

**- Final -**  
**Education Building**  
**2014 Indoor Air Quality Assessment**

**Prepared For:**



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**PRIVATE AND CONFIDENTIAL**

## **Executive Summary**

The Environmental Health and Research Safety Department, of Simon Fraser University, (SFU), commissioned Arcose Consulting Ltd. (Arcose) to complete an indoor air quality (IAQ) assessment of the Education Building, located in the Burnaby, BC campus of SFU.

This assessment took place over a number of phases, starting in January 2014 and ending in June 2014.

Over the history of the Education Building there have been a number of building envelope leaks reported. It is our understanding that in the last 5-years, the Faculty of Education documented concerns related to water ingress, air quality and fungal contamination. These concerns were reported to encompass approximately 40% of the space that they occupy.

Water leaks throughout the building have resulted in water damage and the suspected presence of fungal contamination.

Just prior to starting this assessment, the Education Building, Grad Wing, underwent major remediation work as part of an in depth review to document site conditions. Information gained from that work helped to ensure that the field investigations identified by this assessment were focused on known areas of concern.

All field work and reporting was overseen by Evan Alvernaz, CIH, ROH, CSP – Principal and Senior Consultant for Arcose Consulting Ltd.

Site observations and analytical results indicate that the Education Building is generally safe for the students and staff of Simon Fraser University to occupy. However, areas of concern were identified, which indicate the need to mitigate occupant and work exposure risks and improve indoor air quality.

Visual inspections identified the presence of water damage and fungal contamination in a number of areas. As in the previously completed Education Building Grad Wing Remediation Report, moisture sources can broadly be grouped as mechanical or building envelope in origin.

In most areas, water damage has not resulted in the presence of fungal contamination; however, small areas of suspect fungal contamination was noted on surfaces in some areas. this contamination could effectively be remediated and the exposure risk controlled by removing a ceiling tile, applying an encapsulant or completing some other minor treatment to minimize the risk. In other areas, where the moisture source had resulted in the breakdown of the substrate effected, moisture was present in an air handling system or the moisture had resulted in fungal contamination covering an area exceeding 100 cm<sup>2</sup>; more invasive remediation techniques are required.

In all areas, if the moisture source responsible for the leak is not repaired, additional fungal growth will occur. Because of the building's long history of leaks and repairs, it is unclear in many areas if the water stains and suspect fungal contamination identified are the product of recent water ingress. Some of the leaks responsible for the water damage may have previously been eliminated or effectively controlled.

The identification of water damage distributed throughout the building is a good indicator that additional fungal contamination may be hidden behind existing building finishes. Based on fungal air sampling results, this contamination does not appear to be having a negative effect on indoor air quality.

Fungal air sampling generally identified spore concentrations indoors, that were similar in type, but at reduced concentrations when compared to spore concentrations outdoors. In the four instances where elevated spore trap samples were identified, fungal contamination was also identified on exposed surfaces in the rooms.

Surface and bulk sampling confirmed the presence of fungal contamination on many of the surfaces sampled.

These results suggest that the absence of visual indications of fungal contamination on surfaces, is a good indicator of the absence of elevated levels of airborne fungal contamination.

An important part of minimizing the risk of exposure to fungal contamination is limiting water leaks that may support growth. When leaks are identified, they should be controlled as soon as possible. An effective building inspection program will help to identify and control leaks before fungal contamination can become a significant problem.

In the longer term, the establishment of an effective system of building envelope and mechanical system repairs will minimize the potential for additional water damage and fungal contamination.

With the exception of relative humidity, most indoor air quality parameters measured were within guideline levels. Low relative humidity levels were identified in one or more areas in 7 of the 12 investigation phases.

Slightly elevated CO<sub>2</sub> levels were identified in only two of the rooms assessed; however, care should also be taken when using CO<sub>2</sub> as an indicator of sufficient outside air.

It is our understanding that the maintenance and operation of mechanical systems are generally overseen by the Facilities Services Mechanical Department and that scheduling and establishment of mechanical system set points are generally overseen by the Facilities Services Energy Management group. Within their individual mandates, these groups appear to have competing priorities. For example, a ventilation system may have been installed and maintained by the Mechanical Department with an understanding of minimum operational requirements, such as the amount of fresh air and time of operation required to achieve acceptable indoor air quality; however, Energy Management may make adjustments to this same ventilation system in an attempt to improve the efficient use of resources.

For those systems where the Mechanical Department and Energy Management have combined responsibility, the establishment of an operation and maintenance manual would help to ensure the efficient operation of mechanical systems and a more collaborative approach.

It was noted that some rooms do not have adequate ventilation. Some of the issues with these rooms included not having adequate supply or return air systems, blocked vents and missing diffusers.

The presence of water in ducting and the humidification system servicing the Archeology Department warrants special concern. Untreated water in an air handling system can result in significant bacterial and fungal growth, including legionella pneumophila. It is our understanding that humidification water was being treated; however, a documented procedure was not available for review.

### **Recommendations**

Based on sampling results, site observations and the conclusions identified above, Arcose recommends the following.

1. It is our understanding that SFU is currently developing a building envelope remediation plan for the Education Building. This plan should be completed and implemented as required to minimize water ingress.
2. All recommended actions identified by the phase inspections, should be implemented.
3. In many areas significant accumulations of dust and debris were noted in and around radiator cabinets. This accumulated dust and debris should be removed and a schedule developed to ensure the regular cleaning of these areas.

