Studies to understand methamphetamine (meth) deposition due to meth production (cooking) in structures were a collaborative effort of Minnesota Pollution Control Agency and Minnesota Department of Health, Public Health Lab (MDH PH Lab) with support of Brownfields 128a funds.
The studies of former meth labs in Minnesota indicate that remediation of structures is not accomplished by the removal of meth “dust.” Meth not only deposits on surfaces but also infiltrates most building materials at low levels. This infiltration of meth into materials affects what is necessary to remediate a given material (HEPA vacuuming, wet washing, sealing), how easily the material is wipe sampled, and how variable adjacent wipe sample results will be.

Currently, a “safe” level of residual meth is not known, although a “cleanup standard” of 1 microgram of meth per one square foot (µg/ft²) has been adopted in some states. (A microgram is 1/1000 of a milligram which is 1/1000 of a gram.) As no health-based or risk-based cleanup standards are currently available for meth, in Minnesota, a process-based cleanup guidance, *Clandestine Drug Lab General Cleanup Guidance*, is found on the Minnesota Department of Health’s website.
The Minnesota studies of former meth lab contamination focused on meth contamination only. Meth is the one chemical associated with meth production that is not commonly found in the home. Meth has also been used as the “indicator” chemical, wipe sampled before and after a meth lab is remediated (cleaned and sealed), to determine cleanup effectiveness. Wipe sampling for meth is unreliable, as our studies have shown. Also, using the level of meth contamination as an indicator that all meth production related contamination has been removed has not been scientifically supported by study. Most of the chemicals used in meth production are considered volatile and, theoretically, will not remain in the well-ventilated former meth lab environment.

Before cleaning and sealing studies could be done, we studied the patterns of meth distribution, that is, how meth production distributes meth on, and as we learned, within building materials. During the course of study, we questioned – and still question -- what information wipe sampling actually provides, especially when using the results from wipe sampling as a cleaning/sealing goal.

The various building materials of a house include, for example, latex-painted sheetrock or plaster, varnished or polyurethaned wood cabinets, floors, and window and door trim, linoleum flooring in kitchens and baths, concrete block walls and concrete floors in the basement, and raw wood studs and rafters in the basement and attic. Will all these building materials clean easily with a detergent and water, or is sealing necessary? Will sealing with either spray-applied latex paint or brush-applied polyurethane greatly reduce the meth contamination able to be sampled using a methanol-dampened wipe? Again, what does this really tell us?

And then, over the course of time, will meth move, for example, from beneath latex paint to the surface and/or into air? Will meth contamination break down over time?

We have developed some information for the questions in white. We can provide preliminary information for some of the questions in yellow.
Unknowns Regarding Health

What are the (primary) exposure routes of concern?

- dermal
- ingestion
- inhalation

Absorption and uptake?

Possible health effects (or not)?

At what exposure levels?

Answers regarding possible health effects in former meth lab structures are few. Study is needed regarding possible health impacts of meth residue as well as the chemical by-products of the methods.

Although the primary exposure route of concern for meth contamination is considered to be dermal (skin) exposure, ingestion by small children due to hand-to-mouth behaviors is of concern. Also, as meth redistributes to air as particles and on dust due to activities (such as vacuuming or sanding in remediation efforts), very low level inhalation exposure is possible. At this time, it is unknown if methamphetamine re-volatizes to air after the initial deposition. Study is necessary to determine size and chemical form of meth being distributed to interiors of structures to answer questions regarding persistence, mobility and possible human exposure and related health effects.

Once a human has made contact with a contaminant, for example, touched a meth contaminated wall, the effects of the contaminant will be limited by the absorption by the body and the uptake of the contaminant by body systems and cells. Possible health effects are not known for low level, chronic exposure of a human to low level meth contamination in a structure. Finally, if health effects are found, at what level of exposure are these effects found?

Currently, a “safe” level is not known, although a “cleanup standard” of 1 microgram of meth per one square foot ($\mu g/ft^2$), or lower level, has been adopted in some states. (A microgram is $1/1000$ of a milligram which is $1/1000$ of a gram.) As no health-based or risk-based cleanup standards are currently available for meth, in Minnesota, a process-based cleanup guidance is found on the Minnesota Department of Health’s website.
Necessary Baseline to Develop Cleanup Guidance

- Understand meth production methods
- Identify meth distribution patterns
- Understand what wipe sampling tells us
  - Ability to wipe sample various materials
  - Affects of different building materials and finishes on results
  - Interpreting wipe sample results

To develop best practices, least cost and effective cleaning methods (and determine whether sealing is necessary), we must understand how meth production distributes meth in clandestine meth lab structures and determine whether building materials “collect” meth differently or sample differently. Although wipe sampling is no longer required required by the Minnesota Department of Health’s Clandestine Drug Lab General Cleanup Guidance (Cleanup Guidance), we must learn to interpret sampling results, pre- and post-clean-up, should wipe sample results be presented.
Variations of two main methods of producing meth are currently used in the US, with regional differences in preferred method and size of operations. In Minnesota, the great majority of meth labs found were small operations where approximately an ounce of meth is made during a “cook.” These small operations in Minnesota, called “user labs,” most often used the Anhydrous Ammonia Method. The Red Phosphorus Method has also been used in user labs, although this method is generally used to create greater quantities of meth as seen in larger production labs.

