in searching for perchlorate contamination around the US?

2. What additional sources of contamination might be discovered?

3. What criteria should be used to design a broader based survey of perchlorate occurrence?

4. Are there concerns for perchlorate contamination outside the US?

# PERCHLORATE CONTAMINATION IN THE ENVIRONMENT

Overview of Perchlorate Issues

## Background

Perchlorate anion (ClO4-) originates as a contaminant in the environment from the solid salts of ammonium, potassium, or sodium perchlorate. Perchlorate salts are quite soluble in water. The resultant anion (ClO4-) is exceedingly mobile in aqueous systems and can persist for many decades under typical groundwater and surface water conditions, due to kinetic barriers to its reactivity with other available constituents. Ammonium perchlorate is manufactured for use as an oxidizer component in solid propellant for rockets, missiles, and fireworks. Because of its shelf life, it must be periodically washed out of the country's missile and rocket inventory and replaced with a fresh supply. Thus, large volumes of the compound have been disposed of in Nevada, California, Utah, and likely other states, since the 1950's. Ammonium perchlorate is also used in certain munitions, fireworks, the manufacture of matches, and in analytical chemistry.

Potassium perchlorate had, until recently, been used therapeutically to treat hyperthyroidism resulting from an autoimmune condition known as Graves' disease. Potassium perchlorate is still used diagnostically to test thyroid hormone (TSH, T3 and T4) production in some clinical settings. The basis for the effect on thyroid hormone function is the competitive inhibition of iodide anion uptake by perchlorate which results in reduced thyroid hormone production. Thyroid hormone deficiencies can affect normal metabolism, growth and development. The limited database on the toxicology of perchlorate confirms its potential to disrupt thyroid hormone production in mammalian test species, but no robust data exist to evaluate the dose-response for this thyroid effect or to evaluate other potential target tissues or effects. There are no existing data to evaluate the effects of perchlorate in potentially susceptible population such as developing fetuses or to evaluate its effects on ecological systems. Studies are now underway to evaluate these potential effects.

## Issues

Perchlorate is of concern because of the existing uncertainties in (1) the toxicological database documenting its health effects at low levels in drinking water; (2) the actual extent of the occurrence of perchlorate in ground and surface waters, which is compounded by some uncertainty in the validation of the analytical detection method; (3) the efficacy of different treatment technologies for various water uses such as drinking water or agricultural application; and (4) the extent and nature of ecological impact or transport and transformation phenomena in various environmental media.

This background discussion paper will provide you with general information and how plans are underway to integrate all the new information from a variety of areas in order to characterize the potential risk that perchlorate contamination may pose. Additional discussion papers will provide you with more in-depth information on these areas, including: (1) development of reliable analytical methods to detect perchlorate; (2) where perchlorate as been found; (3) the assessment of the health effects and toxicology studies to derive a benchmark value by which to evaluate risk; (4) research underway to evaluate the ecological impacts; and (5) development of treatment technologies to address various water uses.

## Where Perchlorate Contamination Occurs

Within several months following the April 1997 development of a low level detection methodology, perchlorate had been discovered at various manufacturing sites and in well-water and the drinking water supplies in California, Nevada, and Utah. At this time, there has not been a systematic national survey of perchlorate occurrence. Only a relatively small number of water supplies have been monitored using the more sensitive method, primarily in the western states with a few sample results now available in the south.

The majority of locations where perchlorate has been detected in the groundwater are in California, associated with twelve facilities which have manufactured or tested solid rocket fuels for the Department of Defense (DoD) or the National Aeronautics and Space Administration (NASA). Two facilities which manufactured ammonium perchlorate in Nevada were found to have released perchlorate to groundwater which is the source for low levels (4 to 16 ppb) in Lake Mead and the Colorado River. This water is used for drinking water supply, irrigation and recreation for millions of people in Nevada, California, Arizona, and Native American Tribes. Other releases have been detected in Utah and Texas.

Information on other potential sites across the country is being gathered from DoD and NASA searches and from U.S. Environmental Protection Agency (EPA) information requests made to perchlorate manufacturers. Initial records indicate that perchlorate has been shipped to facilities in 37 states. EPA has notified State, Tribal, and local governments when the it has evidence of perchlorate manufacture and use in their jurisdictions.

## Interagency Perchlorate Steering Committee (IPSC)

An Interagency Perchlorate Steering Committee (IPSC) was formed in January 1998 to bring together government representatives from the EPA, DoD, Agency for Toxic Substances and Disease Registry (ATSDR), National Institute for Environmental Health Sciences (NIEHS), and affected State, Tribal, and local governments. Participation in the IPSC has also been solicited from other governmental entities.

The charter of the IPSC is to facilitate and coordinate accurate accounts of related technological issues (occurrence, health effects, treatability and waste stream handling, analytical detection, and ecological impacts) and to create information transfer links for interagency and

intergovernmental activities regarding these areas of concern.

The IPSC recently collaborated with EPA's Office of Research and Development (ORD) on a report to a Congressional House committee that assesses the state-of-the-science on the health effects of perchlorate on humans and the environment and the extent of perchlorate contamination. The report also contained recommendations for future research to address emerging issues.

