WSP Project No. 161-06021

Subject: **Environmental Services – Mould Investigation**
Citadel Hill Service Tunnel, Halifax, Nova Scotia

1. INTRODUCTION

WSP Canada Inc. (WSP) was retained by Parks Canada to complete a Mould Investigation of the underground utility services tunnel located beneath the Halifax Citadel National Historic Site of Canada. Suspected mould contamination was identified during electrical and structural assessments completed by WSP in May, 2016.

The purpose of this investigation was to confirm the presence or absence of mould prior to bidding future electrical and structural repairs in the tunnel. The investigation was conducted by a WSP representative on October 4th, 2016, with assistance from HSE Integrated for confined space entry and fall arrest. The investigation included the collection of air samples, tape lift samples and a bulk sample for analysis of the presence of mould species in the service tunnel.

2. SCOPE OF WORK

The investigation included the following activities:

- Collection of four (4) air samples from within the service tunnel and one (1) exterior sample to analyze for the presence of mould species in the air environment of the tunnel, as well as background settings.
- Collection of three (3) tape lift samples and one (1) bulk sample to analyze for the presence and type of mould species on suspected surfaces.
- Preparation of a final report describing the results of and recommendations from the survey.

The methodology and results of the sampling program are described in detail in Section 7 of this report.

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3. SITE DESCRIPTION

The service tunnel is made up of corrugated steel pipe plate and is approximately 2.1 metres in diameter and 83 metres long. Utilities located within the tunnel include a 300 mm diameter PVC sanitary sewer main, a 600 mm diameter PVC storm main, a 150 mm diameter ductile iron water main, a gas main, along with telephone and electrical cables. The tunnel is considered a confined space, with access to the tunnel provided by two manholes, located at each end of the tunnel. At the time of the investigation, access to the service tunnel was provided through a manhole located in the courtyard of the historic property.

Lighting within the tunnel was poor at the time of the site visit, however a fibrous suspected mould was visible on an unidentified dual cable (identified in Figure 1 below), and black mould-like staining was visible in patches along multiple surfaces including PVC pipes, metal and other surfaces.

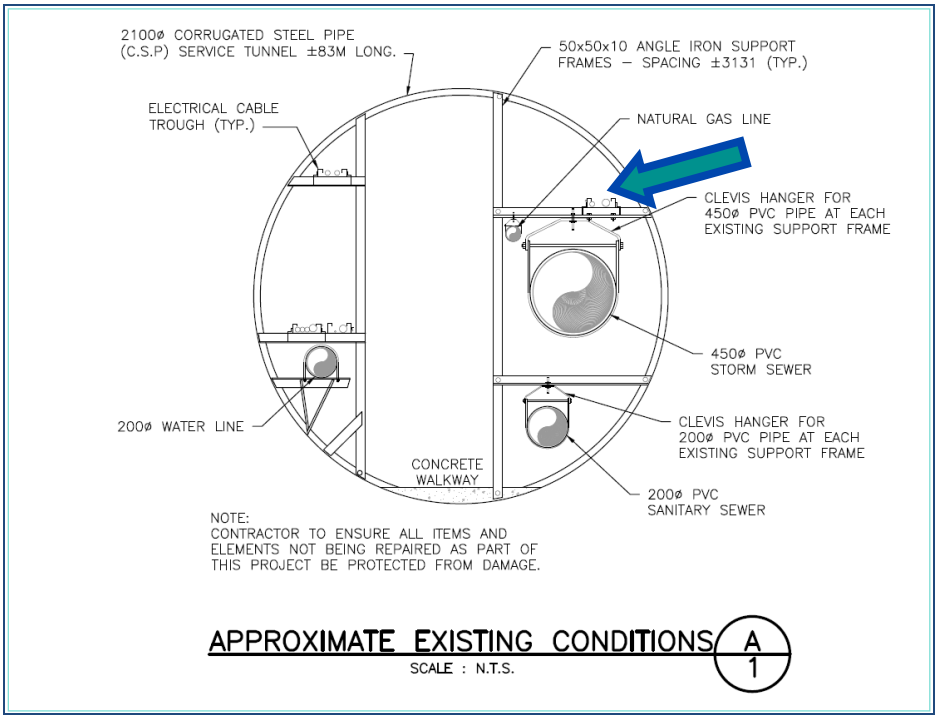

Figure 1: Approximate existing conditions (indicating service locations) in the service tunnel. The unidentified dual cable with fibrous growth is indicated by a blue arrow.

4. BACKGROUND INFORMATION

Micro-organisms such as fungi, bacteria, viruses and pollen, are natural and ubiquitous components of the outdoor and indoor environment. Fungi, often called ‘mould’, or ‘mildew’, originate on plants, leaves and in soil. Yeasts are also fungi. Over 100,000 species of fungi are known to exist and many have yet to be classified; most produce spores that are designed to be transported through the air.

Mould spores are brought into indoor environments through ventilation systems, open windows or doors, or animal and human activity. If conditions exist that allow fungi to grow

indoors (i.e. a suitable temperature, organic substrate/nutrients, and adequate moisture), concentrations will increase to levels that are typically not found in buildings. Mould growth indoors primarily occurs when water damages cellulose-containing building materials and/or furnishings (such as wood, drywall, wallpaper, ceiling tiles, etc.) or impacts building-materials with high organic contents due to catastrophic or chronic events such as leaks, floods, condensation (associated with high humidity or cold spots), improper design or operation of humidification systems and building envelope failures. Under these conditions fungal growth may present a risk to the building structure itself (through degradation of building materials) as well as to occupants in the building (through exposures and potentially adverse health effects).

Spores will typically germinate anywhere where both adequate moisture and nutrients exist. Therefore, strategies to prevent microbial growth include eliminating or reducing excess moisture by sealing the building envelope to avoid water infiltration, controlling interior humidity levels to below 60%, providing effective filtration of exterior particulates, proper operation and maintenance of HVAC systems, and keeping indoor environments clean and tidy. Unforeseen circumstances such as floods and sudden leaks can occur, however, and effective techniques and procedures should be implemented to remove standing water and dry saturated building materials.

5. REGULATORY FRAMEWORK

There are no regulated exposure threshold limit values or standards for microbials. Several reasons for this are as follows:

- It is not possible to collect all bio-organisms using a single sampling method. The methods used to collect, culture and analyze samples vary greatly. Sampling equipment is size-specific, for example, settle plates will collect only large microbials, and centrifugal samplers will miss the larger spores. Microbials may be culturable, nonculturable, and non-viable. Fungal and bacterial fragments can be allergenic. Different growth medians will support the growth of different fungal species, depending on the formulation and moisture availability. Incubation time and temperature also favour selective organisms.
- Collection methods do not reflect actual human exposure. Microbial concentrations in air will vary by several orders of magnitude in one location and between sites. Short 'grab' samples cannot represent real exposure values over a work period.
- Information relating both viable and non-viable microorganisms is presently insufficient to establish dose-response relationships. Very few epidemiological studies have been done. The issue is further complicated by the secondary by-products that many microbial species produce, such as mycotoxins, endotoxins, volatile organic compounds, antigens, β-1,3-glucan, etc. that may be more potent than the microbial itself. These 'indicator' measurements do not accurately reflect total exposure.

There is a wide variation in individual susceptibility to microbials and various factors such as genetics, age, personal habits, health, pre-existing conditions, medication, and previous exposure, will affect people's reaction. Furthermore, building occupants are exposed to a large variety of complex and variable chemical and biological mixtures at work, outdoors and at home. Consequently, exposure information is imprecise because agents, other than those identified and measured, will also be present and may be responsible for some of the health responses by exposed persons. Biological markers of exposure to fungi are largely unknown.

6. MOULD ABATEMENT PROTOCOLS

Although there are no regulatory requirements in Nova Scotia for mould assessments, agencies such as Health Canada and Provincial Ministries have generally been accepted as the authorities on this topic. The guidelines set out in the Canadian Construction Association document CCA 82-2004 are generally accepted as an industry standard for mould assessment, the minimum requirements of which, are:

- Mould remediation should be carried out by a qualified environmental abatement contractor that specializes in mould remediation. Workers performing the abatement should be properly trained and use the appropriate personal protective equipment. Canadian Construction Association guidelines CCA 82-2004 “Mould Guidelines for the Canadian Construction Industry” must be followed for removal and cleaning procedures within the building. Level 2 or Level 3 mould abatement procedures, including negative air pressure vented to the outdoors, should be followed for removal and cleaning procedures.
- Inspections should be conducted by a qualified Environmental Consultant prior to abatement, to ensure the abatement enclosure has been set up as per the regulations, during abatement to ensure mould guidelines are being followed, and following abatement to conduct a final visual assessment to document all mould contaminated materials have been removed.

Mould abatement protocols as outlined in the CCA 82-2004 document were reviewed in conjunction with the Canadian National Master Construction Specification (Sect 02 85 00 – Mould Remediation).

7. MOULD SURVEY

7.1 VISUAL OBSERVATIONS

WSP representative Stephanie Barkhouse visited the site on October 4, 2016. At the time of site investigation, the following observations were noted:

- A fibrous growth was observed along a dual cable, which travels most of the length of the service tunnel. The location of the cable has been identified in Figure 1, above.

Photo 1 (left) and **Photo 2** (right): growth observed along dual unidentified cable, as collected in tape lift sample Tape1, and bulk sample Bulk1

- Visible mould staining was observed along multiple surfaces within the service tunnel, including the storm and sanitary sewers lines as indicated in Photos 3 and 4 below.

Photo 3 (left) and **Photo 4** (right): staining observed along the pipes within the service tunnel as sampled in tape lift sample Tape4

- Damp conditions, including visible pooled water at the base of the tunnel during the May 2016 site visit, and evidence of precipitation of metals was also observed, as indicated by the arrows in Photo 5 below; a musty odour was also noted.

