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MEMORANDUM

February 14, 2008

TO: William O'Sullivan, Director
Division of Air Quality

FROM: John Jenks, Chief
Bureau of Technical Services

SUBJECT: Predicted Impact of Diesel Emissions due to Locomotive Idling at the Raritan Rail Yard (Raritan, Somerset Co.)

The Bureau of Technical Services (BTS) has completed the modeling of the existing 15 acre Raritan Rail Yard. New Jersey Transit (NJT) and BTS worked together to evaluate air quality impacts of several scenarios of yard operations with respect to National Ambient Air Quality Standards (NAAQS) and cancer risk. The modeling reflects accurate information on locomotive operations and their location obtained from NJT, along with train idling emission factor data from EPA. This is expected to be a worse case emission level, with actual emissions lower during idling. The results of the modeling described below include NJT's reduced idling hours under their "Idling Minimization Program" operating scenario.

The Idling Minimization Program will reduce the cumulative number of idling hours by the locomotives at the Rail Yards from the previous level of 742 hours per week to no more than 137 hours per week. The Idling Minimization Program will be in effect when the minimum ambient temperatures at the Rail Yard remain above 0^oF at night. If, in the unlikely event, the temperature drops below 0^oF, the idling patterns at the Rail Yard will reflect the previously operating pattern. The likelihood of significant idling due to below zero temperature is remote since, during the entire 5-year meteorological period used in this study, the temperature went below 0^oF on only three days. Furthermore, there has been only one additional day below zero degrees recorded at the nearest weather reporting station since 1986.

Modeling Methodology and Assumptions

Dispersion Model - Aermod Version (06341).
Meteorological Data – 1991-1995 Newark International Airport surface data/Atlantic City upper air data (1991 worst-case year).
Number of Idling Locomotives and Duration of Idling – Nine departing and arriving locomotives, up to 18 instances of temporary (less than one hour) idling locomotive layover

during the day, both weekday and weekend idling patterns; locomotives that experience the longest idling times were located nearest the maximum impact area; M. Judd (NJ Transit) e-mail to P. Hanna (NJDEP), August 14, 2007.

Source Characterization – Volume sources, each 6.3 m in length and 4 m in height released 4 m above the ground (center point). Volume sources distributed across the Rail Yard according to figure supplied by NJTransit (email to M. Dower, 25 July, 2007)

Diesel Emission Factor[a] – 44.0 grams/hr per idling locomotive from the EPA document *Emission Standards for Locomotives and Locomotive Engines*, 1998 (Chuck Moulis, EPA). The emission rate is based on the use of 2000 ppm sulfur fuel. We acknowledge that NJ Transit is transitioning to 500 ppm sulfur fuel and experts believe that will reduce the emission rate by 3-10% (conference call with Chuck Moulis from EPA OTAQ and Steve Fritz from Southwest Research Institute on 10/9/07). [a]Additional explanation of the basis for this factor is contained in the attached NJDEP Memorandum from Melinda Dower to John Jenks dated 10-17-2007

Type of Engine – EMD-16-645E3B built between 1965-1971, 3000 HP (R. Marcolina March 13, 2007 e-mail).

Background PM-2.5 Monitor – Chester NJ, 2004-2006 data.

Special Receptors – Elementary School Building, residences to the northeast, and residences to the south. The location of these receptors in relationship to the Rail Yard is shown in Figure 1.

Proposed Idling Minimization Program

The Idling Minimization Program will significantly reduce idling except when minimum ambient temperatures at the Rail Yard fall below 0^{o}F at night (apart from normal operations such as maneuvering and engine spin down). Idling prior to the Idling Minimization Program at the Raritan Rail Yard includes 87 hrs, 42 min each weekday and 151 hrs, 49 min each day on the weekend. Figure 1 shows the modeled concentrations of PM-2.5 around the train yard prior to the implementation of the Idling Minimization Program. The Idling Minimization Program is projected to result in a reduction of the train idling hours to 21 hrs, 23 min per day during weekdays and 14 hrs, 57 min per day on the weekends (approximately 1 hour per day per locomotive). By implementing the Idling Minimization Program at 0^{o}F, the total locomotive idling hours is reduced by over 80%. Based on recent historical weather records the likelihood of all the locomotives needing to idle overnight is less extremely low.

