A Perspective on O'Hare Airport vs. Peotone (proposed) Airport Pollution Impact

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Executive Summary

Pollutants emitted from sources associated with O'Hare Airport operations are shown to have considerably larger population impacts than would be the case if the same pollutants were emitted at (relocated to) the proposed airport at Peotone, south of Chicago, due to a number of factors.

One significant factor is that the population densities surrounding Peotone are substantially less than those around O'Hare, in many cases by almost 10:1 less. Any pollutants will obviously impact fewer people in this lower density environment.

Another factor is that wind directions other than from a small (SW to SE) quadrant tend to direct Peotone sourced pollutant flow towards areas of very small population densities whereas O'Hare's flow is to relatively high population density areas no matter which way the wind blows.

As a result of these considerations, using approximate geographical models, it is shown that pollutant emissions from O'Hare will impact or significantly impact about *4 million more people* than if the same air operations were placed at Peotone.

Additionally, population impacts of dangerous secondarily formed pollutants such as ozone and NO2 are demonstrated to be substantially less with emissions from Peotone instead of O'Hare, affecting some *450,000 – 850,000 more people* (1-2mph summer winds) at O'Hare than at Peotone.

Introduction

Approximate geographical models of surrounding population densities are created for both airports as shown in figures 1 and 2. It is assumed that pollution effects extend out to a 30-mile radius from the airports. Though it is known that winds can carry pollutants for many tens or even hundreds of miles (especially fine particulate matter i.e. "PM2.5"), both increased volumetric dispersion and small population densities beyond 30 miles makes the approximation appropriate to the estimate goal here.

Numbers of affected populations are simply calculated from the assumed population distributions and compared. A refinement is made for "significantly affected" as compared to "affected". Additional commentary is then provided relative to meteorological effects and secondarily formed pollutants such as ozone and nitrous oxides.