Photo 5: visible pooled water at the base of the tunnel during the May 2016 site visit, and precipitation along the tunnel walls are indicated by arrows in the photo above

7.2 AIR SAMPLING ANALYSIS

Samples for airborne microorganisms were collected in representative locations using spore trap sample collection techniques. In a typical spore trap sample, such as an Air-O-Cell cassette, air is drawn through an opening and must flow around an adhesive coated glass slide. As the air flow changes direction, the trajectory results in airborne particulate impacting and sticking to the glass slide while the air continues out through the exit opening of the

cassette. After collection, the glass slide is removed from the cassette and analyzed by a laboratory by direct microscopic examination (DME).

Air samples were collected utilizing a Bio-Pump Plus sampling pump with Air-O-Cell cassettes at a sampling time of 5 minutes, or measurement based on 75 litres of air. Spore trap samples were then submitted to an EMSL Canada in Mississauga, Ontario for analysis using Direct Microscopic Exam (DME). The sample is viewed at 400X magnification and individual spores are counted and grouped to the genus level where possible, based on spore morphology (i.e., size, shape, colour, etc.). This analytical method provided a total spore count as all spores identified are counted, whether viable or non-viable. Results from analysis of the spore trap are reported in raw spore count, and spores/m3. Results are then compared to reference samples (i.e. samples collected from outdoor air and/or indoor air areas with no concerns) for both numbers and types of mould. WSP interprets the differential between results from suspect areas in reference to the control sample(s) and provides an interpretation in one of the following manners:

Low Levels: The indoor spore counts were less than the outdoor counts and/or their numbers are not high enough to be of significance in the indoor environment. Recommendations will be minimal.

Moderate Levels: The indoor spore counts are moderately elevated compared to outside and to surrounding areas. Recommendations will be made.

High Levels: The indoor spore counts are extremely high compared to outside and surrounding areas. Recommendations will be made.

Contaminating Spores: The presence of contaminating spores likely indicates that a chronic source of moisture accumulation exists/existed. The presence of these mould spore types/concentrations in the air is typically considered a concern from an indoor air quality perspective. Typical contaminating mould spore types include but are not limited to:

- *Stachybotrys*
- *Chaetomium*

In addition to the numerical comparison of spore counts, as described above, interpretation is also based on the similarity of species and relative distribution of species found in control samples compared to those found in samples from areas of concern.

A total of five (5) air samples were collected from within the service tunnel and at the exterior to evaluate the air quality at the time of the investigation. **Table 7-1** below indicates the location and results of the air samples collected and analyzed. Refer to Analytical Results in Appendix A for Laboratory Certificate of Analysis.

Table 7-1: Air Sampling Locations and Results

SAMPLE ID	SAMPLE LOCATION	TOTAL SPORE CONCENTRATION (ELEMENT/M^3)	COMMENTS AND IDENTIFIED SPORE TYPES
AIR1	East end of tunnel	1310	• Low levels of Cladosporium, Ganoderma and Hyphal Fragments • Moderate levels of Basidiospores
AIR2	Near light fixture 3	750	• Low levels of Ascospores, Aspergillus/Penicillium, Cladosporium, and Stachybotrys • Moderate levels of Basidiospores **Contaminating Spores Present: Stachybotrys**
AIR3	Between light fixtures 5 and 6	720	• Low levels of Ascospores, Aspergillus/Penicillium, Basidiospores, Cladosporium and Stachybotrys **Contaminating Spores Present: Stachybotrys**
AIR4	West end of tunnel	1150	• Near the courtyard entrance, where manhole cover was open at time of sampling • Low levels of Ascospores, Basidiospores, Cladosporium, and Hyphal Fragments • Moderate levels of Aspergillus/Penicillium
AIR5	Exterior reference sample	1880	• Sample collected outside at the courtyard entrance point to the service tunnel • Low levels of Alternaria, Ascospores, Cladosporium, and Ganoderma • Moderate levels of Basidiospores

7.3 TAPE LIFT AND BULK ANALYSIS

Tape-lift & bulk sampling of suspect mould contaminated materials was performed to confirm the presence or absence of mould growth. Tape-lift sampling was carried out using an adhesive BioTape® microscope slide supplied by the analytical laboratory. The adhesive portion of the BioTape® was pressed against the suspect mould growth, peeled off and placed in a clean sealable labeled bag/container. The samples were then forwarded to EMSL Analytical Inc. in Mississauga for analysis by direct microscopy. **Table 7-2** below indicates the location and results of the tape lift samples collected and analyzed. Refer to Analytical Results in Appendix A for Laboratory Certificate of Analysis.

Table 7-2: Tape Lift & Bulk Sampling Results

SAMPLE ID	LOCATION	FUNGAL IDENTIFICATION	CATEGORY
TAPE1	Between light fixtures 6 and 7 – fibrous growth	Hyphal Fragment	High
		Rhinocladiella	Rare
TAPE3	Near light fixture 3 – metal with no obvious staining	Cladosporium	Rare
		Hyphal Fragment	Rare
TAPE4	Near light fixture 3 – black staining	Arthrospores	Low
		Aspergillus/Penicillium	Rare
		Chaetomium*	**Rare**
		Cladosporium	Rare
		Hyphal Fragment	High
BULK1	Between light fixtures 6 and 7 – fibrous growth	Hyphal Fragment	High

***Contaminating Spores Present: Chaetomium (TAPE4)**

7.4 SUMMARY OF FINDINGS

Findings are summarized below:

- Levels of Basidiospores, Cladosporium and Ascospores were identified in the exterior air sample (AIR5) at higher concentrations than identified within air samples collected from the service tunnel.
- Visible signs of mould growth and staining were observed in various areas throughout the service tunnel.
- The mould indicator species Stachybotrys was identified within the service tunnel in air samples AIR2 and AIR4 at low levels. Stachybotrys was not identified within the exterior reference air sample (AIR5).
- Aspergillus/Penicillium were identified to be present within air samples AIR2, AIR3 and AIR4 collected within the service tunnel. Aspergillus/Penicillium was not identified within the exterior reference air sample (AIR5).
- Hyphal Fragments were identified to be present within air samples AIR1 and AIR4 collected within the service tunnel. Hyphal Fragments were not identified within the exterior reference air sample (AIR5).
- Hyphal Fragments were identified in rare to high levels in all tape lift and bulk analysis samples collected within the service tunnel.
- The mould indicator species Chaetomium was identified to be present in the tape lift sample TAPE4 at low (i.e. “rare”) levels. Chaetomium was not identified in any other sample collected.

The observations and laboratory findings noted above indicates that mould growth is present within various areas throughout the service tunnel. The presence of visible mould growth and staining within the service tunnel indicates that any disturbance of the mould-affected materials will likely lead to an increase in airborne concentrations of mould spores.

8. CONCLUSIONS/RECOMMENDATIONS

1. As mould concerns have been identified within various areas throughout the service tunnel, WSP recommends Canadian National Master Construction Specification (Sect 02 85 00.003 – Mould Remediation Maximum Precautions) mould clean-up procedures within these areas of concern, including negative air pressure vented to the outdoors, for removal and cleaning procedures, as per the CCA 82-2004 document. The following should be conducted:

    a. A mould abatement enclosure should be constructed at both entrance points to the service tunnel. Air-tight seals should be created for any conduits leading to adjoining structures with human occupancy.

    b. Air scrubbing, with a HEPA filter fitted air scrubber, should be conducted continuously during all mould remediation activities and overnight/on weekends until mould remediation is complete.

    c. Air scrubbing can be conducted with stand-alone equipment within the mould remediation enclosure(s), or as a negative air unit external to the remediation enclosure and exhausting to outdoors, or both.

    d. All water damaged and/or mould-affected materials should be removed, and the back-side of the materials should be inspected for visible mould growth. If mould growth is found on the back-side of removed materials, these materials should be removed two (2) feet beyond the visible mould presence.

    e. Any insulation present behind water damaged and/or mould-affected materials should be inspected. Any insulation which is wet or visibly mouldy should be removed and disposed of.

    f. Following completion of items a-e, all the non-porous materials (e.g. metals, glass and hard plastics) and semi-porous materials (e.g. wood, concrete) within the area of concern should be HEPA vacuumed and wet wiped using a suitable biocide cleaning solution. Non-porous materials can be re-used after being cleaned.

    g. Clearance air sampling should be conducted to document airborne levels of mould prior to installation of any interior finishes or insulation.

    h. If any mould is discovered beyond that discussed within this report, the following actions should take place:

        i. All water damaged and/or mould-affected materials should be removed from the area as mould waste, and if visible mould growth is observed, material should be removed to a radius of two (2) feet away from the visible mould.

        ii. All the non-porous (e.g., metals, glass and hard plastics) and semi-porous materials (i.e. wood, concrete) within the area of concern should be HEPA vacuumed and wet wiped using a suitable biocide cleaning solution, including a radius of 2 feet away from the visible mould.

        iii. Clearance air sampling should be conducted to document airborne levels of mould prior to installation of any interior finishes.

2. As water intrusion and moisture generation appear to be an inherent feature of the service tunnel, water and moisture controls should be put into place in order to prevent future mould growth from occurring. For example, adequate ventilation should be put in place and regular inspections should be done in order to monitor water intrusion and moisture levels. Should the issue persist, all future persons entering into the service

tunnel should do so only while wearing appropriate mould PPE including, but not limited to:

a. NIOSH-approved Half-face Filtering Facepiece Respirator (N95 minimum)
b. Full-body dust-impervious coveralls with attached hoods (i.e. Tyvek suit)
c. Dust-impermeable gloves appropriate for the work
d. Safety glasses or goggles
e. Other appropriate PPE as required by the work being done (i.e. hard hat, safety vest, safety boots, confined space and fall arrest requirements, etc.)

