# Review of Vapor Sampling Results for the Neighborhood Surrounding the Madison Kipp Corporation

PUB-RR-931 December 2012


*DNR Photo*

Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707
dnr.wi.gov, search "brownfield"

## Summary

Indoor air and sub-slab vapors have been sampled by the Wisconsin Department of Natural Resources (DNR) and Madison Kipp Corporation (MKC) at 50 homes in the neighborhood surrounding the MKC property. This report summarizes the 2012 DNR-led investigation of the vapor intrusion risk in the South Marquette and Waubesa neighborhood surrounding MKC. The 2011 investigation by MKC and the 2012 investigation by DNR has established the extent to which perchloroethylene (PCE) has impacted homes at levels above acceptable state and federal guidelines.

Here are the highlights of this two-year effort:

- Of the 50 homes sampled for vapor intrusion, 47 were sampled in the DNR-led investigation in 2012.
- To date, 26 vapor mitigation systems have been installed.
- Three homes located adjacent to high levels of PCE soil contamination on MKC property had significantly elevated sub-slab levels of PCE.
- Nine neighborhood homes had sub-slab PCE above conservative, project specific vapor screening levels. The source of sub-slab PCE at two of these homes is indeterminate.
- Four homes exceed conservative, project-specific indoor air action levels. The source of PCE in indoor air at three of these homes is indeterminate.
- No homes exceeded the current (2012) DNR indoor air screening levels.

Table 1 summarizes the vapor sampling results for the 2011 and 2012 vapor investigation. For a discussion of vapor screening levels, see page 3.

**Table 1**
**Summary of 2011/2012 Vapor Sampling Results for Homes in the MKC Neighborhood**

| Vapor Screening Levels | # Homes Exceeding Screening Level for Sub-slab Vapors | # Homes Exceeding Screening Levels for Indoor Air |
|---|---|---|
| Project Specific Screening Levels for MKC (former DNR screening levels) | 12*<br>(2 from indeterminate sources) | 4<br>(3 from indeterminate sources) |
| Current (2012) DNR Screening Levels | 3 | 0 |

*Includes homes listed in bullets 3 and 4

## Madison Kipp investigation

Madison-Kipp Corporation (MKC) has operated in the City of Madison since 1902. The original manufacturing facility, located at 201 Waubesa Street, Madison, is still in use as a factory for precision parts for automobiles and other vehicles. The plant is closely bordered to the east (S. Marquette Street) and west (Waubesa Street) by single-family homes, by the Goodman Community Center to the north and Atwood Avenue to the south. Perchloroethylene (PCE) was used at the MKC plant historically.

In 2002, DNR was first informed by MKC about notable levels of PCE-contaminated soil on the east side of the plant and in several backyards. In 2005, MKC undertook treatment of PCE-contaminated soils on the east side of the plant and installed soil vapor probes in the backyard of three adjoining neighbors in 2006. In 2008, after several years of testing soil vapors in the residential backyards with PCE-contaminated soils, near-home soil vapor samples revealed elevated levels of PCE vapors.

In early 2011, sub-slab sampling by MKC for PCE in soil vapors from beneath the basements at these three homes found PCE levels well above current (2012) vapor intrusion risk screening levels. PCE was not detected in indoor air at two of these homes, but in the third home PCE was slightly above the conservative, project specific indoor air risk screening level. Shortly afterwards, MKC installed sub-slab depressurization systems (aka radon mitigation systems) at these three homes, in addition to two other homes, one on the north side and one on the south side of the group of three homes, for a total of five mitigated homes. A sub-slab depressurization system (SSDS) is very effective at removing soil gas, including radon and chemical vapors, from beneath homes and venting the gases harmlessly into the atmosphere.

An on-going groundwater investigation by MKC has revealed that PCE impacts the shallow and deep groundwater. Contamination has been found to depths of more than 200 feet beneath the ground surface. Shallow PCE contamination residing at the water table can be a source of vapor migration to surrounding buildings. MKC studies show that the extent of PCE contamination at the water table (shallow groundwater) is limited in area and does not appear to extend beyond an area bordered to the east by S. Marquette Street and to west by Waubesa Street (Figure 1).

## DNR investigation

In 2012, the DNR, through a contract with an environmental engineering firm, investigated homes for vapor intrusion in the neighborhood surrounding MKC. The investigation involved collecting vapor samples from beneath each home's foundation (sub-slab samples); indoor air samples from the basement; and outdoor air samples. The homes investigated included those immediately adjacent to MKC property and selected homes directly across South Marquette and Waubesa Streets. Vapor samples were also collected from selected homes on Dixon St. (1 block east of MKC) and Corry St. (1 block west of MKC). The goal of the sampling was to identify any additional homes where PCE vapors might pose a health risk to the residents.