Monthly teleconferences are held to update participants on events and breaking news regarding controversial or technological issues. Public meetings, such as the May 1998 meeting in Henderson, Nevada, will be held to distribute the most current scientific information on the key issues and to hear stakeholder and public concerns.

## An Integrated Approach to Risk Characterization: Current Activities

A number of key pieces of information are necessary to characterize the risk of perchlorate contamination in order to formulate appropriate management strategies to mitigate potential risk. Accurate characterization of exposures rely on reliable analytical detection methods. The exposure estimates can not be gauged with respect to their risk unless a robust health risk estimate is available. Treatment technologies should be targeted to levels of concern and tailored to the intended use of the water. Research to obtain additional data and development of new methods or applications are underway in most of these areas to ensure that the state-of-the-science is brought to bear on addressing the unique issues of perchlorate contamination. Technology transfer is necessary so that all affected parties and concerned citizens are apprised of accurate and reliable information that is up to date with the evolving state-of-the-science.

### Reliable Analytical Methods

As noted above, the first critical data needed for a comprehensive risk characterization is accurate information on occurrence: where the contamination occurs, the nature (type) and extent (magnitude) of the exposure. Occurrence survey studies require a reliable and accurate analytical method for detecting perchlorate in drinking water and various aquifer types or other environmental media (e.g., irrigated food crops). Ion chromatography (IC) is the state-of-the-art technology for analysis because historical methods based on gravimetry, spectrophotometry, or atomic absorption are non-specific for perchlorate. There are several existing IC methods, including the recent analytical method developed by the California Department of Health Services (CA DHS), Dionex, and one developed by the Air Force Research Laboratory/Operational Toxicology Branch (AFRL/HEST). These methods depend upon retention time in a standard to identify any peak with the same or similar retention time as perchlorate in a water sample. The robustness of existing IC methods for the analysis of perchlorate in water with high total dissolved solids has been questioned. Research is underway that will evaluate the variability, reproducibility, accuracy and precision of the IC methods across laboratories and to determine the appropriate concentration ranges for measurement.

**Health Effects Assessment**

The second critical piece of information is to have a comprehensive health effects evaluation that can serve as the basis for development of exposure guidance levels. The toxicology data available to evaluate the potential health effects of perchlorate are extremely limited. The EPA Superfund Technical Support Center issued a provisional reference dose (RfD) in 1992 and a revised provisional RfD in 1995. The provisional RfD values (1992 and 1995) were based on an acute study in which single doses of potassium perchlorate caused the release of iodide from the thyroids of patients with Graves' Disease. Uncertainty factors that ranged from 300 to 1000 were applied to account for missing endpoints and extrapolations required to calculate a lifetime human exposure level. Standard assumptions for ingestion rate and body weight were then applied to the RfD to calculate the reported range in the ground water cleanup guidance levels of 4 -18 parts per billion (ppb). The CA DHS adopted 18 ppb as its provisional action level. An RfD is calculated as an estimate of a daily human exposure that will result in no deleterious noncancer effects over a lifetime. Ideally, an RfD is based on a database that evaluates an array of endpoints that address potential toxicity during various critical lifestages, from developing fetus through adult and reproductive stages. New studies were begun in 1997 and are underway to provide data on these missing endpoints. Additional new studies will also provide data to evaluate the potential for cancer risk. The National Center for Environmental Assessment (NCEA) in the Office of Research and Development (ORD) of the EPA plans to evaluate these new data and issue a new assessment with a revised RfD at the end of September 1998. The new assessment, all the new data and the study protocols will then be subjected to an external peer review in October 1998 before the assessment is finalized.

**Ecological Impact Assessment / Transport and Transformation**

Another potential area of health impact is on ecosystems and via indirect exposure pathways (e.g., agriculture or fishing). Searches of available databases have revealed minimal information on the ecological effects of ammonium perchlorate or any of its other salts. Essentially no reliable data exist for its effects on various soil, sediment or aquatic receptors including: aquatic vertebrates, aquatic or sediment invertebrates, bacteria or plants. Approaches for the evaluation of effects on ecological receptors is complicated by the lack of data on its environmental transport and transformation processes. These include data on the effects of soil chemistry (soil composition, adsorption processes, particle size and water saturation, complexation behavior with humic and fulvic materials, pH, etc.), movement characteristics in various media, adsorption to soils of high and low cation and anion exchange capacity, and the effect of ammonia. Development of predictive environmental transport and transformation models would be useful both to assessing ecological impact as well as directing sampling strategies to determine occurrence monitoring sites. Research has been recommended to develop data on the effects of perchlorate on various ecological receptors and the various parameters needed to develop reliable transport and transportation models that can forecast the fate of perchlorate in various aquifer types and environmental media.