9. LIMITATIONS

This survey was representative of the current conditions at the time of this investigation. Should mildew or musty odours or other issues again present themselves, a further assessment should be conducted. Contractors should be warned of the possibility of undisclosed materials (mould) when breaking into enclosed areas.

This report was written by Stephanie Barkhouse, B.Sc., CET with technical review provided by Erin Haatvedt, CIH and senior review by Sean Cassidy, P.Eng, Manager, Environment – Dartmouth.

Very truly yours,
WSP Canada Inc.

Stephanie Barkhouse, BSc., CET
Environmental Engineering Technologist

Erin Haatvedt, CIH
Project Manager – Environmental

Encl.: Appendix A – Laboratory Certificates of Analysis
Appendix B – Canadian National Master Construction Specification
(Section 02 85 00.003 – Mould Remediation Maximum Precautions)

Appendix A

Laboratory Certificates of Analysis

EXPANDED FUNGAL REPORT™

Prepared Exclusively For

WSP Canada, Inc.

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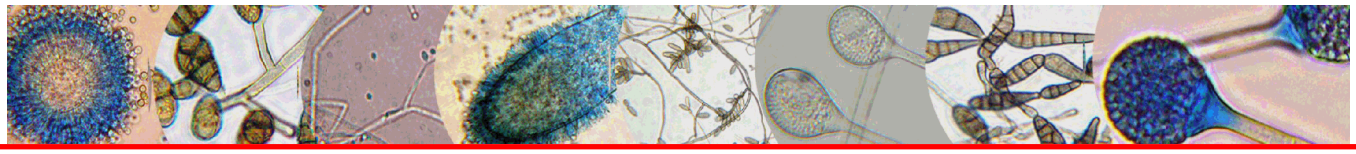
Report Date:	**10/6/2016**
Project:	**161-06021**
EMSL Canada Orde	**551610646**

ACCREDITED
Environmental Testing Cert #2845.08



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EMSL Order: 551610646
Customer ID: 55GNVR34
Collected: 10/04/2016
Received: 10/05/2016
Analyzed: 10/06/2016

Proj: 161-06021

1. Description of Analysis

Analytical Laboratory

EMSL Canada Inc. (EMSL Canada) is a nationwide, full service, analytical testing laboratory network providing Asbestos, Mold, Indoor Air Quality, Microbiological, Environmental, Chemical, Forensic, Materials, Industrial Hygiene and Mechanical Testing services. Ranked as the premier independently owned environmental testing laboratory in the nation, EMSL Canada puts analytical quality as its top priority. This is assured by our high quality personnel, including experienced microbiologists with graduate degrees. Our quality is recognized by many well-respected federal, provincial and private accrediting agencies, such as the American Association for Laboratory Accreditation (A2LA). A2LA is a nonprofit, non-governmental, public service, membership society providing laboratory accreditation based on internationally accepted criteria for competence (ISO/IEC 17025:2005). A2LA accreditation is also recognized internationally through its membership with the International Laboratory Accreditation Cooperation (ILAC).

EMSL Canada is an independent laboratory that performed the analysis of these samples. EMSL Canada did not conduct the sampling or site investigation for this report. The samples referenced herein were analyzed under strict quality control procedures using state-of-the-art microbiological methods. The analytical methods used and the data presented are scientifically and legally defensible

The laboratory data is provided in compliance with A2LA accreditation and the ISO 17025 standard for the particular test(s) requested, including any associated limitations for the methods employed. These data are intended for use by professionals having knowledge of the testing methods necessary to interpret them accurately.

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Air Samples - Spore traps:

Spore traps are commercially available sampling devices that capture airborne particles on an adhesive slide. Air is pulled through the device using a vacuum pump. Spores, as well as other airborne particles, are impacted on the collection adhesive. Using spore trap collection methods has inherent limitations. These collection methods are biased towards larger spore sizes.

The analysis for total spore counts is a direct microscopic examination and does not include culturing or growing the fungi. Therefore, the results include both viable and non-viable spores. Some fungal groups produce similar spore types that cannot be distinguished by direct microscopic examination alone (i.e., *Aspergillus/Penicillium*, and others). Other spore types may lack distinguishing features that aid in their identification. These types are grouped into larger categories such as Ascospores or Basidiospores.

Fungal spores are identified and grouped by morphological characteristics including color, shape, septation, ornamentation, and fruiting structures (if present) which are compared to published mycological identification keys and texts. EMSL Canada reports provide spore counts per cubic meter of air to three significant figures. Please note that each spore category is reported to three significant figures. Due to rounding and the application of three significant figures the sum of the individual spore numbers may not equal the total spore count on the report. EMSL Canada does not maintain responsibility for final volume concentrations (counts/m3) since this volume is provided by the field collector and can not be verified by EMSL Canada.

EMSL Canada analyzes spore traps using phase contrast microscopy. There is a wide choice of collection devices (Air-O-Cell, Micro-5, Burkhard, etc.) on the market. Differences in analytical method may exist between spore trap devices.

Spore trap results are reported in spores per cubic meter of air. Due to the other airborne particles collected with the spores, EMSL Canada reports a background particle density. Background density is an indication of overall particulate matter present on the sample (i.e. dust in the air). High background concentrations may obscure spores such as the *Penicillium*/*Aspergillus* group. The rating system is from 1-5 with 1 = 1 - 25% of the background obscured by material, 2 = 26 - 50%, 3 = 51 - 75%, 4 = 76% - 99%, 5 = 100% or overloaded. A background rating of 4 or higher should be regarded as a minimum count since the actual concentrations may be higher than those reported. EMSL Canada will not be held responsible for overloading of samples. Sample volumes are left to the discretion of the company or persons conducting the fieldwork.

Skin fragment density is the percentage of skin cells making up the total background material, 1 = 1 - 25%, 2 = 26 - 50%, 3 = 51 - 75%, 4 = 76-100%. Skin fragment density is

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considered an indication of the general cleanliness in the area sampled. It has been estimated that up to 90% of household dust consists of dead skin cells.

2. Analytical Results

See attached data reports and charts.

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Test Report: Air-O-Cell(™) Analysis of Fungal Spores & Particulates by Optical Microscopy (Methods EMSL 05-TP-003, ASTM D7391)

Lab Sample Number:	551610646-0001			551610646-0002			551610646-0003		
Client Sample ID:	AIR1			AIR2			AIR3		
Volume (L):	75			75			75		
Sample Location:	EAST END OF TUNNEL			NEAR LIGHT FIXTURE 3			BETWEEN LIGHT FIXTURE 5 AND 6		
Spore Types	**Raw Count**	**Count/m³**	**% of Total**	**Raw Count**	**Count/m³**	**% of Total**	**Raw Count**	**Count/m³**	**% of Total**
Alternaria	-	-	-	-	-	-	-	-	-
Ascospores	-	-	-	1*	10*	1.3	1	40	5.6
Aspergillus/Penicillium	-	-	-	3	100	13.3	1	40	5.6
Basidiospores	28	1200	91.6	13	560	74.7	5	200	27.8
Bipolaris++	-	-	-	-	-	-	-	-	-
Chaetomium	-	-	-	-	-	-	-	-	-
Cladosporium	3	100	7.6	1	40	5.3	9	400	55.6
Curvularia	-	-	-	-	-	-	-	-	-
Epicoccum	-	-	-	-	-	-	-	-	-
Fusarium	-	-	-	-	-	-	-	-	-
Ganoderma	1*	10*	0.8	-	-	-	-	-	-
Myxomycetes++	-	-	-	-	-	-	-	-	-
Pithomyces	-	-	-	-	-	-	-	-	-
Rust	-	-	-	-	-	-	-	-	-
Scopulariopsis	-	-	-	-	-	-	-	-	-
Stachybotrys	-	-	-	1	40	5.3	1	40	5.6
Torula	-	-	-	-	-	-	-	-	-
Ulocladium	-	-	-	-	-	-	-	-	-
Unidentifiable Spores	-	-	-	-	-	-	-	-	-
Zygomycetes	-	-	-	-	-	-	-	-	-
Total Fungi	**32**	**1310**	**100**	**19**	**750**	**100**	**17**	**720**	**100**
Hyphal Fragment	1	40	-	-	-	-	-	-	-
Insect Fragment	-	-	-	-	-	-	-	-	-
Pollen	-	-	-	-	-	-	-	-	-
Analyt. Sensitivity 600x	-	43	-	-	43	-	-	43	-
Analyt. Sensitivity 300x	-	13*	-	-	13*	-	-	13*	-
Skin Fragments (1-4)	-	1	-	-	1	-	-	2	-
Fibrous Particulate (1-4)	-	1	-	-	2	-	-	2	-
Background (1-5)	-	2	-	-	3	-	-	3	-

Bipolaris++ = Bipolaris/Drechslera/Exserohilum
Myxomycetes++ = Myxomycetes/Periconia/Smut

No discernable field blank was submitted with this group of samples.

Sneha Panchal, M.Sc.,RMCCM Laboratory Manager

High levels of background particulate can obscure spores and other particulates leading to underestimation. Background levels of 5 indicate an overloading of background particulates, prohibiting accurate detection and quantification. Present = Spores detected on overloaded samples. Results are not blank corrected unless otherwise noted. The detection limit is equal to one fungal spore, structure, pollen, fiber particle or insect fragment. "*" Denotes particles found at 300X. "-" Denotes not detected. Due to method stopping rules, raw counts in excess of 100 are extrapolated based on the percentage analyzed. EMSL maintains liability limited to cost of analysis. This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities or analytical method limitations. Interpretation and use of test results are the responsibility of the client. Samples received in good condition unless otherwise noted.