After contacting 51 homeowners in the neighborhood, 47 homeowners allowed access to their property for collection of both sub-slab vapor and indoor air samples. MKC performed sub-slab vapor and indoor air testing at 11 of those 47 homes, all of which are located northeast and immediately adjacent to MKC property. DNR's contractor sampled sub-slab vapor and indoor air at 42 of the 47 homes. The testing took place between March and November 2012. The results of the sub-slab vapor and indoor air sampling performed in 2012 are summarized in Figure 5.

## Summary of sub-slab vapor and indoor air results at properties surrounding MKC

Sub-slab vapor samples collected by MKC in 2011 from the three homes immediately adjacent to the PCE soil contamination ranged in concentration from 305 parts-per-billion-Volume (ppbV) to 1,080 ppbV. The sub-slab concentrations at all three homes were well above the current, 2012 DNR vapor risk screening level.

Of the 47 homes tested between March and November 2012, sub-slab concentrations did not exceed 20 ppbV, which is significantly less than concentrations found at the three homes initially tested. Seven homes located adjacent to MKC exceeded the conservative, project

specific vapor screening level of 6.0 ppbV. Figure 2 illustrates the sub-slab vapor results.

Two homes located on Dixon Street had sub-slab PCE concentrations of 6.1 and 7.1 ppbV, slightly above the conservative 6.0 ppbV vapor risk screening level. All other homes tested in the immediate vicinity had sub-slab concentrations less than the screening level of 6.0 ppbV. The slightly elevated sub-slab PCE concentrations at the two homes on Dixon Street are unlikely to be due to vapor migration from MKC. These two Dixon Street homes are located more than 300 feet away from MKC and well beyond the conservative estimate that vapors can travel 100 feet through soil. The homes in between MKC and these two homes have sub-slab concentrations that are much lower than the two Dixon Street homes. If PCE were coming from MKC, homes closer to MKC would have sub-slab levels that were much higher than the two Dixon Street homes. As discussed below, other sources of PCE may be common inside residences (called "background" sources). If there are PCE vapor sources inside a home, the vapor can migrate from indoor air to the sub-slab making it difficult to distinguish the original PCE source.

Three of the 47 homes had indoor air concentrations above the conservative, project specific indoor air action level of 0.6 ppbV. The indoor air concentrations in these three homes may be influenced by a PCE source within the home or the condition of the home foundation may allow greater connection with the indoor air. This is discussed below in the section on background sources of PCE.

Figures 3 and 4 illustrate the indoor air PCE results for all the homes tested. The charts include the 2011 and 2012 indoor air screening levels and the 90th percentile background indoor air concentration of PCE found in American homes not affected by vapor intrusion. The screening levels and background indoor levels are discussed below.

## Health-based vapor screening levels and decision criteria for installation of mitigation systems

Results from sub-slab vapor and indoor air samples were compared to thresholds based on U.S. Environmental Protection Agency's (U.S. EPA) risk screening tables (www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). The DNR applies the lowest, health-based screening level that will protect people from both cancer and non-cancer risks. Prior to February 2012, DNR used the following PCE vapor risk screening levels:

- Indoor Air – 0.6 ppbV (parts-per-billion-Volume)
- Sub-slab Vapor – 6.0 ppbV

In February 2012, after 20 years of study and internal review of the toxic properties of PCE, U.S. EPA revised the carcinogenicity and toxicity screening levels for PCE. DNR's revised screening levels, based on U.S. EPA's data are now:

- Indoor Air – 6.2 ppbV
- Sub-slab Vapor – 62.0 ppbV

The DNR chose to use the older screening levels that were in effect in 2011 for evaluating the indoor air and sub-slab vapor sample results from the homes near MKC for the purpose of deciding where mitigation systems should be offered to homeowners. This added a 10-fold factor of safety to the current 2012 screening levels, which are already considered very protective of human health. All 47 homes evaluated were below the 2012, revised PCE health risk screening values for both sub-slab vapors and indoor air.

For homes located on S. Marquette and Waubesa Streets where sub-slab PCE concentrations equaled or exceeded 6.0 ppbV, DNR offered to install SSDS in homes at no cost to the homeowner. In addition, when sub-slab PCE concentrations were detected at levels less than 6.0 ppbV, DNR also installed a SSDS if homeowners requested mitigation. To date, DNR has installed mitigation systems at five homes where sub-slab concentrations exceeded 6.0 ppbV. DNR installed SSDS at 16 additional homes where homeowners requested the systems, but sub-slab PCE concentrations were less than the sub-slab risk screening level of 6.0 ppbV. DNR has installed 21 mitigation systems to date. Up to 8 additional mitigation systems are pending installation.

