AIR QUALITY IMPACT SIMULATION DUE TO ROAD NOISE BARRIERS ON THE NEIGHBOURHOOD

The study of the impact of a new or existing roads on the environment in its totality : noise, atmospheric pollution, smoke & fire in case of accident, has become a requirement of the day. Any pollution impact mitigation solution must work on all of them simultaneously.

In the Blanc-Mesnil region, North of Paris, the proposal to install noise barriers on the junction of the highway A1 and the national road RN2 (Lindbergh Bridge) until the Descartes Bridge may have resulted in a sharp rise of the noise and atmospheric pollution. Moreover, the proposed addition of another traffic lane on the highway also increases the traffic significantly thereby requiring the analysis of air quality, noise and fire hazard simultaneously. Thus in 1999, Fluidyn, an engineering firm and developer of Fluidyn-PANROAD, a 3D Fluid Mechanics simulation software for Roads' Environment and Safety was asked by the government to conduct the mathematical modelling.

The proposed infrastructure modifications included addition of lanes as well as designing noise propagation barriers such that they do not block the pollution in general and smoke dispersion in case of fire . The simulation was done for following scenarios:

- The impact of the Highway A1 in 1999 as a reference state,
- The impact in 2015 *if no* modifications are done from the reference state,
- The impact in 2015 *taking into the account* the proposed modifications (future state).

On a very complex urban topography and an altitude variation from 42m to 80m, the emission sources and the weather conditions were taken into account to simulate the dispersion of pollutants in the atmosphere in the presence of various designs of noise barriers. Following pollutants dispersion was simulated: NO_2, CO, PM, C_6H_6, SO_2, Pb from 1000 vehicles/hour.

The buildings near the highway, acoustic barriers; the vegetation, the road network which may influence the wind fields (figure 1) are taken into account in a 3D model. Since the calculation is 3-dimensional, the wind field conditions vary with the altitude and are influenced by the topographical features and the temperature of the ground e.g. roads, building, urban areas, wooded areas…The emission of various pollutants is evaluated from the official tally of vehicles for two scenarios: annual mean daily traffic and a peak-congested traffic. For the peak condition, the chosen wind velocity was 0.5m/sec at the ground level with the road T° raised by 2°C.

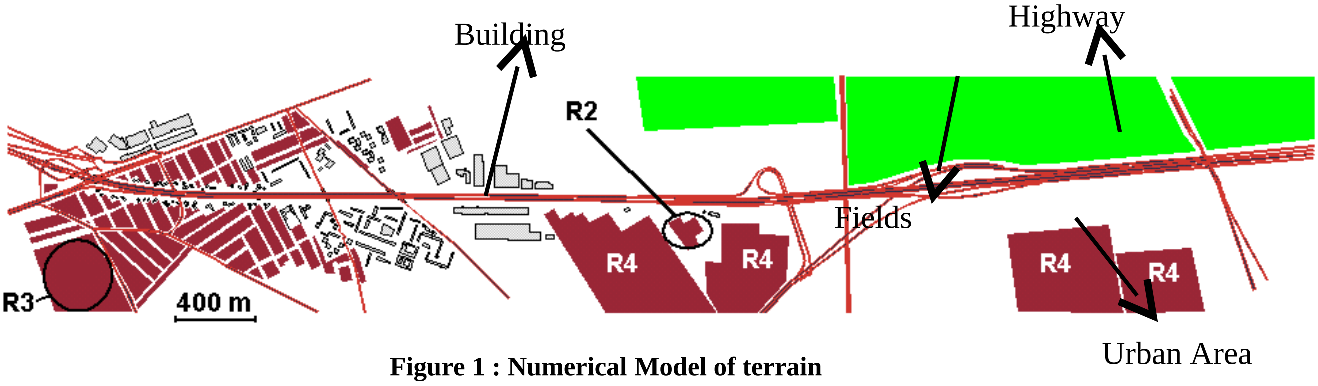


Figure 1 : Numerical Model of terrain

Noise barriers design was optimised according to the presence of schools, hospitals and housing on both sides of the road while keeping in mind the air flow conditions. Various designs were tested and finally 3 different designs were retained and used according to the neighbourhood: partial cap barrier, half cover in both directions of the traffic, total cover on only one side of the traffic.

Interesting results obtained were the concentrations in µg/m^3 at a height of 1.5 meters (human height) for each of the 3 scenarios (1999, 2015 with and without optimised noise barriers) and for each pollutant studied. The highest concentration of pollutants for 1999 and 2015 without any changes is found on the highway itself due to the existence of slopes on both shoulders of the highway resulting in the retention of the pollutants on the road.