**Treatment Technologies**

The health estimate such as the oral RfD is typically compared against the exposure estimates to characterize potential health risks. Such a comparison will also target the levels to which reliable treatment technologies must be developed. Perchlorate is very unreactive towards

most reducing agents when cold and dilute and has low reactivity as an oxidant due to kinetic barriers. These same properties make developing treatment technologies difficult, especially at low concentration levels. No one technology or process will likely provide an effective solution for every occurrence of perchlorate contamination in water supplies due to a large number of independent variables. Different technology may also be developed depending upon the intended use of the treated water (e.g., drinking water versus agricultural application). Treatment technologies and processes have been developed by industry and the Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/MLQE) to recover perchlorate for reuse and to treat residual wastewater containing high concentrations of perchlorate, i.e. 500-10,000 parts per million (ppm), from the manufacture and maintenance of rocket motors. Research is underway to develop technologies that meet the new challenge of treating low-concentration (5 ppb to 500 ppm) perchlorate contamination present in ground and surface water supplies.

## EPA's Future Regulatory Plans:

The Safe Drinking Water Act (SDWA), enacted by Congress in 1974 and amended in 1986 and 1996, provides the basis for safeguarding public drinking water systems from contaminants that pose a threat to public health. The purpose of SDWA is to protect public health by ensuring that public drinking water systems provided tap water that is safe for drinking and bathing. Within EPA, the Office of Ground Water and Drinking Water (OGWDW) develops National Primary Drinking Water Regulations (NPDWR) to control the levels contaminants that may occur in public drinking water systems.

The 1996 amendments to the SDWA require EPA to publish a list of contaminants that are not currently subject to a NPDWR and are known or anticipated to occur in public water systems. This list, known as the Contaminant Candidate List (CCL), will be the source of priority contaminants for research, guidance development, and selection of contaminants for making regulatory determinations and/or monitoring by the States. The SDWA requires EPA to make a determination of whether or not to regulate not less than 5 contaminants from the CCL by 2001. The CCL must also be reviewed and updated every 5 years, or again in 2003.

With broad public input and consultation with the scientific community, a draft CCL was published on October 6, 1997. The draft CCL specifically requested comment on whether to include perchlorate on the CCL based on the limited information EPA had received on its occurrence in drinking water supplies at the time of publication. As a result of the public comments and additional occurrence information obtained, the Agency determined that sufficient information exists to raise concern over perchlorate's potential public health impact, and it was added to the final CCL published on March 2, 1998.

The CCL consists of 50 chemical and 10 microbiological contaminants and is divided into two categories: (1) contaminants for which sufficient information exists to begin to make regulatory determinations by 2001, and (2) contaminants for which additional research and occurrence information is necessary before regulatory determinations can be made. Perchlorate is identified as a contaminant needing additional research in the areas of health effects, treatment

technologies, analytical methods, and more complete occurrence data.

## State Regulatory Plans:

In 1997, the CA DHS and California EPA's Office of Environmental Health Hazard Assessment reviewed the EPA risk assessment reports for perchlorate. As a result, California established its action level of 18 ppb. Perchlorate concentrations lower than 18 ppb are not considered to pose a health concern for the public, including children and pregnant women. CA DHS advises water utilities to remove drinking water supplies from service if they exceed the 18 ppb action level. If the contaminated source is not removed from service due to system demands and if drinking water that is provided by the utility exceeds the action level, CA DHS will advise the utility to arrange for public notification to its customers. On August 1, 1997, CA DHS informed drinking water utilities of its intention to develop a regulation to require monitoring for perchlorate as an unregulated chemical. Legislative action to establish a state drinking water standard for perchlorate has been introduced but has not been brought to a vote (CA Senate Bill 1033).

The Nevada Division of Environmental Protection (NDEP) has authority under Nevada Water Pollution Control Regulations to address pollutants in soil or groundwater that pose a threat to the waters of the state. The State's Corrective Action Regulations direct NDEP to establish Action Levels for hazardous substances, pollutants or contaminants using drinking water standards (MCLs), background levels or protective levels (determined by IRIS or equivalent). In August, 1997, Nevada determined that the health-based action level of 18 ppb, as established in California, would be the recommended action level for cleanup pending a more current risk assessment.

No other state is known to have adopted action levels for perchlorate primarily since levels greater than 18 ppb have not been found in water supplies in other States.

## Technology Transfer and Public Outreach

Accurate information and communication tools are needed to keep the general public, water utilities and their customers informed regarding the state-of-the-science and important issues related to perchlorate toxicity, including: analytical detection methods, occurrence, treatment technologies, ecological impact, and environmental transfer and transformation.

Bringing effective water treatment technologies to bear on perchlorate contaminated drinking water quickly and affordably is one of the primary goals of technology transfer. This requires emphasis on two important factors in the rapid development and implementation of new technologies. First, information regarding technology development and application activities should be disseminated to the widest possible audience. The IPSC will continue to collect and disseminate information regarding treatment technologies and remain involved in facilitating research and technology demonstration efforts. Effective tools that reach a broad spectrum of the public, such as discussion papers, teleconferences, an updated Web page, and news releases have been developed. Subcommittees of the IPSC are been charged with developing and updating discussion papers. EPA's Office of Water (OW) is developing a website with links to the Office of Solid Waste and Emergency Response (OSWER) and the National Center for Environmental Assessment (NCEA). EPA regional offices have been working with State authorities on news releases.

Second, drinking water authorities and purveyors of drinking water treatment technologies need to be involved as partners in research and technology demonstration. The IPSC will again serve to coordinate these activities as required. Attention to these key technology transfer issues will ensure that sound treatment strategies are developed and implemented which are responsive to the unique requirements of each affected area.