There are three phases necessary to produce methamphetamine: Pseudoephedrine extraction, conversion of pseudoephedrine to methamphetamine base (a volatile liquid), and the precipitation of meth HCl from the meth base. The production phases of methamphetamine produce two chemical forms of meth with different chemical and physical properties. Meth base, an intermediate product, is a semi-volatile that can disseminate throughout a structure as a vapor or convert to meth acid over time. Meth hydrochloride (HCl), the desired end product, is not volatile under normal conditions and can often be found in areas where dust or other particulate matter accumulate. Therefore, meth is distributed as a vapor, aerosol and/or particulates during “cooking.”

The conversion of pseudoephedrine to methamphetamine using the Red Phosphorus method is by a series of chemical substitutions, using hydriodic acid and red phosphorus. Due to the nature of this chemical process, the “Red P” method often generates more side products and impurities that increase the production hazards.

The conversion to meth from pseudoephedrine by the Anhydrous Ammonia method employs the classic Birch Reduction reaction rather than a series of substitutions as occurs when the Red Phosphorus method is used. Due to this direct conversion, the Anhydrous Ammonia Method is less prone to by-product formation than is the Red Phosphorus Method.

In the third phase, a reaction of salt and acid create hydrogen chloride (HCl) gas which is bubbled through the meth base in solvent. The product precipitates from solution as meth HCl. Much of the contamination found in former meth lab structures is thought to be distributed during the “salting out” phase.
The graphic above describes the possible solid, liquid and gaseous wastes that may contaminate structures. After the cooking process has stopped, most of the hazards decrease dramatically. Proper removal of the production wastes and bulk chemical supplies eliminates many of the risks associated with clandestine methamphetamine labs. Also, volatile chemicals and solvents such as ammonia, methanol, ether, or acetone will move into air and will be readily removed from the structure by ventilation. Study is needed to determine contaminants other than meth that may exist in former meth lab structures.

Some residual contamination created from repeated “cooks” can persist long after all production has ceased. Semi- or non-volatile production chemicals such as acids, bases, and other corrosives, precursor chemicals (pseudoephedrine and ephedrine), and products used or created in the manufacturing processes are more persistent. These can be volatilized or aerosolized as fine particles during the cooking process and deposited on surfaces and in materials, such as carpeting and fabrics. Meth is deposited and infiltrates materials as a combination of meth vapor, meth hydrochloride particles, and meth attached or possibly sorbed onto other particles such as dust.

The extent and concentration of meth contamination in former labs is extremely variable. Factors such as the scale and duration of the lab, cooking method used, ventilation of the cook site, and technique of the lab operator impact the level of residual contamination of the site. Also, the act of “smoking” meth volatilizes meth and may distribute some meth hydrochloride.

Other contaminants may persist. A list of contaminants most likely found at a meth lab site are listed in Appendix B of the document Outdoor Contamination due to Meth Lab Waste Disposal: Assessment and Cleanup. http://www.pca.state.mn.us/cleanup/meth.html The solid and liquid wastes may also be emptied into septic systems, onto the ground or into burn pits.

The primary concern of outdoor contamination is possible effects on ground water. The level of concern regarding possible contaminants in ground water depends on how quickly they break down in the environment, how likely they are to move in the ground water, and how toxic they are.

Acetone, ethanol, isopropanol, and methanol (HEET) can rapidly break down in soil and ground water and are not typically persistent. Ammonia, sulfuric acid, lye (NaOH), phosphoric acid, and hydrochloric acid (HCl or muriatic acid) will neutralize in the soil environment almost immediately and do not pose a long-term risk. Mineral spirits and naphtha are composed of chemicals that can degrade slowly but as these tend to bind to the soil matrix, they typically do not migrate far in the soil and ground water. The chemicals benzene, toluene, ethylbenzene, and xylene (BTEX) can impact surrounding points of exposure if they are disposed of in large quantities. While these are all biodegradable and mobile in the ground water environment, these compounds rarely move more than 200 feet away from leaking underground storage tanks.

Methyl ethyl ketone (MEK) and ether are also biologically degradable though they can persist in groundwater at high concentrations and may impact nearby wells or surface water. At concentrations below one part per million in ground water, these typically degrade in the vicinity of the disposal. Ether would be the most persistent of these compounds.

Trichloroethane, freon and other chlorinated solvents are very persistent groundwater contaminants and deserve more scrutiny. Small amounts of these chemicals can impact nearby wells and surface water and can travel long distances from the point of disposal. If these chemicals are present in groundwater, MPCA staff or guidance documents should be consulted.
Studies of clandestine meth lab-contaminated materials from former meth lab sites are named by city location and discussed in these documents. Brief summaries of background information germane to the studies at the former meth lab sites are provided in “Overview of Former meth lab study sites.” Each meth lab site has had very different histories, much of which we are unable to know. Studies at each site were chosen based on law enforcement reports, location of known cook sites, use of buildings and future plans for the site, length of access to the site, and the questions in mind when we had access to each site.

Unfortunately, access to former meth labs was difficult to obtain due to owners’ concerns. This difficulty in access created problems in repeating studies at multiple sites. Many observations discussed were found at only one or two sites due to inability to repeat the studies and, therefore, much of our study information is preliminary. We hope that other researchers will attempt similar studies.
Sampling at former meth labs, we have been studying the distribution horizontally and vertically of meth on surfaces, the infiltration of meth into building materials, and the effectiveness of wipe sampling vs. other sampling methods with a range of building materials. We have evaluated attempts to clean carpeting, painted wallboard, and HVAC systems. A former meth lab house was remediated, with extensive wipe sampling done – over 300 wipe samples were collected of different materials after each step in remediation. We’ve studied meth in air in former meth lab environments, including during and after heating, ventilation and air conditioning (HVAC) system cleanings to determine redistribution of meth to air and other human exposure pathways.
This photo is from a former meth lab in Isanti – an anhydrous ammonia method long-term (two-plus years) lab, highly-contaminated with meth, with much “smoking” in the residence. This wall is in the master bedroom/surveillance room. In attempt to understand distribution of meth on surfaces, we sampled with methanol-dampened wipes in adjacent 6” x 6” areas, both vertically and horizontally. (Note the blue chalk snap lines.) The results of the vertical sampling found a simple linear correlation so surprising, we repeated the sampling and found a similar surprising correlation.
This is a diagram of the wall from the previous slide with the wipe sample results shown from both samplings. Sampling areas are 6" x 6" and values are reported as µg/ft². Note the variability in sample results from adjacent sample areas. Also note the vertical trend of increasing meth contamination from floor to ceiling.