PM-2.5 National Ambient Air Quality Standards (NAAQS) –

Table 1 lists the maximum predicted annual PM-2.5 concentrations with the Idling Minimization Program in effect year round. The impact due to diesel locomotive emissions are combined with representative PM-2.5 background levels and compared to the PM-2.5 NAAQS. All diesel particulate emissions are assumed to be PM-2.5. Compliance with the annual PM-2.5 NAAQS is predicted at all locations. Figure 2 shows the spatial distribution of the future annual PM-2.5 concentrations due to idling locomotive emissions predicted in the vicinity of the Rail Yard. This figure does not include background PM-2.5 concentrations.

Following the Idling Minimization Program, locomotives in the rail yard will only be idling for a maximum of 1 hour in any 24-hour period. Figure 3 shows the highest 24-hour modeled concentrations of PM-2.5 around the rail yard resulting from this Program.

Table 2 shows the maximum predicted 24-hour PM2.5 concentrations for the conditions above $0^{o}F$ for the future case (using the actual meteorology over the period 1990-1994 at Newark).

Table 1: Predicted Annual PM-2.5 Impacts – Idling Minimization Program (ambient temperatures above $0^{o}F$)				
Receptor	**Annual PM-2.5 Concentration [a] (μg/m^3)**	**PM-2.5 Background [b] (μg/m^3)**	**Total PM-2.5 Impact (μg/m^3)**	**NAAQS [c]**
Elementary School	0.13	10.0	10.1	15
Residents (northeast)	0.05	10.0	10.1	15
Residents (south)	0.04	10.0	10.0	15
Maximum offsite	0.78	10.0	10.8	15

a. NJDEP interim annual PM-2.5 significant impact level (SIL) is 0.3 μg/m^3. This SIL in New Jersey is used to evaluate new major stationary sources until the federal EPA adopts a national SIL.
b. Average annual concentration measured at Chester from 2004 to 2006.
c. The PM-2.5 annual National Ambient Air Quality Standard is **15 μg/m^3** calculated as a 3-year average from three successive annual averages.

Table 2. Maximum Predicted 24-hour PM-2.5 Impact – Idling Minimization Program (Weekday/Ambient Temperatures above $0^{o}F$)				
Receptor	**24-Hour PM-2.5 Concentration [a,b] (μg/m^3)**	**Background PM-2.5 [c] (μg/m^3)**	**Total PM-2.5 Impact (μg/m^3)**	**NAAQS [d]**
Elementary School	0.65	30.3	30.9	35
Residents (northeast)	0.23	30.3	30.5	35
Residents (south)	0.19	30.3	30.5	35
Maximum offsite	2.82	30.3	33.1	35

a. 24-hour PM-2.5 value represents the eighth-highest value representing the 98th percentile concentration to reflect the NAAQS.
b. NJDEP interim 24-hour PM-2.5 significant impact level (SIL) is 2 μg/m^3. This SIL in New Jersey is used to evaluate new major stationary sources until the federal EPA adopts a national SIL.
c. Average 24-hour 98th percentile concentration measured at Chester from 2004 to 2006.
d. The PM-2.5 24-hour National Ambient Air Quality Standard is **35 μg/m^3** comprised as the 3-year average of three successive years of the 98th percentile 24-hour average.