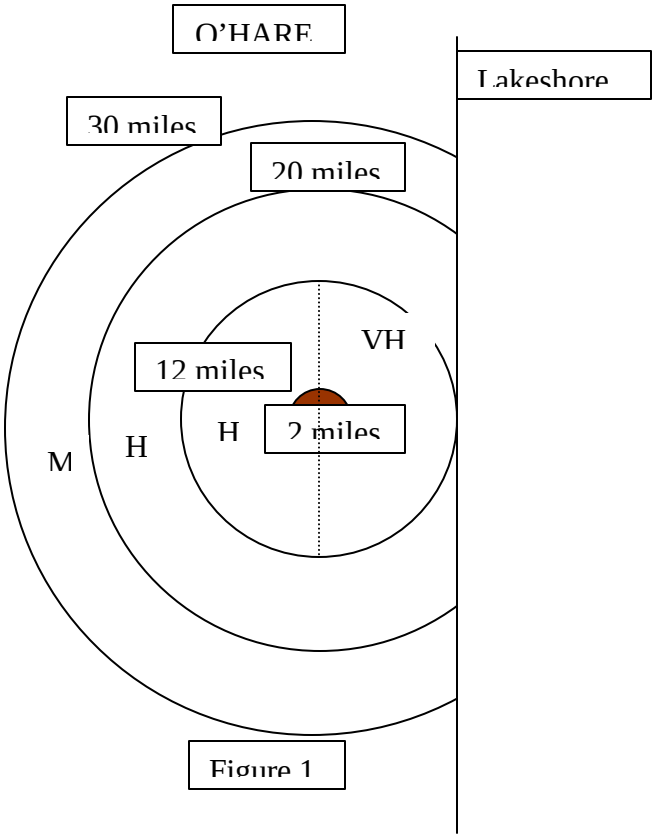

Figure 1

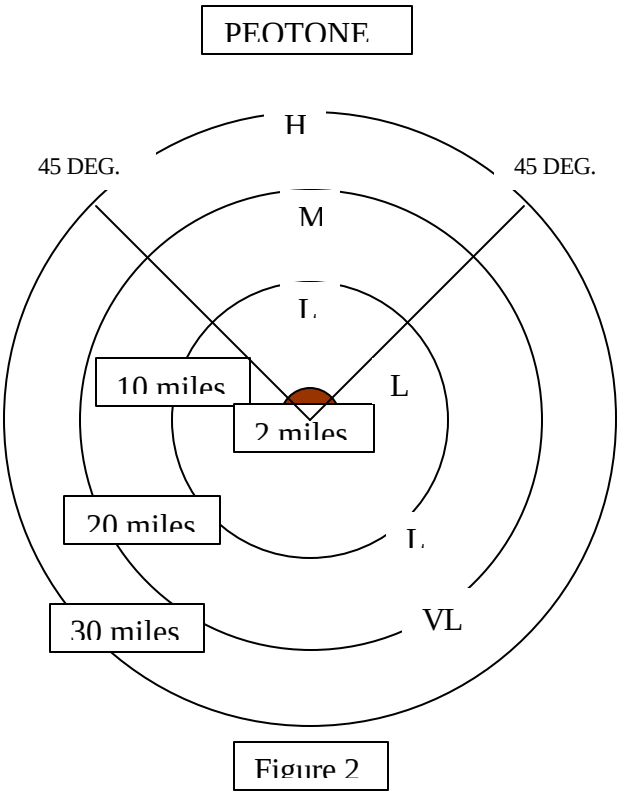

Figure 2

NOTES
* Distances represent radius from airport center (miles), with airport radius = 2 miles.
* VL, L, M, H and VH represent areas of low, medium, high and very high population densities.

CALCULATIONS

Population densities in the Chicagoland area run to below 1000/sq.mi. to as high as around 15,000/sq.mi. Let VL=500, L=1000, M=2300, H=4000 and VH=10,000.

Assume that the lakeshore eliminates 1/4 of the third outward radius area for O'Hare and 1/5 of the fourth radius area. For Peotone, the upper segments are 1/4 of the total radial areas.

Then the total population affected in the O'Hare case is:
P= [(pi*12*12)/2-(pi*2*2/2)]*(10,000+4000)+pi*(20*20-12*12)*3/4*4000+pi*(30*30-20*20)*4/5*2300
= 3,078,768 +2,412,748 +2,890,272 =**8,381,788** people.

The total affected population for Peotone is:
P= pi*(10*10-2*2)*1000 + pi*(20*20-10*10)*3/4*1000 +pi*(30*30-20*20)*3/4*500
+pi*(20*20-10*10)*1/4*2300 + pi*(30*30-20*20)*1/4*4000
=301,593+706,860+589,050+541,926+1,570,800 =**3,710,229** people.

Thus, pollution from O'Hare affects 126% or 4,671,559 more people than pollution from Peotone, assuming winds blow generally in all directions for equal amounts of time/speed throughout the year.

SECOND LOOK

The initial calculation of estimated number of people affected by airport pollution is most representative of short-term pollution peaks i.e. for periods of hours or a few days rather than for long-term average levels (e.g. a year). This is because no discrimination was made for the time averaging of the wind directions over greater areas at greater distances.

Taking this into account essentially brings into consideration the concept of "degree of affect", with a lessening degree (again for longer term averages only) for greater distances from the pollution source. This interpretation complicates the issue in that it requires some criteria to be associated with "affected", beyond that of simple pollutant presence or not (i.e. the peak interpretation again).

The average degree of affect, due strictly to wind direction variance over the year, would result in a decrease in pollutant concentration proportional to distance from the source. At larger distances e.g. 10X airport pollution source diameter, the fall off of concentration might be expected to be more proportional to the square of the distance from the source.

An additional concentration spreading affect would be vertical winds, which would increase pollutant mixing throughout a larger vertical air layer, which in turn reduces the average ground level concentration. The impact of mixing would tend to increase with distance for relatively stable meteorological conditions. Such stable conditions would tend to correspond, for example, to overcast but not stormy summer days, calm winter days, sunny or not, and evenings in general. Very unstable conditions, such as encountered on hot, sunny, summer days, can result in tremendous pockets of strong, vertical winds (both up and down) and, therefore, a statement cannot be made about pollutant concentration variation with distance under these near-stormy conditions.

Detailed analysis of these effects is beyond the scope of this discussion. As an approximation of the impact, an attempt to differentiate between those "significantly affected" and those "affected" is made by assuming that a difference between the two categories would be represented by a factor of 10 change in pollutant concentration. The more conservative view of a concentration fall-off proportional to the square of the distance is chosen. The outer population band is eliminated for both the O'Hare and Peotone cases, based on the observation that the square of its nominal distance, 25 miles, as compared to the square of the nominal distance of the inner band, approximately 7 miles, represents a factor exceeding 10:1.

For the **O'Hare** model, the outer band (20-30 miles radius) represents 2,890,272 affected people. Thus, the totals become **8,381,788 affected** people with **5,491,516 significantly affected**.

For the **Peotone** model, the outer band represents 589,050+1,570,800 =2,159,850 people. Thus, the totals become **3,710,229** people affected with **1,550,379 significantly affected**.

FINAL CONSIDERATIONS

It is noted that some pollution concentrations, such as ozone and nitrogen dioxide (NO2 from oxidation of NO) tend to reach maximum levels at some distance from the airport source, as they are primarily produced secondarily due to solar interactions and/or interactions with other ambient chemicals. These important and often dangerous pollutants need some amount of formulation time, which translates to distance, given a finite wind speed. Ozone forms primarily during the noon-to-6PM time frame during summer months, with formulation rates affected by the presence of other chemicals (generally, more ozone forms when greater amounts of other chemicals from other pollution sources are present).

