



# **INDOOR AIR QUALITY/ OFF-GASSING ISSUES**

**CITADEL HIGH SCHOOL  
Halifax, NS**

**January 2008**

## *Executive Summary*

Without a doubt, Citadel High School is one of the best, if not the absolute best, school ever constructed in Nova Scotia. We fully expect it to achieve LEED certification.

There is always more that can be done, and processes can be improved. However, it has to be recognized that the standard of school construction in Nova Scotia is acknowledged [by whom?] as being among the highest in Canada. There are costs and benefits to this, and we believe we have achieved an acceptable balance.

In terms of healthy school design and construction, Nova Scotia is leading edge. Not perfect, by any stretch, but certainly very progressive as compared to other jurisdictions across Canada.

While problems at Citadel have manifested themselves as "inadequate off-gassing time", this is an unrealistic simplification of a very complex process. In fact, off-gassing time is really a surrogate to conducting air quality testing to prove the air quality meets current standards. [This needs to be reconciled with [redacted] statement that "Human bodies are more sensitive than those machines."]

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And this is what is now done in Nova Scotia on a routine basis now.

All of the air testing--every single test-- was below the thresholds established by LEED, Health Canada, and US Environmental Protection Agency. By all accounts, and contrary to media reports, the school was absolutely safe for students and staff on opening day. Indeed, the school had the **LOWEST** rate of absentee staff during the September-December, 2007 period.

Having said this, the school was completed later than expected, and there were odors in the building that would negatively affect sensitive people. While we do not want to see even a single person affected negatively, it is acknowledged that we cannot build structures that are guaranteed not to affect very sensitive people. The number of people who complained of symptoms was small relative to the 1500+ people in the building, and it behooves anyone to justify putting these 1500 people back into their old schools while Citadel was left for months to "off-gas".

[The thing to be careful of here is that nobody is suggesting this. The real issue is of ensuring that effective procedures are in place with respect to the new school project so that we can avoid having to be faced with this kind of scenario.]

There were lessons learned from Citadel and one recommendation resulting from this report.

We would be remiss if we did not acknowledge the extraordinary care and due diligence exhibited by the building designers, constructors, project management staff, inspectors, school board staff, and those that selected and installed the Furnishings and Technology. Their efforts have gone unsung for the most part.

## ***What is Off-Gassing (Flush Out)?***

Much has been made in the media and other correspondence upon the opening of Citadel High School about the building causing staff/students to be sick. This has been blamed, for the most part, on inadequate off-gassing (Flush Out) prior to occupancy.

This report is intended to be a factual account of what actually transpired at Citadel High and what the expectations were.

Simply stated, there is no accepted definition of what off-gassing entails or the time required. Off-Gassing is intended to mean the airing out of a building or building components (e.g. furnishings) to reduce the amount of harmful gases given off by the time the building is occupied. There is no set procedure or time frame that the writer could find for this process, although LEED came the closest.

### **US Environmental Protection Agency**

The US Environmental Protection Agency in its IAQ Design Tools for Schools simply states: *"Consider a building flush-out at the end of the construction process and before occupancy."* It goes on to say that *"through careful materials selection and material minimization, the designer can greatly reduce or even eliminate the need for air out and flush out."*

This same section discusses "Flush-out" as follows:

*"Flush out is when large amounts of outdoor air are forced through a recently completed building for a period of 3 to 90 days so that the majority of pollutant emissions from building materials, finishes, and furnishings can be removed from the building before occupancy. The recommended minimum volume of outdoor air needed for flush out is the amount needed to ventilate the full school at least once each hour (1 ACH or air change per hour), 24 hours a day, 7 days a week. [For how long at this rate?] At a minimum, all mechanical ventilation systems should be set to provide the largest amount of outdoor air as practical from the final construction stages when floor products and paints are applied through the first few days of occupancy. Based on a 90-day flush out of two different office buildings, the state of Washington now requires a minimum 30-day flush out period for all its new public buildings. California's building standards also require a 1 hour daily flush out prior to normal building occupancy [Again, how long is this to happen? Does it extend to after occupancy?] to reduce contaminants that may build up when the ventilation is off overnight"*