## Background PCE concentrations in indoor air

Indoor air typically contains volatile organic chemicals (VOCs) from consumer products, building materials, and outdoor (ambient) air. Indoor air concentrations resulting from these sources are commonly referred to as "background" when assessing the potential for intrusion of sub-surface contaminant vapors. Because PCE is found in common household items such as glues, metal cleaners, dry cleaned clothes, etc., it is usual to find certain levels of PCE in indoor air in residential homes. The presence of indoor or ambient air sources of PCE can make assessment of sub-surface vapor intrusion challenging.

U.S. EPA compiled information from indoor air studies throughout the United States and then reported summary statistics for indoor air concentrations in residential homes that are not expected to be affected by vapor intrusion. The U.S. EPA study found that PCE, along with several other volatile chemicals, is commonly found in residential indoor air. The indoor air of half of American homes can be expected to contain between no detection and 0.32 ppbV of PCE (equal to the 50th percentile). An indoor air concentration of between no detection and 1 ppbV can be expected at 1-in-10 homes (equal to the 90th percentile).

In order to separate possible sources of PCE, ambient air, indoor air and sub-slab vapor samples are collected. If vapor intrusion is a source of air contaminants in a home, the sub-slab concentrations are expected to be at least 10 times greater than the indoor air concentration when the home has an intact cement foundation. This is because vapors accumulate beneath the home foundation to a certain level before the vapors move into the home and present a risk to persons breathing the indoor air. Vapors originating in the home can also move from the indoor air to the sub-slab. One way to help identify whether vapors are from the sub-surface or indoor air is to calculate the relationship (or ratio) of indoor air concentration to sub-slab vapor concentration. For homes with intact cement foundations, if the ratio between indoor air and sub-slab concentrations is greater than 1:10 (or 0.1) then the source of PCE is more likely to be from inside the home or from ambient air than from the sub-surface. Very little reduction in concentration between sub-slab and indoor air is expected at homes with dirt crawl spaces, deteriorated cement foundations or other conditions that provide conduits between the sub-slab soils and the indoor air.

Of the 47 homes tested, PCE was found above the 0.6 ppbV indoor air screening level at three homes. At all three homes the ratio of PCE concentration of indoor air to sub-slab vapor, as shown in Table 2, was greater than 0.1. Two possible conditions may explain the high ratios at these three homes. The indoor air PCE concentrations may be influenced by a source within the home or the condition of the home foundation allows greater connection with the indoor air. None of the 47 homes had indoor air concentrations greater than the 2012 indoor air screening level of 6.2 ppbV.

**Table 2**
**PCE Concentrations: Indoor Air to Sub-Slab Ratios**

| Address | Sampling Week | Indoor Air Concentration (ppbV) | Sub-slab Concentration (ppbV) | Ratio Indoor Air to Sub-slab Concentrations |
|---|---|---|---|---|
| *249 Waubesa | 6/4/12 – 6/8/12 | 5.88 | 5.99 | 0.98 |
| 266 Waubesa | 6/4/12 – 6/8/12 | 1.31 | 3.97 | 0.33 |
| 156 Dixon | 8/20/12 – 8/24/12 | 2.08 | 4.75 | 0.44 |
| 156 Dixon | 9/3/12 – 9/7/12 | 1.18 | 7.1 | 0.17 |

*This home has a perimeter drain system installed through the interior foundation that may have allowed vapors to migrate into the indoor air.

## Conclusions

The following conclusions can be drawn from this data:

1. The 2011 vapor investigation of three homes immediately adjacent to the PCE soil contamination on the MKC property found significantly elevated PCE vapors beneath the home foundations. These three homes along with the two homes to the north and south received mitigation systems.

2. The 2012 investigation of 47 homes shows that the health risk due to vapor migration away from the MKC property appears to be limited in extent. Seven homes adjacent to MKC had sub-slab concentrations above the conservative, project specific vapor screening level of 6.0 ppbV. Sub-slab concentrations at all 47 homes was significantly less than the new, 2012 vapor screening level of 62 ppbV.

3. Three of the 47 homes had indoor air concentrations greater than the 0.6 ppbV screening value. At all three homes the ratio of indoor air to sub-slab vapor concentration indicates that either the indoor air is influenced by an indoor PCE source or that the foundation allows connection between the sub-slab and indoor air.

4. All 47 homes tested are below the current (2012) PCE indoor air and sub-slab vapor screening levels. At the concentrations measured, all levels are below the health-based screening levels for indoor air and sub-slab vapors.