# PERCHLORATE CONTAMINATION IN THE ENVIRONMENT

Analytical Methods

## Introduction

In January of 1997, the California Department of Health Services' Division of Drinking Water and Environmental Management requested the Sanitation and Radiation Laboratory Branch (SRLB) to test for perchlorate in drinking water wells potentially affected by groundwater migrating from the Aerojet facility near Sacramento. Existing U.S. Environmental Protection Agency (EPA) risk assessment studies on perchlorate indicated that a reporting limit of at least 4 parts per billion (ppb) would be necessary. No procedures were available for measuring perchlorate at such low levels. An Ion Chromatographic (IC) method was capable of detecting 400 ppb and during the previous year Aerojet had improved the method to detect 100 ppb. By March 1997, SRLB and an analytical equipment manufacturer had developed an IC method that achieved a method detection limit of approximately 1 ppb and a reporting limit of 4 ppb. This method was used to detect perchlorate above the 4 ppb reporting limit in wells near the Aerojet site. Testing began on other wells throughout California, adjacent to sites that had known association with the use or manufacture of perchlorate-containing products. By January 1998, perchlorate had been detected in over 100 water supply wells in California and in Lake Mead and the Colorado River.

An increasing number of commercial and government laboratories have adopted the improved analytical method, leading to further discoveries of perchlorate contamination and an increase in monitoring water supplies. Development of a formal published method documenting the reproducibility and limitations of the technique is expected to facilitate the acceptance of perchlorate testing at low concentrations by laboratories across the country. The need for a reporting limit of 4 ppb taxes the sensitivity and reproducibility of the current IC method. A collaborative study of existing IC methods is planned for the near future. Work is also being planned to develop different analytical techniques to confirm the results of the IC method.

Monitoring water supplies and identifying possible sources of perchlorate contamination are not the only needs for analytical capability. A reliable and accurate method for analysis of perchlorate is essential for research in human health risk assessment, treatment technologies, and ecological toxicology. Results of these assessments may place additional requirements on analytical methods.

## Characteristics of the Current Method

There are two components to perchlorate analysis, (1) separation of perchlorate from all other species in water, and (2) measurement of the separated perchlorate against suitable standards.

## Separation

Separation of perchlorate and other like dissolved species (anions) in water is based on the attraction (affinity) of perchlorate for a special organic exchanger (ion exchange resin) packed into a column for convenient use. The anions are carried through the column by a flow of solution (mobile phase or eluent). As the anions move through the column they separate into thin bands. Since the relative strength of the attraction of the different anions to the ion exchange resin is expected to be different for each dissolved specie, they separate and come off (elute from) the ion exchange column at different times. As the anions pass through the detector, the detector response is registered as peaks with a peak area or peak height proportional to concentration and at a retention time characteristic of the anion.

## Detection

The separated bands of anions are detected by the electrical properties created by the combination of the mobile phase and anion in the detector at a given time. The property of the solution to conduct electrical charge is called the conductivity. A conductivity detector is able to detect and measure the subtle differences of solution conductivity and thereby measure the relative contribution of the anion of interest to the total conductivity.

Ideally, only the anion of interest would be present in the small volume of eluent containing the separated band of perchlorate while the eluent would be nonconducting, presenting the lowest background and highest sensitivity. Because the mobile phase is also conducting and adds to the overall background, the ideal situation can not be realized but something very close can be achieved. By removing (suppressing) the species in the mobile phase that contribute to the background but retaining the anion of interest by use of a special technique, conductivity, detection (sensitivity), and signal measurement can approach the ideal. This is the general approach used by most of the current IC methods.

## Method Variations

Since the presence of perchlorate in various water supplies has become important, a number of method changes have been tried to increase the sensitivity of the IC method. The basic system components remain the same, an ion exchange column, eluent, some method of suppression, and conductivity detection. The hardware (pumps, tubing, materials of construction, the suppressor, and the detector) does not contribute directly to the chemistry of the separation. The chemistry of the eluent and the ion exchange resin seem the most promising variables to investigate at this time. Many laboratories and some commercial IC manufactures are presently engaged in this research and development.

## Interferences

The elution time is the only parameter, at this time, that is used to determine if the peak can be presumed to be perchlorate. If other, yet unknown anions are also eluted at the same time as perchlorate, the IC method can not indicate the difference. If such were the case, the presence of

and concentration of perchlorate would be unclear and a false positive would result with no method to further separate perchlorate from the interfering species. The common approach is to measure the elution times for other anions that might be present in water, alone and as mixtures with perchlorate. By a process of elimination it may be found that under a specified set of conditions perchlorate and only perchlorate will elute from the column. An attractive alternative is to develop a perchlorate-specific method which alone or in combination with IC would measure the concentration of perchlorate uninfluenced by any other chemical specie. This latter approach is a fertile, yet unexplored field of research and development.

## Ongoing Actions and Next Steps

The analytical subcommittee of the Interagency Perchlorate Steering Committee (IPSC) is coordinating a collaborative study of the existing IC method and its variations. This method has been used to measure perchlorate in all water supplies where perchlorate has been tentatively identified. The subcommittee is composed of four scientists from EPA, the states of California and Utah, and the United States Air Force.