EPA's top 10 recommendations include the following:

*"In order to flush polluted air out of the school, bring adequate outdoor air into the building using the school ventilation system. Maintain minimum outdoor air ventilation rates consistent with ASHRAE 62.1, which for classrooms, is about 15 cubic feet per minute(cfm) of outdoor air per person."*

Upon asking the specific question "What period of time do you recommend to "flush out" a building upon completion" of the US Environmental Protection Agency, I was referred to the following article from the US Department of Energy on Building Commissioning:

### Consider Building "Flush-Out"

Consider a building flush-out period to reduce possible indoor air quality contamination after construction completion and prior to occupancy. This involves running the mechanical system with tempered 100% outside air for an extended period of time (two weeks). Flushing out the building may be particularly important when high VOC and particle-emitting construction materials, furnishings, interior finishes and cleaning agents have been applied. Care should be taken with regard to humidity levels and microbial growth depending on the seasonal weather conditions. All ventilation air filters should be changed as a final step of building flush-out.

As can be seen, if a flush-out is considered, a two-week period is recommended.

**National Best Practices Manual** [Is this a US document or Canadian?]

The National Best Practices Manual for building High Performance Schools states:

"Allow adequate time for the installed materials and furnishings to "off-gas" before the school is occupied. Run the HVAC system continuously at the highest possible outdoor air supply setting for at least 72 hours after all the materials and furnishings have been installed."

### Health Canada

Health Canada weighs in on the issue in its *Tools for Schools Action Kit for Canadian Schools*. While it acknowledges that off-gassing can continue for long periods of time (months or years), they do not specify an off-gassing period of time. They state:

"whenever new products with the potential for off-gassing are installed, allow adequate time for off-gassing before re-occupying the area, and increase ventilation with outdoor air until off-gassing odours and any irritation symptoms no longer occur"

[The interesting thing to note is that this uses the existence of symptoms as a gauge for when to stop the "flush-out" period. [REDACTED] makes reference to "environmental illness" as a condition where "...people ... become more sensitive to indoor air pollution..." If this is true, then the process recommended by Health Canada would have to be considered imprudent.]

This, of course, is a reasonable approach, provided it is not taken to mean a period of time until the most hyper-sensitive person no longer experiences symptoms. Generally, one would consider the ASHRAE approach where they apply the 20/80 rule. That is, things are probably OK if 80% of the occupants are OK.

Health Canada, in its *Environmental and Workplace Health* document, takes the approach that the best way to eliminate harmful gases in the building is through source control, which was fundamental in the design and construction of Citadel. They also suggest to

*"increase the flow of outside air during both occupied and unoccupied hours (e.g. run ventilation system continuously until levels are within an acceptable range)" [A common comment from those who complain of the air quality issues at Citadel High School is that we cannot use the low VOC materials issue as the main defence against air quality issues. They maintain that the flush-out period is the key approach and that the longer, the better.]*

### **School Planning and Management Journal**

In an article by Ken Leach in the *School Planning and Management* publication, he espouses the importance of reducing off-gassing, again, by source selection. He advocates higher ventilation and better filters, but does not suggest that an off-gassing period at the end of construction is necessary.

### **Michel Joffres Study**

In a very extensive study entitled *Indoor Air Quality in Canadian Schools*, Dr. Michel Joffres references off-gassing of materials several times, but did not include any specified time frame for off-gassing the building. Once again, the emphasis is on source control to reduce emissions.

### **CASLE**

There are a number of articles written by CASLE (Karen Robinson, et al) that discuss off-gassing. Among a great deal of such articles, the following are pertinent to off-gassing:

In the article Steps Towards Healthier New Schools, Ms. Robinson writes:

*"off gassing {for gymnasium} for 8 weeks before occupancy made a difference too {in air quality}"* Emphases added. There are other references to the benefits of off-gassing but no specific times.

### **Nature Natural**

The website Nature Natural talks about off-gassing in general and the health effects of poor indoor air quality. It states that these gases are known collectively as VOCs (volatile organic compounds) and the need to reduce them. It does not refer to a specific off-gassing period.