Initial report from: 10/06/2016 12:26:47

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Proj: 161-06021

Test Report: Air-O-Cell(™) Analysis of Fungal Spores & Particulates by Optical Microscopy (Methods EMSL 05-TP-003, ASTM D7391)

Lab Sample Number:	**551610646-0004**			**551610646-0005**					
Client Sample ID:	**AIR4**			**AIR5**					
Volume (L):	**75**			**75**					
Sample Location:	**WEST END OF TUNNEL**			**EXTERIOR SAMPLE**					
Spore Types	**Raw Count**	**Count/m³**	**% of Total**	**Raw Count**	**Count/m³**	**% of Total**			
Alternaria	-	-	-	1	40	2.1			
Ascospores	1	40	3.5	3	100	5.3			
Aspergillus/Penicillium	18	770	67	-	-	-			
Basidiospores	7	300	26.1	30	1300	69.1			
Bipolaris++	-	-	-	-	-	-			
Chaetomium	-	-	-	-	-	-			
Cladosporium	1	40	3.5	10	430	22.9			
Curvularia	-	-	-	-	-	-			
Epicoccum	-	-	-	-	-	-			
Fusarium	-	-	-	-	-	-			
Ganoderma	-	-	-	1*	10*	0.5			
Myxomycetes++	-	-	-	-	-	-			
Pithomyces	-	-	-	-	-	-			
Rust	-	-	-	-	-	-			
Scopulariopsis	-	-	-	-	-	-			
Stachybotrys	-	-	-	-	-	-			
Torula	-	-	-	-	-	-			
Ulocladium	-	-	-	-	-	-			
Unidentifiable Spores	-	-	-	-	-	-			
Zygomycetes	-	-	-	-	-	-			
Total Fungi	**27**	**1150**	**100**	**45**	**1880**	**100**			
Hyphal Fragment	1*	10*	-	-	-	-			
Insect Fragment	-	-	-	-	-	-			
Pollen	-	-	-	-	-	-			
Analyt. Sensitivity 600x	-	43	-	-	43	-			
Analyt. Sensitivity 300x	-	13*	-	-	13*	-			
Skin Fragments (1-4)	-	1	-	-	1	-			
Fibrous Particulate (1-4)	-	1	-	-	1	-			
Background (1-5)	-	2	-	-	2	-			

Bipolaris++ = Bipolaris/Drechslera/Exserohilum
Myxomycetes++ = Myxomycetes/Periconia/Smut

No discernable field blank was submitted with this group of samples.

Sneha Panchal, M.Sc.,RMCCM Laboratory Manager

High levels of background particulate can obscure spores and other particulates leading to underestimation. Background levels of 5 indicate an overloading of background particulates, prohibiting accurate detection and quantification. Present = Spores detected on overloaded samples. Results are not blank corrected unless otherwise noted. The detection limit is equal to one fungal spore, structure, pollen, fiber particle or insect fragment. "*" Denotes particles found at 300X. "-" Denotes not detected. Due to method stopping rules, raw counts in excess of 100 are extrapolated based on the percentage analyzed. EMSL maintains liability limited to cost of analysis. This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities or analytical method limitations. Interpretation and use of test results are the responsibility of the client. Samples received in good condition unless otherwise noted.

Initial report from: 10/06/2016 12:26:47

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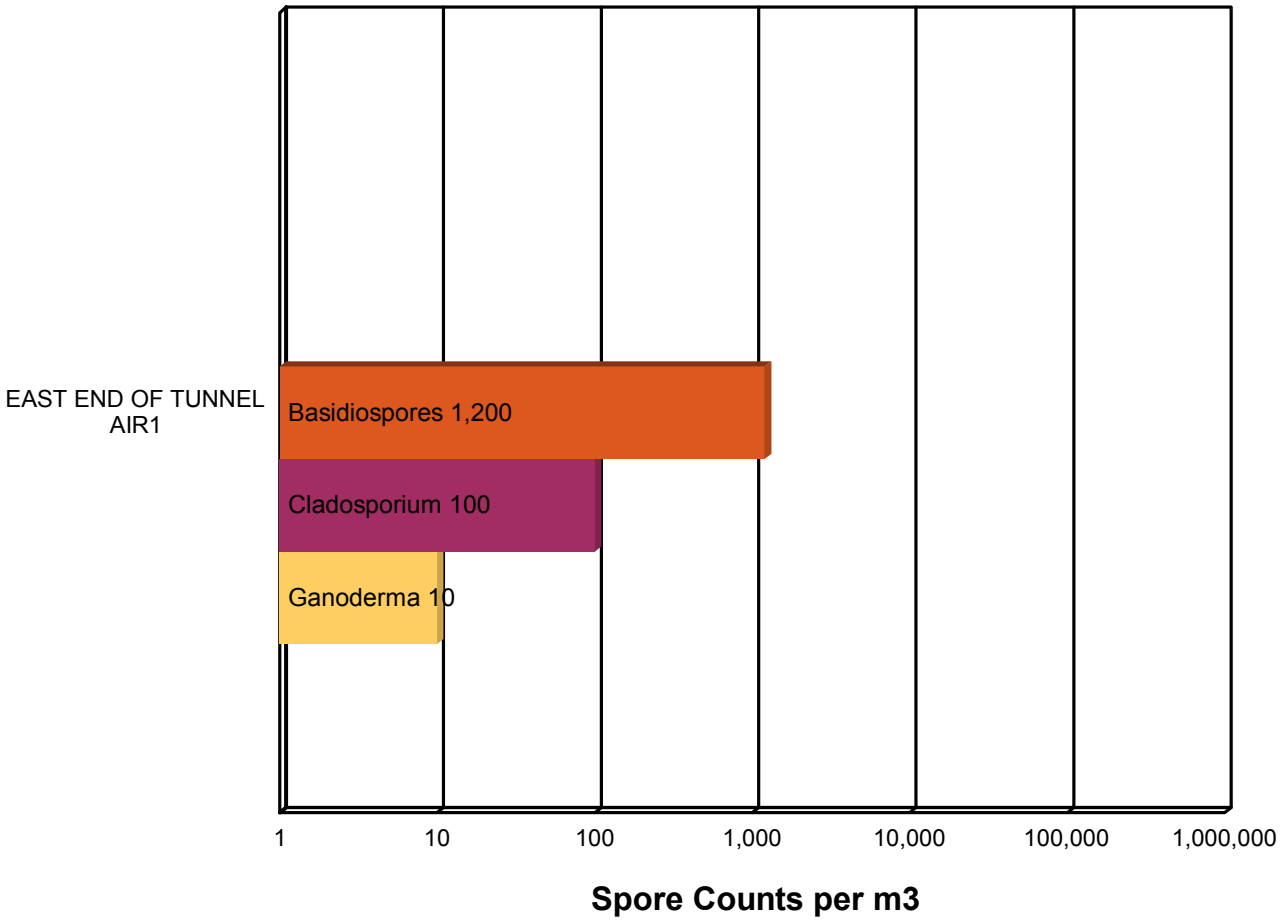
Attn: Stephanie Barkhouse
WSP Canada, Inc.
1 Spectacle Lake Drive
Dartmouth, NS B3B 1X7

EMSL Order: 551610646
Customer ID: 55GNVR34
Collected: 10/04/2016
Received: 10/05/2016
Analyzed: 10/06/2016

Proj: 161-06021

Spore Trap Report: Total Counts



* The chart is displayed using a logarithmic scale. Bar size is not directly proportional to the number of spores.

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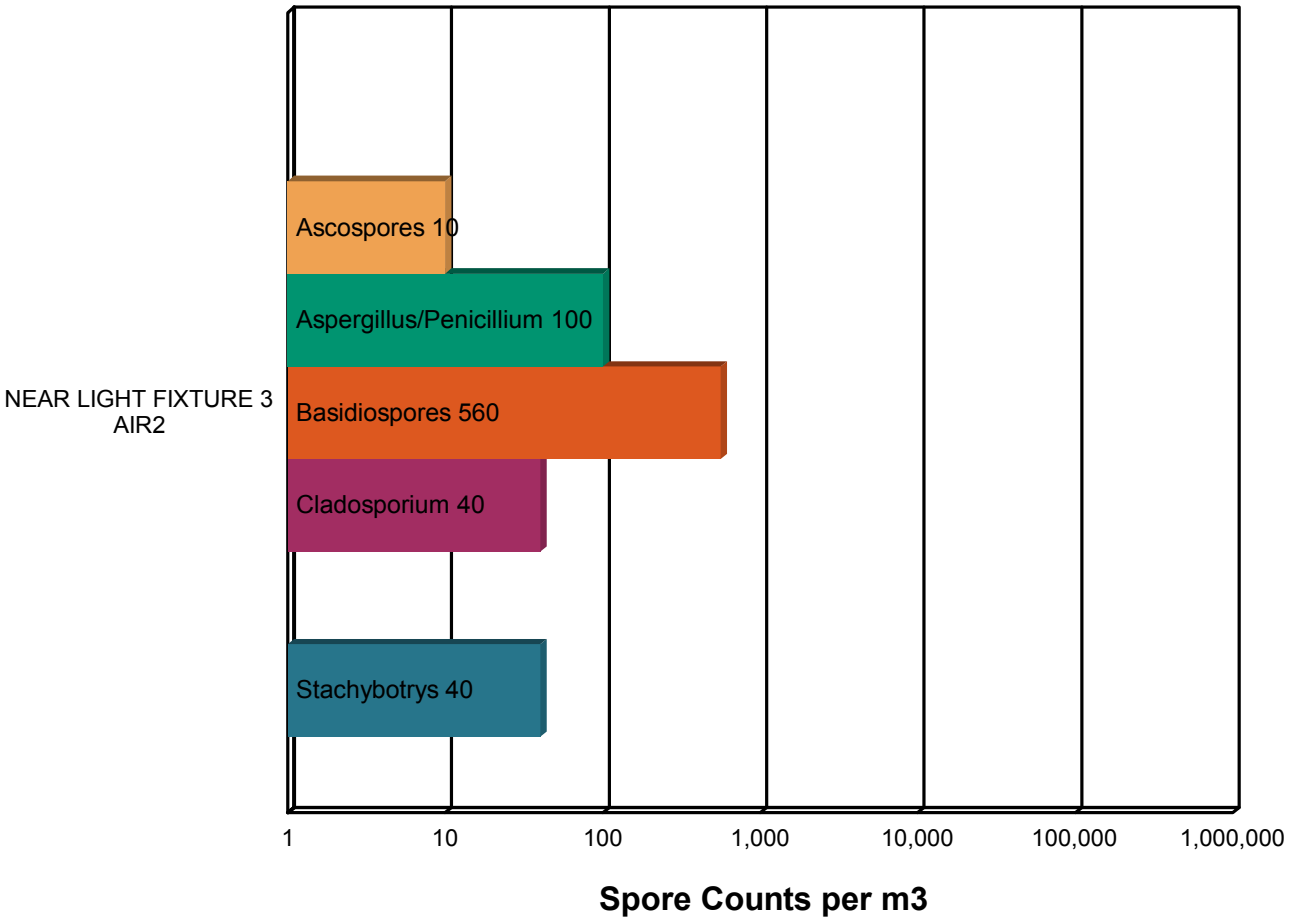