The primary purpose of this study was to discover possible patterns of methamphetamine (meth) distribution on wall surfaces as baseline information for sampling and cleaning studies. Side-by-side, 6" x 6" areas of painted drywall were sampled with methanol dampened cotton gauze wipes. Samples were taken both horizontally and vertically along the length and height of the wall. Due to the highly significant linear correlation found in the first vertical sampling event, vertical and horizontal samplings were repeated on the same bedroom wall.

The following two charts display results of the two sampling events. Of great interest is the vertical distribution of meth; meth concentration in wipe samples increases as distance from the floor increases.

Understanding the distribution of methamphetamine on wall surfaces is necessary in deciding where to sample for different purposes and to better interpret lab results. Also important to understand is the degree of variability in results of wipe samples when adjacent samples are collected and analyzed by consistent methods.
Vertical Meth Distribution – High Contamination Site (Isanti)

This first vertical sampling was done along the left side of the window. The highly significant linear correlation ($R^2 = 0.88$) is rarely found in environmental studies. This indicates that meth residue wipe sample results are progressively higher moving from floor to ceiling.
Vertical Meth Distribution #2 – High Contamination Site (Isanti)

The second vertical sampling was done further to the left of the window. Again, a strong linear correlation, $R^2 = 0.77$, is seen.
In review of the horizontal sampling data, the horizontal meth concentrations below the window display the effect of the window on meth deposition. In the second sampling, horizontal sampling above the window does not show obvious effects of the window although the meth concentrations spike at the right of the window in both samplings. It may be notable that a corner shelving unit to the right of the window presented high meth contamination results; cooking and/or smoking may have occurred on or near these shelves.

Horizontal sampling showed significantly higher concentrations ($p < 0.016$) above the window (mean, $171.7 \, \mu g/ft^2$) than below the window (mean, $140.5 \, \mu g/ft^2$). More variability is seen in the “below window” data set due to a bell-shaped curve of results directly beneath the window. The independent populations displaying higher contamination in the series above the window compared to the series below the window supports the linear vertical correlations of increasing levels of meth with increasing distance from the floor.
At a second, lesser contaminated site (Delavan), the strong correlation of increasing levels of meth with distance from the floor to ceiling was again seen in a similar vertical sampling of adjacent areas with a similar significant correlation ($R^2 = 0.83$, $p<.0015$). Ceiling fans, if used, did not seem to interrupt deposition.

This information impacts interpreting wall sampling results – a pre-cleanup sample taken at toddler height on a latex painted wall will generally give lower results than one at adult chest height. If pre- and post-cleanup sampling results are to be compared, the height of sampling on a latex painted wall, and most probably other building materials, must be similar.
At this lesser contaminated site, variation from the linear deposition pattern was seen above the heat register vent in the one and two feet above; the samples from this area were slightly higher. Of interest is that although this sampling was done on the same wall as the slide previous, each sample value was significantly higher in this vertical than the comparative sample of the vertical just discussed. That is, the heat register may have affected the results of all samples. The possibility that this is due to chance is p<0.0035.
The new owner of the Isanti former meth lab site allowed invasive sampling of the living space before cleaning and remodeling. The relatively large meth production site was in operation for over two years using the anhydrous ammonia method. This is the same room discussed in previous slides, mapped with vertical and horizontal sampling. Meth lab contaminated wallboard was removed for wipe sampling, washing and penetration studies to be done in the analytical lab. One foot by one foot wallboard sections were taken with notes of where an area had been previously wipe sampled for the earlier meth distribution studies. The purpose of these studies was to determine meth residence in layers and materials of wallboard.

As you will see in the following slides, preliminary lab analyses indicate that methanol dampened wipe samples over the same area in series will remove similar amounts of meth per sample. That is, as meth appears to reside primarily in paint, wipes will continue to remove thin layers of paint and meth. Methamphetamine was not found in gypsum.
In this stacked column graph, adjacent meth lab contaminated wallboard sections were wipe sampled four times in succession. The remaining paint was then peeled from the wallboard for extraction and analysis for meth. The face paper of the wallboard was also removed and extracted for meth analysis.

In this heavily contaminated wallboard, the great majority of meth contamination resides in the latex paint of the wallboard. See the serial wipe sampling study for a graphic, tables and explanation of the study.

A wipe sample fails to show the level of meth contamination in this latex painted wallboard.

Compare this chart to a lesser contaminated site’s results (see next slide).
Another way to understand this is that each successive wipe sample collects a portion of the meth that has penetrated the latex paint. Several adjacent vertical sections of meth lab contaminated wallboard from a short-term, lesser contaminated site were also wipe sampled four times in succession. The remaining paint (Delavan) was then peeled from the sheetrock for extraction and analysis for meth. When compared to the more heavily contaminated wallboard just shown, the bottom section of this stacked column graph shows that a greater percentage of the total meth in the paint is collected by the first wipe sample. The top section of each stack again shows that even after serial wiping four times, meth will be found in the paint.