4. Mechanical system recommendations:

- a. The building's ventilation system should be balanced and adjusted so that all spaces are provided with an adequate allotment of outside air in accordance with the Ventilation Procedure identified by ASHRAE.

Until such time as this work can be completed, occupants should be encouraged to open windows when present in their rooms to improve airflow.

- b. Rooms that currently do not have adequate air flow, or no air flow, should be modified to ensure that they are adequately ventilated in accordance with the BC Building Code requirements and ASHRAE standards.
  - c. A systematic inspection of reheat system and radiator system water valves and fitting should be completed to allow for the identification and repair of leaks.
  - d. An operation and maintenance manual should be developed for the building's heating, ventilation and air conditioning systems. This manual should include all operations currently completed by Facilities and Energy Management. It should identify set points and operation parameters so that all personnel with responsibility for the system have a common understanding of the system and how it should operate.
  - e. Untreated water should not be permitted in air handling system components.
5. A system of regular inspections should be implemented to assist with the prompt identification and repair of leaks and suspect fungal growth.
- a. These inspections should be completed by four different groups, each looking at different elements:
    - i. On a routine and ongoing basis, building occupants should report any signs of water leaks or fungal contamination to their supervisor. The process for reporting signs of water leaks and fungal contamination should be well documented.
    - ii. On a monthly basis, the Health and Safety Committee should complete inspections of all areas as part of their regular inspection process. The committee should look for indications of new water damage, changes in previous water damage and the appearance of suspect fungal contamination. When any of these conditions are identified, a report should be forwarded to Facilities for repair and remediation, as required.

- iii. On a quarterly basis at a minimum, Facilities should complete an inspection of mechanical system components to identify the presence of leaks and water ingress. Repairs should be completed as required to eliminate leaks and water ingress.
  - iv. On an annual basis, the Environmental Health and Research Safety Department should complete an audit of the quarterly and monthly inspections to ensure that they are being completed as specified and that repairs are being completed as required.
- b. Health and Safety Committee members should receive training on: fungal awareness, inspection procedures and remediation procedures.
6. Because of the widespread identification of water stained and water damaged building materials, there is a potential for fungal contamination to be hidden behind existing finishes. When completing renovation or remediation work, which involves opening wall and ceiling spaces, the assumption should be that fungal contamination may be present in these spaces and appropriate procedures followed to minimize the exposure risk.
7. SFU should develop internal procedures for the investigation, identification, remediation and communication of fungal contamination concerns. These procedures should be based on recognized standards such as ACOEM, evidence based statement, Adverse Human Health Effects Associated with Molds in the Indoor Environment, The New York City Department of Health, Guideline on Assessment and Remediation of Fungi and Indoor Environments, November 2008 Edition, and the Institute of Inspection, Cleaning and Restoration Certification (IICRC), S520 Standard and Reference Guide for Professional Mold Remediation.

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Appendix 4: Fibre in Air Sampling

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Appendix 6: Air Sampling Results

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## **1 INTRODUCTION**

The Environmental Health and Research Safety Department, of Simon Fraser University, (SFU), commissioned Arcose Consulting Ltd. (Arcose) to complete an indoor air quality (IAQ) assessment of the Education Building, located in the Burnaby, BC campus of SFU.

This assessment took place over a number of phases, starting in January 2014 and ending in June 2014.

Just prior to starting this assessment, the Education Building, Grad Wing, underwent major remediation work as part of an in depth review to document site conditions. Information gained from that work helped to ensure that the field investigations identified by this assessment were focused on known areas of concern.

All field work and reporting was overseen by Evan Alvernaz, CIH, ROH, CSP – Principal and Senior Consultant for Arcose Consulting Ltd.

## **2 REGULATORY LIMITS, ACTION LEVELS AND HEALTH EFFECTS**

Indoor air quality is specifically regulated by Section 4.70 to Section 4.80 of the British Columbia, Occupational Health and Safety Regulation (BC OHSR). The BC OHSR identifies minimum requirements for indoor air quality in workplaces and makes reference to guidance from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) standard and WorkSafeBC publications. This guidance identifies comfort parameter (temperature and relative humidity), minimum ventilation rates, indicators and methods to determine acceptable indoor air quality (e.g. measurement of carbon dioxide), and maximum acceptable levels for contaminants (e.g. carbon monoxide).

Section 4.79 of BC OHSR requires that an employer investigate indoor air quality complaints when they arise in the workplace. These investigations may include an assessment for the presence of fungal contamination.

The Workers' Compensation Act (WCA) also identifies responsibilities for workers, employers and owners. Section 116 (e) (ii) requires that workers report hazards in the workplace to their supervisor or employer. This includes reporting the presence of fungal contamination and water leaks.



## **2.1 General Indoor Air Quality**

The indoor air quality assessment was conducted following guidance from ASHRAE standard 62-2013: Ventilation for Acceptable Indoor Air Quality; and WorkSafeBC, Indoor Air Quality: A Guide for Building Owners, Managers, and Occupants.