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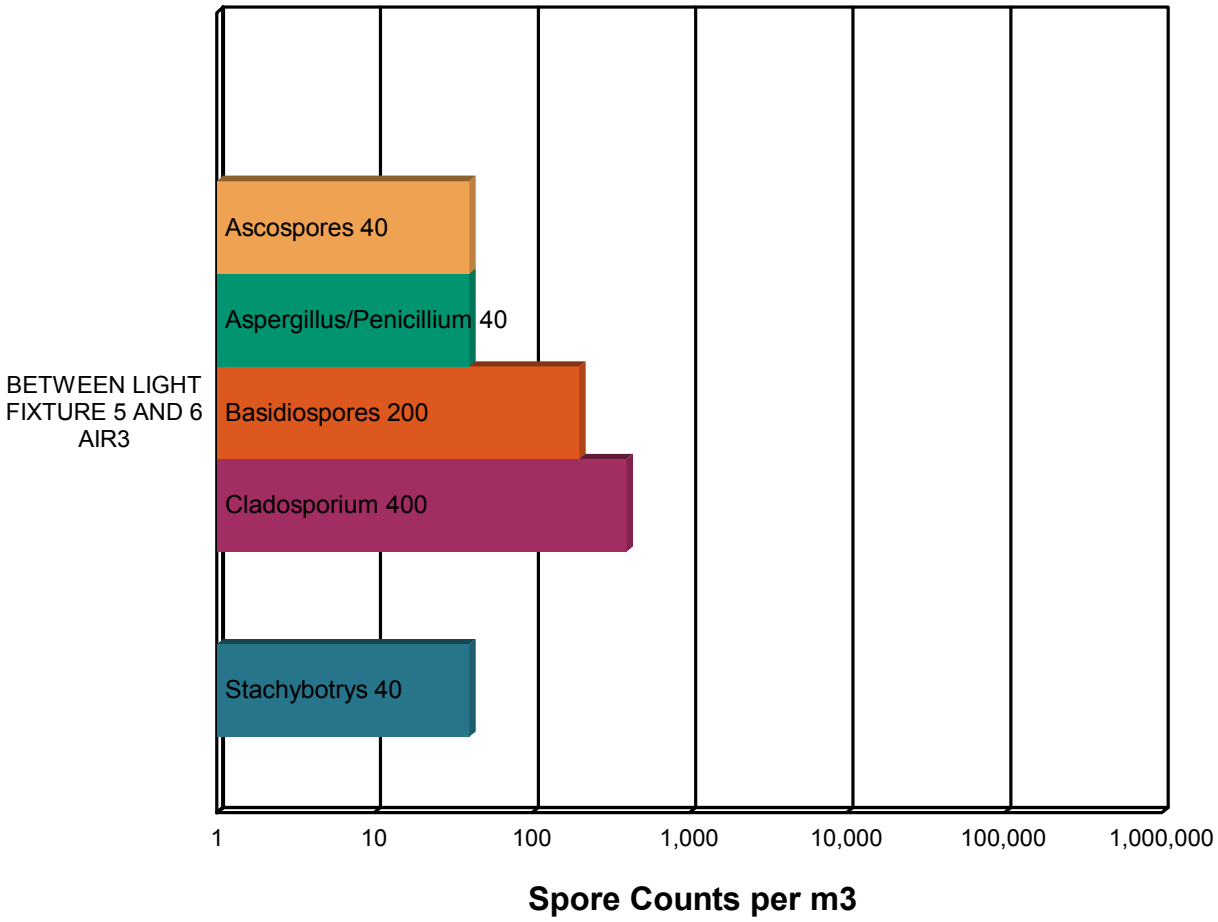

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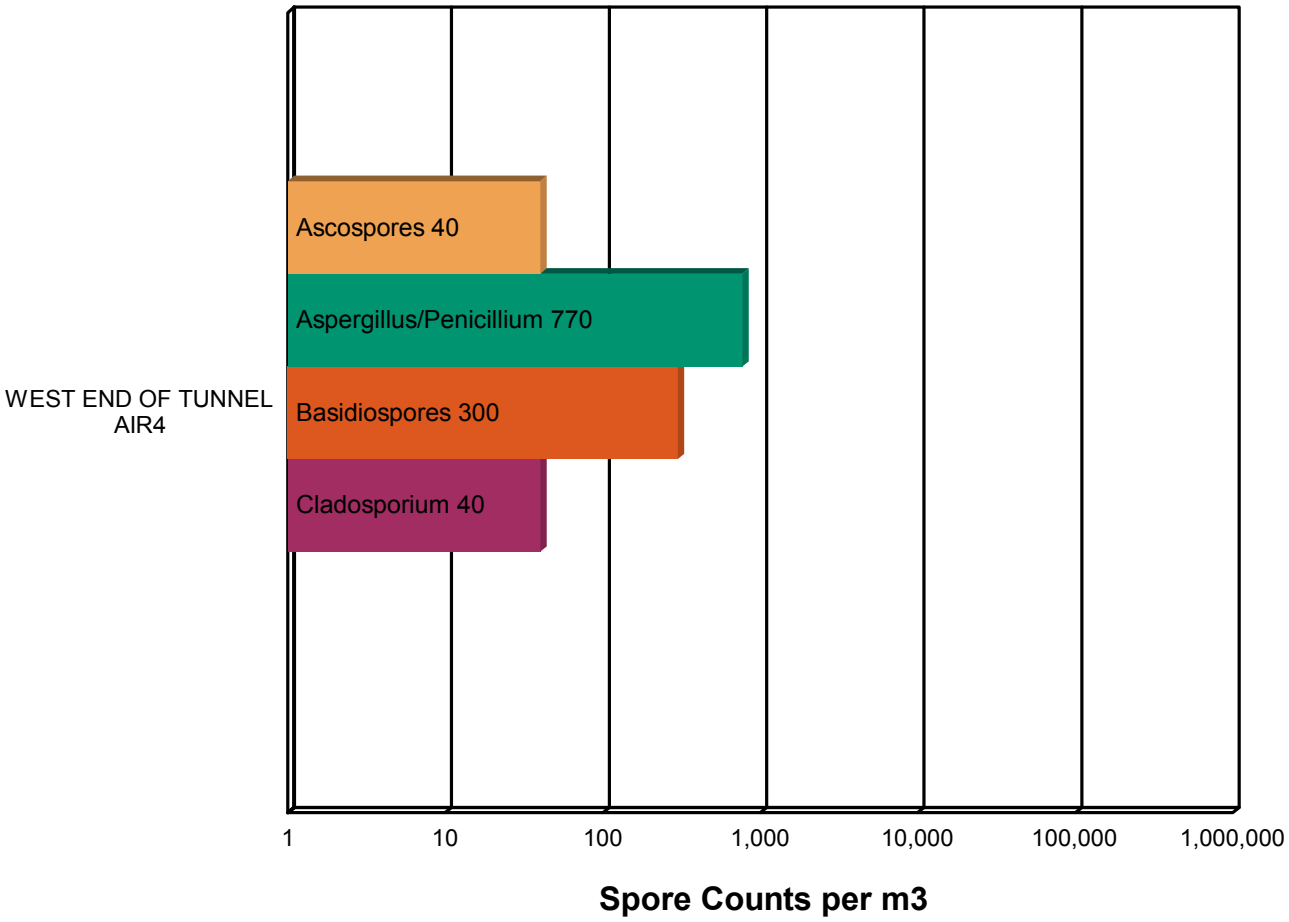