To understand the possible reasons for the difference in percentage of total meth collected in the first and subsequent wipe samples, we review the difference in the labs’ histories. The previous slide displays results for a painted wallboard sample from a long-term, highly contaminated lab which had most probably been exposed to repeated cooks using “box labs” (small portable meth lab kits) and repeated and heavy smoking of meth by the many inhabitants. This repeated contamination may have caused the meth to further infiltrate the paint. As the lab was known to exist for approximately three years, it is also possible, though less probable, that the owner decided the room needed a new coat of paint.
In this graph, lesser contaminated wallboard has been wiped ten times in succession to determine depth of meth penetration. Serial wipe sampling of low-level meth contaminated sheetrock demonstrates that meth can continue to be sampled above the 1 µg/ft² level even after six wipe samplings with methanol-dampened wipes. Paper from the wallboard was visible at this point; this indicates that meth permeates the entire layer of latex paint.

More work was done on several samples collected from the Isanti site to determine if meth infiltrates the sheetrock behind the latex paint. Careful layering studies of contaminated wallboard found meth on both the front and backside of the collected wallboard samples but not in the gypsum core of wallboard.

These layering studies provide evidence that meth was not moving through the gypsum but instead moving behind the wallboard. The surface peels of contaminated wallboard (both painted and unpainted) were the most concentrated samples for that section of sheetrock. Samples of the paper that was left behind after the paint peel (the last bit glued to the gypsum) were either below detection limit or contaminated at only trace amounts. These observations imply that the meth contamination is able to penetrate the wall cavities, for example, through electrical outlet openings and move behind the wallboard.

For a graphic representation of the layering studies, see “Meth Lab Contaminated Latex Painted Wallboard – Layering Studies.” For quality control studies on recovery of meth from gypsum, see “Gypsum recoveries”

At this point, it is notable that methanol, the solvent used for wipe sampling, is much more aggressive than detergent and water; this indicates that rigorous cleaning of latex-painted wallboard will not remove all meth contamination. A small cleaning study of lab contaminated wallboard supports this theory. See slide “Serial Washing Study” under the Cleaning section of this slide show.
To this point, we have discussed study of meth in latex painted wallboard. In a former meth lab structure, almost all building materials are penetrated by meth. Wipe sample results for this bare sheetrock from this cook’s corner in the attached garage (Isanti site) returned results of only 7 µg/ft². As this seemed unlikely, the unpainted sheetrock was removed for extraction analysis of the wallboard layers at the analytical lab. Results were: front peel of paper in the low 300’s, very little in gypsum, (12 – 58), back paper peel at 500 and 568. For more information, see John’s Corner unpainted wallboard. Wallboard is often found in newer construction as part of the heating, ventilation and air conditioning (HVAC) system’s duct work. In attempts to explain the very low wipe sample results, it is notable that the unpainted wallboard appeared wet with methanol after wiping and possibly the paper and gypsum draws the methanol from the wipe rather than the methanol dissolving the meth residue onto the sampling pad.
In Minnesota, meth cookers often prefer basements, generally constructed of unpainted or painted concrete block walls and concrete floors, as cook sites. When attempting to sample concrete block, it is apparent that the mechanical action of wiping this rough surface with a gauze is inefficient.

Concrete and grout scrapings (material chiseled 1/8” to ¼” deep) were taken from three former meth lab sites; extracted and analyzed results were compared to the wipe samples. Again, surface wipes proved to give non-representative results of the total meth infiltrating the porous cement block and grout. Again, it appeared that methanol was soaking into the concrete block and that meth residue settled into the porous cement is unavailable for wipe sampling.
This is the ceiling above the wall in the more heavily contaminated site (Isanti) discussed in prior slides. Identical size wipe samples were taken next to scrapes of ceiling texturizing in two rooms of a former meth lab, this master bedroom and the kitchen. Wipe sample results and scrape sample results were consistent within sample type across the ceiling, however, the sampling methods showed great difference in values – wipe results for meth were 4 to 7% of meth found in the scrape samples in the same area adjacent (for example, wipe results were found to be in the high 100’s-low 200’s and scrape results were in the low to mid 3000’s).
Surface texture creates obvious problems for wipe sampling. Porosity of building materials is another problem. The various building materials of living structures and outbuildings introduce differences in ability to sample and interpret sampling results. At this site and others, side-by-side wipe sampling of different building materials demonstrated differences in results. Compare adjacent wipe sample results of different materials -- foil-faced insulation board between the studs had very low and similar sampling results (2.4, 4.6 µg/ft²). Results of adjacent wipe samples of raw wood studs were 15.4, 17.3 µg/ft².
Total extraction studies of these building materials compared “near surface” invasive sampling to adjacent wipe sample results. Invasive sampling removed contaminated materials by peeling (e.g., latex paint, wallboard paper, wallpaper), scraping (e.g., grout and paneling), and chiseling (e.g., concrete block, raw wood studs and rafters) to approximately 1/8 to ¼ inch depth. From every building material, meth contamination results were greater in the total extractions when compared to wipe sample results.

For a look at the variation of wipe sample results in a small basement room where cooking was done, see the graphic “Basement – Cook Bench Room.”
Analytical Labs’ Results Vary

- Study #1 – 48 wipes were spiked with meth HCl and meth base at 0.0, 5.0, 50.0 and 150.0 µg/sample
- Study #2 – 72 wipes were spiked with meth HCl and meth base at 0.0, 0.4, 4.0, 40, 120 µg/sample
- Six environmental laboratories analyzed the wipe samples using their standard operating procedures

At this time, there is no nationally standardized analytical method for analyzing wipe samples for meth. To investigate whether analytical labs get similar results for meth residue analyses, we spiked wipes with varying levels of meth and submitted the wipes to six analytical labs. The analytical lab results were highly variable and discouraging in the two studies of spiked wipe sample send-outs to the same six labs.

