

Noise Impacts of Landfills and Surface Mines Turned into Landfills

Extended Abstract # 183

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INTRODUCTION

Maryland must have been underwater thousands of years ago. Just about 10-ft below the surface of several counties there lays a mixture of sand and gravel, just perfect for mining. Companies purchase the land, mine the product from about 10-ft to 30-ft deep, and “reclaim” the land. The reclamation is in the form of a sanitary or rubble fills or, frequently, as a lake, used to attract developers to build instant “waterfront” homes.

The noise from the mining process is in several phases:

- the removal and storage of topsoil, the building of a berm (if necessary)
- the removal of product, the transportation of the product to a wash plant (on- or off-site), the storage of the product, and the reclamation of the site
- when the reclamation is a landfill, the continuous operation of that process (until capacity is reached.)

So noise may continue from initial groundbreaking until capacity is reached, anywhere from five to 20-years.

This paper presents approaches to evaluate the property line noise limits, and abatement approaches, of construction and operation of a project that starts off as a surface mine and ends up a landfill. The procedures to analyze the operations, determine emission noise levels, and estimate property line sound pressure levels are also be discussed along with issues as to metric used, approach to propagation (not in the biblical sense) of noise, and abatement techniques.

STUDY

Noise Emission

Land preparation starts with an excavator, a front end loader, a bulldozer, and an off-road or on-road haul truck. The top soil is partially removed and the earth below is either removed or is used to build a berm. The excavator and the dozer, front end loader, and truck may work together, although often it is excavator and truck. As the site is mined, these pieces of equipment may be joined by other similar pieces. So it is important to know noise output (emission) from these pieces.

The noise output is a function of horsepower, engine rpm, loading, and work cycle. Often this is, at best, variable and at worst, unknown. The total emission is a function of several pieces of equipment. The only way to get this quantitative information is to measure the sound pressure level at a point and determine

emission (in terms of sound power level) based on propagation.

The work cycle is not standard. Front-end loader, dozer, or even excavator, may move anywhere around the site. As the operation is commencing with all four basic pieces of equipment operating simultaneously¹, we measure and log the sound at a distance of about² 100- to 150-ft. The space between the microphone and the cluster of equipment is usually cleared and hard (acoustically reflective) ground. We measure in octave bands in 1-sec intervals and record Lmax and Lmin (both on fast and slow response), and Leq. The end result is a sound level history as a set of spectra (max, min, Leq) every second versus time. How this is used depends on the metric needed.

From the sound pressure history, and an assumption of a fixed distance between source and microphone, the sound power spectra is calculated based on

$$L_w = L_p + 10 \times \log (R^2) + K$$

Where L_w = sound power by frequency and A- and Z-weighted. (dB re 10^{-12} W)

L_p = measured sound pressure by frequency and A- and Z-weighted. (dB re 20×10^{-6} Pa)

R = distance from microphone to assumed acoustic center of cluster of equipment. (ft or m)

K = constant that depends on SI or Imperial units, on ground effects, etc.

Knowing sound power, the noise emission can be used to determine noise immission at any point based on propagation.

Noise Propagation

Propagation, the path of sound from one location to another is somewhat controversial. Basic theory assumes ideal small or large sources, and the effects of ground absorption, wind, thermal gradients, foliage, and barriers are not well defined. Nevertheless, standards for propagation exist. Internationally, the most common model is ISO 9613-2 “Acoustics-Attenuation of sound during propagation outdoor-Part 2: general method of Calculation” and many countries have their own national standards. Recently, Canada adopted ISO 9613-2 as their national standard. The United States has no standard and the most commonly used standard is for vehicle noise, the controversial “Traffic Noise Model” produced by The US Department of Transportation. Further, many consultants in the USA have their own approach, not standardized at all. One program, “Environmental Noise Model,” from RTA Technologies, uses algorithms that seem to work but are not necessarily based on a standard.

We use CadnaA³, a popular program that meets ISO 9613-2 exactly. Saying that, the tasks of modeling is not that simple. Files with ground elevation contours, buildings, and perhaps vegetation need to be imported. Ground absorption, foliage effects, etc., must be estimated as inputs to the program. And we know little about temperature inversions, wind velocity at elevation, and exact position of sources. So there is uncertainty in the modeling too.

Noise Immission

¹ This is the worst case.

² We say “about” because the distance from the microphone to the source changes significantly, with one moving source and especially with several moving sources. The reality is that the distance is not well-defined and a source of uncertainty.

³ Developed by DataKustik, Gewerbering 5, Greifenberg 86926, Germany

The noise at the receiver, what he or she receives, is the immission. Normally, depending on code requirements, the not-to-exceed sound level limits are found at the property line of the mine/landfill or at the property line of the receiving land, or at the façade of the nearest habitable building. Often it depends on local zoning and time of day.

