HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 90-170-L2053
JOHNSON JUNIOR HIGH SCHOOL
LARAMIE COUNTY SCHOOL DISTRICT #1
CHEYENNE, WYOMING
JULY 1990

Hazard Evaluation and Technical Assistance Branch
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I. INTRODUCTION

On February 14, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Superintendent of Schools in the Laramie County School District #1 to investigate a problem at the Johnson Junior High School located in Cheyenne, Wyoming. The requestor was concerned about employee health within the school where frequent employee complaints were reported and consisted of headaches, burning eyes, sneezing, runny noses, and hoarseness progressing to laryngitis. The Wyoming State Health Department had conducted an extensive mold study of the school in comparison to another school where no problems had been reported. Also the Laramie County School District #1 (LCSD #1) had conducted quarterly monitoring for fiberglass since April of 1989. Additional problems which had been investigated included copper and lead levels in the drinking water and a study of a high ground level of electricity throughout the building. On April 11-12, 1990, a NIOSH investigator conducted an initial and environmental survey at the building. During this survey, background information on the nature of the request was obtained, reports of previous environmental investigations were reviewed, a walk-through survey of the building was conducted, and environmental samples were collected in the building.

II. BACKGROUND

The Johnson Junior High School was built in 1982 and a new 19,000 square foot wing was added in 1987. The building was occupied in January of 1983 and currently there are 95 faculty, 7 custodians, 6 secretaries, 12 cooks, 1 maintenance supervisor, and 875 students. The building is a two-story brick building with a total floor space of approximately 136,500 square feet. Figure 1 shows the layout of the school. The older part of the school is serviced by 11 constant volume heating and ventilating (HV) systems. Heat is individually controlled in each room or zone using water-heated coils located in the ventilation ducts leading into the room/zone. Two variable volume heating, ventilating and air-conditioning (HVAC) systems handle the new wing of the school. All the ducts throughout the school are lined inside with fiberglass insulation. The fresh air supply vents are all located on the roof of the building.

According to reports, teachers began reporting problems in the school shortly after they occupied the building in 1983. The most common problems reported are runny nose, hoarseness to the point of losing the voice, upper respiratory problems, and eye irritation. The first record of investigations at the school date to November of 1988 when a consultant from the State of Wyoming Occupational Health and Safety program conducted an investigation and reported that there was no problem with the air quality at that time. In March of 1989, air samples were collected for fiberglass, again by the State OSHA office; the air levels were all less than 0.01 fibers per cubic centimeter of air (fibers/cc). The LCSD #1 then began monitoring for fiberglass in air in April, October, and December of 1989. The highest level of fiberglass found in the 13 samples was 0.024 fibers/cc.

III. MATERIALS AND METHODS

The NIOSH evaluation consisted of: (1) an examination of the building's HV and HVAC systems; (2) an examination of the building for identifiable contaminant sources; (3) interviews with representatives from the building management and the employees in the building; and (4) an environmental survey designed to assess the building's air quality. The specific measurements and types of samples collected in the environmental survey are detailed in the following list.

A) Instantaneous measurements of carbon dioxide (CO_2) concentrations were made at several different times and locations throughout the building and outdoors. These measurements were made using a GasTech (Model RI 411) portable direct-reading CO_2 analyzer capable of measuring CO_2 concentrations from 50 to 5000 parts per million (ppm). The instrument was calibrated before use and checked against the outdoor levels at various intervals throughout the workday.

B) Measurements of dry bulb and aspirated wet bulb temperatures were made at several different times and locations throughout the building and outdoors using a Bendix Model 566 Psychrometer. These data were used to determine relative humidity using a psychometric chart.

C) Concentrations of formaldehyde were measured using Draeger 0.2/a direct-reading colorimetric indicator tubes. The samples were collected using a Draeger hand pump according to the manufacturer's instructions.

D) Concentrations of carbon monoxide (CO) were measured using a Draeger Model 190 Datalogger. This is a direct-reading instrument which uses an electrochemical sensor to detect CO.