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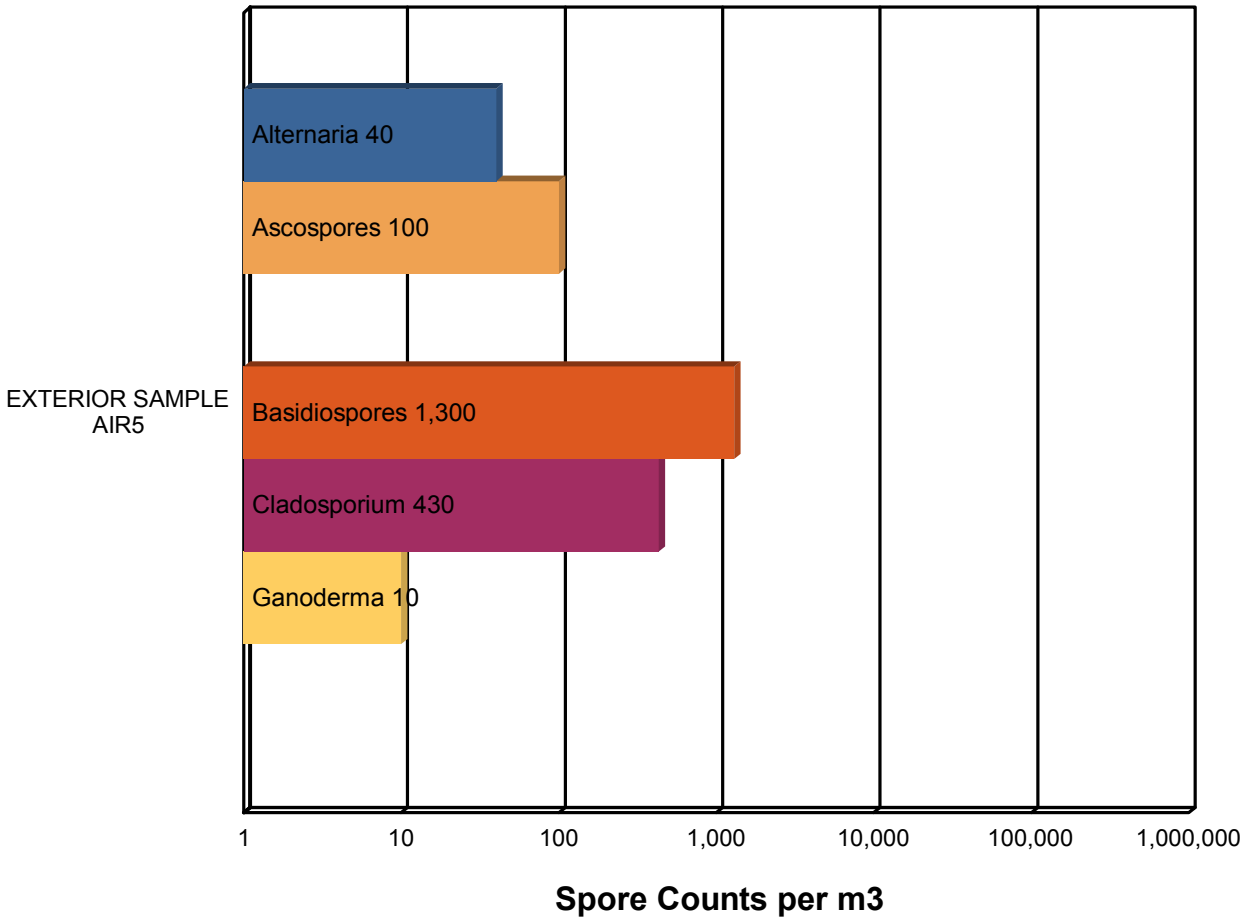

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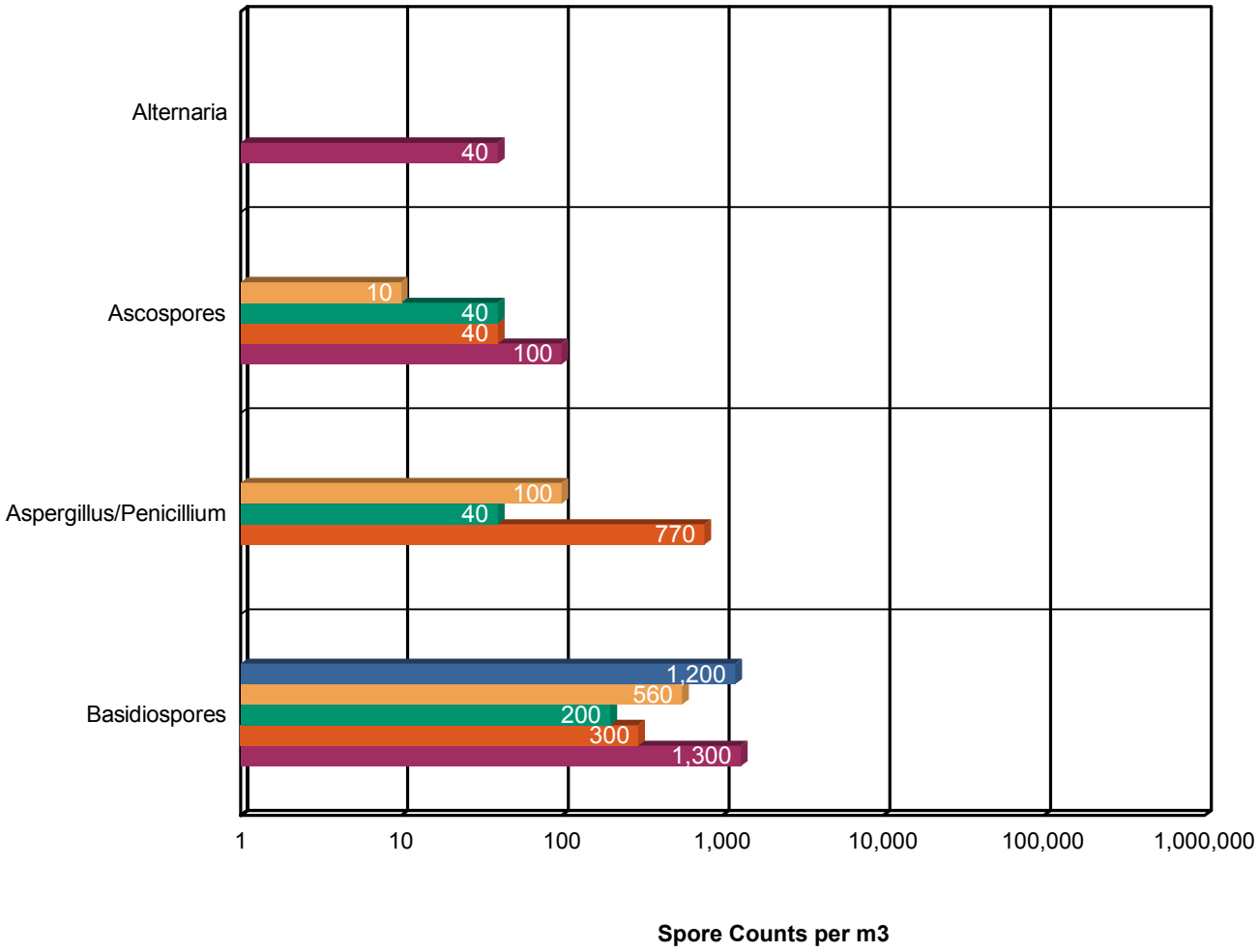
Background Comparison Chart



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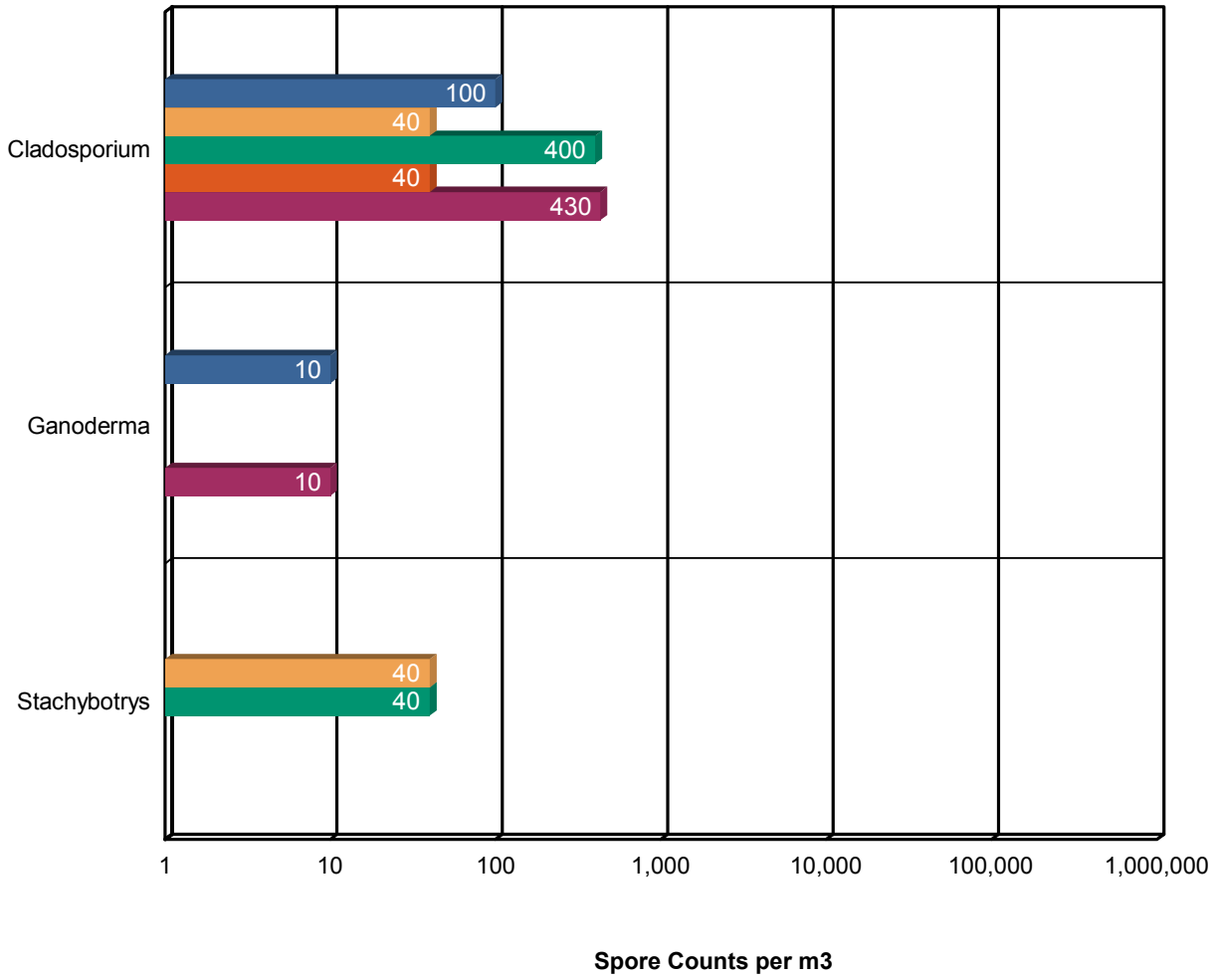
Background Comparison Chart



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Test Report: Microscopic Examination of Fungal Spores, Fungal Structures, Hyphae, and Other Particulates from Bulk Samples (EMSL Method: M041)

Lab Sample Number	Client Sample ID	Location	Fungal Identification	Category
551610646-0009	BULK 1	BETWEEN LIGHT FIXTURE 6&7	Hyphal Fragment	High

No discernable field blank was submitted with this group of samples.