Thus, substantially lesser amounts of ozone and NO2 will be formed from a given amount of pollutant emissions from Peotone as compared to O'Hare, due to the initially much lower levels of ambient air pollutants surrounding Peotone than O'Hare. In other words, these secondarily formed pollutants, such as ozone and NO2, experience a compounding effect (exponential?) when they result from O'Hare emissions as compared to Peotone due to the already high levels of chemical compounds present in the atmosphere that the ozone/NO2 constituents are injected into.

There can also be a significant difference in solarization effects between the two locations, favoring much reduced ozone formation from Peotone emissions. This is due to synchronization effects of emission timing, wind speeds and solarization timing.

For example, worse case ozone conditions generally arise in mid-summer, on hot days with minimal wind speeds, allowing critical pollutant "build-ups" in advance of high solarization levels. Assume airport emissions occur evenly from 7AM to 10PM, wind speed is a low 1mph with maximum solar intensity between 12 noon and 5PM. It can be seen that by 12 noon, airport emissions (front) have traveled only 5 miles distant and that by 5PM, the emissions front has progressed only 10 miles from the airport. Ozone formation will be concentrated within this 0-10 mile distance, with generally decreasing concentration over that distance, all other things constant.

Assuming the light winds randomly shift direction over about a 90 degree range (e.g. SW to SE) the number of significantly ozone-affected people can be estimated as those within the 10 mile long "wedge" nearest the airport. The area of this wedge is approximately A=pi/4*(D^2-4)=75 sq. mi. for D=10 miles.

For O'Hare, this will amount to about 75*(10,000+4000)/2=525,000 people. For Peotone, the number is about 75*1000=75,000 people. Thus, an estimated 450,000 more people will be significantly affected by ozone from O'Hare emissions as compared to Peotone emissions, if the concentration of other chemicals in the atmosphere is the same for each, which is obviously not the case. Thus, on a apples-to-apples basis, Peotone's ozone affected number would most likely be substantially less than 75,000 while O'Hare's number might be even greater than 525,000.

With a 2 mph wind, an additional ozone area is added equivalent to about A2=pi/4*(20^2-10^2)=235 sq. mi. In O'Hare's case, this adds an additional 235*4000=940,000 people for a total ozone impacted people count of about 940,000+525,000=1,465,000 people. The same conditions at Peotone result in an additional 235*2300=540,500 impacted people for a total 540,000+75,000=615,500 people. [Once again, the Peotone figure is most likely considerably lower due to much reduced ambient air other chemical concentrations as compared to O'Hare.]

Finally, sea-breeze affects ("lake-breeze" in this case) can substantially elevate atmospheric pollutant concentrations in locales between the source and the lakeshore. The Peotone location will be much less prone to these concentration effects due to its greater distance to the lakeshore. To illustrate, a sea-breeze frontal zone that approaches to within 2 miles of O'Hare will still be about 20 miles away from Peotone, allowing greater pollutant dispersion there before entering the front. Also, most fronts that move west well beyond O'Hare will still not reach Peotone, dramatically influencing pollutant distribution differences.

If the prevailing wind speed is 1 or 2 mph, then Peotone ozone formation out to 10 or 20 miles between 7AM and 5PM will start to rapidly reduce in concentration before it reaches any sea-breeze front penetration short of about 20 or 10 miles, whereas O'Hare ozone will be strongly into the circulating sea-breeze zones in both cases.

SUMMARY

AIRPORT	# AFFECTED PEOPLE	# SIGNIFICANTLY AFFECTED PEOPLE	AFFECTED PEOPLE RATIO	SIGNIFICANTLY AFFECTED PEOPLE RATIO
O'HARE	**8,381,788**	**5,491,516**	--	--
PEOTONE	**3,710,229**	**1,550,379**	--	--
O'HARE vs. PEOTONE	**+4,671,559**	**+3,941,137**	**2.26**	**3.54**
O'HARE vs. PEOTONE ozone (1mph)	525,000 Vs. 75,000	**+450,000**	--	**7.0**
O'HARE vs. PEOTONE ozone (2mph)	1,465,000 Vs. 615,000	**+849,500**	--	**2.4**

CONCLUSIONS

Given the simplifying assumptions here, it is seen that about 4 million more people are affected or significantly affected by overall pollution emanating from O'Hare as compared to the same pollution source being placed at the proposed Peotone airport.