### **Healthy Schools Construction Guidelines for New School Buildings (Nova Scotia)**

In the "Building Readiness Guidelines for New School Buildings" prepared by the Healthy Schools Construction Committee here in Halifax, there is no mention of off-gassing. It emphasized source control of materials (as do all of the other sources) as the primary method of improving IAQ, but suggested testing and a final inspection as the means of knowing when the building is ready for occupancy.

In the Healthy School Design and Construction document prepared by the Healthy Schools Construction Committee, September 2002, the following are references to off-gassing time frames:

- a) Under the section on flooring, it states  
*"allow adequate (possibly several months) off-gassing."*
- b) Under the Contract Task List it states:  
*"Allow for sufficient off-gassing time after completion of school before it is occupied."*
- c) Under Program Task List, it states:  
*"Off-gas new computers and plastic/PVC encased equipment (turn on and heat up, for several weeks if needed)." This section also refers to the need to off-gas gym equipment and some furnishings, but no specific time frame is mentioned.*
- d) Under Source Control section, it is stated that the chairs be off-gassed by the supplier  
*"in a well-ventilated location several months before they are shipped." This same section indicates that "In some finished products formaldehyde will continue to off-gas indefinitely..."*
- e) In the section on Flush out Procedure, item 4 reads as follows:  
*"Maintain the flush out for as long as possible or necessary-usually a minimum of 24 hours, but sometimes as long as several months, depending on the materials being off-gassed and amount being off-gassed. Some experts recommend that after completing the aggressive flush out, a high ventilation rate should be maintained for at least a year"*

In a document provided by **Nova Scotia School Board Occupational Health and Safety Program Administrators**, and included as an appendix in the **Healthy School Design and Construction Manual**, they requested that gymnasias be completed early due to off-gassing. They also suggested that

*"all schools must have at least three week gas-off period and base line testing for formaldehyde, VOC, noise and lighting levels prior to occupancy. Gym floor coating is never to be applied or drying while the building is used by students."*



LEED

One of the most common references to flush out is that required by LEED. There are a number of LEED criteria, but the one most applicable appears to be from the Canada Green Building Council, LEED Green Building Rating System. This document refers to three options for testing for air quality before occupancy. These include:

- Option 1 Building Flush Prior to Occupancy ( About a three week process)
- Option 2 Building Flush Overlapping with Occupancy
- Option 3 IAQ Testing Prior to Occupancy.

Construction process have used a number of strategies for achieving this. Energy Design Resources suggests allowing for option 1 (two weeks in the schedule) and option 3 in case there is insufficient time at the end of the construction schedule. It also states that commissioning activities may occur during the flush out period. The Mechanical Contractors Association of America endorses this protocol.

Obviously, source selection of materials is a very high LEED priority and highly emphasized in this document.

CMHC

5.20 (1) Canada Mortgage and Housing Corp. deal mainly with houses. However, they (Dr. [redacted]) have been asked to comment on school off-gassing and advise they have no protocol for flushing out houses. They advise that the longer the flush out the more effective it will be. It will depend on the amount of emitting substance, ventilation rate, temperature and relative humidity. They suggest a two-week period is better than none, but four weeks would be even better.

Cross Canada Survey on School Building Flush-out:

by: ? Paul Macellan, DOE.

A survey was conducted coast to coast in Canada to determine what other Department of Education offices do with respect to off-gassing (flushing out) schools. They were also asked if there was any air quality testing regime carried out prior to school occupancy.

Generally, it was found that no such process existed. They neither flushed out the buildings nor tested for air quality prior to the move in.

It was found that Newfoundland is considering going with LEED (silver) as a building standard. That standard provides for three options, one of which provides for flushing out the building (generally two weeks is anticipated—depending on the building ventilation system capacity).

Some other provinces are either now going with LEED standard or anticipate going with a LEED standard in the future.

It should be noted that the remaining two options involve flush out with occupants in the building and thirdly, a baseline IAQ air testing using USEPA "Compendium of Methods for the Determination of Air Pollutants in Indoor Air."