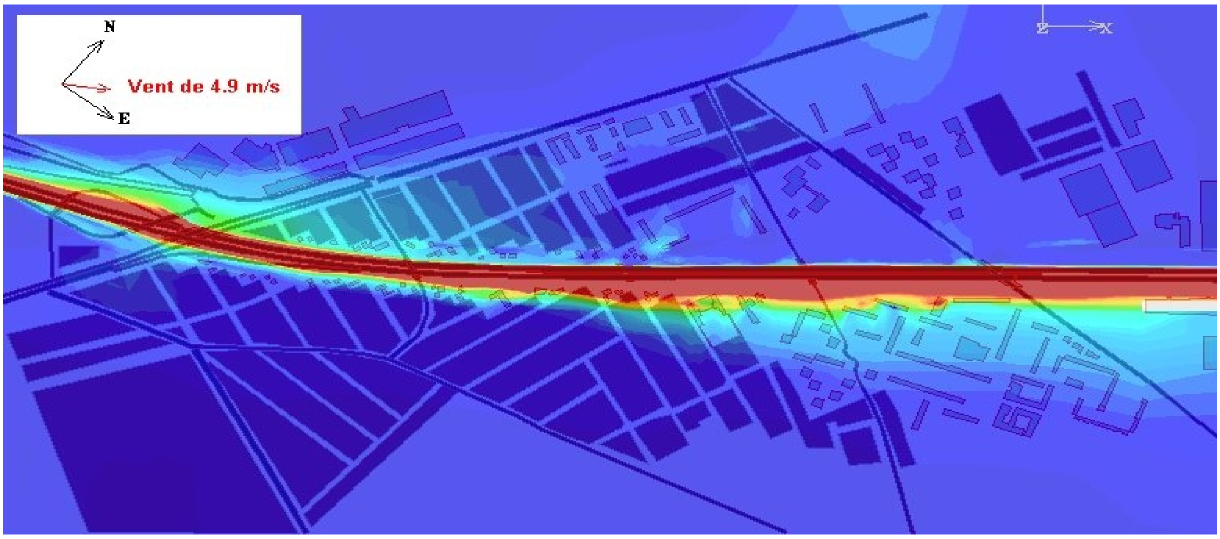
For 2015, with the Noise barriers, the pollutants are retained on the highway. Though the vehicular movement and wind velocity have a more significant channelling effect. The effect of the road temperature also becomes more significant as barriers act as chimney. Thus we have higher pollution concentration on the highway and on the areas downwind and less pollutant concentration on immediate neighbourhood of the noise barrier. Each kind of noise barrier with a different impact profile is tested in the model decreasing the pollution impact on the inhabited areas and carrying it forward to un-inhabited areas.

The high pollutant concentration observed in the reference situation -horizon 1999, shows an excedency in the air quality objectives for PM10 as well as NO2 in residential areas and in school grounds. The simulation for 2015, without noise barriers, shows an improvement in the pollutant concentration by the reduced emissions expected at that horizon even if the objectives of the air quality are still exceeded.

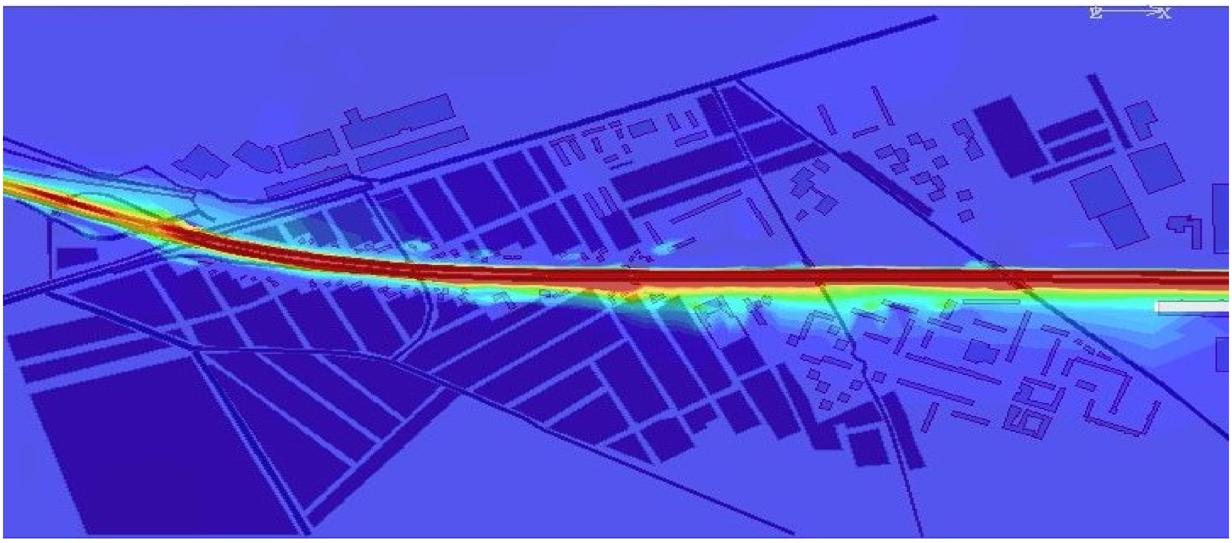
The addition of the noise barriers as designed, partial covering and canalising the strong concentrations on the highway A1, improves the air quality in the neighbourhood. No excess in the air quality objectives have been observed apart from on the highway A1 itself.

