Long-Term Environmental Management at School and Daycare Sites

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Educational facilities, more than any other single land use, inspire public concern over exposure to hazardous substances. Yet from California to the New York islands, new schools and daycare centers are being constructed on or near toxic sites while more and more existing schools have been found to be threatened by existing toxic plumes. The technologies exist to eliminate toxic pathways—such as vapor intrusion—but strategies are only beginning to emerge to ensure that those technologies remain protective for the life of the underlying contamination. Particularly at schools or school sites with known or potential vapor intrusion, comprehensive site management plans are necessary to ensure that students and other building occupants are protected from toxic exposure.

The reasons for the focus on school and daycare exposures are somewhat obvious:

- Children are not only physically more vulnerable to toxic exposures than adults, but as a society we place a priority upon protecting them.
- We tend to view schools as a sanctuary from violence, poverty, natural disasters, and hazardous environmental conditions.
- School attendance is obligatory.
- Most schools are publicly owned.
- While some people try to ignore or even cover up toxic exposures to try to protect their property values, the sale price of a school is irrelevant.

Recently Opened Showcase Campus in the Bronx, New York

Why Toxic School Sites?

It is remarkable, therefore, that there are so many toxic Kindergarten-12th Grade (K-12) schools. There are numerous reasons:

First and foremost, in established metropolitan areas, such as New York City and Los Angeles, most parcels of vacant or underutilized land large enough to support new school campuses are former industrial properties. In the late 1990s Los Angeles sited its Belmont Learning Complex on a contaminated oilfield. New York recently currently completed the Mott Haven campus on a former railyard. Alvarez High School in Providence, Rhode Island, was built on the former Gorham Silver manufacturing plant.

Second, in some locations industries have donated un-needed portions of their properties to local school districts. In 1946, FMC sold 20 acres adjacent to (downwind and downgradient from) its Middleport, New York pesticide plant to the Roy-Hart Middle and High Schools for a dollar.

Monitoring Wells on the Roy-Hart Campus, Middleport, New York

Third, there are sites where school builders simply ignore or downplay the environmental risks. The private St. Croix Preparatory School in Stillwater, Minnesota was constructed above a Superfund toxic plume. While the current risk is likely low, other open land, away from the plume, is available in the area.

The tendency to build new schools on contaminated sites is strengthened by typical school siting policies. Sites are usually selected before environmental reviews are conducted.

When problems are found, site proponents are unwilling to revisit siting decisions for fear of losing construction funding.

There are also unlucky existing schools. The Atlantic Highlands Elementary School, Atlantic Highlands, New Jersey, is located across the street and downgradient from a facility—in this case, a former auto servicing shop—that discharged volatile organic compounds into the groundwater that flows under the school.

Day Care

Day care centers or nursery schools for young children are similar to schools, but they have characteristics of their own. They have received a great deal of attention in New Jersey, where a Gloucester County facility called Kiddie College slipped through the regulatory cracks and was built in a former thermometer manufacturing plant still contaminated with mercury. However, nationally they have still not received the attention that K-12 schools are finally receiving.

They should, because many daycare centers are located in industrial buildings and business parks for the convenience of parents. For example, at the former Raritan Arsenal, also in New Jersey, a daycare center was opened above a PCE plume, requiring vapor mitigation.

Furthermore, daycare centers are often built by private concerns, with no accountability to locally elected bodies. Frequently, they are small, so they lack the facilities staff and expertise usually found in public school districts. They typically lack the capability to identify potential environmental problems before construction (or leasing of existing buildings), and they generally do not have the capacity to conduct long-term management if such controls are put into place.

Dig & Haul

What all these sites have in common is that students, as well as teachers and other staff, are occupying classrooms and using athletic fields and other open spaces situated above residual contamination. In New York City schools, officials are reluctant to scrape all soil containing toxic substances above health-based standards, arguing that the contamination is “historic fill” characteristic of much of the City. Under pressure from South Bronx community, the School Construction Authority (SCA) agreed to excavate hot spots on the Mott Haven campus’ open areas, but it still is relying upon engineering controls to prevent human contact with contaminated soil and to prevent flooding and other scenarios from causing the release of, and exposure to, contamination. The SCA has installed a multi-layer cap and drainage system, supported by a Site Management Plan that includes regular inspections and a maintenance plan.