### ***Where Are We, in General, Regarding Off-Gassing?***

It has been acknowledged by CASLE, and others, that Nova Scotia is a leader in healthy school construction. We go beyond what any known school jurisdiction in Canada is doing to provide environmentally sustainable and healthy schools.

Notwithstanding, we still get complaints about air quality. Some are well-founded while others are completely misguided. [This comment has 2 problems. Firstly, it is quite aggressive. Secondly, it implies that someone is "guiding" incorrectly.]

The province will continue to take a proactive approach, and implement and monitor procedures and materials to ensure schools are designed and constructed to reasonably meet healthy standards. That is not to say our new schools will, or even can, accommodate every hyper-sensitive person. Such a building probably does not exist – we need to accommodate such students and staff on an individual basis. The expectation is that there will be very few such affected people. Besides their home, they will find schools the healthiest places they can go.

While much has been made about the length of the off-gassing period, it is really the end result that matters. It is well known that materials can off-gas for many months or even years. There is no agreed upon standard period of off-gassing but instead, variations exist, from one hour to several months and in at least one case, a whole year. Obviously, one has to weigh the period of off-gassing with the potential of keeping students in their old building for a longer period of time. Certainly parents would want documented proof that such a process is in the best interests of all. [Again, we will be criticized if we are seen as recommending a lesser process because of this issues. We are going to be held to an appropriate standard for the new building, independent of anything else. If there are issues with the buildings they are in now, that will need to be addressed as well.]

Because off-gassing has not been well defined, much confusion exists about how much off-gassing time has been provided at the opening of the school. For example, when does it actually begin—when the ventilation is turned on or after substantial completion? How much work can be done after substantial completion (deficiencies) and still consider the period as off-gassing time? LEED has provided the best guidelines that we have seen to date. It would certainly seem to meet recommendations from Health Canada and USEPA, as well as the basic intent of the Healthy Schools initiative in Nova Scotia.



As evidenced by CMHC, more off-gassing time will reduce the amount of gas given off while occupants are present, but there really is no standard. They suggest four weeks or more. CASLE suggests eight weeks. Again, while more may be better, every building is different. The only real indicator of adequate off-gassing is to test for the harmful gases prior to occupancy. [REDACTED]

[REDACTED] do not agree.]

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LEED provides for the option of off-gassing the building or air quality testing prior to occupancy. At Citadel, BOTH were carried out, albeit not entirely meeting LEED standard. The off-gassing time was compromised by other work going on, and in particular a glycol leak in the main foyer. The third LEED option of air quality testing was also carried out, as in previous schools, but that regime of testing did not meet LEED standards. [I question the thought that, because we did not achieve the LEED standard for flush-out due to a small amount of work being done after Substantial Performance, the flush-out period was rendered ineffective. Does work in one small section of a large building mean that the flush-out period does not achieve what it is intended to? A possible approach could be to use the standard for infection control in healthcare construction projects. This mandates that a barrier is constructed around the work area, with a negative air pressure maintained within and the air exhausted directly to the exterior. If the required work areas are small in size and number, this approach should satisfy even [REDACTED] that the flush-out period is not rendered ineffective. Achieving the LEED point should NOT be the gauge of effectiveness in these circumstances.]

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Due to the late completion of the building, the formal commissioning still has not been completed. This is a very detailed process which is intended to resolve any outstanding issues (of which there are some, as in any new building). At this time, an effort is being made to complete this work as soon as possible. [A common criticism of the Citadel situation is that air balancing was not done or various ventilation deficiencies exist.]

## *What was Done at Citadel with Respect to Off-Gassing?*

The following gives an account of what transpired at Citadel with respect to off-gassing the school prior to occupancy in September 2007. The off-gassing issue was given high prominence as a result of past experience and trying to meet the Healthy School Design and Construction guidelines prepared by the Healthy Schools Construction Committee in 2002. [I need more information about this committee and its recommendations.]