To review the labs’ results, see the “Analytical Results of Round Robin Studies #1 and #2. The linked charts identify analytical labs only as "Lab A - Lab F." MPCA will NOT disclose the labs’ names.
Labs’ Reported Results

- Nearly half of the reported results were outside the general acceptance criteria (+/- 30% recovery of the spiked amount)
- One lab reported sample results at and under 5.0 µg/sample as “not detected”
- One lab did not report accurate results for any of the spike values

Note that there is no current acceptable range of spike sample recoveries specifically for meth analyses.
Interpretations – Labs’ Results

Variation

- Some laboratory reporting levels cannot detect meth at levels of cleanup “standards”
- Consistency in reporting could be improved by:
  - Publishing a standard analytical procedure
  - Developing a proficiency testing (PT) sample
  - Requesting a NIST-traceable meth standard for routine quality control procedures

We found that some analytical labs’ could not find very low level meth on a spiked wipe and therefore, could not report results at levels used as a cleanup “standard,” such as 1 µg/ft². Recommendations for improving consistency in analytical lab results are listed.
Towards Reporting Consistency

- Require laboratory accreditation to promote accuracy, precision, and comparability of data
- Notify vendors of the need for proficiency testing samples
- Improve consistency in sampling technique through training

Minnesota Department of Health’s (MDH) Environmental Laboratory Certification Program’s (ELCP) certifies analytical laboratories that generate environmental data for government agencies for regulatory purposes. The Environmental Laboratory Certification Program (ELCP) certifies laboratories that have provided assurances that appropriate systems are in place to generate reliable data.

To promote analytical lab results consistency regarding meth wipe samples, as of January 30, 2007, the MDH's ELCP added ephedrine, pseudoephedrine and methamphetamine to their list of analytes. These analytes are under the “Emerging Contaminants” certification for the Resource Conservation Recovery Program.

Remediation contractors will need to use a state certified analytical lab to show the local authority that their post remediation data is reliable. It is the responsibility of the contractor to assure that the laboratories they use obtain this certification. It is also the responsibility of the local oversight authority to assure that record of this certification accompanies the laboratory data submitted with the contractor's final report.

The process of certifying an analytical laboratory requires 60 days. Due to this time requirement, present remediation projects and projects begun prior to July 1, 2007, shall be waived of this requirement. Any subsequent remediation projects will require certification of the analytical laboratory performing the analysis of wipe samples.
Historically, cleanup contractors tend to sample at chest level on walls typically painted with latex paint. Our site studies have shown that the level of meth is affected by vertical height on a latex painted wall. Other building materials' results may also be affected by height in the room although this effect may not be as apparent due to other variables in wipe sampling a specific building material (for example, the rough and porous surface of concrete discussed).

As we’ve just seen, the lack of consistency in results of an unofficial spiking of wipes sent to six labs was discouraging.

Although the current Cleanup Guidance does not require wipe sampling, parties may choose to wipe sample. If wipe sampling, the Cleanup Guidance recommends sampling “nonporous” materials (listed in the Cleanup Guidance and in a slide below). To compare wipe sample results, use results from the same building materials sampled at the same height using the same sampling protocol (action done by the sampler), using the same solvent, analyzed by the same analytical lab. A wipe sampling protocol is provided in the Cleanup Guidance.
Interpretations for Wipe Sampling

- Sampling for meth with methanol wipes
  - does not indicate total mass of meth on or in a material
  - does not indicate mass available to humans by dermal, inhalation or ingestion routes

The studies' results shown in the previous slides impact interpretation of wipe sample results. As methanol-dampened wipes “mine” meth in latex paint, wipe sampling latex paint for meth will almost always have positive results.

Results of wipe sampling from most building materials which are mostly porous, for example, concrete block, raw wood rafters and studs, and ceiling texture, collect a small quantity of meth relative to the actual load in the building material.

Question the interpretation of wipe sampling results – Results do not represent the total mass of meth on or in a building material, or the possible dermal, inhalation or ingestion exposures due to meth deposition. What do wipe sample results represent?
Interim – IF Sampling for Meth

- Wipe sampling to show presence, but
  - May miss meth in unpainted sheetrock, concrete, unsealed wood, brick
- Directed wipe sampling from “nonporous” surfaces per Cleanup Guidance
  - Metal (preferred)
  - Ceiling fan blade (topside)
  - HVAC cold air plenum
  - Horizontal “uncleaned” surfaces

If wipe sampling is done, we recommend using wipe sample results qualitatively to determine meth presence. Surfaces we believe may sample more efficiently and provide better understanding of the level of contamination in a structure are listed as those we would “recommend” for wipe sampling at this time.
As we’ve seen, wipe sampling of raw wood, unpainted wallboard, cement block and other porous materials collects little of the actual load of meth residue. As we’ve learned, the production phases of methamphetamine produce two chemical forms of meth with different chemical and physical properties. Meth hydrochloride (HCl), the desired end product, is not volatile under normal conditions and can often be found in areas where dust or other particulate matter accumulate. Micro-vacuuming, an alternative sampling method studied, collects meth HCl particles and meth HCl attached to dust and particulates. For details on the sampling train used for micro-vacuuming, see the next slide.