Hopefully, however, there will not be many new schools built over residual surface soil contamination. Scraping and replacing contaminated surface soil is a cost-effective way to protect students, faculty, and others, while avoiding the long-term costs and challenges of maintenance and monitoring, so dig and haul, not long-term site management, is likely to be the preferred remedy.

Vapor Intrusion

The bigger challenge, in fact, is managing sites with confirmed or potential vapor intrusion. No one has compiled a list, but I keep hearing from communities where schools exist or are proposed to be built above soil or groundwater contaminated with volatile substances. While the solvents trichloroethylene (TCE) and tetrachloroethylene (PCE) are the most common problems, volatile compounds may also include hydrocarbons such as benzene (as at the Manhattan Center for Science and Mathematics), naphthalene, and mercury (as was discovered at Kiddie Kollege).

Vapor intrusion describes the upward migration of toxic vapors from the subsurface into overlying buildings. Unless buildings have heating, ventilation, and air conditioning (HVAC) systems that maintain continuous positive air pressure, the negative air pressure in most buildings (including homes and schools) actually sucks toxic vapors from the subsurface. These chemicals are usually present in liquid form, so they move with the groundwater and are often found downgradient from the sites where they were released.

The volatile substances *partition*, slowly releasing vapors into the soil gas found between the water table and the surface. As the soil gas rises into the buildings, it *attenuates* (reduces in concentration) as it spreads out, so toxic vapor concentrations inside are typically 1/50 to 1/1000 of what can be measured in the soil. Nevertheless, if source concentrations (usually in groundwater) are high enough, vapor intrusion is a continuous completed pathway. While it is possible for schools and others to replace contaminated drinking water with bottled water or water piped in from other sources, it is impractical in most cases to provide substitute air.

Van Cleve at McGuffey School in Dayton Ohio, Closed in Part Due to Vapor Intrusion

Where volatile toxic substances are found in the shallow subsurface, the likelihood that vapor intrusion will pose a significant risk is a function of the concentration of those substances in the soil gas, the make-up of the soil, weather, and the condition of the building. Gases “find” cracks and other openings in the slab or flooring to enter a building. Reducing the concentrations of volatile substances such as TCE and PCE in groundwater is difficult, and even if possible it may take decades to achieve concentrations low enough to no longer feed vapor intrusion.

Typically, regulatory agencies require that action be taken to limit exposures where indoor air concentrations (for existing buildings, obviously) exceed a health-based standard or where soil gas concentrations exceed a multiple of those targets, based upon assumed attenuation. For existing structures, New York State applies matrices that use both indoor air and soil gas readings to determine whether action, monitoring, or no action is required.

States and EPA regions with active vapor intrusion programs use indoor air action levels on the order of micrograms per cubic meter, and those numbers may go lower—approaching “background” or outdoor air concentrations—as new toxicological research is completed.

If there is a migrating plume with higher groundwater or soil gas concentrations upgradient, then the decision to mitigate should consider those higher levels. In most cases mitigation is less expensive than the level of frequent monitoring necessary to conclude that mitigation remains unnecessary.

Vapor Mitigation

Fortunately, occupants of a threatened building may be protected through mitigation strategies such as the sealing of the slab or floor and the installation of a subslab depressurization system, or for buildings with crawlspaces, sub-membrane depressurization systems.

For existing buildings, sealing may involve the plugging of cracks, holes, and gaps with rubber or other substances that are impermeable to gas migration. For new buildings, a vapor barrier such as high-density polyethylene may be carefully laid under the building, with all perforations (for utility lines, for example) and elevator shafts sealed. Utility trenches and tunnels should also be closed off. Regulatory agencies generally consider vapor barriers helpful, but sufficiently unreliable that by themselves they are not considered adequate mitigation.

Sub-structure depressurization, based upon decades of radon gas mitigation, is considered more reliably protective. Pipes with holes are inserted into the soil and connected through manifolds to a vertical exhaust vent containing a blower fan. In existing buildings, these pipes are inserted through the slab. In new buildings, they are laid horizontally under the foundation. While such systems may incidentally ventilate toxic gases into the outdoor air, they are protective because they reduce the soil gas pressure. When the soil gas pressure is lower than the indoor air pressure, air from inside the building flows downward instead of vapor from beneath intruding into the structure.