E) One fiberglass sample was collected using a Gilian Hi-flow sampling pump calibrated at 1.0 liters per minute and a 25-mm cellulose ester membrane filter in a cassette with a conductive cowl hood.

IV. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus, such contact may increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of air contamination criteria generally consulted include: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs); (2) the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Values (TLVs); (3) the U.S. Department of Labor (OSHA) federal occupational health standards; and (4) the indoor air quality standards included in the recommendations of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The first three sources provide environmental limits based on airborne concentrations of substances to which workers may be occupationally exposed in the workplace environment for 8 to 10 hours per day, 40 hours per week for a working lifetime without adverse health effects. The ASHRAE guidelines specify recommended outside air ventilation rates needed to maintain acceptable indoor air quality for the majority (at least 80%) of a building's occupants.

The industrial criteria for the substances evaluated in this survey are presented in Table 1. A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures. A discussion of the substances evaluated in this survey and the ASHRAE comfort and ventilation guidelines is presented below.

A. Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath, and, if monitored in the indoor air, can often be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor ambient concentration of CO_2 is about 350 ppm. Typically the CO_2 level is higher inside than outside (even in buildings with few complaints about indoor air quality). However, if indoor CO_2 concentrations are more than 1000 ppm (3 to 4 times the outside level), the building may be receiving inadequate outside air, or the air may be poorly distributed by the HVAC system. Under these conditions, complaints such as headache, fatigue, eye and throat irritation may frequently be reported. Although the CO_2 is not believed to be responsible for these complaints, a high level of CO_2 does indicate that other contaminants in the building may also be increased and could be responsible for symptoms among building occupants.[1]

B. Formaldehyde

Formaldehyde and other aldehydes may be released from a variety of common materials including; foam plastics, carbonless paper, particle board, plywood and textile fabrics. It is also a common by-product in pouring of molds in foundry operations. The fact that formaldehdye is found in so many home products, appliances, furnishings, and construction materials has prompted several agencies to set standards or guidelines for residential formaldehyde exposure. Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; asthma; and skin rashes. It is difficult to ascribe specific health effects to specific concentrations of formaldehyde to which people are exposed, because they vary in their subjective responses and complaints. Irritative symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are uncommon.[2] Recent animal studies have prompted a concern with the potential carcinogenicity of this substance.[3]

C. Carbon Monoxide

Carbon monoxide can occur as a waste product of the incomplete combustion of carbonaceous fuels. Sources of carbon monoxide in indoor environments include tobacco smoke, malfunctioning or improperly vented heating systems, and the introduction of contaminated air from outside sources such as loading docks. Carbon monoxide exposure in sufficient concentrations can result in headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death.[4]

D. Fibrous Glass

Fibrous glass is the name for a manufactured fiber in which the fiber-forming substance is glass. Its primary use is for thermal and acoustical insulation of residential and commercial buildings. Larger diameter fibrous glass (>3.5 micrometers) may result in skin, eye and upper respiratory tract irritation and a relatively low incidence of fibrotic (lung) changes. The health effects of smaller diameter fibers is less clear. Animal studies have shown fibrous glass to be tumorigenic but this effect has not been demonstrated in humans.[5]

E. Temperature and Relative Humidity

The majority of references addressing temperature and humidity levels as they pertain to human health frequently appear in the context of assessing conditions in hot environments. Development of a "comfort" chart by ASHRAE presents a comfort zone considered to be both comfortable and healthful. This zone lies between 73° and 77°F (23° and 25°C) and 20 to 60 percent relative humidity.[6]

F. Ventilation

Neither NIOSH nor OSHA has developed ventilation criteria for general offices. Criteria often used by design engineers are the guidelines published by ASHRAE. Until recently, the ASHRAE Ventilation Standard 62-73 (1973) was utilized, but recommendations were based on studies performed before the more modern, air-tight office building became common. These older buildings permitted more air infiltration through leaks and cracks around windows and doors, and through floors and walls. Modern office buildings are usually much more airtight and permit less air infiltration. Due to the reduced infiltration, ASHRAE questioned whether the 1973 minimum ventilation values assured adequate outdoor air supply in modern, air-tight buildings.