5. The extent of PCE vapor intrusion health risk to residents in homes near the MKC property has been defined. The current data indicate that the health risk from vapor intrusion in the neighborhood due to PCE contamination of soil and shallow groundwater from MKC property has been quantified and addressed through installation of sub-slab depressurization systems.

## References

U.S. EPA, June 2011, Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990 – 2005): A Compilation of Statistics for Assessing Vapor Intrusion, EPA-530-R-10-001, www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

U.S. EPA Regional Risk Screening Tables, www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

Wisconsin DNR web site, Madison Kipp Corporation, dnr.wi.gov/topic/Brownfields/kipp.html

## Figure 1 - Extent of PCE in Water Table Wells at MKC

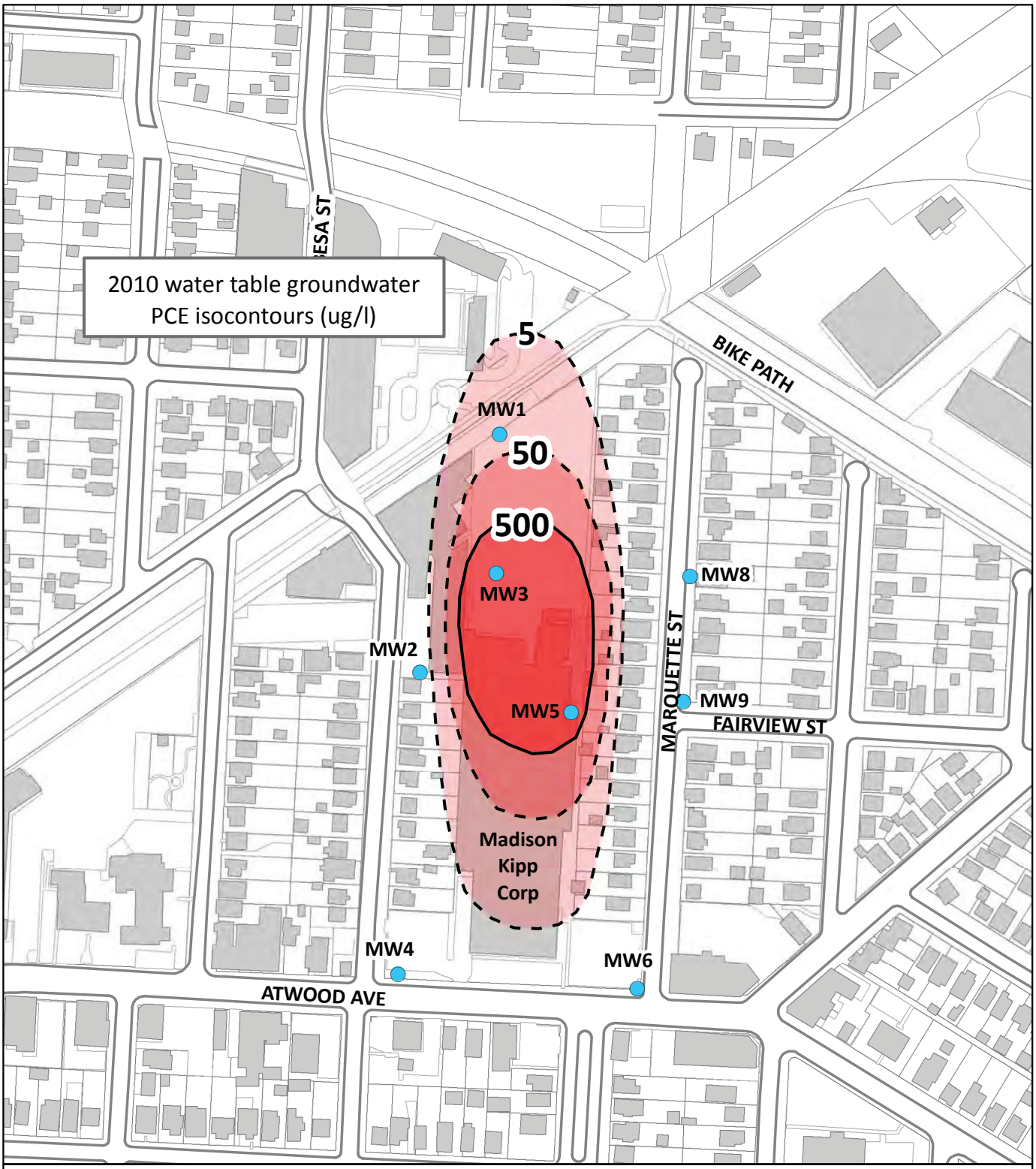



FIGURE 1
2010 Tetrachloroethylene (PCE) Isocontrous in Shallow Water Table Wells
Prepared by City of Madison Engineering (2/29/12)

Note: Data for MW7 and MW8 are from August 2011.
Dashed lines are approximate.