Following pictures show the noise barrier in use now since 2004.

Scenario 1999



Scenario 2015 without infrastructure modification



Horizon 2015 with modification

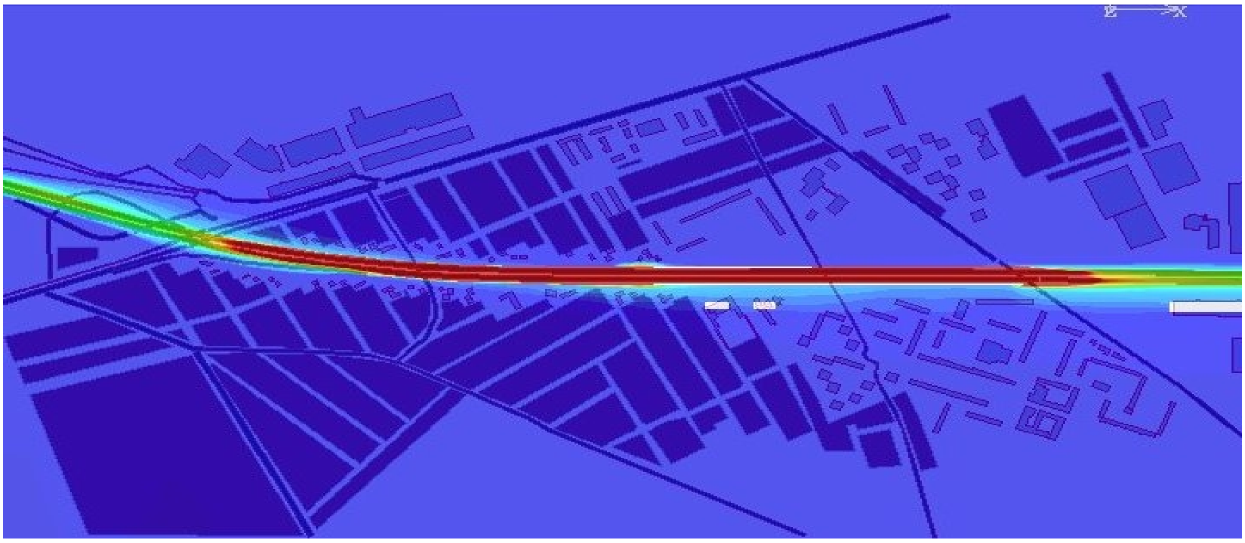
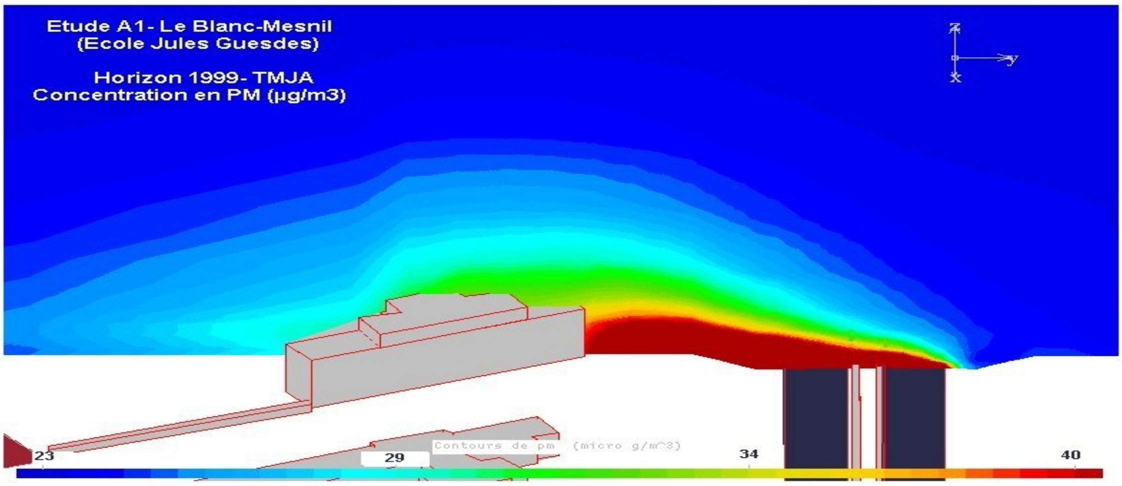
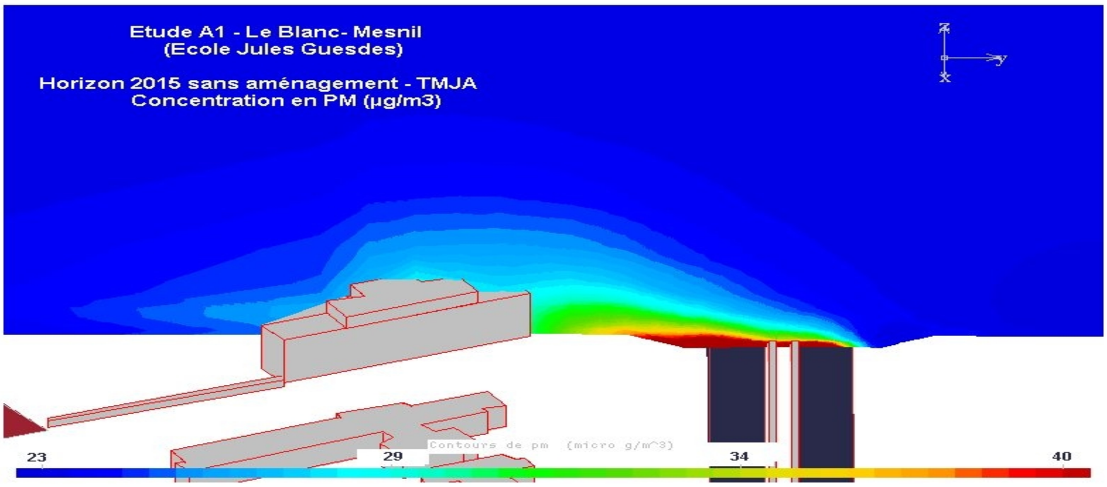