### *2.1.1 Carbon Dioxide and Carbon Monoxide*

ASHRAE standard 62-2013: Ventilation for Acceptable Indoor Air Quality outlines procedures for ensuring the presence of acceptable indoor air quality. Outlined in the standard are three procedures for ensuring acceptable indoor air quality: the Ventilation Rate Procedure, the Indoor Air Quality Procedure and the Natural Ventilation Procedure.

The Indoor Air Quality Procedure was used for this assessment. By following this procedure and maintaining contaminant concentrations below recommended values, it is generally expected that acceptable indoor air quality will be achieved.

CO<sub>2</sub> is produced by respiration and its production can be influenced by metabolic rate. It can be used as a tracer gas to indicate the amount of outdoor air delivered to a space. Studies indicate that 15 cubic feet per minute (cfm) per persons of outdoor air will dilute odours from bio-effluents to a level that will satisfy the majority (~80 %) of visitors to a space. This equates to a steady state CO<sub>2</sub> concentration of 700 parts per million (ppm) above outdoor CO<sub>2</sub> levels (typically approximately 350 PPM), which represent a CO<sub>2</sub> concentration of just over 1000 ppm. WorkSafeBC mandates the assessment of ventilation rates unless indoor CO<sub>2</sub> levels are less than 650 ppm above ambient outdoor levels (approximately 1000 PPM).

Elevated levels (above ~ 1000 ppm) of CO<sub>2</sub> in an office environment will generally produce complaints of headaches and stale, stuffy air. An exposure limit of 5,000 ppm is identified for CO<sub>2</sub> by WorkSafeBC; however, a typical office environment should have CO<sub>2</sub> concentrations well below this level.

Care must be taken when using CO<sub>2</sub> as an indicator of adequate fresh air. A number of assumptions are made when using CO<sub>2</sub> in this manner, as identified by ASTM Standard D6245 – 12: Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation. These assumptions include occupancy load and associated steady state rate of CO<sub>2</sub> generation by building occupants.

Carbon monoxide (CO) is produced by the incomplete combustion of organic materials. CO levels are measured as an indicator of the quality of outside air being introduced into the workspace. CO in outside air is typically generated by vehicles on busy roadways adjacent to a building, vehicles idling near the fresh air intake of a building, or industrial processes on sites adjacent to a building. CO levels are also measured to assess the performance of combustion devices inside of a building that may impact air quality, such as defective heat exchangers in the HVAC system.

The primary toxic action of CO is the inhibition of cell oxidation following inhalation exposure. Absorbed CO binds with hemoglobin to produce carboxyhemoglobin (COHb), resulting in temporary reduction in the oxygen-carrying capacity of the blood. COHb levels above 10% may be noticed by symptoms such as headaches, and low-level CO exposure has been shown to cause a decrease in psychomotor task performance.

CO levels should not exceed 9 ppm in a typical office environment.

### *2.1.2 Temperature and Relative Humidity*

Temperature and relative humidity are comfort parameters that are important in the perception of good air quality and occupant comfort. Acceptance of the thermal environment and the perception of comfort and temperature are related to metabolic heat production, its transfer in the environment, and the resulting physiological adjustments and body temperatures. Heat transfer is influenced by air temperature, thermal radiation, air speed, humidity, activity, and clothing. Because of individual differences, it is impossible to create a thermal environment that will satisfy all occupants. Standards are generally created to specify an environment that is acceptable to at least 80% of the occupants.

Relative humidity is a measure of the moisture in the air. Low humidity can result in drying of skin and mucous membranes, leading to complaints of dry noses, throats and eyes. High relative humidity can result in building damage and the growth of contaminants such as fungi and dust mites.

Typical guideline levels for relative humidity and temperature range from 30% to 60% relative humidity and 20°C to 26°C for temperature. In the summer, because of acclimatization, the acceptable temperature may be as high as 27°C when relative humidity levels are on the low side of the guideline relative humidity range (~30% relative humidity).

## **2.2 Fungal Contamination**

The American College of Occupational and Environmental Medicine (ACOEM), has prepared an evidence based statement, titled Adverse Human Health Effects Associated with Molds in the Indoor Environment. As noted by this statement, fungal exposure may adversely affect health through allergy (immune mediated response), infection or toxicity. Of these three, allergy is the most common adverse health affect for healthy individuals working and living in an office or home environment. Allergic responses are most commonly experienced as asthma or hay fever. A less common immune mediated response is hypersensitivity pneumonitis (HP), which may occur after exposure to very high concentrations of fungal contaminants.

Some species of fungi are capable of producing secondary metabolites, or mycotoxins. Penicillium is an example of fungi producing mycotoxins with beneficial uses. Serious health effects to mycotoxins are known to occur in agricultural settings as a result of exposure to organic dust or ingestion of fungal contaminated food. It is reasonable to assume, that similar adverse health effects could occur to workers involved in the remediation of heavily fungal contaminated materials, if appropriate precautions were not followed. However, these environments are different than a typical home or office environment. As noted by ACOEM in their statement, "current scientific evidence does not support the existence of a causal relationship between inhaled mycotoxins in the home, school, or office environment and adverse human health effects".

Individuals with compromised immune systems (e.g: people undergoing certain cancer treatments, AIDS patients and people with uncontrolled diabetes) can be at significant risk of experiencing serious fungal infections.