The referee facility is the EPA Office of Research and Development, Environmental Sciences Division, Environmental Chemistry Branch located in Las Vegas. The study design will evaluate the within laboratory precision (repeatability), between laboratory precision (reproducibility), method accuracy (bias), detection limit, and sensitivity. These are basic questions requiring an empirical (factual) solution. The results of this collaborative study will serve as a basis to focus future research and method development, with the overall goal to publish a standardized method or methods for low level perchlorate determination.

## Questions for Discussion

Because the measurement of perchlorate will likely encompass other analytical strategies, the analytical subcommittee is interested in public comments on the following issue areas:

1. What are other IC technologies, if any? High pressure liquid chromatography, other anion exchanger not based on organic supports or modified surfaces?

2. What are other non IC technologies? Ion specific electrode, spectrophotometric methods, derivatization of perchlorate to facilitate detection by other techniques?

3. What are some possible analyte, perchlorate, specific method possibilities?

4. How do anions, such as chloride, fluoride, sulfate, sulfite, nitrate and nitrite, etc. and cations, such as sodium, potassium, and calcium commonly found in groundwater sources affect the ion chromatography, sensitivity, and specificity of perchlorate analysis?

5. Does the presence of organic solvent affect the ion chromatography, sensitivity and specificity of perchlorate analysis?

6. How stable is perchlorate in general, and with respect to light/dark storage conditions, container type, and the presence of other anions?

# PERCHLORATE CONTAMINATION IN THE ENVIRONMENT

## Health Effects / Toxicology of Perchlorate

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## Introduction

A significant portion of the expedited research underway to address perchlorate contamination in the environment has been dedicated to obtaining a reliable and comprehensive data base on the health effects and toxicology of perchlorate. Such robust data are necessary to develop a health risk assessment that includes an estimate called a reference dose (RfD) which can be used to evaluate the potential risk of human exposures. The RfD can also be used in risk management programs to help guide the range where analytical methods must be effective and to target treatment technologies. The health effects data serve as the lynchpin in the overall integrated approach to addressing the emerging issues of perchlorate contamination.

## Background

The currently available database on the health effects and toxicology of perchlorate or its salts is very limited. The majority of human data are clinical reports of patients treated with potassium perchlorate for hyperthyroidism resulting from an autoimmune condition known as Graves' disease. Potassium perchlorate is still used diagnostically to test thyroid hormone [thyroid stimulating hormone (TSH), triiodothyronine (T3), and thyroxine (T4)] production in some clinical settings. The basis for the effect on thyroid hormone function is the competitive inhibition of iodide anion uptake into the thyroid gland by perchlorate anion (ClO4-) which then results in reduced thyroid hormone production.

It is difficult to establish a dose-response for the effects on thyroid function from daily or repeated exposures in normal humans from the data on patients with Graves' disease because of a variety of confounding factors, including: the effect of the disease, that often only a single exposure and not repeated exposures were tested, that only one or two doses were employed, and that often the only effect monitored was iodine release from the thyroid or control of the hyperthyroid state. There are limited data in normal human subjects and laboratory animals that support the effect of perchlorate on thyroid hormones, but the majority of these additional studies suffer from the same limitations with respect to the number of doses and exposures. These limitations prevent establishment of a quantitative dose-response estimate for the effects on thyroid hormones after long-term repeated exposures to perchlorate in healthy human subjects.

The typical objective of a health risk assessment is to evaluate a comprehensive array of testing endpoints that represent various life stages in which potential effects could occur, e.g., the developing fetus through adult and for effects on reproductive capability. Thyroid hormone deficiencies, such as those induced by perchlorate, can affect normal metabolism, growth and

development. No robust data exist to evaluate other potential target tissues or effects. There are no data to evaluate the effects of perchlorate in potentially susceptible population such as developing fetuses, nor are there data on the effects of perchlorate on reproductive capacity of male or female laboratory animals.

Benign tumors have been reported in the thyroids of male Wistar rats and female BALB/c mice treated with repeated, high dose exposures (2 years at 1,339 and 46 weeks at 2,147 mg/Kg-day, respectively) of potassium perchlorate in drinking water. Benign tumors in the thyroid have been established to be the result of a series of progressive changes that occur in the thyroid in response to interference with thyroid-pituitary homeostasis (i.e., perturbation of the normal stable state of the hormones and functions shared between these two related glands). This progression is similar regardless of the cause of the thyroid hormone interference (Hill et al., 1989; Capen, 1997; Hurley et al., submitted). The EPA has adopted the policy that an assumption of a threshold based on these precursor lesions along the progression is appropriate for the dose-response of chemicals which cause this type of disruption in the thyroid when they do not have genotoxic activity, i.e., cause damage to DNA or show other genetic disruption (U.S. EPA, 1998). Therefore, a dose-response estimate established using the no-observed-adverse-effect level for the precursor lesions should be an estimate also protective for potential benign tumor development. Existing shorter-term studies indicate that perchlorate causes changes in the thyroid typical of the progression described and genotoxic studies are underway to establish that perchlorate does not have any activity relevant to carcinogenicity.