PM Concentrations on sub-zero days

Historical meteorological records over the last 17 years show only four days of sub-zero temperatures. Figure 4 shows the maximum predicted 24-hour PM2.5 concentrations on the worse case of these days. On such days the locomotives would idle all night long. The modeling results in this scenario can be confusing, because although the concentration may go above 35 $\mu g/m^3$, there is no NAAQS violation. This is because a NAAQS violation doesn't occur until eight days per year go over the threshold. Since sub-zero temperature days are so rare, there aren't enough sub-zero days during the year to generate a violation. In addition, previous meteorological records show that on most extremely cold days there is a wind speed of 10 knots that would tend to disperse the emissions from the idling locomotives and reduce the concentrations of PM 2.5. The increased risk associated with idling one additional day per year is negligible.

<u>Carcinogenic Health Effects</u>

Table 3 lists the predicted worst case incremental cancer risk due to the emissions from the idling locomotives after the Idling Minimization Program is in effect. Figure 5 shows the spatial distribution of this predicted risk. The values range from 12 in a million at the residential area to the south to 39 in a million at the school assuming continuous 70-year exposure. The incremental cancer risk is an estimate that assumes a 70 year lifetime exposure, the worst case meteorological conditions, and unit risk factors which are based on toxicity. These include safety factors to account for uncertainty. Because of the conservative nature of the risk assessment process, these assumptions typically overestimate the risk.

The risk to children at the school is actually much less than 39 in a million. The calculated maximum actual risk assumes a person is living (24/7) at the school location for 70 years. Considering the time spent at school, the children's exposure is less than 1/65 of a lifetime. Another exposure consideration is that the children are at school during the day and the trains idle at night. This further reduces the risk. However, children may be more sensitive to the PM2.5 emissions because of their age. The EPA recently recommended a potency factor of three when adjusting the unit risk factor for school age children. Using this potency factor, together with reduced exposure, the maximum calculated risk for the children at the school would be about 2 in a million. While there is considerable uncertainty in estimating cancer risk, using conservative assumptions on risk, exposure, and sensitivity, the risk would be in the negligible range.

Table 3. Maximum Predicted Cancer Risk – Idling Minimization Program

Receptor	**Annual Concentration [a] ($\mu g/m^3$)**	**Unit Risk Factor [b] $(\mu g/m^3)^{-1}$**	**Incremental Cancer Risk [c]**
Elementary School	0.13	3 E-04	39 in 1,000,000
Residents (northeast)	0.05	3 E-04	15 in 1,000,000
Residents (south)	0.04	3 E-04	12 in 1,000,000

a. The above table does not include background diesel concentrations that are estimated to be 0.5 $\mu g/m^3$ in the region according to USEPA's 1999 National Air Toxic Assessment (NATA).

b. Unit risk factor from California EPA (2002)

c. Assumes 70 year inhalation exposure, although exposures at the Elementary School are expected to be less than a life time and not at night, so the risk will be less (see text for further explanation).

Non-Carcinogenic Health Effects

Table 4 shows the non-cancer risk estimates and lists the predicted annual concentration of diesel particulates and compares these values to the highest ambient air concentration at which no adverse health effects are expected (i.e., the reference concentration). All predicted concentrations are far less than the reference concentration.

Table 4. Maximum Predicted Hazard Index – Idling Minimization Program [a]			
Receptor	**Annual Concentration ($\mu g/m^3$)**	**Reference Concentration ($\mu g/m^3$) [a, b]**	**Hazard Index [c,d]**
Elementary School	0.13	5.0	0.03
Residents (northeast)	0.05	5.0	0.01
Residents (south)	0.04	5.0	0.01

a. The above table does not include background diesel concentrations that are estimated to be 0.5 $\mu g/m^3$ in the region according to USEPA's 1999 NATA.
b. From IRIS, estimate of a continuous inhalation exposure for a given duration to the human population that is likely to be without an appreciable risk of adverse non-cancerous health effects.
c. Assumes annual exposure
d. Hazard index below 1 indicates negligible health risk.

NJDEP Risk Management Procedures for Facility-Wide Risk from Existing Sources

When evaluating the health risk of facility-wide emissions from an existing source,

- Cancer risk greater than 1000 in a million – unacceptable risk. Take immediate action to reduce risk.