### **The Team**

At the beginning of the design process, the Halifax Regional School Board hired an environmental consultant to review specifications, attend meetings, and advise on matters related to delivering a healthy building. [REDACTED] S. 20(1)

This school design followed the procedures required to obtain LEED (Leadership in Energy and Environmental Design) certification and as such, had considerable oversight ["oversight" isn't the best word to use here.] on health and environmental matters. This was assured with a LEED consultant reviewing products and processes, the contractor providing LEED information to make decisions, and the designers specifying only products acceptable to meet LEED standards. A very experienced project manager and full-time site inspector were also employed.

As the project drew to a close, training was provided to the board staff and a custodian hired several months before occupancy.

Overall, this team would be considered as competent as any ever put together to deliver a school.

### **Material Source Selection**

By far, the most important aspect of delivering a healthy school is to ensure selection of materials that have low VOC (volatile organic compounds), particularly low or no formaldehyde. This was specified at this school and achieved to the highest standard yet for any school constructed in the province. All adhesives, paint, coatings, sealants, and composite wood were strictly controlled by the contractor and verified by the LEED consultant. The following will provide some rationalization for this statement:

#### 1. Paints

All paint was latex, low VOC, and applied as early in the construction process as possible to assure no off-gassing at occupancy. Due to construction delays, a small amount of painting was carried out until just before occupancy.

#### 2. Wood Products

All millwork, wall paneling, plywoods, doors, and wood blocking

In other versions of this same document, you are named specifically (K. Robinson) + you are the only person named as being "The Team"

was specified and supplied with no added formaldehyde. The laminates were all heat applied at the factory and all edges were factory finished. Cuts and holes were sealed on site. Some holes in the laminates required for technology cords were not sealed but the impact of this would be minor owing to the low VOC materials used. Due to the low VOC content, sealing cut edges considered "belt and braces".

Wood products used in the tech production lab for curriculum were not controlled by the contractor or LEED.

All of the wood doors are the Lambton EnviroDesign Series, containing no Urea Formaldehyde.

The gymnasium Robbins wood floor adhesives and sealants contain no VOCs and the sub-floors (plywood) are formaldehyde-free.

### 3. Adhesives

All floor adhesives were zero VOCs or very low VOCs. The highest VOC product was 1.7 g/l with a LEED maximum of 50 g/l.

Wall adhesives were low VOC with a rating of 45g/l and a LEED standard of 70 g/l.

The rubber base adhesive was zero VOCs.

Plastic laminate counter tops were factory applied.

### 4. Acoustic Panels

These are not regulated by LEED but were similar to those used in other schools. The panels have a core fibreglass material called *SpinGlas* which is *Green Guard Certified* for low emission. They were protected with plastic until the major construction was complete.

It should be noted that these panels were used extensively throughout this school, in quantities far exceeding any other school. Nevertheless, their low emission qualities seemed to work. Some additional testing is anticipated to verify the low emissions of these panels.

### 5. Ceiling Tiles

This building was designed with only a small fraction of ceiling tiles normally used in a school, due to the open ceiling concept. Those tiles installed in the offices, corridor and music room were formaldehyde free. They were installed as late in the construction period as possible so as to reduce possibility of their absorbing any construction odours.

### 6. Blinds

The blinds in this school were selected based on a study carried out

by the HRSB consultant Enviro-Health Consulting Ltd.

7. **Communication Boards** The standard communication boards used in all schools was specified for this school. They contain no urea-formaldehyde or other VOCs.
8. **Gym Divider Curtains** [REDACTED] trying to get info s. 20(1)
9. **Bleachers** The bleachers consisted of refinished units from the former St. Patrick's High School and new vinyl seat bleachers. These were refinished with low VOC finish. All units were placed in the gyms by June 4 and assembled by June 18.
10. **Vinyl tile** The tiles used were low emission. The tile finish process (waxing) and adhesive would have the biggest impact on air quality (see other sections).
11. **Rubber Baseboard** The product used is far superior to vinyl base in terms of off-gassing. It was a styrene butadiene rubber, non-WHMIS controlled.
12. **Sealants** A total of 30 different sealants were approved for use on the project for different applications. All but two meet LEED standards and the two that did not were used outside or underground.
13. **Kitchen Epoxy Grout** The material used was a food-grade.
14. **Fibreglass Insulation** All fibreglass insulation used in the walls of the building was formaldehyde-free.  
All fibreglass pipe insulation (Alley-K) was covered and wrapped. In exposed areas, a PVC cover was used for protection.
15. **Duct Work** All metal duct work was specified and delivered oil-free to meet Healthy Schools guidelines.