At times, the receiver height above the ground is specified but if not, a choice of receiver heights, at the same location at the property, will significantly change results because barrier noise reduction effects are reduced as receiver height is increased.

Metrics

The code determines the metric needed, if indeed the code is sufficiently explicit. Often it is not. It might say “sound level cannot exceed 55 dBA.” This is vague and really unenforceable. But in Maryland, at least for the state code,⁴ the requirements are Maximum⁵ A-weighted Sound Levels, specified based on zone and time of day. So, this determines how we interpret measured data. We do it in steps:

1. We conservatively estimate distance from the microphone to the equipment cluster. That is, we take the furthest approximate distance.
2. We plot maximum FAST A-weighted sound pressure level versus time and found highest point.
3. That point in time corresponds to a spectrum that produced that maximum level.
4. That spectrum is used for maximum sound power determination. This is the sound power input to the model.

Noise Abatement

The computer model input shows elevations at the source, at the receiver, and all intervening points. Noise attenuation is mostly due to distance, to barriers produced by hills, to barriers produced by specially constructed berms, and to other minor factors, like sound absorption. Figure 1 shows an example of the first lift of a landfill. Ground contours are shown. The next lift is started by placing a perimeter berm (barrier) at the start of the lift to reduce the noise. The computer program uses the sound power of the sources, the barrier effects of the ground contours, and algorithms of all other attenuations to calculate sound levels at receivers based on the height of the berm⁶. Figure 2 shows a noise map, the appearance of which can be represented as equal level sound contours, etc., and the distribution of sound. The immissions at the closest receivers exceeds the code and hence a barrier of sufficient height must be built to attenuate the sound sufficiently.

⁴ Code of Maryland, Title 26

⁵ Surprisingly, the Code does not state “fast” or “slow” response but to be conservative, the fast response is used.

⁶ In Maryland, noise produced by constructing the berm is exempt from the noise requirements.