- Cancer risk less than 1000 in a million but greater than 100 in a million (significant risk)
  - Implement short-term (less than 1 year) risk minimization strategy.

- Cancer risk less than 100 in a million but greater than 10 in a million (significant risk)
  - Implement long-term (more than 1 year) risk minimization strategy.

- Cancer risk less than 10 in a million – negligible risk; a formal risk minimization strategy is not required. Continue efforts to minimize risk.

Uncertainties Affecting Cancer and Non-cancer Risk Predictions in Table 3

- Actual emissions during idling will be less than those modeled here.

- Emissions from locomotives traveling through the rail yard are not evaluated separately. These are considered as part of the background exposure.

- The cancer risk prediction for the next 70 years assumes the diesel locomotive idling emission rate used will remain constant for the next 70 years. Emissions will decline as cleaner fuels (ultra low sulfur diesel (ULSD)) are used and as locomotives are replaced with lower emitting diesel engines.

- The predicted cancer risk assumes a continual 70-year inhalation exposure to the modeled diesel particulate concentration. A person will not be present at the locations 24 hours per day or for 70 years, especially at the school.

- The incremental cancer and non-cancer risk reference concentration predictions only include emissions from idling locomotives at the Raritan Rail Yard. Risk of background air contaminant levels from other sources is not included in other than the comparison with the National Ambient Air Quality Standards.

Conclusions

1. Annual PM2.5 levels – both the pre and post-idling reduction operations do not cause an exceedance of the annual NAAQS.

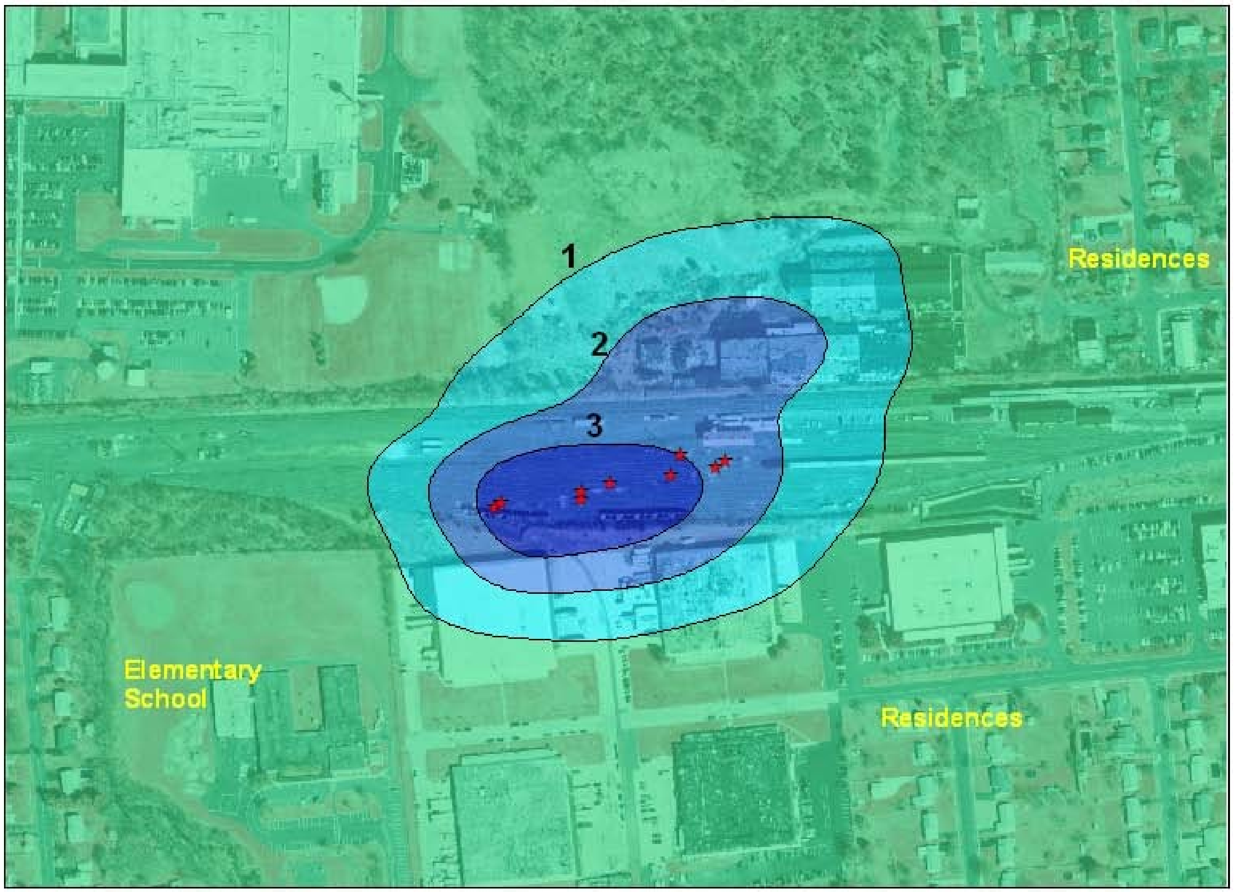
2. 24-hour PM2.5 levels – the pre-idling reduction operations were predicted to cause an exceedance of the 24-hour NAAQS in the area immediately north and south of the idling area. With idling reduction, there would be no exceedance of the 24-hour NAAQS.