The New York City Department of Health, Guideline on Assessment and Remediation of Fungi and Indoor Environments, November 2008 Edition, provides guidance on procedures to remediate fungal contamination when present. As noted by this guideline, the types of controls and personal protective equipment used changes depending on the amount and location of the fungal contamination. The more fungus present, the greater the level of control needed to minimize worker and occupant exposures.

The presence of fungal contamination actively growing on indoor surfaces should result in some remediation work to minimize occupant exposure risk. Whenever possible, the moisture source that resulted in the presence of the fungal contamination, should also be eliminated or controlled to prevent the growth of additional fungal contamination. If all moisture sources have been eliminated, additional growth will not occur.

When conducting air sampling for fungal contamination using direct microscopic analysis techniques, indoor sample results should be compared to results from control samples collected outdoors. If control samples cannot be collected from outdoors, indoor control samples should be collected. Generally, indoor spores should be similar in type to outdoor spore types; however, they should be present at reduced concentrations. If spore concentrations indoors are present in significantly greater concentrations, when compared to outdoor samples, additional investigation should occur. Also, if spores of certain indicator types of fungi are present indoors (e.g. Stachybotrys), additional investigation may be warranted.

### **3 SCOPE OF WORK**

The following scope of work was completed in accordance with Arcose revised proposal, P2013-1012.

This investigation was completed in several phases over the course of six months. Each phase represents a collection of rooms and areas which have been grouped together.

Approximately 250 rooms in the Education Building were inspected as part of this assessment. These inspections were focused on identifying indications of fungal contamination, water ingress, suspect odours and other indoor air quality concerns.

Ceiling tiles and access hatches were opened for inspection purposes in a number of areas.

Interviews were conducted with site personnel to better understand the building's history and mechanical system. In addition, just prior to starting the site assessment a web based survey was distributed to the various departments housed in the Education Building. Responses to these surveys were then compiled by the departments and forwarded to the Environmental Health and Research Safety Department and Arcose. The survey results were used to focus inspections on occupant areas of concern.

Spore trap (air) samples were collected in occupied spaces distributed throughout the building. Samples were collected prior to disturbing building materials. Sampling locations were selected based on the appearance of suspect fungal contamination or water damage and occupant/client areas of concern. Samples were also collected from indoor areas without indications of water staining or fungal growth for reference purposes. On most sampling days, a minimum of 2 outdoor control spore trap samples were collected for reference purposes.

In addition to the spore trap samples, 6 bulk samples and 13 tape-lift samples were collected from suspect fungal contaminated materials.

A baseline indoor air quality assessment was completed. Spot measurements were collected of carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), relative humidity (RH) and temperature (T) levels.

Concurrently with this investigation fibre in air sampling was conducted to determine whether fiberglass fibers were airborne. A copy of that investigation is included in **Appendix 4**.

As phase investigations were completed, summaries of initial findings and observations, were issued. Where required, these summaries included interim recommendations for occupant health and safety.

This report was prepared at project completion and provides a brief synopsis of the findings from the Summary of Initial Findings and Observations. It also provides observations, conclusions, and recommendations that apply to the Education Building as a whole.

## 4 METHODOLOGY

Inspections were completed to identify fungal contamination, indications of water ingress, unusual odours, excessive dust and debris and other areas of concern. Ceiling tiles were moved and access hatches were opened for inspection purposes in a number of areas. Inspections were limited by the presence of furniture, equipment and stored materials.

A plan to complete inspections in phases was developed to ensure that all areas in the Education Building were included. However, the inspection process was dynamic. As information became available, or if sampling results identified areas of concern, additional inspections and sampling were completed.

Information from the Education Building, Grad Wing Remediation Report 2013/2014 helped to ensure inspections were adequately focused on areas previously identified to be of concern for water ingress and fungal contamination. A copy of the Grad Wing report has been included in **Appendix 1**.

Airborne fungal spore identification was conducted using Zefon *Air-O-Cell* spore trap sampling cassettes designed for the rapid collection of both viable and non-viable fungal spores. Samples were collected by attaching the cassettes to a high volume air-sampling pump calibrated to run at a flow rate of 15 litres per minute. Samples were analyzed via light microscopy and the results were reported as a count per cubic metre of air (count/m<sup>3</sup>). This count includes viable and non-viable fungal spores.

Tape-lift and bulk samples were collected from suspect fungal contaminated materials and submitted for analysis. Samples were collected and sealed in individual containers and were analyzed using direct microscopic techniques.

All fungal samples were sent to EMLab P&K, LLC for analysis.

A TSI Q-Track was used to collect spot measurement of key indicator parameters for indoor air quality. Measurement were collected of carbon monoxide, carbon dioxide, temperature and relative humidity levels. The meter was allowed to stabilize in each assessed area for two to three minutes prior to a reading being taken.

## 5 SITE HISTORY AND OBSERVATIONS

The Education Building is located on the North edge of SFU's Burnaby Campus (**Appendix 3: Photograph 1**). The building is a three storey concrete building, which was constructed in two phases. The first phase was constructed in 1978, with an addition on the North end of the building constructed in 1983.

Over the building's history there have been a number of building envelope leaks reported. It is our understanding that in the last 5-years, the Faculty of Education documented concerns related to water ingress, air quality and fungal contamination. These concerns were reported to encompass approximately 40% of the space that they occupy.

Water leaks throughout the building have resulted in water damage and the suspected presence of fungal contamination.