The exact form of mitigation depends upon the construction of the building. Buildings with crawlspaces are likely to have vapor membranes under the flooring with ventilation between the membrane and the soil. Vapor intrusion may be also minimized through building design, including ventilated podium construction (with parking or other unoccupied uses on the ground floor), adjusting building footprints, and appropriate HVAC systems.

It should be recognized that mitigation cannot lower indoor air concentrations below ambient (nearby outdoor) concentrations. Since ambient levels for some chemicals, such as TCE and PCE, exceed health-based standards at many locations, that may be a reason *not* to install mitigation. On the other hand, that's a reason to seek an alternate location for the school or to address the source before construction is approved.

Elements of Long-Term Management

Vapor mitigation systems are proven to be protective, but only as long as they are functioning as designed. Thus, an integral part of mitigation is long-term management, including inspection, monitoring, operation and maintenance, contingency plans, and public notice. When schools officials in Providence and Brooklyn suggest they have addressed the potential for vapor intrusion simply by designing vapor barriers and depressurization systems into new buildings, they are only doing half their job. Fortunately, the long-term management of vapor mitigation can be integrated into school operations.

Wherever mitigation is required, it should be supported by a long-term Site Management Plan (SMP), developed along with the remediation plan before construction, and then updated before occupancy. Note that the SMP should address all contamination remaining on site that

Vapor Mitigation Systems at Atlantic Highlands Elementary School, New Jersey

would prevent unrestricted use and unlimited access, not just volatile substances likely to cause vapor intrusion.

Ironically, schools are well situated to manage environmental risks over the long-term. The administrative structure will remain in place as long as the school is in operation. There is centralized responsibility. Building maintenance occurs regularly. Even if another party, such as a property owner (for a leased school) or a responsible party (polluter) agrees to conduct site management activity, the school operator can agree to take residual responsibility.

The SMP should summarize both the remediation and mitigation at the site, and it should include the following elements. While many are specific to vapor intrusion mitigation, some may also apply to other engineering controls.

1. Notice. The SMP, including a summary for lay readers, and reports (sampling, inspection, contingency activities, etc.) generated under its requirements should be available to the public, and each entrance to the campus should contain a sign or plaque reporting that the property is subject to an environmental SMP, with instructions for accessing it either in school offices or on line. Such a sign should inform, but not unnecessarily frighten, school occupants.

2. Monitoring of Physical Parameters. Immediately after installation, the functionality of mitigation systems and soil caps should be confirmed. Vapor barriers should be smoke tested for leaks and sealed wherever a penetration is found.

Depressurization systems should be pressure-tested at distal locations and modified if the pressure differential does not meet design objectives. Pressure testing should continue periodically for as long as there is contamination on site and the building is occupied. Depending upon site conditions, that could be quarterly or annually.

3. Indoor air sampling. Consultants normally do not recommend indoor air sampling, or only call for it immediately after installation. They argue that pressure-testing can confirm that no soil vapor will make it into the building. But parents usually want direct confirmation that the air is safe, and they seek direct reports on the indoor air. That's a reasonable position.

Of course, if the principal mitigation strategy is *not* depressurization, pressure testing is inappropriate.

Once the subsurface contaminants are identified, indoor air analysis should focus on those. Indoor sources of those contaminants should be identified and removed, and ambient (nearby outdoor) air should be tested at the same time as indoor air to ensure that it is not the source of indoor contamination. It should be made clear to the entire school community that the presence of toxic substances, while a concern no matter what the source, does not always indicate that vapor intrusion is occurring.

Ideally, if there is no centralized HVAC system, each distinct airspace should be sampled. Vapors under an entire slab can become concentrated inside if there is a preferential pathway into one room, and that will not be detected if testing is done in another room.

Provision should be made to incorporate new sampling technologies as they emerge. Within the next few years, vapor alarms may become available to test cost-effectively for a small number of volatile contaminants at the very low concentrations associated with vapor intrusion.

4. Groundwater Monitoring. At some schools, such as the Roy-Hart schools, sampling suggests that vapor intrusion is not currently a problem, but that volatile organic compounds are found in groundwater plumes pointing in the direction of the school. Periodic monitoring is necessary to demonstrate that such plumes will not migrate under the buildings.