Problems noted in using this sampling method reflect difficulties in controlling consistency in sampling. For example, the total area contacted by the angle cut tubing is likely less than the area contacted by wipe sampling with gauze. With this in mind, standardizing the sampling protocol might include the number of passes required to optimize contact with the sampling area, or standardizing sampling time, e.g., sample for 10 seconds. Also of concern, as the pressure put on the slant cut nozzle against the surface affects air flow, does it also affect sample collection?

Difficulties were also found in how to report sample results – by µg/ft² for comparison purposes? By µg/g of sample collected? While micro-vacuum sampling this used brick fireplace, small particles of brick were noted in the glass fiber filter cassette. In other words, the micro-vacuum sampling does not collect only meth HCl particles and dust but also small bits of the sampled material.

In summary, although promising, micro-vacuum sampling presents problems in how to sample and how to best report results – should lab results be reported as microgram per area sampled, such as wipe sampling, or by weight of meth per weight of dust? As micro-vacuuming appears to collect meth on dust, meth mass per dust mass seems most usable. However, the weight of building material particles skews the relative amount of meth.
The sampling train and methods used incorporated those of sampling for asbestos. Micro-vacuuming was accomplished using a high-volume pump (SKC item # 225-9541) calibrated at 20 liters/min with an acid-treated glass fiber filter cartridge (SKC #225-9004) connected to a high flow pump by a piece of Tygon tubing. A nozzle on the inlet of the filter canister was created by cutting an approximately two inch piece of tubing at a 45 degree angle. This angle cut tubing was lightly pressed and run along the surface of the material to be sampled in the same manner of wipe sampling (“N” and “Z” patterns).
In attempts to better understand meth distribution and infiltration of porous building materials, adjacent samples were taken of building materials using different sampling methods. At this site (Dayton), 6” x 6” areas of exposed wood studs were sampled with methanol-dampened wipes, by micro-vacuum, and chisel sampled (1/4” to ½” deep) for methanol extraction.

Wipe samples of the raw wood studies gave relatively identical results (15.4, 17.3 µg/ft²). Extraction results varied with distance from cook site – (180, 374 µg/ft²). Micro-vacuum sampling results (8.6, 81.4) showed some promise of more representative sampling (reflecting distance from cook site) on rough, porous surfaces than wipe sampling results, although more study must be done.

This comparative sampling of wipe samples and micro-vacuuming results was done at four sites, investigating raw wood studs and rafters, carpeting, upholstery materials and drapery, and clothing. Interpretations of all sites’ results indicate that micro-vacuum sampling can be used to indicate presence of meth contamination in materials that can collect dust, such as raw wood studs and rafters and carpeting. The method may also be used to indicate meth contamination presence for materials such as concrete block and brick. Smooth materials such as fabrics cannot be reliably micro-vacuumed.

Wipe sample and micro-vacuum results are compared for raw wood rafters from another site, St. Peter.
Will meth HCl or meth on dust re-mobilize via air currents, body movements, foot traffic and cleaning such as vacuuming? Concerns regarding inhalation exposure of remediation workers and subsequent residents led to developing methods for sampling meth in air. The same sampling trains were used for both personal and area air sampling. See the next slide for more information on sampling trains used.

Sampling was done at three former meth lab sites during low to mid-levels of activity. The former meth lab sites had not had meth production activity in one month to over two years. The results of personal air sampling found meth at very low levels, generally below the quantitation limit (BQL<0.1 µg/sample). The highest levels were found at the short-term lab site above where meth activity was ceased three months before and at another former lab site that had ceased activities within the same month. The three quantifiable results were 4.4 E-04, 4.6 E-04, and 4.8 E-04 µg/l. The greatest adult male inhalation exposure would be 7.3 µg/day, if all meth inhaled were taken into the body's cells. For more information, see the tables from the three sites.

Area air sampling levels were sampled in four sites with volumes of air ranging from X to Y liters. Meth in air sampling results are shown in data review reports per site.

In the photo above, the sampler is wearing a personal air sampling pump with a 37-mm acid-treated dual-filter cartridge while beating a couch cushion to simulate a small child jumping on a couch. The area air sampling value for meth during this activity at Delavan resulted in the highest level of meth in all meth in air site studies.
Meth in air sampling was accomplished using two sampling trains. In the earlier studies, Minnesota used acid-treated glass fiber filters to collect meth in air attached to personal air sampling pumps calibrated at 2 liters of air flow per minute (L/min). The 37-mm acid-treated glass fiber filter cassettes have a primary and backup filter (dual filter cassette). These filters will collect particles to 0.1 microns in size and acidify the meth base should it still exist as vapor in air.

To ensure that all meth in air was being collected, MPCA contracted with the University of Minnesota (U-MN) to validate the meth in air sampling train. The University chose to assemble a meth in air sampling train including a 37-mm glass fiber filter cassette and an acid-treated silica gel sorbent tube. This sampling train required the personal air sampling pumps to be used at 1.5 L/min due to resistance increased by use of the sorbent tube; the increased resistance would shut down the personal air sampling pumps at 2L/min. The 37-mm glass fiber filter cassettes are rated at 1 micron for particle size collection. The acid-treated sorbent tube is expected to collect meth base vapor and any sub-micron particles that may have passed through the glass fiber filters. For more information, see “Sampling for meth in air”.