The minimum rate of outside air permitted under ASHRAE Standard 62-1989 is 20 cubic feet per minute (cfm) /person for general office areas.[7] The basis of the outside air supply rates recommended by ASHRAE is for maintaining an indoor air quality that is considered acceptable by at least 80% of the building's occupants. However, unless referenced or specified by local building codes, building owners are not required to comply with these ASHRAE Standards. Most building codes refer to an earlier version of this standard (ASHRAE Standard 62-73), which was intended to conserve energy rather that promote adequate indoor air quality.

V. RESULTS

A. HVAC System Inspection

The ventilation system in the school is composed of six zones which include ten heating and ventilating (HV) systems in the older part of the school and two HVAC systems in the new wing. No humidification is provided and only the new wing has air-conditioning. The HV systems are constant volume with supplemental heat provided in individual rooms or zones by hot water coils. The new wing has a variable volume, computer-controlled system which supplies a constant temperature of 65° F unless individual rooms call for additional heating or cooling. All the ventilation ducts in the school are lined inside with fiberglass insulation. The area between the ceiling and the roof (or floor) serves as the return air plenum. Due to complaints over the last year, all the fiberglass filters on the fresh air intakes are now changed at least every three months. Prior to September of 1989, filters were changed infrequently. For example, filters were changed in January of 1989 and next in September 1989. Continuous complaints have been received about temperature regulation in the new wing since it opened. Most of the teachers felt that it was too cold throughout the winter. The temperature in the hallway of the new wing remained about 65 °F for most of the investigation while the classrooms were at temperatures in the low to mid 70s°F.

An inspection of the ventilation system revealed that there was a general deterioration of the fiberglass lining inside the ducts as evidenced by fiberglass accumulation on the inside of the grill on the exhaust plenums, apparent fiberglass particles settled on furniture in the classrooms, and large pieces of fiberglass missing from the few ducts that could be visually inspected from the inside. There was also evidence of water damage in the ceilings under where the fresh air intakes are located on the roof. According to the maintenance supervisor, rain and snow would be blown and sucked into the fresh air intakes until covers were installed in January of this year. The water would come into the fresh air intake, run down the ducts, and leak out at the point where the ducts turned horizontally. The water also increased the deterioration of the fiberglass lining. Once the fiberglass was loosened, the velocity in the ducts was sufficient to pull the fiberglass off, sometimes in large pieces. The maintenance supervisor reported at least two cases where the inline heating coils had been nearly blocked by loose fiberglass. One such coil, which was visually inspected, did have a significant amount of fiberglass accumulated on the fins of the heating coils.

In the metals room (Rm #98, Figure 1), there were two welding booths, a mini foundry complete with furnace and mold pouring locations, and a variety of metal working machines. The pour area was ventilated through a particulate/charcoal filter system ("Smoke-Eater") and the exhaust was circulated back into the room. The welding stations were controlled by another identical system. There was a local exhaust on the wall behind the foundry furnace which exhausted to the outside. The internal scrubbing systems were unable to handle the emissions from the poured molds and the welding fumes. The room quickly became filled with smoke and strong odors. This room had been the source of numerous odor complaints from teachers in other rooms in the building.

B. Environmental Survey Results

The results of the measurements taken for carbon dioxide are provided in Table 2. As evidenced by this data, the indoor concentrations of CO_2 ranged from 400 ppm to a high of 2000 ppm in one room. With the exception of Room 42 in the new wing and in the new wing hallway in the afternoon, the rest of the building had concentrations below the guideline of 1000 ppm CO_2 used by NIOSH in indoor air quality investigations to indicate problems caused by lack of outside air ventilation.[1] The outdoor air concentration of CO_2 was found to average 300 ppm. The ISS room (#42) definitely has a problem with a lack of fresh air. By the afternoon, the levels were twice that recommended for a room with sufficient fresh air. The room was also quite hot.