### **Off-Gassing Process**

The original intent was to complete the building (substantial performance) by July 15, 2007. Following that time period, minor deficiencies would be completed, furnishings installed, etc.

This allowed at least 23 days to meet the requirements for option 1 for LEED flush out of the school.

Due to the very compressed construction period, which was greatly exacerbated by a severe shortage of skilled tradesmen, the building could not be completed by the intended date. The projected date of completion was moved to end of July and then to mid August. The contractor was finally granted substantial performance on September 4, 2007.

By August 15, all of the ventilation fans were operating and the school was being ventilated 24/7, notwithstanding some work still going on, primarily in the central core area. Indeed, the entire classroom block had been well completed by this time, and was being partially ventilated since August 10. A total of 80,000 CFM of 100% outside air is provided, resulting in about four air changes per hour for the classrooms. Other areas of the school would receive air changes varying from 10 per hour (washrooms) to less than one per hour (mechanical and electrical rooms).

It should be clearly understood that the ventilation system was operated 24/7 (and at the time of writing of this report, still is). Minor shut down of individual systems (there are five main systems) was carried out to allow adjustments and for air-balancing. Notwithstanding reports to the contrary, the ventilation system operated 24/7 from August 15, with short stoppages of individual units.

Another issue raised by some was that the ventilation system was not being operated at full capacity. It is true that the gymnasium systems and one of the classroom systems was found to be operating at about 82% of designed capacity. This would indeed prolong the flush-out of the building. This situation was discovered when the air balancing was finally carried out (there were extraordinary problems with the sub-contractors who do this work), and was corrected on November 12.

In defense of this situation, the mechanical ventilation engineers indicate that the building is ventilated far beyond ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers—the acknowledged industry standard) and even at 82% capacity, the school still exceeded ASHRAE standards.

By August 15, then, the clock began on meeting the LEED flush out standards. Due to ongoing work in the building, the LEED consultant would not approve this period as meeting LEED requirements (strictly no painting, wet, smoky or dusty work to be done anywhere in the building is the criteria for starting LEED clock). Finally, a glycol leak that destroyed gypsum walls and ceilings in the lobby necessitated remedial work which extinguished all hope of meeting LEED flush out requirements.

This is not to say the building was not flushed out at all. It certainly was. It does mean, however,

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that it was not flushed out for the time period anticipated, and there were odours in the building upon opening of the school. The testing conducted on August 20-28, and subsequently on September 23, October 28, and December 8 indicated that there were no harmful VOCs or other air quality issues in the building. This means, in particular, that there were no harmful levels of benzene or formaldehyde, as some have suggested.

The gymnasias were scheduled to be completed by the end of May 2007 as an added assurance that they would be off-gassed before school opened. They were indeed completed on time and clearance air testing indicated that the protocol used to control off-gassing was effective. This protocol was developed by DOE, in conjunction with the Healthy Schools Committee, a number of years ago because of the high VOC created in finishing gymnasium floors. The gym floor finishes do not meet LEED standards and consequently needed extra precautions.

### **School Cleaning**

Cleaning of the building was carried out either by board staff or under their indirect supervision to ensure it met board standards. All materials used were approved and identical to those used by the board at all of their schools.

Having said this, the delay in completing the construction work put great pressure on the board in terms of having adequate time to clean and wax floors and ensure final dusting was complete. On-going construction during the cleaning added extra pressure. The board is certainly not a stranger to such conditions and put many of their best staff on the job.

Odors from the cleaning and waxing materials were evident in the building upon opening of the school. While none of this produced harmful levels of gases, as evidenced by the testing, it was nevertheless an irritant to building occupants. Having said that, cleaning is a process always done on a daily basis within hours of staff and students entering the building.