The University’s report on validating the glass fiber filter and acid-treated sorbent tube sampling train is reported in “Meth Lab Sampling: Air and HVAC Systems”
To ensure that the dual-filter cassettes were collecting all meth in air, as particles suspended or as residual meth base, and to determine whether the simpler sampling train used in the early studies provided valid data, the Minnesota Department of Health Public Health Lab compared sampling trains in a parallel study. Results clearly indicate that the acid treated glass fiber filters are an effective sampling media for meth base vapor. The recovery was ~ 100% and no breakthrough was observed. MDH PH Lab’s opinion is that an acid treated glass fiber filter cassette with a duplicate breakthrough filter would not require a separate sorbent tube backup; the meth base vapor would be converted to meth acid upon interaction with the acid treated filters. This would substantially decrease volatility and would eliminate the need for the downstream sorbent tube. In addition, MDH PH lab notes that the U-MN’s low concentration work supports this conclusion. The U-MN observed that even with a non-treated filter, the downstream sorbent tube is only needed under conditions of high concentration or prolonged sampling time. For more information, see “Meth in Air Sampling QC Studies.”

Lessons learned in these studies -- Many of the meth in air samples were near or below the analytical method’s quantitation limit, with many samples receiving only an estimated concentration. For future studies, this issue should be addressed by either increasing the sampling amount or lowering the method quantitation limit. A more sensitive analytical method with a quantitation limit of 1 ng/sample would aid in the analysis of low-level contamination samples such as the former meth lab air monitoring samples.
Before discussion of the next section regarding cleaning studies, recall that the former cleanup standard adopted was the detection limit for meth by analytical labs. The probable intent was to approach zero meth in former meth lab environments. Analytical lab capabilities can identify much lower levels of meth on a sample at this time.

As we have seen, wipe sampling to indicate cleanup to a non-health based standard is a confusing undertaking. Minnesota’s Cleanup Guidance does not require pre- and post-remediation sampling.
MN Guidance as Process-Based:
Goal is Mass Removal

- As clean-up standard is NOT health-based
  - No, minimal, and acceptable residual risk based on use
- Objective - To minimize exposure
  - Remove largest, most easily removed masses of meth residue – e.g., carpeting
  - HEPA vacuum porous materials
  - Wash sealed surfaces twice plus rinse
  - Seal meth-infiltrated building materials

Until a health-based standard and/or standardized sampling methods and protocols per building material are identified, our objective is to minimize possible exposure to meth. Decisions regarding rigor of cleaning/sealing of a structure are based on possible use of the structure (i.e., will the structure be lived in?) and residual risk acceptable. See the Cleanup Guidance for discussion of risk.

To minimize exposure to meth residue and other possible contaminants, recommendations are made to remove personal items and all non-structural, difficult to clean materials, such as carpeting, wallpaper, paneling and ceiling tile, from the structure. The greatest mass of meth in the structure is most likely in carpeting.

Wet washing is not effective in cleaning some porous materials such as raw wood rafters and studs – HEPA vacuuming is recommended. Due to residual meth remaining after cleaning, sealing may be required for highly contaminated finished wood surfaces such as wood flooring and cabinets.
The *Cleanup Guidance* recommends removal of all non-structural, difficult to clean materials, e.g., ceiling tile, wallpaper, and paneling.
Carpets – Largest Removable Mass

Carpeting collects meth distributed in air, spills, traveling meth, and other chemicals used to make meth. Even the best industrial steam/extraction cleaning could not reduce meth to levels acceptable for infant and toddler contact. See “Attempts to Clean Carpeting.” Keep in mind that other chemicals used to make meth or by-products of meth production are not necessarily removed by cleaning.
Sampling carpeting is also problematic as great variability in meth deposition is found within a room of carpeting. The values above are total extraction values of meth from carpet in the master bedroom of the long-term lab (Isanti) discussed earlier. The results are located in the approximate area of the room from which the samples were taken.

For total extraction of meth from carpet, samples were cut to soak whole samples including fibers and backing, fibers alone and backing alone in methanol, to determine residence of meth within the components of carpeting. When results were reported as µg/ft², the majority of meth contamination was extracted from the backing. For the table of results, see “Isanti carpet samples.”
Similar to the serial wipe study of meth contaminated latex paint on wallboard discussed prior, the intent of this study was to determine whether wet washing with detergent would reduce meth contamination adequately, or if sealing is required of painted surfaces. For each wash sample, the sampler washed the section with Simple Green solution with gauze and placed the gauze into a sample jar. Washing was done once, twice or three times per section. All sections were rinsed, then wipe sampled. Each gauze wipe was analyzed individually with results as shown. A methanol-dampened wipe followed the washing of each section.

Each wash removed only a small and similar amount of the meth in the wallboard -- the majority remained in the paint as indicated by wipe sample results and extraction of the paint and paper (not separated in this study). (Note: the extraction value is not shown on the graph). For more detail, see “Serial Washing Study of Heavily-Contaminated Wallboard.”
The question of whether heating, ventilation, and air conditioning (HVAC) systems should be cleaned to reduce possible meth exposure is complicated by concerns that HVAC cleaning may redistribute meth contamination to air and recontaminate the structure. HVAC cleaning at this site, St. Peter, was done prior to personal item removal, tear-out of contaminated building materials, and cleaning and sealing events. A statewide available company was hired to do a standard HVAC cleaning. While cleaning, air sampling trains were run on all levels for methamphetamine (meth) collection. The sampling trains consisted of personal air sampling pumps calibrated at 1.5 l/min with 37-mm glass fiber filters and acid-treated silica gel sorbent tubes. See more information on air sampling at this site.