In response to these concerns a number of measures have been taken to stop building envelope leaks and limit water ingress, including: epoxy injections in concrete cracks, re-roofing, resealing windows, improving window drainage, and improvements to perimeter flashing. While these measures have reduced water ingress, they have not stopped it.

Between October 2013 and February 2014 the Grad Wing underwent a complete remediation, and was stripped back to its basic elements. This work was documented in a separate report by Arcose Consulting Ltd., dated May 1, 2014. The information gained from that remediation work and subsequent building envelope studies, completed by others, are being used to establish a template for remediating building envelope leaks throughout the building.

There have been a number of concerns expressed by occupants in the building, including:

- Musty smells
- Suspect fungal growth
- Cold and flu like symptoms
- Dust
- Headaches
- Lung, throat and sinus infections
- "Allergens"
- Congestion
- Runny noses
- Itchy skin
- Dry itchy eyes
- Itchy noses and throats
- Excessive heat
- Stuffy rooms
- Stale air
- Noise
- Asthma
- Condensation on windows
- Eyes stinging
- Coughing
- Difficulty working in rooms for sustained periods of time
- Local exhaust ventilation system shutting off
- Leaks

On an as reported basis, SFU personnel have investigated and responded to complaints brought forward to them.

This assessment looks more broadly at the complaints and investigates the building's indoor air quality at a macro level, while collecting data on a space by space basis to provide detailed recommendations for each space assessed.

## 6 INITIAL OBSERVATIONS AND RECOMMENDATIONS

Site assessments were completed in several phases, with recommendations for areas with immediate concerns noted in Summary Updates. A listing of the various phases is provided below.

- Phase 1: Mechanical Rooms and TLC Renovation areas
- Phase 2: Undergrad Wing
- Phase 3: Field Programs
- Phase 4: Archeology 9000
- Phase 5: Archeology 8000
- Phase 6: Education Central
- Phase 7: TLC/Creative Services
- Phase 8: Grad Studies and Classroom
- Phase 9: Education 7000 Level, Research
- Phase 10: Upstairs Wing
- Phase 11: Dean's Hallway
- Phase 12: Gym
- Phase 13: Fibre in Air Sampling
- Phase 14: Renovated Areas

To assist with prioritizing, a recommend action priority was provided, which placed recommendations into one of four categories with suggested timelines for completion. Please see below.

Recommended Action Priority	Description
1	Not a current occupant hazard. The area of concern should be monitored. If there is a change in the severity or magnitude of the area of concern, a reassessment should occur.
2	There is a potential for a minor risk to occupants to develop. Action to eliminate the hazard or to minimize the risk should occur within a year.
3	There is a potential for a risk to occupants to develop. Action to eliminate the hazard or to minimize the risk should occur within 90 days.
4	There is some risk to occupants and action should be taken to minimize the risk. Action to eliminate the hazard or to minimize the risk should occur without delay.

Where a priority action of 3 or 4 was identified, specific recommendations for remediation were provided in the Summary Updates.

All of the observations and actions priorities identified by these summaries have been compiled into a table, which has been included in **Appendix 2**.

## **7 HEATING VENTILATION AND AIR CONDITIONING (HVAC)**

The Education Building has a number of air handling units (**Appendix 3: Photograph 2**) which provide conditioned air, that has been filtered and partially heated. The air may receive additional heating from reheat units (**Appendix 3: Photograph 3**) located in ceiling spaces. The air is delivered through supply air ducting and diffusers (**Appendix 3: Photograph 4**) to individual spaces. Once the supply air has been delivered to a space, it may be further heated by locally controlled radiator units (**Appendix 3: Photograph 5**).

The air is brought back to the air handling units through return air systems, which are generally connected to ceiling plenum systems and the rooms with short sections of ducting. Some of these sections of ducting were noted to be metal foil wrapped fiberglass (**Appendix 3: Photograph 6**).

Fresh outside air may be added to the return air, which is then generally filtered, heated as required, and pushed out through ducting to various zones to begin the process again.

Fresh outside air may also enter occupied spaces through open windows and doors.

In some recently renovated areas in the Education Building it is our understanding the reheat units may also have inline filters and may locally recirculate supply air.

In most areas in the Education Building, air handling units do not have the ability to provide cooling; however, air handling units in Archeology and The Learning Centre (TLC)/Creative Services area are able to cool supply air. A number of small rooftop heat exchangers were noted to be present. It was unclear which areas these units service.

To protect artifacts, humidified air is provided to the Archeology Department, museum (**Appendix 3: Photograph 7**). It is our understanding that this humidifier is scheduled for replacement in 2014. Provision of humidified air is not the standard in our moderate, West Coast climate for a typical office or school building.



Most of the air handling units servicing occupied areas are operated by a direct digital control (DDC) system. Energy Management schedules the operation of these systems, which typically run from 7:30 AM to 4:30 PM, unless operational needs dictate otherwise. Within the parameters established by Energy Management, the operation of the fans is normally triggered when indoor temperatures drop below 17 degrees Celsius (°C), however, fans can be forced to run continuously.

The fresh air dampers for individual air handling units are set by an operator; however, each damper has a minimum set point for fresh air. These minimum set points range from 25% to 0%.