Bipolaris++ = Bipolaris/Dreschlera/Exserohilum Myxomycetes++ = Myxomycetes/Periconia/Smut
* = Sample contains fruiting structures and/or hyphae associated with the spores.

Category	Count/area Analyzed
Rare	1 to 10
Low	11 to 100
Medium	101 to 1000
High	> 1000

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Test Report: Microscopic Examination of Fungal Spores, Fungal Structures, Hyphae, and Other Particulates from Tape Samples (EMSL Method: M041)

Lab Sample Number	Client Sample ID	Location	Fungal Identification	Category
551610646-0006	TAPE 1	BETWEEN LIGHT FIXTURE 6&7	Hyphal Fragment	High
			Rhinocladiella	Rare
551610646-0007	TAPE 3	NEAR LIGHT FIXTURE 3	Cladosporium	Rare
			Hyphal Fragment	Rare
551610646-0008	TAPE 4	NEAR LIGHT FIXTURE 3	Arthrospores	Low
			Aspergillus/Penicillium	Rare
			Chaetomium	Rare
			Cladosporium	Rare
			Hyphal Fragment	High

No discernable field blank was submitted with this group of samples.

Bipolaris++ = Bipolaris/Dreschlera/Exserohilum Myxomycetes++ = Myxomycetes/Periconia/Smut
* = Sample contains fruiting structures and/or hyphae associated with the spores.

Category	Count/area Analyzed
Rare	1 to 10
Low	11 to 100
Medium	101 to 1000
High	> 1000

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3. Understanding the Results

EMSL Canada Inc. is an independent laboratory, providing unbiased and scientifically valid results. These data represent only a portion of an overall IAQ investigation. Visual information and environmental conditions measured during the site assessment (humidity, moisture readings, etc.) are crucial to any final interpretation of the results. Many factors impact the final results; therefore, result interpretation should only be conducted by qualified individuals. The American Conference of Governmental Industrial Hygienists (ACGIH) has published a good reference book covering sampling and data interpretation. It is entitled, Bioaerosols: Assessment and Control, 1999.

Fungal spores are found everywhere. Whether or not symptoms develop in people exposed to fungi depends on the nature of the fungal material (e.g., allergenic, toxic, or infectious), the exposure level, and the susceptibility of exposed persons. Susceptibility varies with the genetic predisposition (e.g., allergic reactions do not always occur in all individuals), age, pre-existing medical conditions (e.g., diabetes, cancer, or chronic lung conditions), use of immunosuppressive drugs, and concurrent exposures. These reasons make it difficult to identify dose/response relationships that are required to establish “safe” or “unsafe” levels (i.e., permissible exposure limits).

It is generally accepted in the industry that indoor fungal growth is undesirable and inappropriate, necessitating removal or other appropriate remedial actions. The New York City guidelines and EPA guidelines for mold remediation in schools and commercial buildings define the conditions warranting mold remediation. Always remember that water is the key. Preventing water damage or water condensation will prevent mold growth.

This report is not intended to provide medical advice or advice concerning the relative safety of an occupied space. Always consult an occupational or environmental health physician who has experience addressing indoor air contaminants if you have any questions.

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4. Glossary of Fungi

ALTERNARIA	
Allergic Potential	Type I allergies (hay fever, asthma), Type III (hypersensitivity pneumonitis)
Industrial Uses	Biocontrol of weed plants ·Biocontrol fungal plant pathogens.
Mode of Dissemination	Wind
Natural Habitat	Common saprobe and pathogen of plants. Typically found on plant tissue, decaying wood, and foods. Soil . Air outdoors.
Other Comments	Alternaria spores are one of the most common and potent indoor and outdoor airborne allergens. Additionally, Alternaria sensitization has been determined to be one of the most important factors in the onset of childhood asthma. Synergy with Cladosporium or Ulocladium may increase the severity of symptoms
Potential or Opportunistic Pathogens	Phaeohyphomycosis {causing cystic granulomas in the skin and subcutaneous tissue}. In immunocompetent patients, Alternaria colonizes the paranasal sinuses, leading to chronic hypertrophic sinusitis
Potential Toxins Produced	Alternariol (AOH) . Alternariol monomethylether (AME). Tenuazonic acid (TeA). Altenuene (ALT). Altertoxins (ATX)
Suitable Substrates in the Indoor Environment	Indoors near condensation (window frames, showers), House dust (in carpets, and air). Also colonizes building supplies, computer disks, cosmetics, leather, optical instruments, paper, sewage, stone monuments, textiles, wood pulp, and jet fuel
Water Activity	Aw =0.85-0.88

ASCOSPORES	
Allergic Potential	Depends on genus and species.
Industrial Uses	
Mode of Dissemination	Forcible ejection or passive release and dissemination by wind or insects.
Natural Habitat	Everywhere in nature.
Other Comments	Ascospores are the result of sexual reproduction and produced in a saclike structure called an ascus. All ascospores belong to members of the Phylum Ascomycota, which encompasses a plethora of genera worldwide.
Potential or Opportunistic Pathogens	Depends on genus and species.
Potential Toxins Produced	
Suitable Substrates in the Indoor Environment	
Water Activity	

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ASPERGILLUS/PENICILLIUM	
Allergic Potential	Type I (hay fever, asthma) ·Type III (hypersensitivity)
Industrial Uses	Many depending on the species
Mode of Dissemination	Wind ·Insects
Natural Habitat	·Plant debris ·Seed ·Cereal crops
Other Comments	Spores of Aspergillus and Penicillium (including others such as Acremonium and Paecilomyces) are small and spherical with few distinguishing characteristics. They cannot be differentiated or speciated by non-viable impaction sampling methods. Some species with very small spores may be undercounted in samples with high background debris.
Potential or Opportunistic Pathogens	Possible depending on the species.
Potential Toxins Produced	
Suitable Substrates in the Indoor Environment	Grows on a wide range of substrates indoors ·Prevalent in water damaged buildings ·Foods (blue mold on cereals, fruits, vegetables, dried foods) ·House dust ·Fabrics ·Leather ·Wallpaper ·Wallpaper glue
Water Activity	Aw=0.75-0.94
Allergic Potential	Type I (hay fever, asthma) ·Type III (hypersensitivity)
Industrial Uses	Many depending on the species
Mode of Dissemination	Wind ·Insects
Natural Habitat	·Plant debris ·Seed ·Cereal crops
Other Comments	Spores of Aspergillus and Penicillium (including others such as Acremonium and Paecilomyces) are small and spherical with few distinguishing characteristics. They cannot be differentiated or speciated by non-viable impaction sampling methods. Some species with very small spores may be undercounted in samples with high background debris.
Potential or Opportunistic Pathogens	Possible depending on the species.
Potential Toxins Produced	
Suitable Substrates in the Indoor Environment	Grows on a wide range of substrates indoors ·Prevalent in water damaged buildings ·Foods (blue mold on cereals, fruits, vegetables, dried foods) ·House dust ·Fabrics ·Leather ·Wallpaper ·Wallpaper glue
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BASIDIOSPORES	
Allergic Potential	Type I allergies (hay fever, asthma) . Type III (hypersensitivity pneumonitis)
Industrial Uses	Edible mushrooms are used in the food industry.
Mode of Dissemination	Forcible ejection. Wind currents.
Natural Habitat	Forest floors. Lawns .Plants (saprobes or pathogens depending on genus)
Other Comments	Basidiospores are the result of sexual reproduction and formed on a structure called the basidium. Basidiospores belong to the members of the Phylum Basidiomycota, which includes mushrooms, shelf fungi, rusts, and smuts.
Potential or Opportunistic Pathogens	Depends on genus.
Potential Toxins Produced	Amanitins. monomethyl-hydrazine. muscarine. ibotenic acid. psilocybin.
Suitable Substrates in the Indoor Environment	Depends on genus. Wood products
Water Activity	Unknown.

CHAETOMIUM	
Allergic Potential	Type I (asthma and hay fever).
Industrial Uses	Cellulase production, Textile testing.
Mode of Dissemination	Wind. Insects. Water splash.
Natural Habitat	Dung. Seeds. Soil. Straw.
Potential or Opportunistic Pathogens	Onychomycosis. C. perlucidum recognized as a new agent of cerebral phaeohyphomycosis.
Potential Toxins Produced	Chaetomin. Chaetoglobosins A,B,D and F are produced by Chaetomium globosum. Sterigmatocystin is produced by rare species
Suitable Substrates in the Indoor Environment	Paper. Sheetrock. Wallpaper.
Water Activity	Aw=0.84-0.89.

