



## **Health Assessment of 2003 Al Mishraq Sulfur Fire Incident**

### **Status: June 2012 ‡**

FACT SHEET 64-007-0612

**Incident Summary:** On 24 June 2003, a fire accidentally ignited at the Mishraq State Sulfur Mine Plant in Iraq. The fire burned for approximately 3 weeks, and a smoke plume was visible on satellite imagery for miles. The plume contained various contaminants including particulate matter and varying concentrations of sulfur dioxide (SO<sub>2</sub>) and hydrogen sulfide (H<sub>2</sub>S). Satellite photos demonstrated that the smoke plume direction, length, and opacity varied throughout the 3 week time frame.



Field sampling data collected by a preventive medicine detachment and anecdotal reports of odors and irritation suggest acute effect levels of SO<sub>2</sub> were not located solely in the immediate vicinity of the fire. On some occasions, acute effect levels were noted at the Q-West Air Base and Life Support Area, 25 kilometers (km) to the south. Satellite imagery shows some limited northerly movement of the smoke plume reaching approximately 50 km to the north up to the Mosul Airfield area. Though some anecdotal reports of odors suggest SO<sub>2</sub> may have reached this far, no field samples were collected from this area.

**Personnel Exposures:** Detected levels for SO<sub>2</sub> and H<sub>2</sub>S from the 2003 sulfur fire are associated with effects ranging from minimal irritation/odor to more severe irritation, coughing and choking sensation. Specific exposure levels and durations experienced by individual troops are assumed to have been quite variable depending on an individual's location, activity, and the day/time. Given limited field sampling data combined with the lack of specificity regarding individual locations and activities during that time, there are no means to specifically identify individual exposures.

USAPHC assumed that the greatest overall exposures were to those assigned to fight the fire. During the initial response, personal protective equipment used by firefighters was likely inadequate against the levels of SO<sub>2</sub> and H<sub>2</sub>S in the smoke. Some firefighters experienced irritation, minor burns and irritative effects such as blood-tinged nasal mucous, but no serious health consequences were recorded. A roster of 191 firefighters and support elements (such as medics) was prepared at the firefighting site. The roster identified individuals primarily from the 101<sup>st</sup> Airborne Division – the 52<sup>nd</sup> Engineer Battalion, 326<sup>th</sup> Engineer Battalion, and the 887<sup>th</sup> Engineer Company. While this roster may not have completely captured all firefighting personnel, it is believed to be a reliable indication of the majority of personnel involved in this activity. These personnel were medically evaluated and had pulmonary function assessments prior to leaving the site. No significant findings were noted.

Significant exposures to other Service members may have occurred. For example, troops were reportedly assigned missions such as securing the perimeter of the Mishraq Plant and/or evacuating local civilians in the area. Varying degrees of intermittent exposure could have occurred to personnel traveling along the main supply route, at Q-West Air Base and Life Support Area, or even the Mosul Airfield. Medical personnel at the Q-West Area reported approximately a 20% increase in sick call visits during this time and noted that one asthmatic had an exacerbation of his condition.

**Health Effects.** Both H<sub>2</sub>S and SO<sub>2</sub> are gases that can produce irritation of the eyes, nose and throat, and coughing. Because these gases are water soluble, they typically penetrate as far as the nose and throat with minimal amounts reaching the lungs unless the person is breathing heavily, breathing only through the mouth (both conditions potentially present with exertion, i.e., Soldiers doing their jobs), or the concentrations are especially high, as was noted in some of the sampling. Information on the combined exposures to the gases is not definitive, though it is plausible that effects may be amplified. At high levels, SO<sub>2</sub> can react with moisture on the skin and in the lungs and cause irritation or even burns. Very high concentrations of SO<sub>2</sub> have caused severe airway obstruction, hypoxemia (insufficient oxygenation of the blood), pulmonary edema (a life threatening accumulation of fluid in the lungs), and death in minutes. Pulmonary edema may be delayed for hours or days. As a result of severe exposures, permanent lung injury may occur. Several human studies have shown that repeated, long term exposure to low levels of SO<sub>2</sub> has caused permanent pulmonary impairment. Though less common, because sensitivity varies amongst people, even relatively low concentrations has been found to produce a reversible decrease in lung function and bronchial constriction in certain individuals. For example, asthmatics have greater susceptibility to effects at lower concentrations.