Since it is much less expensive to build mitigation into a new building than an existing one, it makes sense to include vapor barriers and passive (without blowers) subslab depressurization systems even if the groundwater and/or soil gas sampling suggest that vapor intrusion is only a possibility. If periodic groundwater, soil gas, or indoor air monitoring finds that contamination is near or under the building, then fans can be installed and activated.

5. Operation and Maintenance. There should be an operation and maintenance plan that assigns responsibility for keeping operating equipment, such as fans, in working order. This may include automatic alarms for reporting system failure. If HVAC systems are considered part of the mitigation system, there should be an enforceable schedule to ensure that ventilation is effective whenever the building is in use.

6. Inspections. There should be a tiered, regular approach to inspecting engineering controls, including fences, soil caps, and the passive components of vapor mitigation systems (such as the visible elements of vapor barriers), as well as the integrity of institutional controls (below). Where fences or pavement are designed to keep students and others from contacting contamination or interfering with remediation or mitigation systems, those should be checked frequently. Since school maintenance personnel normally (or are supposed to) check the buildings and grounds each school day, frequent environmental inspections can be conducted with a minimum of extra work.

7. Institutional Controls. There should be clear, enforceable prohibitions on activities that would undermine remediation and mitigation systems (such as drilling holes in the slab), as well as changes in use of the property that might increase the likelihood of exposures.

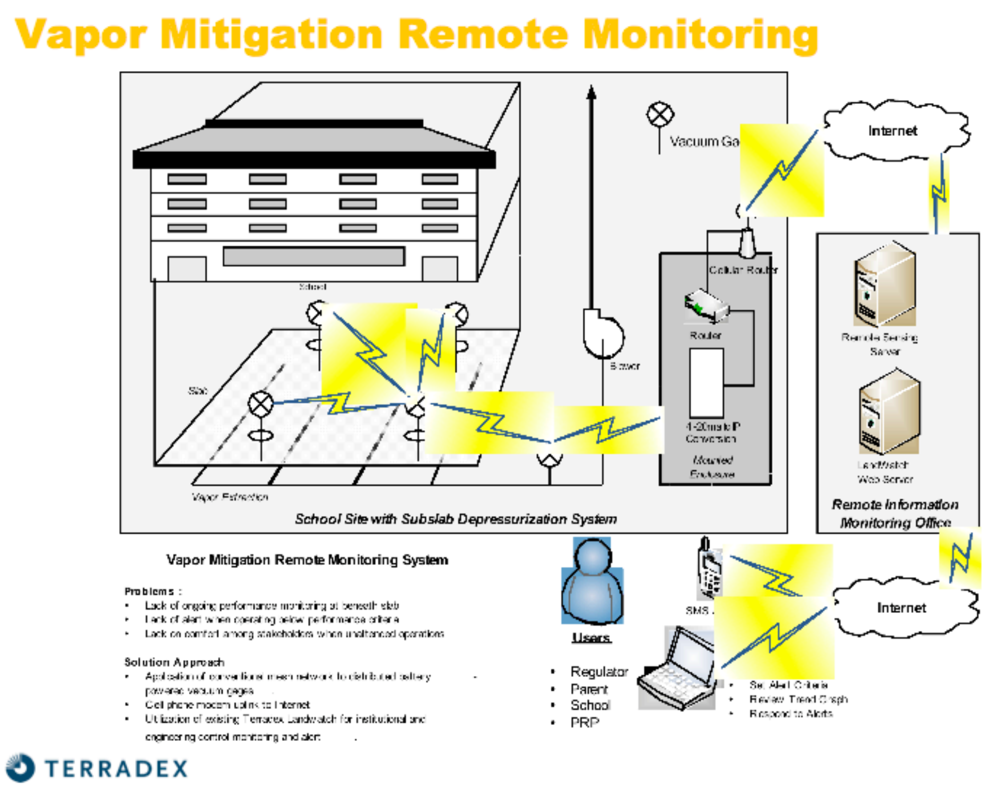
8. Training. All school personnel charged with inspection and operation and maintenance, as well as those charged with reviewing their reports, should be trained in their tasks so they may properly determine when and to whom to report problems. Training should explain the purpose of each activity, as well as how to conduct it.