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CLADOSPORIUM	
Allergic Potential	Type I (asthma and hay fever).
Industrial Uses	Produces 10 antigens.
Mode of Dissemination	Air
Natural Habitat	Dead plant matter. Straw. Soil. Woody plants
Potential or Opportunistic Pathogens	Edema. keratitis. onychomycosis. pulmonary infections. Sinusitis.
Potential Toxins Produced	Cladosporin and Emodin.
Suitable Substrates in the Indoor Environment	Fiberglass duct liner. Paint. Textiles. Found in high concentration in water-damaged building materials.
Water Activity	Aw 0.84-0.88
Allergic Potential	Type I (asthma and hay fever).
Industrial Uses	Produces 10 antigens.
Mode of Dissemination	Air
Natural Habitat	Dead plant matter. Straw. Soil. Woody plants
Potential or Opportunistic Pathogens	Edema. keratitis. onychomycosis. pulmonary infections. Sinusitis.
Potential Toxins Produced	Cladosporin and Emodin.
Suitable Substrates in the Indoor Environment	Fiberglass duct liner. Paint. Textiles. Found in high concentration in water-damaged building materials.
Water Activity	Aw 0.84-0.88

GANODERMA	
Allergic Potential	Ganoderma species are known to cause allergies in people on a worldwide scale.
Industrial Uses	Biopulping of wood for the paper industry. Potential medicinal use due to: 1. Inhibition of Ras dependent cell transformation, 2. Antifibrotic activity, 3. Immunomodulating activity, 4. Free-radicle scavenging
Mode of Dissemination	Wind.
Natural Habitat	Grows on conifers and hardwoods worldwide, causing white rot, root rot, and stem rot.
Other Comments	Used in traditional Chinese medicine as an herbal supplement. It is also known as a "shelf fungus" because the fruiting body forms a stalk-less shelf on the sides of trees and logs. It is sometimes called “artists conk” because when you scratch the white pores of the fruiting body, the white rubs away and exposes the brown hyphae underneath. Thus, pictures can be produced on the fruiting body.
Potential or Opportunistic Pathogens	Unknown.
Potential Toxins Produced	
Reference	References: Craig, R.L., Levetin, E. 2000. Multi-year study of Ganoderma aerobiology. Aerobiologia 16: 75-81. http://www.pfc.forestry.ca/diseases/CTD/Group/Heart/heart6_e.html
Suitable Substrates in the Indoor Environment	Unknown.
Water Activity	

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STACHYBOTRYS	
Allergic Potential	Type I (hay fever, asthma)
Industrial Uses	Unknown.
Mode of Dissemination	Insects, Water, and Wind
Natural Habitat	Decaying plant materials and Soil.
Other Comments	Stachybotrys may play a role in the development of sick building syndrome. The presence of this fungus can be significant due to its ability to produce mycotoxins. Exposure to the toxins can occur through inhalation, ingestion, or skin exposure.
Potential or Opportunistic Pathogens	Unknown.
Potential Toxins Produced	Mycotoxins produced by Stachybotrys include Roridin A, Roridin E, Roridin H, Roridin L-2, Satratoxin G, Satratoxin H, Isosatratoxin F, Verucarin A, Verucarin J, and Verrucariol.
Suitable Substrates in the Indoor Environment	Water damaged building materials such as: ceiling tiles, gypsum board, insulation backing, sheet rock, and wall paper. Paper. Textiles.
Water Activity	Aw=0.94

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Collected: 10/04/2016
Received: 10/05/2016
Analyzed: 10/06/2016

Proj: 161-06021

Books

- Bioaerosols: Assessment and Control. Janet Macher, Ed., American Conference of Governmental Industrial Hygienists, Cincinnati, OH 1999.
- Exposure Guidelines for Residential Indoor Air Quality. Environmental Health Directorate, Health Protection Branch, Health Canada, Ottawa, Ontario, 1989.
- Fungal Contamination in Public Buildings: Health Effects and Investigation Methods. Health Canada, Ottawa, Ontario, 2004.
- IICRC: S500 Standard and Reference Guide for Professional Water Damage Restoration. 3rd Edition, Institute of Inspection, Cleaning, and Restoration Certification, Vancouver, WA, 2006

  IICRC: S520 Standard and Reference Guide for Professional Mold Remediation. 1st Edition, Institute of Inspection, Cleaning, and Restoration Certification, Vancouver, WA, 2004
- Field Guide for the Determination of Biological Contaminants in Environmental Samples. 2nd Edition, American Industrial Hygiene Association, 2005.

Consumer Links

Read the full text of AIHA's "The Facts About Mold" consumer brochure.
<http://www.aiha.org/get-involved/VolunteerGroups/Documents/BiosafetyVG-FactsAbout%20MoldDecember2011.pdf>

The Occupational Safety and Health Administration (OSHA)
http://www.osha.gov/SLTC/molds/index.html

CDC Mold Facts
http://www.cdc.gov/mold/faqs.htm

CDC Stachybotrys - Questions and answers on Stachybotrys chartarum and other molds
http://www.cdc.gov/mold/stachy.htm

IOM, NAS: Clearing the Air: Asthma and Indoor Air Exposures
http://www.iom.edu/Reports/2000/Clearing-the-Air-Asthma-and-Indoor-Air-Exposures.aspx

National Library of Medicine-Mold website
http://www.nlm.nih.gov/medlineplus/molds.html

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Proj: 161-06021

California Department of Health Services (CADOHS)
http://www.cal-iaq.org/separator/mold-and-dampness/about-mold

Minnesota Department of Health
http://www.health.state.mn.us/divs/eh/indoorair/mold/index.html

New York City Department of Health and Mental Hygiene
<http://conyers.house.gov/index.cfm/issues?p=toxic-mold>

H.R.: The United States Toxic Mold Safety and Protection Act
<http://conyers.house.gov/index.cfm/issues?p=toxic-mold>

EPA

"Should You Have the Air Ducts in Your Home Cleaned?"
<http://www.epa.gov/iaq/pubs/airduct.html>

General information about molds and actions that can be taken to clean up or prevent a mold problem.
<http://www.epa.gov/asthma/molds.html>

“A Brief Guide to Mold, Moisture, and Your Home” - Includes basic information on mold, cleanup guidelines, and moisture and mold prevention
http://www.epa.gov/mold/moldguide.html

“Mold Remediation in Schools and Commercial Buildings” - Information on remediation in schools and commercial property, references for potential mold and moisture remediators.
http://www.epa.gov/mold/mold_remediation.html

FEMA

“Homes That Were Flooded May Harbor Mold Problems” - Information and tips for cleaning mold.
http://www.fema.gov/news-release/homes-were-flooded-may-harbor-mold-problems

“Dealing With Mold & Mildew in Your Flood Damaged Home.
http://www.fema.gov/pdf/rebuild/recover/fema_mold_brochure_english.pdf

“Prompt Flood Cleanup Can Help Prevent Health Problems” - How to clean up in-house mold problems (not large or serious exposures).
http://www.fema.gov/news-release/prompt-flood-cleanup-can-help-prevent-health-problems

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Proj: 161-06021

6. Important Terms, Conditions, and Limitations

A. Sample Retention

Samples analyzed by EMSL Canada will be retained for 60 days after analysis date Storage beyond this period is available for a fee with written request prior to the initial 30 day period. Samples containing hazardous/toxic substances which require special handling will be returned to the client immediately. EMSL Canadareserves the right to charge a sample disposal fee or return samples to the client.

B. Change Orders and Cancellation

All changes in the scope of work or turnaround time requested by the client after sample acceptance must be made in writing and confirmed in writing by EMSL Canada. If requested changes result in a change in cost the client must accept payment responsibility. In the event work is cancelled by a client, EMSL Canada will complete work in progress and invoice for work completed to the point of cancellation notice. EMSL Canada is not responsible for. holding times that are exceeded due to such changes.

C. Warranty

EMSL Canada warrants to its clients that all services provided hereunder shall be performed in accordance with established and recognized analytical testing procedures and with reasonable care in accordance with applicable federal, state and local laws. The foregoing express warranty is exclusive and is given in lieu of all other warranties, expressed or implied. EMSL Canada disclaims any other warranties, express or implied, including a warranty of fitness for particular purpose and warranty of merchantability.

D. Limits of Liability

In no event shall EMSL Canada be liable for indirect, special, consequential, or incidental damages, including, but not limited to, damages for loss of profit or goodwill regardless of the negligence (either sole or concurrent) of EMSL Canada and whether EMSL Canada has been informed of the possibility of such damages, arising out of or in connection with EMSL Canada's services thereunder or the delivery, use, reliance upon or interpretation of test results by client or any third party. We accept no legal responsibility for the purposes for which the client uses the test results. EMSL Canada will not be held responsible for the improper selection of sampling devices even if we supply the device to the user. The user of the sampling device has the sole responsibility to select the proper sampler and sampling conditions to insure that a valid sample is taken for analysis. Any resampling performed will be at the sole discretion of EMSL Canada, the cost of which shall be limited to the

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reasonable value of the original sample delivery group (SDG) samples. In no event shall EMSL Canada be liable to a client or any third party, whether based upon theories of tort, contract or any other legal or equitable theory, in excess of the amount paid to EMSL Canada by client thereunder.

E. Indemnification

Client shall indemnify EMSL Canada and its officers, directors and employees and hold each of them harmless for any liability, expense or cost, including reasonable attorney's fees, incurred by reason of any third party claim in connection with EMSL Canada services, the test result data or its use by client

Appendix B

Canadian National Master Construction Specification (Sect. 02 85 00.003 – Mould Remediation Maximum Precautions)