Although further study is recommended, concerns regarding meth redistribution by HVAC cleaning have been lessened as no quantifiable meth levels were found in four hours of air sampling during and after the HVAC cleaning. Future recommendations for cleaning HVAC systems should be based on the level of meth contamination. This system was heavily contaminated throughout the system as identified by extensive study sampling; due to the heavy contamination in the ducting of an unoccupied house, we determined that the meth contaminated dust mat was best removed from within the ductwork.
To clean the HVAC ducting, a strong vacuum and HEPA filter unit were used to pull air and collect dislodged dust. To dislodge the dust mats, an eight foot long 180 psi air hose with spinning fiberglass whips was pushed as far as possible into the cold air returns while the system was under negative pressure. After dislodging dust with the air whip attachment, the attachment was removed and the stronger pressure of the air hose without the whip attachment was used to move the dust toward the main trunk line. Cold air returns are horizontal runs which collect more dust and require more agitation and air pressure. Because the heat register lines run to the basement vertically, the stronger pressure of the air hose without the air whips was not required.

The furnace’s A-coil, which resembles a radiator core within the furnace, was air cleaned but not wet cleaned.
Wipe sampling within heat registers and cold air returns after HVAC cleaning revealed significant meth contamination reduction with the removal of the matted dust. For detailed information, see “St. Peter - Post-cleaning and Post-sealing Results.” Pre-cleaning sample ranges for cold air returns were (273, 1487 µg/ft², approximate), n = 6, and for heat registers (90.3, 213.2 µg/ft²), n = 7. In all cases, approximated meth contamination values of cold air returns were at least twice as high as the level found in the heat register of the same room.

The ranges of meth contamination for post-cleaning results for cold air return trunks and the furnace plenum (23.8, 196.5 µg/ft², actual), n = 3, and heat registers (24.6, 80.2 µg/ft², actual), n = 7, were greatly reduced but not eliminated by removal of the meth contaminated dust mat.

Although this single site study’s findings are preliminary, as air sampling for meth during and after HVAC cleaning did not indicate increases in levels of airborne meth, the low level contamination remaining in the HVAC system is not likely to be redistributed by furnace operation.
This property was chosen to study meth distribution as well to clean and seal the living structure to reduce possible exposures to future residents. Cleaning and sealing methods were chosen to optimize meth reduction and thus, minimize future possible human exposures. Goals of the project included:

- Better understanding of meth deposition on and infiltration into building materials and finishes comprising structures where meth has been produced;
- Optimizing reduction of initial methamphetamine levels and determining cost effective methods by sampling between phases of cleaning and sealing the interior of the home;
- Identifying meth contamination levels, as sampled using methanol-dampened wipes, that can be attained by cleaning and sealing, or cleaning only.

At the St. Peter site, building materials sampled, cleaned, and in most cases, sealed, included: raw wood rafters and studs, latex paint on plaster and wallboard (both smooth and textured), varnished cabinetry, formica, varnished wood flooring, painted cement floor, painted and unpainted concrete block, and varnished knotty pine paneling.

Overall, post-cleaning results revealed that double-cleaning followed by a rinse with clear water is effective in substantially reducing meth contamination, although sealing is often required to further reduce meth contamination toward 1 µg/ft². Double washing and rinsing of the latex painted walls reduced the higher level meth contamination results found in the kitchen – painting further reduced the levels. In the case of lower meth contamination in the bedrooms, double washing and a rinse minimally reduced the low levels.

In some cases, cleaning of varnished wood and other wood surfaces was less effective. (See the linked spreadsheet below noting post-cleaning results for the kitchen cabinets, wood flooring, and foyer door.) Post-cleaning, attic steps and knotty pine paneling revealed lower levels of meth contamination. Basement steps, with a paint finish, did not clean readily or were possibly recontaminated by tracking of meth. The varnish on the windows’ wood trim and casings was worn to the point of nonexistence. When sampled for meth contamination, this partially unsealed wood yielded higher levels of contamination.

Sealing these wood surfaces using water-based polyurethane provided very good results. The minor exceptions were the kitchen door (post-sealing sample of 23.4 µg/ft²), the foyer door (12.7 µg/ft²), and the living room window casing (13.7 µg/ft²), all very low levels.

See the full report on the St. Peter cleaning study and the spreadsheet of results.
Although we are confident of our recommendations to remediate former meth lab structures by a prescribed process and to approach any wipe sample results with many questions, much of our study has been limited in site number and scope. That is, much study is still needed – repeat of our studies and other studies involving other questions.

Other great questions/need for study include:

• Mobility of meth deposited in structures -- Will sealing residual meth remaining after cleaning protect future residents from exposure? Does sealing with latex or oil-based paints or polyurethane prevent meth exposure to subsequent residents?
• Need for health-based standards for meth as well as other chemicals used in production of meth – toluene, iodine, etc. – and by-products of meth production.
• Need for more representative sampling methods for the wide-variety of building materials that can become contaminated; the remediation industry is numbers-driven.
California’s Office of Environmental Health Hazard Assessment (OEHHA) is currently working on a risk-based cleanup standard for meth in former meth labs. At this time, an exhaustive literature indicates that a threshold dose for meth is probable. Appropriate factors with which to model human exposure pathways to meth are being determined with the USEPA. OEHHA has contracted with the University of California in San Francisco to study transfer of meth from surfaces to skin and absorption of meth through skin.

Later this year, OEHHA will also be setting risk-based standards for other contaminants in concern. The chemicals of greatest concern are by-products of the Red Phosphorus method, the method used in large “super-lab” operations. Though the list is subject to change, the chemicals chosen to develop risk-based cleanup standards will be chosen based on toxicity, the potential of the chemical to persist in the former meth lab environment.
The United States Environmental Protection Agency has begun to review needs for study to develop federal meth lab remediation guidelines. The USEPA, with the Drug Enforcement Agency, is to publish guidelines by January 2008. The USEPA also intends to develop federal health-based guidelines for former meth lab remediation by January 2011.
Questions regarding these studies may be addressed to Steve Lee at stephen.lee@state.mn.us.