Measurements of temperature generally ranged from 72°F to 75°F in the old wing and 65-66°F in the hallway of the new wing. The classrooms in the new wing were generally much warmer, more in the 72-75°F range. The outside temperature ranged from a low of about 45°F to about 65°F in the afternoon. The temperatures throughout the school were generally within the ASHRAE guidelines[6] of 73 to 77 degrees F except in the halls of the new wing. These temperatures stayed close to 65°F all day.

Detector tube samples collected for formaldehyde in the Metals Shop after three molds had been poured resulted in levels of 0.2 ppm directly above the molds and not detectable (< 0.05 ppm) in the center of the room. No carbon monoxide (CO) was measured in the school except in the Metals Shop after a mold pour when levels of 55 ppm were found directly above the molds, 15 ppm two feet from the molds, and ambient levels of 1 ppm throughout the room.

One sample for airborne fiberglass was collected in a central upstairs room (#282) during a full class day. The sample result was 0.024 fibers/cc, which is comparable in concentration to other airborne samples collected by the school district. This level is much less than the 3 fibers/cc exposure limit recommended by NIOSH. While this sample measured the airborne fibers of interest from a respiratory standpoint, it does not discount the amount of large fiber fiberglass which was evident on surfaces throughout the building.

C. Results of Interviews

Anecdotal interviews with employees of the school indicated episodic complaints of nonspecific symptomatology, i.e., itchy eyes, hoarseness usually progressing to loss of voice, headaches and fatigue. Questionnaires had been distributed by the school nurse prior to NIOSH's arrival. Twenty-six teachers and secretaries responded out of a total teacher/secretary population of 101 (26%). From these questionnaires, 65% reported that the air was too cold (100% of those working in the new wing reported that the air was too cold), 42% complained that the air was too hot on occasion, 50% complained of odors and dust in the air, and 30% complained that the air was too stuffy. The symptoms that were reported included itchy eyes (54%), runny/stuffy nose (42%), headaches (31%), sneezing (27%), hoarseness (27%), sore throat (19%), and cough (19%). These numbers may be misleading due to the fact that only 26% of the affected population completed the questionnaire, and it is possible that persons experiencing health problems or discomfort were more likely to volunteer to participate.

VI. DISCUSSION AND CONCLUSIONS

Building-related illness episodes have been reported more frequently in recent years as buildings have been made more air-tight to conserve energy and to reduce air conditioning expenses. Modern office buildings are constructed primarily of steel, glass, and concrete, with large windows that cannot be opened, thus making the building totally dependent on mechanical systems for air conditioning. Contaminants may be present in make-up air or may be introduced from indoor activities, furnishings, building materials, surface coatings, air handling systems, and the building occupants. Symptoms often reported are eye, nose, and throat irritation, headache, fatigue, and sinus congestion. Occasionally, upper respiratory irritation and skin rashes are reported. In some cases, the cause of the symptoms has been ascribed to an airborne contaminant, such as formaldehyde, tobacco smoke, or insulation particles, but most commonly a single cause cannot be pinpointed.

During the course of this survey, only the presence of fiberglass could be identified as a possible environmental agent that could be responsible for some of the symptoms reported by the employees. While airborne levels of fiberglass were not found in high concentrations from limited sampling, fiberglass dust was visually identified on surfaces throughout the school. Measurements of ventilation system parameters (i.e., CO_2, temperature, and relative humidity) revealed the system to be supplying sufficient quantities of adequately tempered air to the various workspaces examined in the old wing. The new wing HVAC system provided air in common hallways which appeared to be too cold relative to the ASHRAE comfort guidelines and there was a problem with a lack of fresh air being provided to room #42. The too cold air may be the result of too few stops on the variable air volume boxes or the lack of terminal re-heat units on the air entering the hallways as compared to that entering the classrooms.

Control of emissions in the metals shop were not being adequately vented as illustrated by high formaldehyde levels, smoke emission, and odors. Storage of chemicals in the Technical Arts Room (#94E) lacked proper ventilation to control volatile solvent emissions into the area. No Hazard Communication Program had been instituted by the school district.