9. Contingency Plans. Each SMP should outline actions to be taken if mitigation systems or other engineering controls fail, if indoor air concentrations exceed standards, or if groundwater contamination approaches a building for the first time. Other contingencies include floods and other natural disasters, as well as emergencies such as fires, pipeline leaks, and building failure. There should also be a plan for addressing toxic vapors that sampling suggests comes from indoor sources or the outdoor air. Some SMPs simply list emergency contact information. That is not sufficient.

10. Organizational and Financial Assurances. The Site Management Plan should contain assurances that the school operator or others have the financial and organizational wherewithal to carry out the requirements of the Plan, and it should specify the continuing role of regulatory agencies. This should not be too difficult where the school operator is responsible for cleanup. It will obviously be present as long as there is a school, and long-term site management will cost a fraction of what it takes to operate the school. Where another party is responsible for cleanup, either it may demonstrate responsibility or the school operator may promise to step in if the other party is unable to continue site management. That's what the New York City Department of Education did at the Information Technology High School in Long Island City, Queens.

11. Continuous management. Some SMPs, such the one covering Info Tech High School, rely upon auto-dialers to report when active mitigation system elements, such as fans, fail to operate correctly. The inherent limitation of such an approach is that the auto-dialers themselves need to be tested frequently.

An alternative, continuous management, is emerging, based upon the widespread and inexpensive availability of Internet connections. Continuous management systems can not only be designed to demonstrate that active systems are operating, but they can report pressure data and even vapor concentration results—if the proper sensors are available. In the not too distant future, I anticipate the routine use of long-term management systems that report continuously on the viability of engineering controls and, as soon as volatile contaminant alarms are available, the safety of indoor air. Such systems are likely both to provide better protection and to cost less money than the periodic sampling that is now the norm. This figure, designed by Terradex. provides a conceptual description of such as system.



12. Classes. Schools provide a unique opportunity to involve building occupants in long-term site management. Here is a recommendation that my colleague, Peter Strauss, and I made for the Manhattan Center for Science and Mathematics:

> **In addition to the long-term management activities required by the SMP, we urge Con Ed and DEC to work with the MCSM faculty to create a class that each term focuses on the environmental management of the school property and the adjacent Harlem River.** One of the best ways to ensure that site monitoring and management continues to be protective is to involve the people who regularly use the site. Because this is a science high school, there is no better way to memorialize the site, its potential risks, the remedy, and the obligation for long-term management than by developing a curriculum dealing with these issues. This will provide students with real-world experience, a continuing community that cares about the specific issues at the school, and an opportunity to work with, and understand, all parties' points of view.
>
> We suggest the development of an inter-disciplinary high school course. The curriculum could include: the history of the manufactured gas industry; the political and regulatory drivers involved in making cleanup decisions; the mathematics of risk assessment; the chemical properties of some of the compounds; the biological effects on the Harlem River; the engineering controls that are under consideration; and some of the hands-on monitoring that will be necessary as long as this site is used as a school.

Similar classes can be tailored to middle schools, and even elementary schools can devote a few days of science education to informing students about school conditions and how they are monitored.

The terms of the Site Management Plan should be legally enforceable. Depending upon the applicable state law, the SMP should be anchored in a legal document such as an Environmental Easement or Land Use Covenant. By preparing the SMP at the time remediation, mitigation, or new construction decisions are made, the costs of long-term management can be weighed against alternatives such as more aggressive cleanup or moving the school elsewhere. Indeed, if it is impractical to provide long-term protection to students at a contaminated school site, they should attend school at a safer location.

More Regulatory Oversight Is Necessary

Large or even medium-sized school districts generally have the capacity to identify contamination before construction, manage remediation, and develop and implement Site Management Plans. But many daycare centers, private schools, and even some public schools are the responsibility of institutions without that capability. Furthermore, private institutions generally lack direct public accountability.

For these reasons, it is essential that state environmental regulatory agencies engage in more active oversight at these facilities. They should have the statutory authority and technical capacity to flag and evaluate proposed schools and daycare centers on or near contamination. For example, California currently has a strong program that reviews proposed K-12 schools before construction, but that highly regarded program does not extend to daycare centers.

Carson-Gore Elementary School, Los Angeles, California under Construction

If school and daycare operators or parties responsible for cleanup cannot demonstrate that they are capable of developing and implementing SMP's, then the regulatory agency should either provide that function or certify a third party—such as a local health department or private institution—to do so.