3. Cancer risk – the predicted worse case cancer risk for constant exposure for 70 years is between 10 in a million and 100 in a million. This is not negligible and justifies continuing long-term efforts to further reduce cancer risk.

Attachments

c: Alan Dresser (BTS)
Peter Mayes (BTS)
Peg Hanna (Diesel Section)
Melinda Dower (Diesel Section)
Robert Marcolina (Diesel Section)

FIGURE 1: MAXIMUM PREDICTED ANNUAL PM2.5 CONCENTRATIONS: PRE-IDLE REDUCTION PROGRAM



Legend

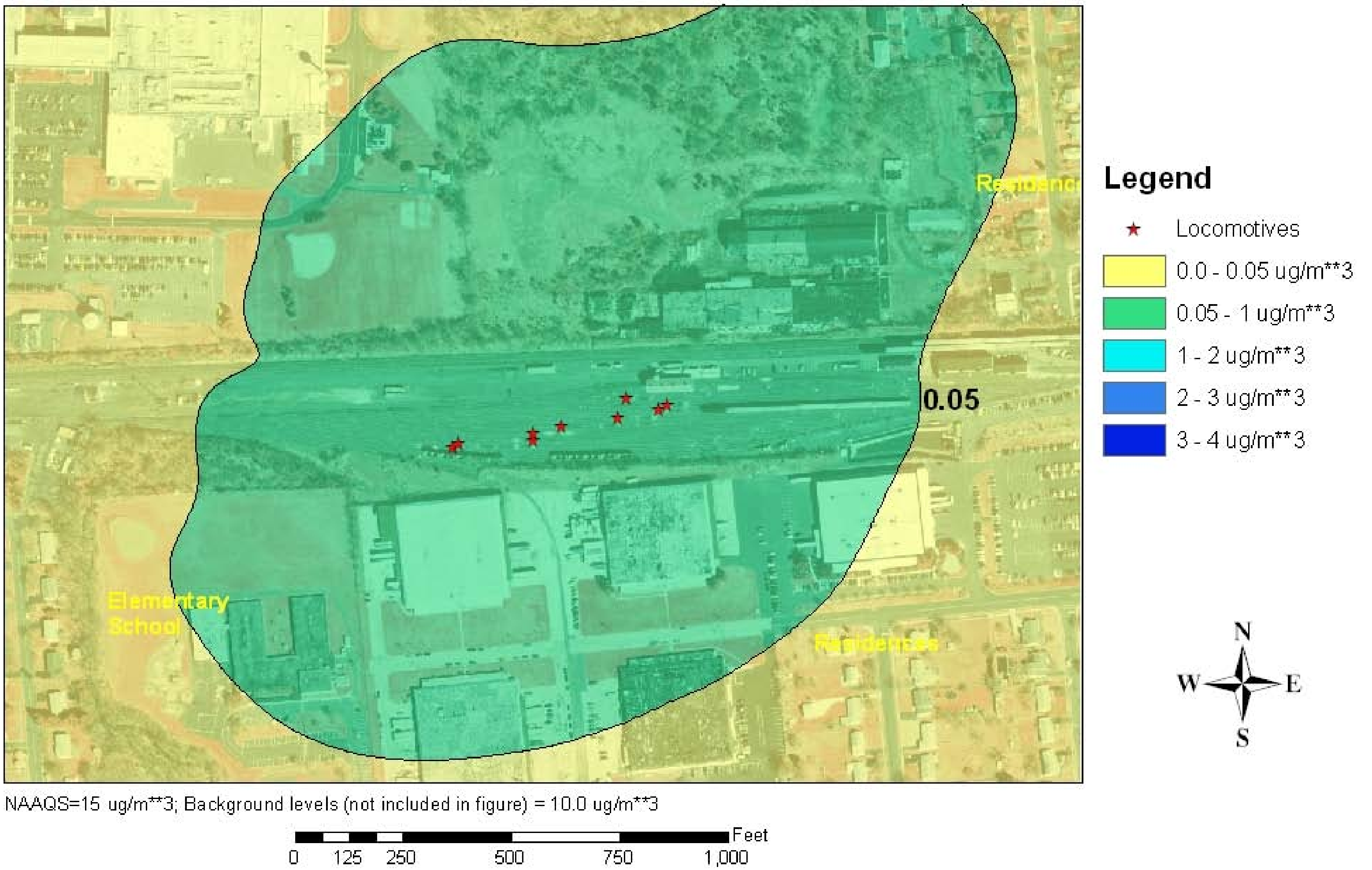
- ★ Locomotives
- 0.0 - 0.05 ug/m**3
- 0.05 - 1 ug/m**3
- 1 - 2 ug/m**3
- 2 - 3 ug/m**3
- 3 - 4 ug/m**3

N
W E
S

NAAQS=15 ug/m**3; Background levels (not included in figure) = 10.0 ug/m**3

Feet
0 125 250 500 750 1,000

FIGURE 2: MAXIMUM PREDICTED ANNUAL PM2.5 CONCENTRATIONS: MAXIMUM 1 HOUR IDLING WHEN TEMPERATURES ARE ABOVE 0 deg.F, BASED ON NEW IDLING PROGRAM



NAAQS=15 ug/m**3; Background levels (not included in figure) = 10.0 ug/m**3

FIGURE 3: MAXIMUM PREDICTED 24-HOUR PM2.5 CONCENTRATIONS FOLLOWING THE IMPLEMENTATION OF NEW IDLING PROGRAM (EFFECTIVE DECEMBER 2007) WHEN TEMPERATURE IS ABOVE 0 deg.F