## Provisional Health Risk Assessment

The EPA Superfund Technical Support Center issued a provisional reference dose (RfD) in 1992 and a revised provisional RfD in 1995. An RfD is calculated as an estimate of a daily oral human exposure that will result in no deleterious noncancer effects over a lifetime. Ideally, an RfD is based on a database that evaluates an array of endpoints that address potential toxicity during various critical lifestages, from developing fetus through adult and reproductive stages. The provisional RfD values (1992 and 1995) were based on an acute study in which single doses of potassium perchlorate caused the release of iodide from the thyroids of patients with Graves' Disease. The no-observed-adverse-effect-level (NOAEL) was determined to be 0.14 mg/Kg-day based on release of iodine in the thyroid followed by incomplete inhibition of iodine uptake. Uncertainty factors that ranged from 300 to 1000 were applied to account for data missing on additional endpoints and extrapolations required to calculate a lifetime human exposure level. Standard assumptions for ingestion rate and body weight were then applied to the RfD to calculate the reported range in the ground water cleanup guidance levels of 4 -18 parts per billion (ppb). The California Department of Health Services (CA DHS) adopted 18 ppb as its provisional action level.

The provisional RfD values issued are listed by the EPA only as provisional because they did not undergo the internal Agency and external peer review required of estimates available on the EPA's Integrated Risk Information System (IRIS). The outcome of an external peer review convened in March 1997 of an analogous RfD derivation by an independent organization, Toxicology Excellence for Risk Assessment (TERA), was the determination that the health

effects and toxicity data were insufficient for a credible quantitative risk analysis. The external peer review panel concluded that the data were not sufficient to rule out effects of perchlorate on other organs, so that it could not be determined unequivocally that the effects on the thyroid were the critical effect. In particular, the reviewers were concerned that developmental toxicity, notably neurological development due to hypothyroidism during pregnancy, could be a critical effect of perchlorate that has not been adequately examined in studies to date.

## New Health Effects / Toxicology Studies Underway

In response to the March 1997 external peer review of the provisional RfD value, a subsequent external peer review of experts was convened in May 1997 to recommend and prioritize a set of studies to address the key data gaps and reduce uncertainties in various extrapolations. The objective of the new studies is to provide a comprehensive database that provides for development of a robust RfD estimate that reduces the uncertainties inherent in the provisional values. Funding for the studies was procured and obligated through a variety of sources, principally the USAF and the Perchlorate Study Group (PSG).1 The protocols for the studies were reviewed by external peer reviewers from the EPA, California EPA, academia, industry, private institutes and Health Canada. The timeframe for the development of these new data has been precedent setting and has been a direct result of a unique partnering initiative. Typical research and development mechanisms would have required a number of years to accomplish these same studies.

Eight new studies were recommended in order to provide a comprehensive array of endpoints. These are described below along with their anticipated role in informing the revised health risk assessment.

**(1) 90-Day Subchronic Oral Bioassay Study.** This study is considered the minimum data requirement for derivation of an oral RfD. The study will identify other target tissues, test young adult rats, and also provide data on the effect of repeated exposure to perchlorate on thyroid hormone levels. These data may also allow reduction of the uncertainty factor applied for database deficiencies.

**(2) Neurobehavioral Developmental Study.** This study will evaluate the potential for developmental neurotoxicity of perchlorate by assessing functional and morphological endpoints in offspring from mother exposed during pregnancy and lactation. Neurotoxicity endpoints may be a critical effect and the developing organism a sensitive subpopulation. These data may allow reduction of the uncertainty factors applied for intrahuman variability and database deficiencies.

**(3) Segment II Developmental Study.** This study will evaluate the potential for perchlorate to cause birth defects in rabbits and will identify a potentially critical effect and subpopulation. This study will also provide data on the thyroid hormone effects in a second species (in addition to rats). These data may allow reduction of the uncertainty factor applied for database deficiencies.

**(4) Two-Generation Reproductive Toxicity Study.** This study will evaluate the potential for perchlorate to cause deficits in reproductive performance in adult rats and for toxicity in the young offspring. This study may identify a potentially critical effect and allow for reduction of the uncertainty factor applied for database deficiencies.

**(5) ADME (Absorption, Distribution, Metabolism, and Elimination) Studies.** These studies will be performed to understand the pharmacokinetics (how perchlorate is absorbed, distributed, metabolized and excreted) of perchlorate in test animals and humans. These data will provide information that will allow construction of quantitative extrapolation of dose across species (e.g., rat to human).

**(6) Perchlorate Mechanism Studies.** These studies will be conducted by a comparison of the existing literature and of new *in vitro* and *in vivo* data that evaluate the effects of perchlorate on the iodide uptake mechanism across species to aid in the quantitative extrapolation of dose.

**(7) Genotoxicity Assays.** These studies will evaluate the potential for carcinogenicity by evaluating mutations and toxic effects on DNA. These data will be useful to evaluate whether the benign thyroid tumors are likely to be a result of the proposed threshold pathogenesis process.

**(8) Immunotoxicity Studies.** These studies will evaluate the potential for perchlorate to disrupt immune function and identify a potentially critical effect. These data may help to reduce the uncertainty factor applied for database deficiencies.