Ozone affected people counts vary with wind speed, with about 450,000 more significantly affected with a 1mph wind, increased to about 850,000 more for a 2 mph wind, at O'Hare vs. Peotone. [Note that increasingly higher wind speeds will at some point result in decreased ozone formation due to pollutant precursor dispersion with resultant concentration reductions.] Ozone and NO2 concentration effects from circulating lake-breeze zones are greatly reduced at the Peotone location.

END NOTE

Population density of various towns/cities.

City	Density
Cicero	14,644
Berwyn	13,875
Chicago	12,749
Oak Park	11,172
Evanston	9583
Oak Lawn	6427
Skokie	6308
Mt. Prospect	5513
Palatine	5047
Wheaton	4938
Arl. Hts.	4633
DesPlaines	4071
Schaum.	3967
Elgin	3779
Aurora	3711
Naperville	3628
Joliet	2791
Orland Pk.	2668

POPULATION DENSITIES
O'HARE and PEOTONE AIRPORTS VICINITY

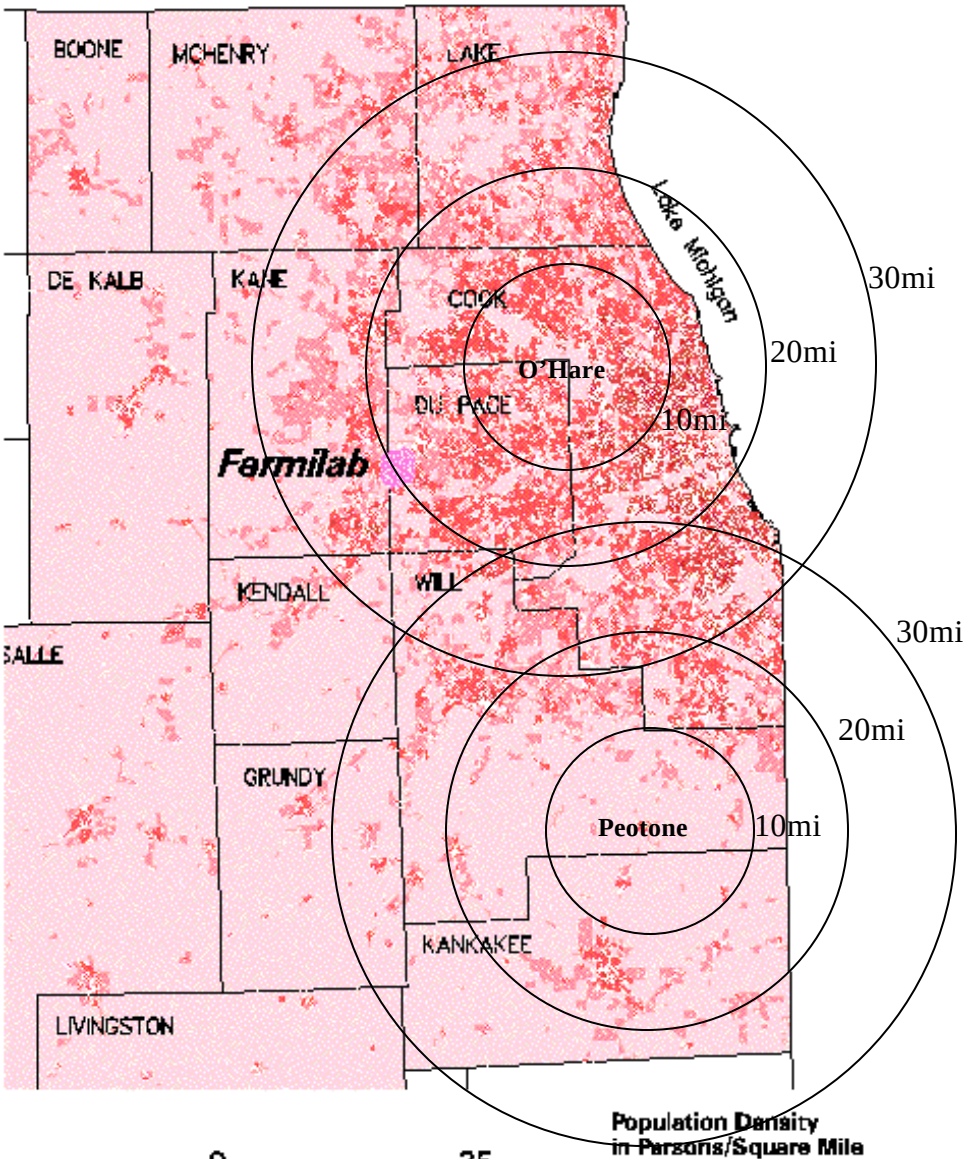

Figure 2
Population Density

(ISGS)