Respiratory and Allergic Immune Response Impacts of
Gravel Pit / Quarry Operations on Adjacent Land / Properties

Calculations for 10 µm Particles:

Dust of this size is the median inhalable diameter specified by the EPA. “The EPA describes inhalable dust as that size fraction of dust which enters the body, but is trapped in the nose, throat, and upper respiratory tract.” The terminal velocity of this size of particle is calculated to be 7.53E-03 m/s using Stokes Law for Fluid-Particle Forces, in the conditions specified previously.

It will therefore take 664 seconds for these particles to fall from a height of 5 meters (16.4 feet).

Wind Speed	Travel Distance
5 km/h (3.1 mph)	0.9 km (.55 mile)
10____(6.2 mph)	1.8 (1.1 miles)
20____(12.4 mph)	3.7 (2.3 miles)
40____(24.8 mph)	7.4 (4.6 miles)
60____(37.3 mph)	11.1 (6.9 miles)
80____(49.7 mph)	14.8 (9.2 miles)

Calculations for 5 µm Particles:

Dust of this size falls within the respirable dust range as specified by the EPA. Respirable dust refers to those dust particles that are small enough to penetrate the nose and upper respiratory system and deep into the lungs. Particles that penetrate deep into the respiratory system are generally beyond the body's natural clearance mechanisms of cilia and mucous and are more likely to be retained

The terminal velocity of this size of particle is calculated to be 1.91E-03 m/s using Stokes Law for Fluid-Particle Forces, in the conditions specified previously.

It will therefore take 2,612 seconds for these particles to fall from a height of 5 meters (16.4 feet).

Wind Speed	Travel Distance
5 km/h (3.1 mph)	3.6 km (2.2 miles)
10____(6.2 mph)	7.3 (4.5 miles)
20____(12.4 mph)	14.5 (9 miles)
40____(24.8 mph)	29.0 (18 miles)
60____(37.3 mph)	43.5 (27 miles)
80____(49.7 mph)	58.1 (36.1 miles)

Conclusion:

Using EPA inhalable dust and Stokes Law for Fluid Particle Forces definitions and calculations, by varying the dust particulate particle size, wind speed, and release height, respirable dust can, and will, impact areas just about anywhere directionally downwind from a gravel pit’s operational activities, unquestionably posing health risks and bearing an impact on adjacent properties, including to residential and school facilities areas and occupants, and particularly on sensitive and vulnerable adults, seniors, and children.

The Effect of Particles on Allergic Immune Responses

http://toxsci.oxfordjournals.org/content/65/1/7.full (including impacts/effects of airborne sulfur (SO2) and silica particulates/particles)

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http://oehha.ca.gov/air/pdf/oehhaso2.pdf (sulfur specific)

> Prior to 1980, controlled exposures of human subjects to SO2 had involved only healthy subjects. In general these studies did not find adverse respiratory effects even at concentrations of 13 ppm (Frank et al, 1962).
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> **In 1980 and 1981, Koenig et al (1980; 1981) and Sheppard et al (1980; 1981) published the results of controlled SO2 exposures in both adolescent and adult subjects with asthma. *The studies by Koenig and Sheppard found that people with asthma were extremely sensitive to inhaled SO2 and therefore may be at increased risk for adverse respiratory effects in communities where SO2 concentrations are elevated even for short periods of time.***

Small particles are the most dangerous

[2768]
Because of the size of the particle, they can penetrate the deepest part of the lungs. Larger particles are generally filtered in the nose and throat and do not cause problems, but particulate matter smaller than about 10 micrometers can settle in the bronchi and lungs and cause health problems. Similarly, particles smaller than 2.5 micrometers tend to penetrate into the gas-exchange regions of the lung, and very small particles ($\leq$ 100 nanometers) may pass through the lungs to affect other organs. Particles smaller than 100 nanometers can pass through cell membranes and migrate into other organs, including the brain. It has been suggested that particulate matter can cause similar brain damage as that found in Alzheimer patients. Particles emitted from modern diesel engines are typically in the size range of 100 nanometers. In addition, these soot particles also carry carcinogenic components like benzopyrenes adsorbed on their surface.

Long-term exposure to fine particulate

[2769]
Pope and colleagues 2002 found that particles smaller than 2.5 micrometers leads to high plaque deposits in arteries, causing vascular inflammation and atherosclerosis. Fine particulate and sulfur oxide-related pollution were associated with all-cause, lung cancer, and cardiopulmonary mortality. The authors concluded that long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality. The authors stress that the legislative limits for engines are unsuitable to protect against particulate matter.

Toxicology of particulate matter

[2770]
According to Valavanides and colleagues 2008, the inflammatory injury, oxidative damage, and other biological effect are stronger for fine and ultrafine particles, such those from exhaust particles from motor vehicles because they can penetrate deeper into the airways of the respiratory tract. These particles pollute urban areas. The authors call for studies on the cytotoxic and carcinogenic mechanisms of particulate matters in the lungs. They stress the importance to understand the formation of particulate matter by internal combustion engines and other sources.

One of the single most useful reference on fugitive emissions is "Fugitive Emissions and Controls, by Hesketh and Cross, 1983, and this work focused on dust. They mention primary fugitive dust sources as being unpaved roads; mining, excavating, crushing operations; and heavy construction operations as the first, fourth, and sixth primary sources. Of particular interest is their citing EPA's emissions study showing that automobiles on unpaved roads may produce up to 75 pounds of fugitive dust per vehicle mile traveled (VMT). The EPA developed an emission factor for vehicles on unpaved roads*:

$$E = (0.81)\,(s)\left(\frac{S}{30}\right)\left(\frac{365 - w}{365}\right)$$

Where E = lb of fugitive emissions / VMT
s = silt content of road surface material, %
S = average vehicle speed, mph
w = mean annual number of days with 0.01 in. or more of rainfall

****Hesketh and Cross also cite an expert as stating that this equation might be modifiable for trucks on haul roads by pro-rating for truck tire surface.***