Additional work may be required to mathematically model the dosimetry (pharmacokinetics) and toxic effects in order to increase the accuracy of a health risk determination, but this will need to be evaluated as the new data become available. An epidemiological study has been proposed to look at infant thyroid hormone data from mothers who were exposed in their drinking water supplies. The analysis would rely on the dose reconstruction data to the level of either a city or census block and will assume either that all women who lived in that area were exposed to that level of perchlorate or impose standard assumptions from other such studies (e.g., 20% of women drink bottled water). The dose reconstruction of what was in the water would have to be constructed on occurrence data once the hydrology in the aquifers and transport and transformation processes can be worked out. Both of these studies are considered refinements to the revision of the RfD that will likely result from the new studies.

# EPA Plans for Revised Health Assessment and Peer Review

## Revised Health Risk Assessment

The National Center for Environmental Assessment (NCEA) in the Office of Research and Development (ORD) of the EPA plans to evaluate the health effects and toxicology data from these new studies and then issue a new assessment at the end of September 1998. The new assessment, all the new data, and the study protocols will then be subjected to an external peer

review in October 1998 before the assessment is finalized. The assessment, data, and protocols will be available to the public at the time of release to external peer review.

Once finalized, this new peer-reviewed health assessment and new oral RfD will serve as a more robust health effects estimate than the existing provisional values with which to evaluate exposure estimates in order to characterize potential risk from perchlorate contamination or with which to develop guidance levels for cleanup and to target treatment technologies.

## External Peer Review of Revised Assessment

Independent, external peer review of the study protocols, toxicity studies, and revised reference dose and health assessment for perchlorate will be critical to ensuring that future decisions based on the RfD will be protective of human health. EPA's Office of Solid Waste and Emergency Response (OSWER) will task a qualified contractor to manage peer review of technical issues related to the development of the reference dose, including study design, conduct of toxicity studies, statistical treatment of data, selection of critical effect, selection of uncertainty factors and risk characterization. The peer review will be conducted by a panel of technical experts in developmental toxicology, reproductive toxicology, genetic toxicology, general toxicology, pathology, biostatistics, dose-response modeling and risk assessment. Peer reviewers will be selected from a pool of candidates nominated by stakeholders in the perchlorate issues. The RfD assessment package, supporting studies, and study protocols for the new data will be distributed to the peer review panel in advance of the peer review meeting. Peer reviewers will independently review the RfD assessment package and supporting studies, and will submit their written comments to OSWER's contractor prior to the peer review meeting. The peer reviewer's comments will be compiled by OSWER's contractor and will be distributed to all of the peer reviewers and the public in advance of the meeting. The peer reviewers will gather for a two day meeting in a location selected based on accessibility to stakeholders and the peer reviewers. The public will be invited to attend and observe the peer review meeting. Following the peer review meeting, the peer review panel will generate a report detailing their comments on the reference dose package and supporting studies. EPA NCEA will generate a responsiveness summary report which will discuss in detail how they will address the comments raised by the peer reviewers. The provisional reference dose will subsequently be issued by EPA.

# Questions for Discussion

1. What are the effects of hypothyroidism in adults versus infants?

2. What relevance do these effects have to children's health?

3. What are the potential impacts to pregnant women who drink contaminated water?

4. How will new information on health effects be used in the future?

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# PERCHLORATE CONTAMINATION IN THE ENVIRONMENT

## Treatment Technologies

## Introduction

Treatment technologies capable of removing perchlorate from water are urgently needed. Water utilities, in particular, need treatment methods that can reliably reduce perchlorate concentrations to low or non-detectable levels. Because the perchlorate ion is nonvolatile and highly soluble in water, it cannot be removed from water by conventional filtration, sedimentation, or air stripping. It appears to be only weakly removed by activated carbon. To be useful, a treatment method must be cost-effective, acceptable to regulatory agencies and the public, cause no other water quality problems, and minimize waste generation. The only option available for reducing perchlorate levels in contaminated water supplies is by blending uncontaminated supplies with those that containing perchlorate. In addition, the degree to which treatment options need to be developed is a function of the forthcoming results of the toxicology and health affects data and resulting peer reviewed reference dose for drinking water.

A few promising technologies are being developed for removal of perchlorate. Some are commonly used in water treatment, others less so. An anaerobic biochemical process has received the most attention, but reverse osmosis and ion exchange are also capable of removing perchlorate. Studies are underway to evaluate the cost, effectiveness, and implementability of these technologies.

The remainder of this fact sheet discusses the current state of perchlorate treatment technology, and current and planned treatment development efforts being carried out as part of U.S. Environmental Protection Agency (EPA) Superfund program studies, U.S. Air Force (USAF) research, water utility funded studies, and the federally funded research effort underway by the East Valley Water District, CA and the American Water Works Association Research Foundation (AWWARF). Technologies are grouped into three categories: physical, chemical, and biochemical.