## Figure 2

# Madison Kipp Sub-Slab PCE Vapor Results

As of November 30, 2012


## Sub-Slab PCE Vapor Concentrations Found in Homes

- Operating Mitigation System
- <6 ppbV (parts per billion Volume)
- <20 ppbV
- >62 ppbV (current EPA action level for sub-slab PCE levels)
- 0.415 Sub-Slab PCE vapor concentration (ppbV)

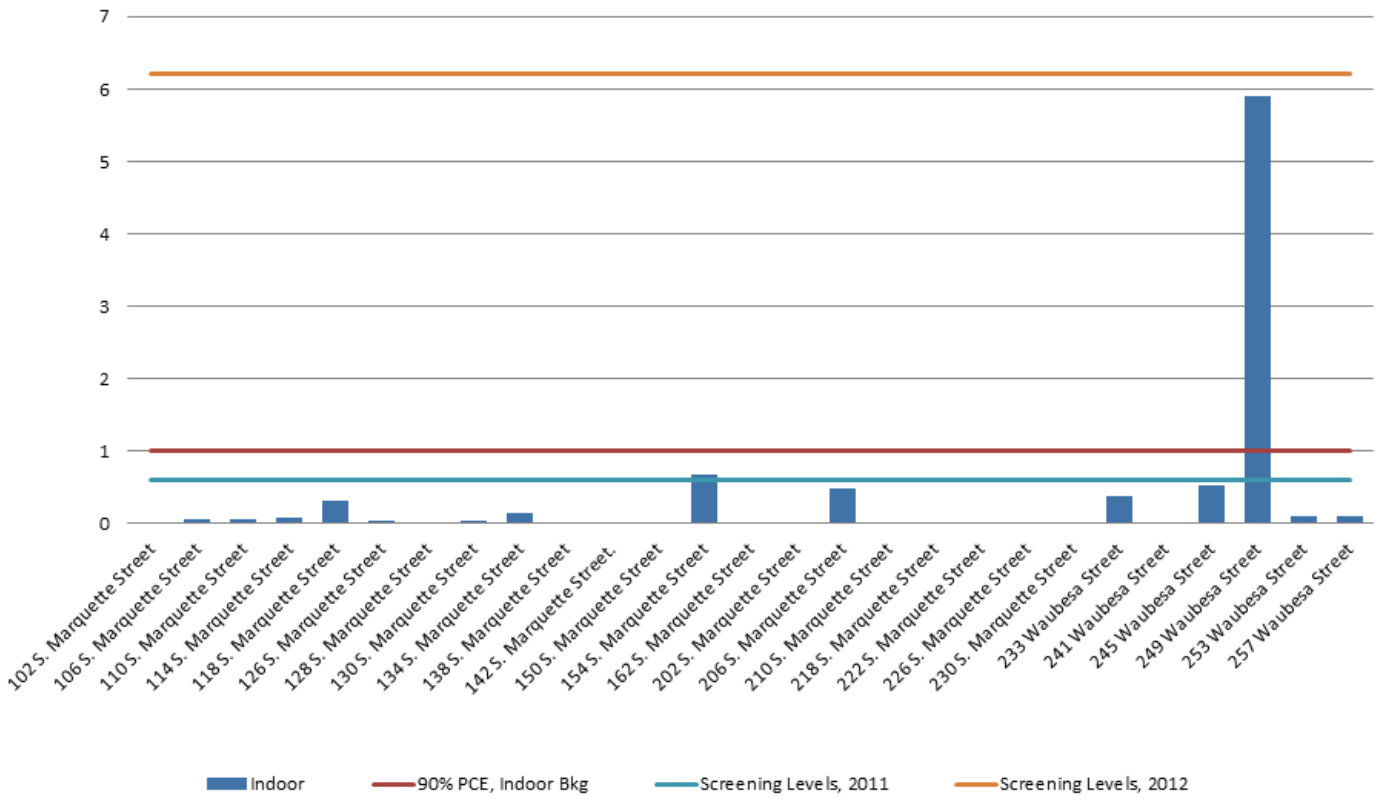
WISCONSIN DEPT. OF NATURAL RESOURCES

N W E S

0 120 240 Feet

November 30, 2012
Aerial Photo: 2010 WROC
C:\geodata\Projects\Madison_Kipp\Kipp Sampling Status