VII. RECOMMENDATIONS

1. The school should continue with its program of preventive maintenance and periodic inspection of the HV and HVAC systems and related equipment. Air filters should be changed at least every three months as recommended by the equipment manufacturer.

2. Due to the poor condition of the fiberglass lining inside the ducts and the maintenance problems the loose fiberglass create, replacement of the ducts is warranted. The presence of fiberglass throughout the school and the potential health problems this may present provides additional justification for replacement of the ducts. Ducts with insulation on the outside (or none at all depending on the situation) are recommended.

3. The HVAC system in the new wing should be adjusted so that temperatures in this wing, particularly in the halls, are more inline with the ASHRAE Comfort Guidelines of 73 to 77°F.

4. More fresh air needs to be directed into Room 42 in the new wing. This might be accomplished by adding a dedicated ventilation duct and control for this room.

5. All the water damaged tiles in the ceiling should be replaced and steps taken to ensure that no water damage can occur again. The new covers on the HV fresh air intakes should solve most of the problems encountered in the past. The deck area on the roof above the back of room 98 should be sealed to prevent additional water leakage in this part of the building.

6. The "Smoke-Eater" systems in the Metals Shop should be replaced with efficient local exhaust ventilation which will exhaust to the outside. This includes the area above the mold pouring and foundry furnace, and the welding stations. An engineering firm should be consulted about the best method for exhausting these areas given the operation that is to be done.

7. The flammable storage cabinet in room 94E should be vented to the outside. A strong chemical odor was noticeable when the cabinet was opened. An inventory of the materials inside the cabinet should be kept along with the material safety data sheets (MSDS).

8. The school system needs to develop a Hazard Communication Program which is in compliance with the Hazard Communication Standard of the Occupational Safety and Health Administration (OSHA). No program was in evidence. A number of the teachers deal with materials which are considered hazardous (silk screen paints, inks, cleaners, and thinners; numerous other art supplies; mold sand, solvents, etc. in the Metals Shop; and numerous cleaning supplies and materials used by the maintenance personnel), yet none of them had ever heard of a Hazard Communication Program or a MSDS.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. Guidance for Indoor Air Quality Investigations. Cincinnati, Ohio: Hazard Evaluations and Technical Assistance Branch, National Institute for Occupational Safety and Health, 1987.

2. National Research Council. Formaldehyde and Other Aldehydes. National Academy Press. Washington, D.C., 1981.

3. National Institute for Occupational Safety and Health. Current Intelligence Bulletin 34--Formaldehyde: Evidence of Carcinogenicity. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) Publication No. 81-111).

4. National Institute for Occupational Safety and Health. Occupational Diseases, A Guide to Their Recognition., Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-181).

5. Criteria for a Recommended Standard Occupational Exposure to Fibrous Glass. DHEW (NIOSH) Publication No. 77-152, April 1977. National Institute for Occupational Safety and Health (NIOSH), Cincinnati, Ohio.

6. Thermal Environmental Conditions for Human Occupancy, ASHRAE Standard 55-1981. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. Atlanta, Georgia.

7. Ventilation for Acceptable Indoor Air Quality. ASHRAE Standard 62-1989. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, Georgia.

Table 1
INDUSTRIAL EXPOSURE CRITERIA FOR SELECTED SUBSTANCES

SUBSTANCE	OSHA PEL	NIOSH REL	ACGIH TLV
Carbon Dioxide	10,000 ppm 8-hr TWA 30,000 ppm STEL	10,000 ppm 8-hr TWA 30,000 ceiling (10 min)	5,000 ppm 8-hr TWA 30,000 ppm STEL
Carbon Monoxide	35 ppm 8-hr TWA 200 ppm ceiling (no minimum time)	35 ppm 8-hr TWA 200 ppm ceiling (no minimum time)	50 ppm 8-hr TWA 400 ppm STEL
Fibrous Glass	10 mg/m3 total dust 8-hr TWA 5 mg/m3 respirable dust	3 fibers/cc 10-hr TWA 5 mg/m3 total dust	10 mg/m3 8-hr TWA
Formaldehyde	1 ppm 8-hr TWA 2 ppm STEL	LFL	1 ppm 8-hr TWA 2 ppm STEL