Filters on the air handling system were changed prior to building occupancy. The filters are of a very high standard, rated at 95% efficiency. Pre-filters are used to prolong the life of the finer filter system. A HEPA filter system is the only level higher than that provided at Citadel, and this has never been done in Nova Scotia nor is it planned.



## ***School Furnishings and Technology***

School furnishings have been blamed for significant off-gassing. It is not always possible to dictate what materials a supplier will use to manufacture the furniture, so time is the best option for off-gassing it.

Similarly, the plastics and components of computer equipment and other high technology equipment are prone to off-gassing issues. Turning them on for a period of time prior to school occupancy was a strong recommendation from the Healthy Schools Committee.

In the selection and installation of the furnishings and technology at the school, three principles were very important. These included environmental (trying to meet Healthy Schools Guidelines), security (keeping the equipment from disappearing), and operational requirements (having the stuff ready for the students). In some instances, not all three could be completely met, but those involved made every conceivable effort to achieve all three.

### **Technology**

There has been criticism that technology was not off-gassed. The facts suggest that this is not the case.

Computers and printers began arriving at the school on August 14. This is one day later than had been scheduled from the very beginning.

The computers and printers were stored in two classrooms in the south/east side of the building. All computers were unwrapped and the packaging moved out of the building within one hour of their arrival at these classrooms. They were immediately turned on and the imaging process started. On August 16, the process of distributing the computers throughout the school was begun, starting on the third floor of the classroom wing. The computers were fully distributed throughout most of the school, by August 21. The labs and some classrooms on the first floor were not done until after August 21. All computers and LCD monitors were turned on as soon as they were unpackaged and were left on continuously, even after they were delivered to their final classroom destination.

It should be noted that the ventilation was running 24/7 (with brief outages due to maintenance on the systems) on the east side of the building since August 10. This means the computers would have been off-gassed by the main ventilation system as soon as they arrived. The elevated temperatures of these rooms, due to summer outside air conditions and building start-up conditions, also hastened any off-gassing. [Is the concept of higher temperatures accelerating off-gassing actually accepted?

It is also important to note that there were no CRT monitors. All monitors were LCD units which require virtually no off-gassing compared to the old CRT monitors. In comparison, Halifax West opened with only one week of computer installation/off-gassing time and all of the monitors were CRT's. Having successfully done that, and subsequently at Kingswood, Sir John A Macdonald, and Barrington, with no reported air quality issues, there was every confidence that the computer systems would contribute no harmful off-gassing.

During the installation of the computers, it was necessary to drill holes in the computer desks to accommodate the wires. It is unknown if this had a deleterious affect on the air quality (due to the small exposure). However, the material drilled through was particle board, urea-formaldehyde bonded. This material can liberate formaldehyde. This process, four holes in desk-tops about 3" diameter, in each classroom took about a week. The holes were covered with plastic grommets.

By August 31, about 95% of all LCD projectors and CCTV units were installed (although these are thought to have minimum off-gassing characteristics--no data is available). These were also turned on to ensure any off-gassing that might occur happened before the majority of staff arrived on September 4.

The computers and printers for the administration were set up in a temporary area and turned on August 17, and run continuously after that.

### **Furnishings**

A relatively large amount of furnishings was transferred from St. Pats and Queen Elizabeth High to the new Citadel High School (estimated at roughly 25%). Most were not an issue, but the recently refinished desks in the administration were still significantly off-gassing when the school opened. The desks were refinished using Danspeed 80, the same material used on Ven Rez desks.

Most of the books, furnishings, equipment, etc. from the old schools were moved into Citadel beginning on about August 16. While this material would have long since been off-gassed, it may have contributed to odours in the new building from the boxes and other packaging.

The newly purchased furnishings was constructed at Ven Rez beginning on July 3 and the first load was delivered to the school on August 7. Most of the furnishings were on site by August 10, including student desks and chairs, computer tables, and office furniture. The furnishings were put into classrooms as soon as the rooms were cleaned and ready (beginning on the third floor), and the remainder were put into the hallways prior to moving into the remaining classrooms. In addition the smaller equipment that arrived was stored in the music rooms as these were larger, with high ceilings with higher ventilation rates. The furnishings were retained in their original shipping containers (plastic and cardboard) until they were put into the classrooms. This would

have a negative impact on any off-gassing of them.