## Physical Processes (Ion Exchange, Reverse Osmosis, Nanofiltration)

There is no doubt that physical processes such as ion exchange and reverse osmosis can remove perchlorate from water. Of the two processes, ion exchange, in which the perchlorate ion is replaced by an innocuous anion (e.g., chloride), is currently receiving the most attention. Ion exchange technologies have not yet been used to remove low levels of perchlorate from drinking

water supplies, but have been widely used in drinking water treatment to remove higher concentrations of nitrate, an anion similar to perchlorate. Perchlorate and nitrate are weakly hydrated in solution, and similar technologies are expected to be applicable to the treatment of both ions. In California's San Gabriel Valley, the Main San Gabriel Basin Watermaster is the primary sponsor of bench and pilot-scale tests of the performance of ion exchange technologies, with results expected by mid-1998. The San Gabriel Valley study is evaluating the cost and effectiveness of removing approximately 30 to 200 parts per billion (ppb) perchlorate from groundwater.

One current challenge is to find an ion exchange resin that can selectively remove perchlorate, thereby limiting the unnecessary removal of other ions which are typically present in far higher concentrations than perchlorate (e.g., chloride, sulfate, bicarbonate). Ion exchange processes (and reverse osmosis and nanofiltration) also generate perchlorate-rich waste brines that may be difficult to dispose. Further treatment of the brine may be needed to reduce its volume or toxicity before disposal.

Nanofiltration and reverse osmosis will also remove perchlorate, but at unknown cost. Pilot-scale tests completed by Harvey Mudd College for the Metropolitan Water District of Southern California have shown that nanofiltration can reduce perchlorate from 18 ppb to less than 4 ppb in a contaminated surface water supply, but at undetermined cost. In addition, the Southern Nevada Water Authority reportedly achieved satisfactory results in tests of in-home reverse osmosis units with trained operators.

## Chemical Processes (Chemical Reduction, Ozone-Peroxide)

Perchlorate is a highly oxidized compound (i.e., it has a strong affinity for electrons). One might therefore expect that perchlorate could be destroyed by adding a chemical reducing agent to convert its chlorine atoms to chloride, a harmless component of table salt. Unfortunately, the chemical reaction between perchlorate and commonly used reducing agents is too slow to be of practical use. Perchlorate may react with more exotic reducing agents, such as titanium, vanadium, molybdenum, or ruthenium, but these chemicals are likely to be too unstable or toxic to be practical for water treatment. Catalysts that could selectively speed the destruction of perchlorate have not been identified.

Ozone-peroxide treatment appears to have minimal effect on perchlorate in water, but ozone-peroxide followed by liquid phase carbon treatment has been shown to remove perchlorate from groundwater at a water supply well in the San Gabriel Valley. EPA is planning additional tests to evaluate the long-term effectiveness, reliability, and cost of the process. AWWARF may also fund additional evaluations of this process as part of its $2 million federally funded perchlorate treatment research program.

## Biochemical Processes (Anaerobic Biochemical Reduction)

To date, more effort has been directed at developing an anaerobic biochemical reduction process than any other treatment option. In the biochemical reduction process, microbes are used to

convert perchlorate to a less toxic or innocuous form. Microbes have been used for decades in the treatment of some drinking water supplies, as part of a process known as slow sand filtration.

The Air Force Research Laboratory, Materials and Manufacturing Directorate began development of biochemical reactor systems for the treatment of high level perchlorate-contaminated wastewater, i.e. 1000 to 10,000 parts per million (ppm), more than eight years ago. A production-scale, continuous-stirred-tank-reactor system began treating wastewater from rocket motor production operations in Utah in 1997. Applying the same concept, pilot-scale tests of an anaerobic fluidized bed bioreactor were completed at the Aerojet Superfund site near Sacramento, California in 1996. The tests demonstrated that a bioreactor could reduce perchlorate concentrations in groundwater from over 5000 ppb to the low hundreds of ppb. A 4000-gallon per minute (gpm) flow-through bioreactor is expected to be online by late 1998 to treat contaminated groundwater before recharge to the aquifer.

Additional pilot-scale tests were recently completed by the Baldwin Park Operable Unit Steering Committee at one of the San Gabriel Valley Superfund sites, where groundwater contaminated with approximately 150 ppb perchlorate must be treated. Results from the San Gabriel Valley tests are encouraging; perchlorate has been reduced to nondetectable levels. The bioreactor also removed nitrate, which is present in the aquifer at 20 to 30 ppm (as NO3). Larger-scale testing at 500 to 1000 gpm will continue later in 1998 at a perchlorate-contaminated drinking water supply well in the San Gabriel Valley. Ultimately, a perchlorate treatment facility with the capacity to treat 20,000 gpm is expected to be built with some or all of the treated water supplied to local drinking water utilities. Although bioreactors appear capable of removing low level perchlorate contamination from drinking water supplies, the cost, reliability, and public acceptance of this technology are not well established.

The Air Force Research Laboratory has also initiated an effort to isolate enzymes from the microorganism responsible for perchlorate reduction. If this effort is successful, enzymes might be used in a fixed-bed reactor system to selectively remove perchlorate over a range of concentrations.

## Summary

Only in the last year has a substantial effort been directed at the development of perchlorate-removal technologies that could potentially be used to treat perchlorate-contaminated drinking water supplies. By late 1998 or early 1999, pilot-scale studies of two or three promising technologies will have been completed, and performance data from a full-scale anaerobic biochemical treatment system should be available. In 2001, results from the $2 million AWWARF research effort will also become available.