Abbreviations and Key
ppm - Parts of contaminant per million parts of air
TWA - Time-weighted average concentration
STEL - Short-term exposure limit; 15-minute TWA exposure
LFL - Lowest Feasible Level

TABLE 2
ENVIRONMENTAL MEASUREMENTS OF INDOOR AIR QUALITY PARAMETERS
JOHNSON JUNIOR HIGH SCHOOL
CHEYENNE, WYOMING
APRIL 12, 1990

Sample Time	Sample Location	CO_2 (ppm)	Comments
6:30 am	Outside bldg	300	
6:45 am	Rm 90A	425	no students in school
6:55	Rm 280	425	
6:58	Commons, center	450	HV-4 area
7:00	Main gym, center	450	HV-5 area
7:01	Metal shop, Rm 98	425	Students allowed in Commons
7:02	Rm 80	400	HV- area
7:03	Rm 56	425	HV-7 area
7:05	Rm 39, new wing	425	HVAC-1 area
7:07	Rm 42, ISS	505	HVAC-2 area
7:08	Rm 40, contols rm 42	375	HVAC-2 area
7:10	Library	425	HV-8 area
7:12	Rm 15	475	HV-8 area
7:13	Rm 210	425	HV-8, 2nd floor
7:14	Rm 210A, greenhouse	425	HV-8, 2nd floor
7:15	Rm22A, chem storage	475	HV-8
7:18	Rm 242	500	HVAC-2
7:20	Rm 258	475	HV-7, students in halls
7:23	Rm 294	500	HV-9
7:23	Hallway	625	Students entering halls
7:24	Hall outside Rm 294	725	Halls crowded with students
7:26	Stairway at Rm 250	775	Students gathering at stairs
7:28	Hall outside Rm 70	800	
7:30	Commons, center	650	Students in area
7:31	Hall outside office	850	Much traffic
7:32	Nurses station, Rm 80D	525	
7:33	Boys restroom, Rm 72	575	
7:34	Teachers lounge, Rm 70	675	Smoking allowed
7:35	Outside new wing	975	A lot of traffic
7:42	Rm 30	725	Two teachers present
10:15	Metals room, Rm 98	725	Students in class
10:55	Metals room	525	No students in class
11:00	Commons, center	825	Lunch ongoing
11:01	Kitchen	525	During lunch
11:02	Main gym	925	Students playing basketball
11:05	Nurses station, Rm 80D	600	
11:06	Sect. desk, Rm 80	625	
11:7	Rm 56	525	No students, window open
11:10	Rm 52	725	15 students in class
11:11	Rm 39, new wing	925	Students in class
11:12	Rm 40	750	Kids in class, 2 windows open
11:13	Rm 42, ISS	1625	Students in ISS, very stuffy
11:15	Rm 35	525	

TABLE 2 (Continued)

Sample Time	Sample Location	CO_2 (ppm)	Comments
11:16	Rm 29, Library	500	Only 4 people in room
11:17	Rm 15	650	Students in class
11:19	Rm 210	500	No students in class
11:20	Rm 210A, greenhouse	475	Room hot due to solar load
11:21	Rm 222A, chem storage	525	
11:22	Rm 220	675	Class full of students
11:25	Rm 235	775	Only a few students
11:25	Rm 241	975	Students in class
11:28	Rm 242	725	Students in class
11:31	Rm 256	725	Students in class
11:32	Hall outside Rm 280	625	Class in progress
11:37	Rm 294, home-ec	500	No students
12:55	Rm 94	725	
13:00	Hall outside new wing	1100	
13:05	Rm 42, ISS	1625-2000	Full with students
13:05	Outside	325	

Evaluation Criteria - Refer to Section IV of Report

Abbreviations and Key
ppm - parts of contaminant per million parts of air
CO_2 - Carbon dioxide

FIGURE 1
Layout of Johnson Junior High School
Cheyenne, Wyoming