Local exhaust fans servicing bathrooms, change rooms and utility areas are typically not controlled by the DDC system, but are instead manually controlled. It is our understanding that most of these fans run continuously. On the evening of April 22, 2014, most bathroom fans inspected were operational between 7:00 PM and 9:40 PM, except Bathrooms 762 and 763, which did not appear to be working.

Return and supply air ducting is typically present at the ceiling level. However, in Rooms 8602, 8603, and 8604 some ventilation ducting was observed to run below grade. On February 13, 2014, below grade ducting in Room 8602 was noted to have water running through it. It is our understanding that SFU is investigating the source of this water and will conduct repairs as required.

It was noted that some rooms do not have adequate ventilation. Some of the issues with these rooms included not having adequate supply or return air systems, manual controls which allowed the ventilation systems to be turned off, blocked vents and missing diffusers.

The following rooms were identified by the various phase inspections to require work to investigate and/or improve their ventilation systems:

- |        |          |
|--------|----------|
| • 760b | • 7619   |
| • 7532 | • 7620   |
| • 7551 | • 7622   |
| • 7552 | • 8501.1 |
| • 7553 | • 8553   |
| • 7554 | • 8620   |
| • 7555 | • 8610.1 |
| • 7608 | • 9641   |
| • 7618 |          |

A maintenance program, which is part of the work order system, is in place for the air handling systems. This maintenance program includes a filter change out schedule, and other maintenance tasks.

## **8 OBSERVATIONS**

Water staining was noted on drywall and wood below windows throughout the Education Building. In most areas the presence of water staining did not also indicate the presence of fungal contamination; however, fungal contamination was present in a number of areas. The heaviest water staining below windows was noted in rooms with North facing windows, in particular in Field Programs and the Undergrad Wing.

When fungal contamination was identified under windows it was localized to small areas, typically only a few centimeters (cm) wide and occupying a contiguous area of less than 100 centimeters square (cm<sup>2</sup>) (**Appendix 3: Photograph 8**).

In many areas, water stains were noted near radiators and reheat system valves. These leaks resulted in water staining and fungal contamination on wood, drywall and ceiling tiles.

Previously repaired concrete ceiling and wall cracks were noted in a number of areas (**Appendix 3: Photograph 9**). In some areas these previously repaired cracks were noted to be weeping (**Appendix 3: Photograph 10**). These weeping cracks may indicate that previous repairs were not successful in controlling moisture ingress.

A number of leaks were also noted under ceiling penetrations.

Leaks from cracks, pipe penetrations and mechanical systems resulted in water staining and damage to the structures below them, including: wood beams, drywall and flooring.

In some areas, significant accumulations of dust and debris were observed in radiator cabinets (**Appendix 3: Photograph 11**). In addition, some of these units were completely obstructed by stored materials (**Appendix 3: Photograph 12**).

## **9 ANALYTICAL RESULTS**

A copy of the laboratories analytical results has been included in **Appendix 5**.

### **9.1 Fungal Air Sampling**

Fungal air sampling generally identified spore concentrations indoors, that were similar in type, but at a reduced concentration, when compared to spore concentrations outdoors. However, spore concentrations which indicated the potential presence of airborne fungal contamination were identified in four areas.

An elevated concentration of *Aspergillus*/*Penicillium* spores was identified in the sample collected from Room 7552 (Sample S6, collected on May 8, 2014). A slightly elevated concentration of *Aspergillus*/*Penicillium* spores was identified in adjacent Room 7553 (Sample S7, collected on May 8, 2014). The presence of fungal contamination had earlier been confirmed in Room 7552 by visual observations and tape-lift sampling (Sample T1, collected on April 16, 2014). These rooms were not being used at the time of this assessment.

A low concentration of *Stachybotrys* spores was identified in the sample collected from Room 8628 (Sample S5, collected on March 13, 2014). This result indicated the potential presence of fungal contamination, which had not been previously identified. A re-inspection of the room, identified a small area of suspect fungal contamination behind a radiator cabinet near a valve, with sample analysis confirming the presence of fungal contamination (Sample B1, collected on March 27, 2014). This room was unoccupied at the time of this assessment.

A slightly elevated concentration of *Aspergillus*/*Penicillium* spores was identified in Room 8680 (Sample S2, collected on March 7, 2014). Based on the site history and visual inspection results, this result was interpreted to indicate the potential presence of airborne fungal contamination. This room was occupied at the time of this assessment, but was subsequently vacated.

The spore trap sample collected from Room 9651A/9652 (Sample S5, collected on May 27, 2014), identified the presence of a slightly elevated concentration of *Aspergillus*/*Penicillium* spores. These results may indicate the presence of airborne fungal contamination. The presence of fungal contamination had earlier been confirmed by visual observations and tape-lift sampling (Sample T2, collected on March 20, 2014). The room was occupied at the time of this assessment but was subsequently vacated.

A summary of air sampling results grouped by inspection phases has been provided in **Appendix 6**.

## **9.2 Tape-lift and Bulk Sampling**

Tape-lift and bulk sampling confirmed the presence of fungal contamination on many of the surfaces sampled.

In response to concern about the potential presence of fungal contamination on drywall with flaking paint (**Appendix 3: Photograph 13**), two tape lift samples were collected (Samples B1 and B2, collected on April 22, 2014). Fungal growth was not identified on these samples.

A summary of tape-lift and bulk sampling results grouped by inspection phases has been provided in **Appendix 7**.