## Figure 3
**PCE Indoor Air Concentrations**
**Homes Adjacent to MKC**




## Figure 4
**PCE Indoor Air Concentrations**
**Homes Not Adjacent to MKC**

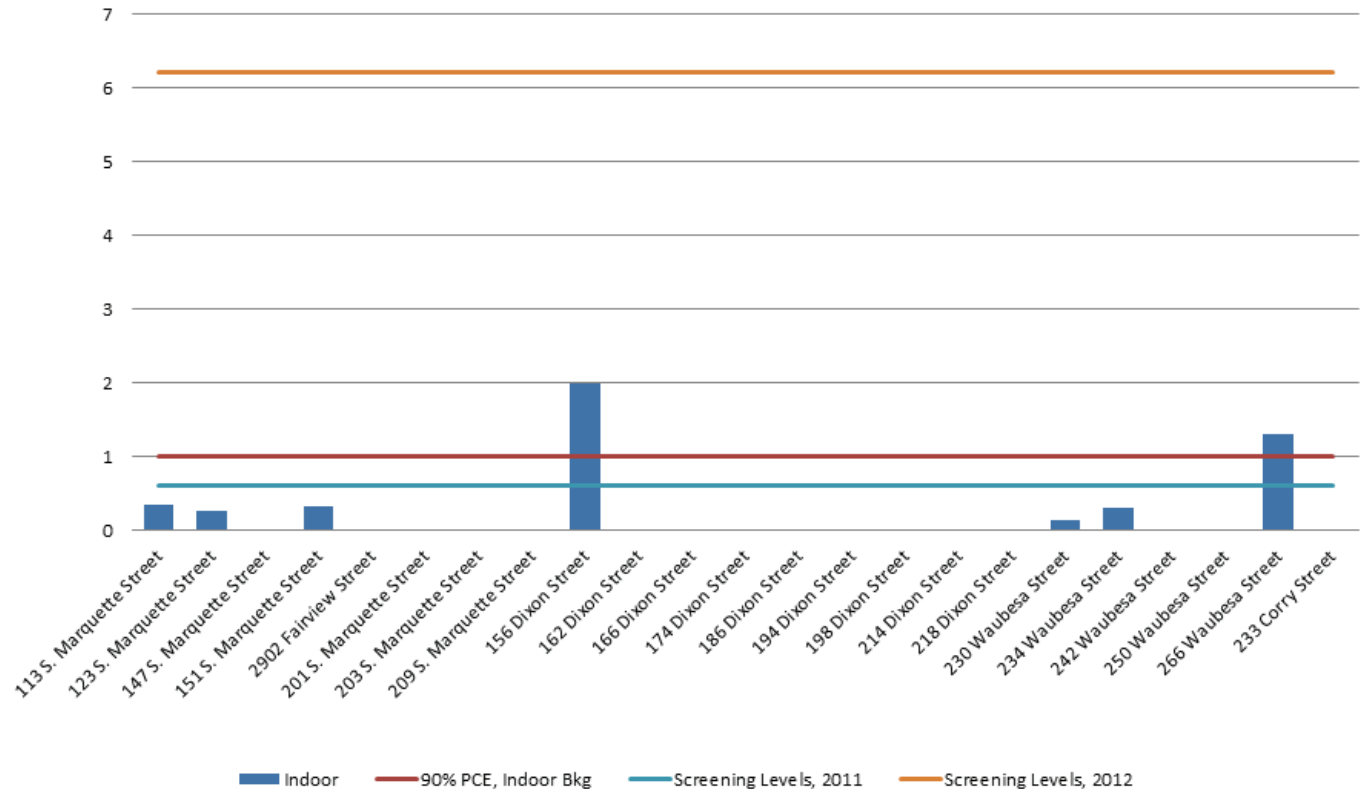


**Figure 5**
**Indoor and Sub-Slab Sample Results from Marquette and Waubesa Streets, Madison**
**Results in ppbV**

| | | |
|---|---|---|
| sub-slab | 6 | elevated, not-elevated |
| Indoor | 0.6 | |