NAAQS= 35 ug/m**3; Background levels (not included in figure) = 30.3 ug/m**3

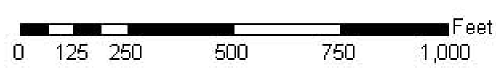
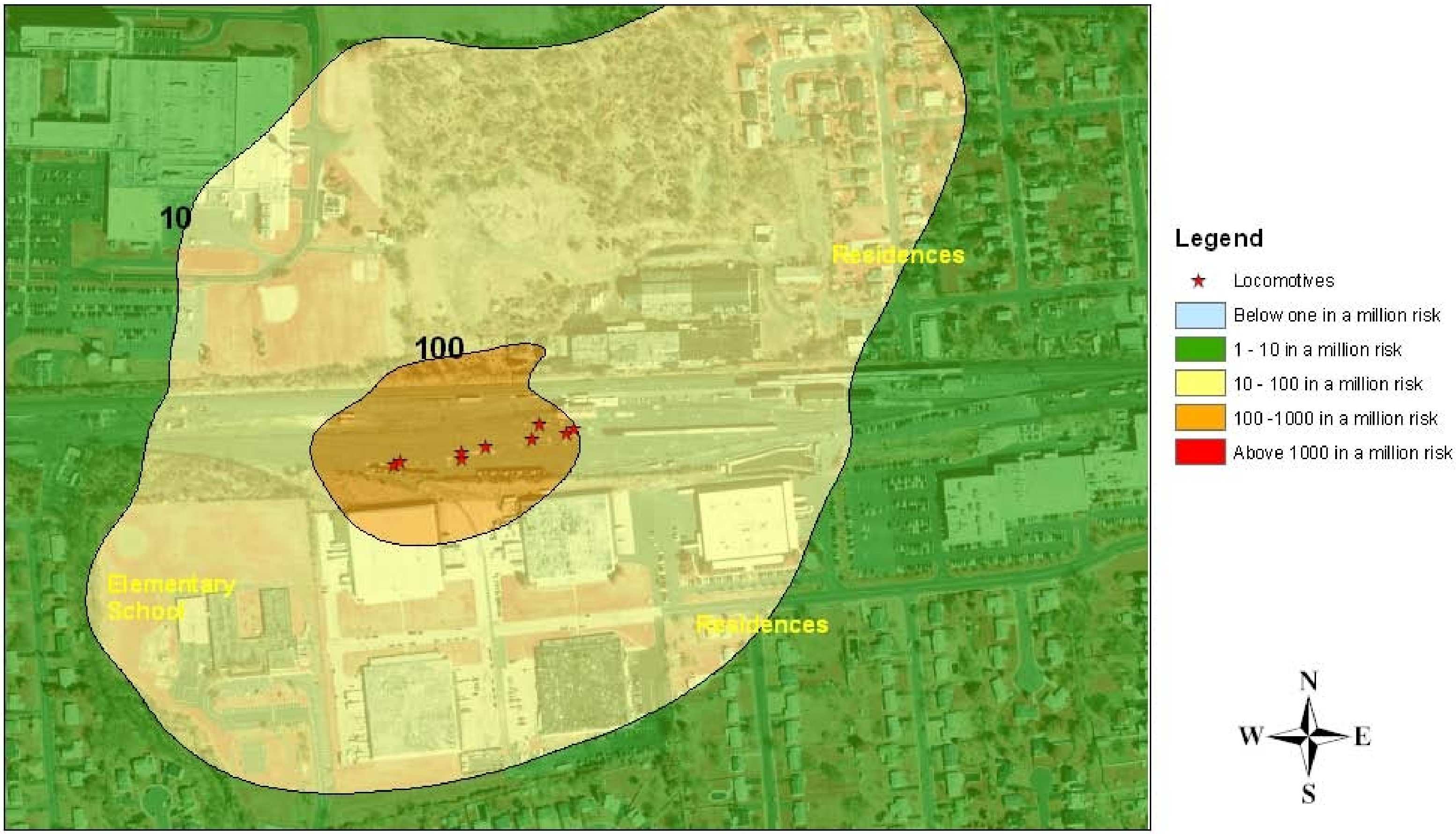


FIGURE 4: MAXIMUM PREDICTED 24-HOUR PM2.5 CONCENTRATIONS- TEMPERATURE BELOW 0 deg.F

NAAQS= 35 ug/m**3; Background levels (not included in figure) = 30.3 ug/m**3

Feet
0 125 250 500 750 1,000

FIGURE 5: MAXIMUM PREDICTED 70-YEAR CANCER RISK (using California factors) BASED ON NEW IDLING MINIMIZATION PROGRAM



Note: Exposures at the Elementary School are expected to be less than a life time and so the risk will be less (see text for further explanation).

No background values included in this figure

Feet
0 125 250 500 750 1,000