### **9.3 IAQ Spot Measurements**

#### *9.3.1 Carbon Dioxide*

Carbon dioxide levels measured were generally well below guideline levels of 1,000 parts per million (650 plus ambient carbon dioxide levels, at 350 parts per million). However, most rooms inspected were not occupied or were not fully occupied at the time that these measurements were collected. Low occupancy levels will reduce carbon dioxide levels.

Carbon dioxide concentrations above the guideline level of 1,000 ppm were identified in Rooms 7618 and 7619. At the time that the measurements were collected, Room 7618 was fully occupied and Room 7619 was empty. These rooms are directly adjacent to each other. These results may indicate that the rooms have a shared ventilation system and that this ventilation system might not be able to provide sufficient amounts of fresh air at times of full occupancy.

#### *9.3.2 Carbon Monoxide*

Carbon monoxide levels measured were all 0 PPM.

#### *9.3.3 Temperature*

Indoor temperatures were generally within recommended guideline levels of 20 °C to 26 °C.

#### *9.3.4 Relative Humidity*

Relative humidity levels in many areas were below guideline levels of 30% to 60%

#### *9.3.5 Fibre in Air Sampling*

Fibre and air sampling results identified fibre concentrations that are less than the method's analytical method of detection (< 0.0025 fibers/cubic centimeter). These results are less than 1% of the WorkSafeBC, 8 hour Time Weighted Average (TWA) exposure limit of 1 fiber/cubic centimeter for synthetic vitreous fibre (i.e. fiberglass) and indicate that fiberglass fibres are not being made airborne.

## **10 DISCUSSION AND CONCLUSIONS**

Site observations and analytical results indicate that the Education Building is generally safe for the students and staff of Simon Fraser University to occupy. However, areas of concern were identified by this assessment, which indicate the need to mitigate occupant and work exposure risks and improve indoor air quality. Please see below for a discussion of these areas of concern.

## **10.1 Visual Inspections and Fungal Contamination**

Visual inspections identified the presence of water damage and fungal contamination in a number of areas. As in the previously completed Education Building Grad Wing Remediation Report, moisture sources can broadly be grouped as mechanical or building envelope in origin.

In most areas, water damage has not resulted in the presence of fungal contamination; however, small areas of suspect fungal contamination was noted on surfaces in some areas. For the most part this contamination could effectively be remediated and the exposure risk controlled by removing a ceiling tile, applying an encapsulant or completing some other minor treatment to minimize the risk. In other areas, where the moisture source had resulted in the breakdown of the substrate effected, moisture was present in an air handling system or the moisture had resulted in fungal contamination covering an area exceeding 100 cm<sup>2</sup>; more invasive remediation techniques are required.

In all areas, if the moisture source responsible for the leak is not repaired, additional fungal growth will occur. Because of the building's long history of leaks and repairs, it is unclear in many areas if the water stains and suspect fungal contamination identified are the product of recent water ingress. Some of the leaks responsible for the water damage may have previously been eliminated or effectively controlled.

The identification of water damage distributed throughout the building is a good indicator that additional fungal contamination may be hidden behind existing building finishes. Based on fungal air sampling results, this contamination does not appear to be having a negative effect on indoor air quality.

Fungal air sampling generally identified spore concentrations indoors, that were similar in type, but at reduced concentrations when compared to spore concentrations outdoors. In the four instances where elevated spore trap samples were identified, fungal contamination was also identified on exposed surfaces in the rooms.

Surface and bulk sampling confirmed the presence of fungal contamination on many of the surfaces sampled.

These results suggest that the absence of visual indications of fungal contamination on surfaces, is a good indicator of the absence of elevated levels of airborne fungal contamination.

An important part of minimizing the risk of exposure to fungal contamination is limiting water leaks that may support growth. When leaks are identified, they should be controlled as soon as possible. An effective building inspection program will help to identify and control leaks before fungal contamination can become a significant problem.

In the longer term, the establishment of an effective system of building envelope and mechanical system repairs will minimize the potential for additional water damage and fungal contamination.

## **10.2 General Indoor Air Quality**

With the exception of relative humidity, most indoor air quality parameters measured were within guideline levels. Low relative humidity levels were identified in one or more areas in 7 of the 12 investigation phases.

Low relative humidity can result in complaints of dry nose, throat eyes and skin; however, there is likely little that can be done to increase humidity levels. Low relative humidity is a byproduct of heating cold air. Heating air increases its capacity to hold moisture. All other things being equal, when an allotment of air is heated, the absolute amount of moisture it contains remains the same; however, because the air has a greater capacity to hold moisture the relative humidity is reduced (i.e. you have increased the denominator, while the numerator remains the same).

Slightly elevated CO<sub>2</sub> levels were identified in only two of the rooms assessed; however, care should also be taken when using CO<sub>2</sub> as an indicator of sufficient outside air.

ASHRAE's Indoor Air Quality Procedure assumes a certain occupancy load and associated steady state rate of CO<sub>2</sub> generation by building occupants. Because the occupant load of the Education Building can be very low at times and is continually changing, these assumption may not be correct for the Education Building. The use of ASHRAE's Ventilation Rate Procedure would likely improve occupant perception of indoor air quality by ensuring the delivery of at least a minimum amount of outside air. This would be particularly true for rooms that are connected to air handling units that currently have a 0% set point for outside air dampers.