| Name(s) First First | First Last | Second First | Second Last | Address | Sample Type | Col: Kipp Date week 3/12 -3/17 | Col: Kipp Date week 3/26 - 3/30 | Col: Kipp Date week 4/9 - 4/13 | Col: DNR Date week 4/9-4/13 | Col:DNR Date week 4/23-4/27 | Col:Kipp Date week 5/7-5/11 | Col:DNR Date week 5/14-5/18 | Col:DNR Date week 6/4-6/8 | Col:DNR Date week 7/2-7/6 | Col:DNR Date week 7/9-7/13 | Col: Kipp Date week 7/23-7/27 | Col: DNR Date week 7/30-8/3 | Col:DNR Date week 8/20-8/24 | Col:DNR date week 9/3 - 9/7 | Col:DNR date week 9/17-9/21 | Col:DNR date week 10/1-10/5 | Col:DNR date week 10/15-10/19 | Col:DNR date week 11/12 - 11/16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Leslie | Bellais | | | 102 S. Marquette Street | Indoor | ND/ND | | | | | | | | | | | | | | | | ND | |
| | | | | | Sub-slab | | | .96/.18 | | | | | | | | | | | | | | 2.7 | |
| Nicole | Rafferty | | | 106 S. Marquette Street | Indoor | | | | | | .061/.045 | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | 2.0/.52 | | | | | | | | | | | | |
| Eric | Bott | Elaina | Anthes | 110 S. Marquette Street | Indoor | 0.06/0.06 | | | | | | | | | | | | | | | ND | | |
| | | | | | Sub-slab | 1.5/0.28 | | | | | | | | | | | | | | | 1.5 | | |
| | | | | DHS SPLIT Sample | Sub-slab | 0.485 | | | | | | | | | | | | | | | | | |
| Marietta | Moen | | | 113 S. Marquette Street | Indoor | | | | | ND | | | | 0.336 | | | | | | | | | |
| | | | | KIPP SPLIT Sample | Indoor | | | | | ND | | | | | | | | | | | | | |
| | | | | | Sub Slab | | | | | 0.3 | | | | 0.228 | | | | | | | | | |
| | | | | KIPP SPLIT Sample | Sub-slab | | | | | ND | | | | | | | | | | | | | |
| Stephen | Josheff | | | 114 S. Marquette Street | Indoor | | .084/.092 | | | | | | | | | | | | | | | | |
| | | | | | Sub Slab | | 1.7/.50 | | | | | | | | | | | | | | | | |
| Judith | James | | | 118 S. Marquette Street | Indoor | 0.014/0.061 | | | | | | | | | | | | | | 0.318 | | | |
| | | | | | Sub Slab | 1.4/.32 | | | | | | | | | | | | | | 2.34 | | | |
| Ann | Freye | | | 123 S. Marquette Street | Indoor | | | | | 0.227 | | | | 0.264 | | | | | | | | | |
| | | | | KIPP SPLIT Sample | Indoor | | | | | ND | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | 0.715 | | | | 1.64 | | | | | | | | | |
| | | | | KIPP SPLIT Sample | Sub-slab | | | | | 0.54 | | | | | | | | | | | | | |
| Elizabeth | Reynolds | | | **126 S. Marquette Street** | Indoor | .046/.045 | | | | | | | | | | | | | | | | | |
| | | | | | Sub Slab | 5.8/.79 | | | | | | | | | | | | | | | | | |
| | | | | DHS SPLIT Sample | Sub Slab | **8.43** | | | | | | | | | | | | | | | | | |
| Patrick | Hannon | Julia | Cosgrove | 128 S. Marquette Street | Indoor | ND/ND | | | | | | | | | | | | | | ND | | | |
| | | | | | Sub-slab | ND/0.18 | | | | | | | | | | | | | | 0.407 | | | |
| Barry | Carleson | Marja | Badger-Carleson | 130 S. Marquette Street | Indoor | ND/.036 | | | | | | | | | | | | | | | ND | | |
| | | | | | Sub-slab | 2.4/.46 | | | | | | | | | | | | | | | 2 | | |
| | | | | DHS SPLIT Sample/Dup | Sub-slab | 2.87/0.732 | | | | | | | | | | | | | | | 2.1 | | |
| Amy | Crikelair | | | **134 S. Marquette Street** | Indoor | 0.14/0.035 | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | **6.2/1.6** | | | | | | | | | | | | | | | | | |
| | | | | | Mitigation | | | | | | | 1.17 | | | | | | | | | | | |
| Anne | Chacon | | | 138 S. Marquette Street | Indoor | | | | | | | | | | | ND/ND | | | | | ND | | |
| | | | | | Sub-slab | | | | | | | | | | | 5.5/1.5 | | | | | 4.1 | | |
| Kenneth | Hennrick Jr. | | | 142 S. Marquette Street. | Indoor | ND/ND | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | 1.4/0.52 | | | | | | | | | | | | | | | | | |
| | | | | DHS SPLIT Sample | Sub-slab | 0.742 | | | | | | | | | | | | | | | | | |
| Eric | Fuller | Kathleen | McHugh | 146 S. Marquette Street | Indoor | | | | | | | ND | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Alice | Schmidt | Erik | Duerr | 147 S. Marquette Street | Indoor | | | | ND | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | ND | | | | | | | | | | | | | | |