Regulators and local agencies should also evaluate all available environmental data, include Phase 2 Environmental Site Assessments conducted by private parties, to determine if off-site sources threaten to cause unsafe exposures at existing schools. Every school I have visited in New York City has turned out to have a volatile organic compound plume under or near the school, but similar contamination may remain unidentified at other schools. New York doesn't evaluate its groundwater, except in a small section of Queens, because it imports nearly all its drinking water. Similar conditions likely exist in other urban centers that don't use their groundwater.

It is likely that many of these urban plumes have been quietly identified or recognized as potentially present by developers and other parties conducting Site Assessments, but they remain off the radar screen of regulators and school operators. If children are to be protected, that data needs to be collected and reviewed.

Americans consider it essential that our schools and other facilities serving young children be safe, but policies and programs to accomplish that goal are few and far between. However, there are enough success stories to use as models to ensure that these facilities are managed, in the long run, in ways that keep our kids safe from toxic contamination in school.

Community Involvement in the Long Run

At any site where residual contamination requires continuing operation and maintenance, monitoring, engineering controls, and activity and use limitations, there is a need to establish an institutional memory of the reasons for the original project as well as the Site Management Plan. Before long, the officials who designed and oversaw both cleanup and construction will have moved on, but the need to manage the site will continue. Site occupants and visitors, as well as neighbors and community-based organizations, often are willing and in an excellent position to ensure that long-term management is indeed long term.

There should be a community involvement plan that is either incorporated into the SMP or stands as a separate document. This plan should be robust enough to remain effective for the life of the school and the life of the contamination, but it should be flexible enough to accommodate the ebb and flow in public interest and new institutional arrangements.

Mott Haven Site Management "Report Card"

1	**Agreed-upon SCA/DOE Tasks**	**Including**	**Letter Grade**
A	Ensure integrity of outdoor covers	Monthly by custodian; annually by engineer	
B	Operate vapor mitigation systems in active mode	24/7 Building Management System; monthly inspection by custodian; annually by engineer	
C	Conduct SSDS pressure tests	Before occcupancy and each time a system is re-started following a repair	
D	Ensure integrity of vapor barriers	Smoke test before occupancy and then annually	
E	Monitor on-site groundwater	Semi-annual sampling	
F	Confirm emergency notifications	Within 48 hours	
G	Confirm advance soil disturbance notifications	15 days before planned activity	
H	Confirm institutional controls	Annual	
I	Publish annual Site Management Reports	By March 1 each year; hard copies in repositories	
2	**Additional SCA/DOE Tasks**	**When**	
A	Evaluate soil cover under existing schools	Annual with quarterly inspection	
B	Sample soil gas	Semi-annual for five years	
C	Sample indoor air	Before occupancy and once every five years	
D	Confirm HVAC operation in new buildings	Annual with routine inspection	
E	Monitor groundwater near barriers	Semi-annual	
F	Convene public meetings	On occupancy and publication of annual report	
G	Place signs on entry-ways	Before occupancy	
H	Establish on-line archive	As soon as possible	
I	Develop community involvement plan	As soon as possible	
3	**Tasks for others**	**By whom?**	
A	Address off-site petroleum sources	Department of Environmental Conservation	
B	Identify and address off-site VOC/SVOC sources	Department of Environmental Conservation	
C	Review reports for *entire* site	Department of Environmental Conservation	
D	Create science curriculum	School staff	

At the Mott Haven campus, the Center for Public Environmental Oversight (CPEO) has been retained by community groups to help them conduct such oversight. We prepared a guide to long-term management along with an annotated *report card* that community members can use to monitor the site. It lists management activities that school authorities have agreed to, additional actions that we recommend, and other key steps to be implemented, primarily by state regulators.

The report card is a tool designed to enable community members to remain engaged indefinitely, long after their independent technical consultants (from CPEO, in this instance) have moved on. This is not as simple as it seems. Though community activists in the South Bronx understand the fundamental issues at this site, they feel most comfortable when they have access to their own technical experts. It is therefore too soon to know how well our particular strategy for long-term oversight is working. We are convinced, however, that community oversight is an essential component of long-term site management, and such long-term management is necessary to make schools on or near toxic property safe.