Figure 3 : PM10 concentration in µg/m^3 at h=1.5 m. in average conditions

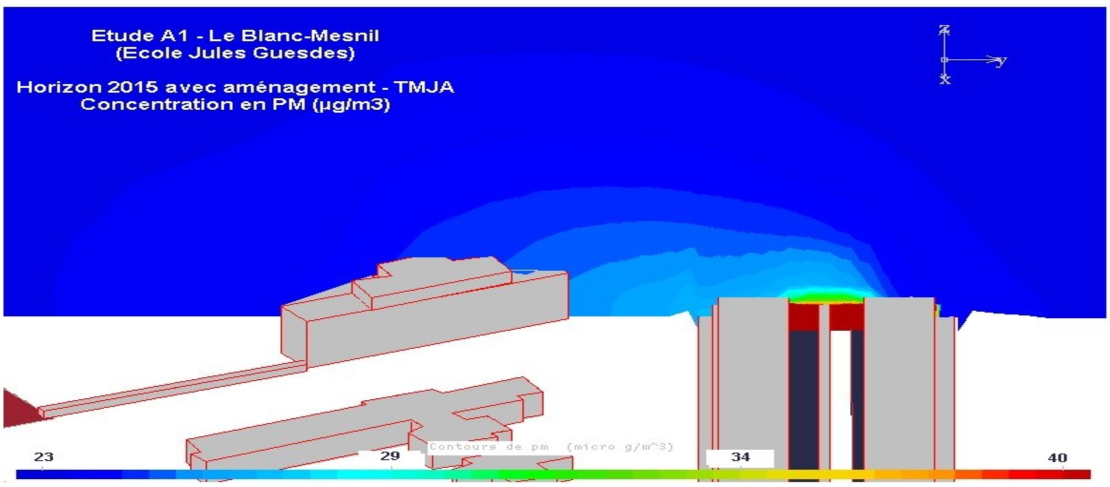
Scenario 1999



2015 without bariiers



2015 with modifications



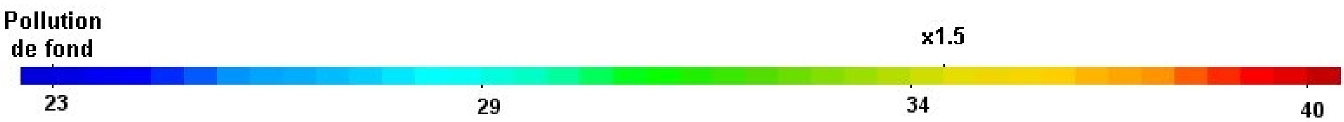


Figure 4 : PM10 concentration in µg/m^3 at the right of the school Jules Guesdes in average conditions