It is our understanding that the maintenance and operation of mechanical systems are generally overseen by the Facilities Services Mechanical Department and that scheduling and establishment of mechanical system set points are generally overseen by the Facilities Services Energy Management group. Within their individual mandates, these groups appear to have competing priorities. For example, a ventilation system may have been installed and maintained by the Mechanical Department with an understanding of minimum operational requirements, such as the amount of fresh air and time of operation required to achieve acceptable indoor air quality; however, Energy Management may make adjustments to this same ventilation system in an attempt to improve the efficient use of resources.

For those systems where the Mechanical Department and Energy Management have combined responsibility, the establishment of an operation and maintenance manual would help to ensure the efficient operation of mechanical systems and a more collaborative approach.

It is our understanding that some of the utility space exhaust fans are manually controlled. It was noted at the time of this assessment that at least two bathroom fans (Rooms 762 and 763) were not operational in the evening hours. The operation of these fans should be verified to ensure that moisture and other contaminants of concern are effectively controlled.

It was noted that some rooms do not have adequate ventilation. Some of the issues with these rooms included not having adequate supply or return air systems, blocked vents and missing diffusers.

The presence of water in ducting and the humidification system servicing the Archeology Department warrants special concern. Untreated water in an air handling system can result in significant bacterial and fungal growth, including legionella pneumophila. It is our understanding that humidification water was being treated; however, a documented procedure was not available for review.

## **11 RECOMMENDATIONS**

Based on sampling results, site observations and the conclusions identified above, Arcose recommends the following.

1. It is our understanding that SFU is currently developing a building envelope remediation plan for the Education Building. This plan should be completed and implemented as required to minimize water ingress.
2. All recommended actions identified by the phase inspections should be implemented.
3. In many areas significant accumulations of dust and debris were noted in and around radiator cabinets. This accumulated dust and debris should be removed and a schedule developed to ensure the regular cleaning of these areas.
4. Mechanical system recommendations:
  - a. The building's ventilation system should be balanced and adjusted so that all spaces are provided with an adequate allotment of outside air in accordance with the Ventilation Procedure identified by ASHRAE.

Until such time as this work can be completed, occupants should be encouraged to open windows when present in their rooms to improve airflow.

- b. Rooms that currently do not have adequate air flow, or no air flow, should be modified to ensure that they are adequately ventilated in accordance with the BC Building Code requirements and ASHRAE standards.

- c. A systematic inspection of reheat system and radiator system water valves and fitting should be completed to allow for the identification and repair of leaks.
  - d. An operation and maintenance manual should be developed for the building's heating, ventilation and air conditioning systems. This manual should include all operations currently completed by Facilities and Energy Management. It should identify set points and operation parameters so that all personnel with responsibility for the system have a common understanding of the system and how it should operate.
  - e. Untreated water should not be permitted in air handling system components.
5. A system of regular inspections should be implemented to assist with the prompt identification and repair of leaks and suspect fungal growth.
- a. These inspections should be completed by four different groups, each looking at different elements:
    - i. On a routine and ongoing basis, building occupants should report any signs of water leaks or fungal contamination to their supervisor. The process for reporting signs of water leaks and fungal contamination should be well documented.
    - ii. On a monthly basis, the Health and Safety Committee should complete inspections of all areas as part of their regular inspection process. The committee should look for indications of new water damage, changes in previous water damage and the appearance of suspect fungal contamination. When any of these conditions are identified, a report should be forwarded to Facilities for repair and remediation, as required.
    - iii. On a quarterly basis at a minimum, Facilities should complete an inspection of mechanical system components to identify the presence of leaks and water ingress. Repairs should be completed as required to eliminate leaks and water ingress.
    - iv. On an annual basis, the Environmental Health and Research Safety Department should complete an audit of the quarterly and monthly inspections to ensure that they are being completed as specified and that repairs are being completed as required.



- b. Health and Safety Committee members should receive training on: fungal awareness, inspection procedures and remediation procedures.
6. Because of the widespread identification of water stained and water damaged building materials, there is a potential for fungal contamination to be hidden behind existing finishes. When completing renovation or remediation work, which involves opening wall and ceiling spaces, the assumption should be that fungal contamination may be present in these spaces and appropriate procedures followed to minimize the exposure risk.
7. SFU should develop internal procedures for the investigation, identification, remediation and communication of fungal contamination concerns. These procedures should be based on recognized standards such as ACOEM, evidence based statement, Adverse Human Health Effects Associated with Molds in the Indoor Environment, The New York City Department of Health, Guideline on Assessment and Remediation of Fungi and Indoor Environments, November 2008 Edition, and the Institute of Inspection, Cleaning and Restoration Certification (IICRC), S520 Standard and Reference Guide for Professional Mold Remediation.

## 12 LIMITATIONS

Based on the information provided, the data and findings presented in this report are believed to be valid at the time of this investigation. The passage of time, changes in site conditions or procedures, or other future events may warrant further analysis.

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## 13 CLOSURE

If you have any questions or require any further information, please contact Evan Alvernaz, of Arcose Consulting Ltd. at (604) 243-9763 or at [evalvernaz@arcose.com](mailto:evalvernaz@arcose.com).

Thank you for using the services of Arcose Consulting Ltd.