**USAPHC Analysis of Long Term Health Implications associated with the Sulfur Fire:** On return to Ft Campbell, preventive medicine personnel hypothesized that in addition to firefighters, there were thousands of other returning Soldiers who may have been exposed to the plume that passed over the Q-west area. Post Deployment Health Assessment Forms (DD2796) from Soldiers redeployed to Ft Campbell confirmed that there were numerous concerns regarding their sulfur fire smoke exposure. Soldiers with immediate health concerns were provided medical evaluations and offered a screening pulmonary function test (PFT). Soldiers with symptoms/abnormal PFTs were referred for further evaluation through the Blanchfield Army Community Hospital (BACH). Medical conditions that required further specialized assessment were referred to Vanderbilt University Medical Center (VUMC). In 2004, as part of its environmental medical surveillance mission, the USAPHC became aware of the screening process at Ft Campbell. At that time there were no clear indications of sulfur fire exposure-related health problems in the redeployed troops, although many of them were still in the evaluation process. A short roster of individuals identified as present in the immediate vicinity of the fire site had been provided to USAPHC. Utilizing this roster, the USAPHC obtained health outcome data to assess long term post deployment outcomes in this group. However, in 2007, the USAPHC became aware of other individuals not on the roster who had been seen at VUMC for shortness of breath with exertion. USAPHC therefore expanded its evaluation to include a much larger group of potentially exposed personnel. To determine who to include in this group, satellite imagery of the plume was used to estimate that exposure(s) would have occurred within a 50 km radius of the Mishraq State Sulfur Plant. The individuals who were located in this area during the event were identified using unit location information from military deployment tracking data. The resulting group included over 6000 personnel. Though the tracking data sources used in 2003-2004 were somewhat limited in completeness and accuracy, this group was considered a conservative estimate of the overall population of potentially exposed persons. Only very limited sample data was obtained, so specific levels of exposure and exposure duration could not be established for any individual. The result of the analysis (*USAPHC Epidemiological Consultation No. 64-FF-064C-07, Mishraq Sulfur Fire Environmental Exposure Assessment*, June 2010) did not show any clear association between sulfur fire exposure and evaluated medical outcomes (e.g., chronic or recurring respiratory diseases). Specifically, the population potentially exposed to the sulfur fire did not demonstrate an increased disease risk when compared to deployed persons not exposed to the fire. However, the results did not rule out the possibility of such an association. Also, the analysis indicated that for overall deployed personnel (including those *not* exposed to the sulfur fire) that there was an increase in post-deployment medical evaluation or care for chronic or ill-defined respiratory conditions when compared to the pre-deployment experience.

**Other Findings.** Although not evident in the larger USAPHC epidemiological analysis, from late 2004 through December 2009, 80 Soldiers reporting unexplained dyspnea or shortness of breath on exertion and citing exposures to the sulfur fire or other deployment inhalation exposures had been referred to and evaluated by a pulmonary specialist at VUMC. As of July 2011, 49 of these Soldiers have had an open lung biopsy at VUMC. All 49 biopsies were reported as abnormal. Of these, 38 were diagnosed with constrictive bronchiolitis while the other 11 were diagnosed with sarcoidosis, respiratory bronchiolitis, interstitial lung disease, hypersensitivity pneumonitis, respiratory bronchiolitis, or other diagnoses. Constrictive bronchiolitis (CB) is an inflammatory and fibrotic lesion of the terminal bronchioles of the lungs. It is irreversible and difficult to treat, so is especially concerning. It is, however, a very uncommon diagnosis. CB has historically been associated with unique inhalation exposures, organ transplantation, certain drugs, and collagen vascular disorders. Individuals with CB typically have shortness of breath with exertion, but may have normal chest X-rays and inconclusive findings on PFTs done at rest. Due to some similarities, symptoms of CB may be attributed to asthma or chronic obstructive pulmonary disease (COPD). Further analysis of the biopsied cases is currently underway. However, it is noted that since some of the biopsied Soldiers given this diagnosis were not exposed to the 2003 sulfur fire. VUMC physicians who originally associated CB with the sulfur fire are now linking it to other deployment exposures (e.g., burn pits, particulate matter). [King MS et al., *N Engl J Med* 2011; 365:222-30.]

**Current Status:** The USAPHC currently considers it plausible that pulmonary conditions in some individuals could be associated with exposure to the 2003 Mishraq State sulfur fire event. Even though the case definition is still being evaluated, constrictive bronchiolitis is included, since this condition has been scientifically associated with very high exposures to SO<sub>2</sub>. While personnel exposure levels and duration varied considerably, individual risk factors or susceptibilities may play a role. Since the actual group of all exposed persons is not definitively known, and since it is not a routine diagnosis, it is possible that others may have this outcome. The 2010 PHC report included several suggested courses of action which are currently being evaluated: follow-up of the biopsied personnel, establishment of a registry, standardized medical evaluations for personnel presenting with shortness of breath or dyspnea on exertion, and baseline PFTs on all Service members prior deployment.

**If you have questions, concerns, or any additional information regarding this incident please contact:**

U.S. Army Public Health Command, Environmental Medicine Program, [USAPHC-EMP@AMEDD.army.mil](mailto:USAPHC-EMP@AMEDD.army.mil)

5158 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5403

DSN 584-2714; COMM (410) 436-2714; FAX Extension-4117