Furnishing of various types continued to arrive at the school and indeed are still arriving as of the date of this report. This is typical for any school and is practically unavoidable.

The paint used on all student chairs and desks is a dry powder electrostatically applied and has no off-gassing. The table tops are MDF as manufactured by Uniboard Canada and contain urea-formaldehyde. The chair seats are plastic (propylene ethylene copolymer) and are similar to chairs used in all schools in Nova Scotia. Off-gassing of these components would be significant but appears to be mitigated by the ventilation as evidenced by the VOC testing regime.

An area of concern expressed during the air quality controversy was the finishing of the edges on all of the student desk tops (all of the other furniture had plastic laminate edges). A request was made to have these edges finished with a water-based finish (Aquatec Platinum by Chemcraft) to seal the composite wood and reduce off-gassing. This was tried at Halifax West on about 60% of the desk tops delivered and it was found that there was absolutely no difference in off-gassing using the water based product compared with the solvent based product normally provided by Ven Rez. In fact, the edge coating in all cases was completely off-gassed by the time it was delivered to the school and the 25% premium cost for the water based material had no discernable benefit. This was evidenced by this not being an issue at Barrington, Kingswood, Sir John A Macdonald or Oyster Pond schools. The premium cost arises not out of additional quality, but because the assembly line process has to be changed to accommodate this, resulting in delay costs. In the final analysis, the standard coating provided by Ven Rez was entirely satisfactory and resulted in *no* additional risk of air quality problems.

## Conclusions

Extraordinary care was taken in the design, construction and supervision of the construction to meet Healthy School Standards. LEED certification is anticipated.

Some highly sensitive people may have been affected by the school environment upon opening. Some of the complaints were unfounded. The number of complaints were relatively few.

The delay in completing construction was unfortunate but not uncommon. The alternative of sending 1,500 students and staff back to St. Pats and Queen Elizabeth would be a much worse alternative. Keeping that many people out of school for several months was an equally bad alternative. [As I noted earlier, this does not make up for inappropriate planning and processes.]

While the air quality testing regime concluded the school was safe to occupy, it was known that some of the staff had high environmental sensitivities. [Is there corroboration for this?] When it became obvious the school would be late in opening, those highly environmentally sensitive people should have been provided with alternatives. Sick time (before entering the school), transfer to an older facility, or part-time duties may have been reasonable alternatives for staff. Transfer of students, with paid transportation costs, for at least one semester could have been considered.

Better and timely communication among the various parties involved could have mitigated the complaints somewhat. Many rumours, untruths, exaggerations, or misinterpretations prevailed at all levels from the construction workers all the way through to the general public. While the board has a procedure for reporting IAQ problems in a school, the high profile of Citadel resulted in that protocol not being followed, with the obvious very public hype.

Additional training of board maintenance staff at the school would have been an asset. A highly qualified person bridging the period from substantial performance of the construction contract (and take over by the board) and the point where the board is entirely comfortable in operating the school would have helped mitigate many of the problems. The current situation is that an already extremely busy principal ends up handling many of the issues that this person would be responsible for. This person was ultimately put into Citadel when this condition was recognized.

Standards must be continuously reviewed for relevance and applicability. LEED should become a standard for new school construction with the goal of silver certification.

Staff of the Project Management and Design divisions of TIR should receive on-going training in healthy schools construction materials and practices.

## Recommendations

At first blush, numerous recommendations appear obvious. However, rather than simply list even more recommendations, this report specifies only one:

### Recommendation

The Nova Scotia Department of Transportation and Infrastructure Renewal needs to strike a high level standing committee to review the contents of this report, along with the Healthy Schools Guideline, and any other lessons learned and develop a specification to be following for all new schools to be constructed in the province. The committee should report to the Minister of TIR no later than the end of the year, 2008.