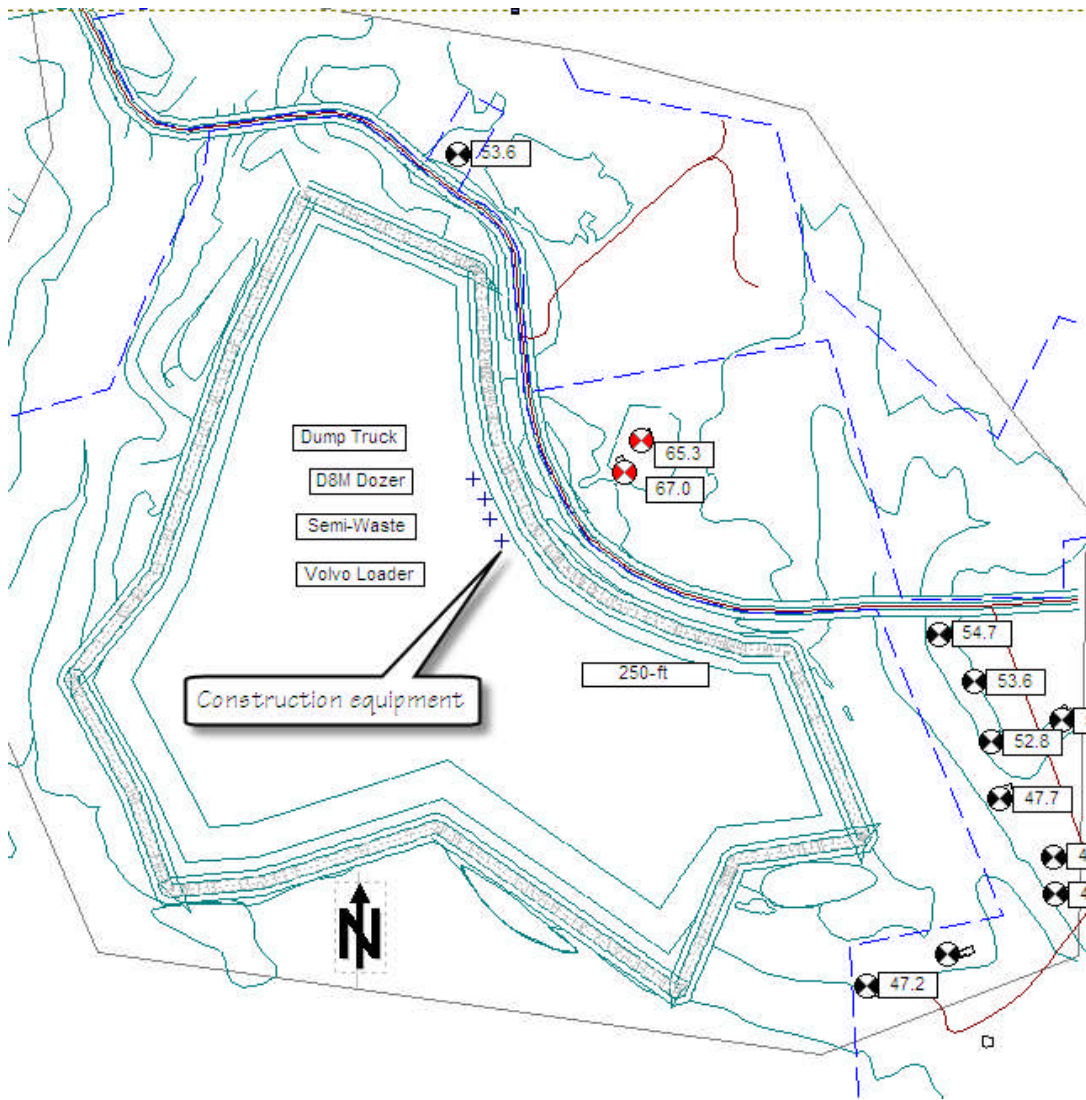


Figure 1 Beginning of a landfill with receiver immission limits

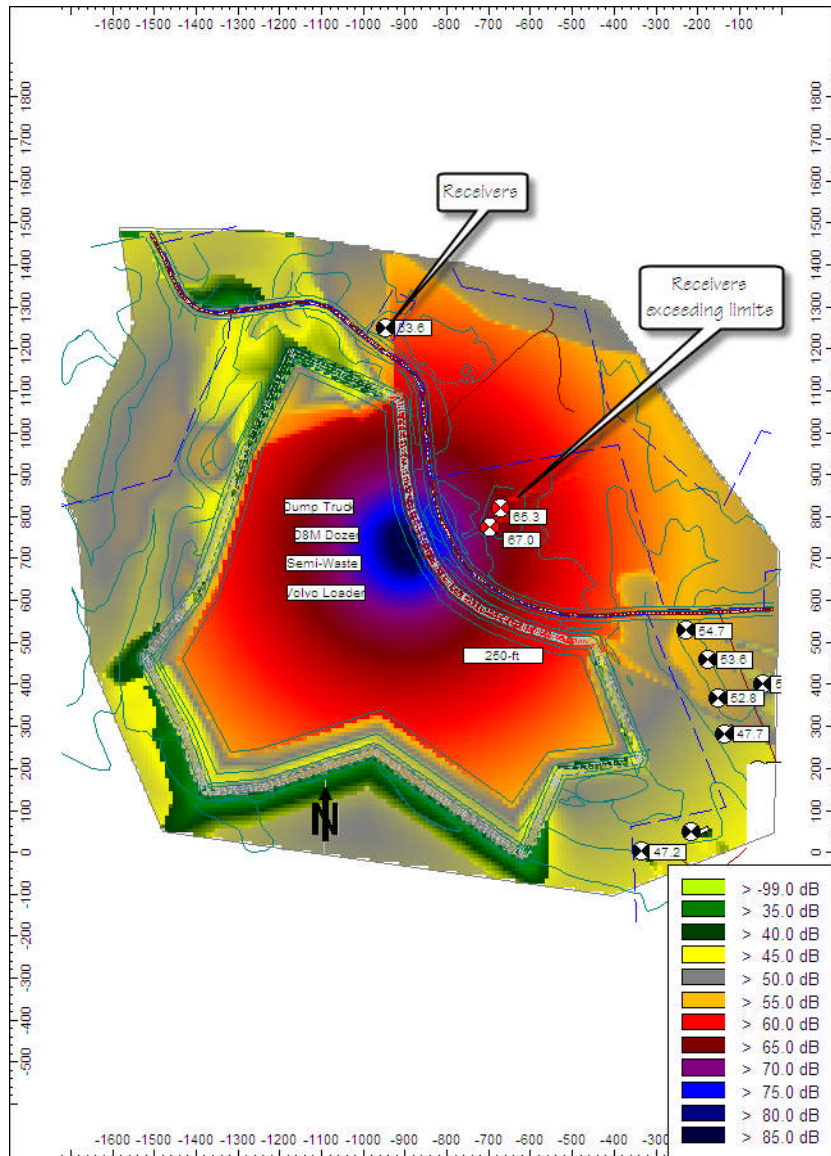


Figure 2 Sound map of the site and nearby residents

SUMMARY

With modern sophisticated software, the acoustical environment of mining operation and subsequent landfill development, at each elevation, can be easily calculated and displayed. Our experiences have been that when neighborhood residents see that the estimated levels will meet code, they are comfortable. However, we tell residents at hearings that, in spite of this model, with the many uncertainties that go into the algorithms, the noise limits must be met: it is the law. This implies that the model does not really control, actual noise levels do, and it makes them less wary of the modeling procedure.

KEY WORDS:

Landfill, noise estimation, sound power, uncertainties