| Irene | Piersma | | | 151 S. Marquette Street | Indoor | | | | | ND | | | | | | | 0.317 | | | | | | |
| | | | | | Sub Slab | | | | | 0.283 | | | | | | | 0.276 | | | | | | |
| Carla | Mills | Sharon | Helmus | 166 S. Marquette Street | Indoor | | | | | 0.17 | | | | | | | | | | | | | |
| | | | | KIPP SPLIT Sample | Indoor | | | | | ND | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Ben | Feifarek | | | 201 S. Marquette Street | Indoor | | | | | | | ND | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | 5.36 | | 0.351 | | | | | | | | | |
| | | | | | Background 4 | | | | | | | | | ND | | | | | | | | | |
| Chad | Goolbis | Brandi | Rogers | **202 S. Marquette Street** | Indoor | | | | | ND | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | | 4.46 | | | | **7.44** | | | | | | | | | |
| Mary Beth | Roemheld | Laurie | Gift | 203 S. Marquette Street | Indoor | | | | | | | ND | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | 2.33 | | 0.252 | | | | | | | | | |
| | | | | | Background | | | | | | | ND | | | | | | | | | | | |
| Karstan | Schilling | | | 206 S. Marquette Street | Indoor | | | | | ND | | | | 0.483 | | | | | | | | | |
| | | | | | Sub-slab | | | | | 0.465 | | | | 0.678 | | | | | | | | | |
| | | | | Duplicate | Sub-slab | | | | | 0.469 | | | | | | | | | | | | | |
| | | | | Background | Outdoor | | | | | ND | | | | | | | | | | | | | |
| Robert | Grether | | | 209 S. Marquette Street | Indoor | | | | ND | | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | 0.256 | | | | | 0.695 | | | | | | | | | |
| Wilder | Brent | | | 210 S. Marquette Street | Indoor | | | | | | | | ND | | | | | | ND | | | | |
| | | | | | Sub-slab | | | | | | | | 1.5 | | | | | | 1.22 | | | | |
| Richard | Amdahl | | | 214 S. Marquette Street | Indoor | | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Virginia | Morehouse | | | 218 S. Marquette Street | Indoor | | | | ND | | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | 0.518 | | | | | 0.753 | | | | | | | | | |
| Dianne | Booth | | | 222 S. Marquette Street | Indoor | | | | | ND | | | | | | | ND | | | | | | |
| | | | | | Sub-slab | | | | | 0.356 | | | | | | | 0.343 | | | | | | |
| | | | | | Duplicate | | | | | | | | | | | | 0.33 | | | | | | |
| | | | | | Background | | | | | | | | | | | | ND | | | | | | |
| Daniel | Pape | | | 226 S. Marquette Street | Indoor | | | | | | | | | | ND | | | | | | ND | | |
| | | | | | Sub-slab | | | | | | | | | | 0.415 | | | | | | 1.1 | | |
| Daniel | Stevens | Pamela | Stevens | **230 S. Marquette Street** | Indoor | | | | | | | | | | | | | | | | | | ND |
| | | | | | Sub Slab | | | | | | | | | | | | | | | | | | **17** |
| Arlene | Brunsell | | | 230 Waubesa Street | Indoor | | | | ND | | | | | 0.125 | | | | | | | | | |
| | | | | | Sub-slab | | | | 0.155 | | | | | 1.27 | | | | | | | | | |
| | | | | Duplicate | Sub-slab | | | | 0.462 | | | | | | | | | | | | | | |
| Anita | van Amber | | | 233 Waubesa Street | Indoor | | | | 0.307 | | | | | 0.376 | | | | | | | | | |
| | | | | | Sub Slab | | | | 0.502 | | | | | 1.45 | | | | | | | | | |
| Becky | Blaschka | | | 234 Waubesa Street | Indoor | | | | | 0.297 | | | | 0.182 | | | | | | | | | |
| | | | | | Sub Slab | | | | | 0.385 | | | | 0.781 | | | | | | | | | |
| Eileen | Eichman (owner) | Sebastian | Boyum (son, renter) | 237 Waubesa Street | Indoor | | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Kate | Thompson | | | 241 Waubesa Street | Indoor | | | | ND | | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | 2.67 | | | | | 4.01 | | | | | | | | | |
| | | | | Background | Outdoor | | | | ND | | | | | | | | | | | | | | |
| Brian | Wolfe | Meagan | Wolfe | 242 Waubesa Street | Indoor | | | | | | | | | ND | | | | | | ND | | | |
| | | | | | Sub-slab | | | | | | | | | 0.35 | | | | | | 0.315 | | | |
| | | | | | Duplicate | | | | | | | | | 0.208 | | | | | | | | | |
| George | Gilbertson | | | **245 Waubesa Street** | Indoor | | | | | | | 0.524 | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | **9.22** | | | | | | | | | | | |
| | | | | | Duplicate | | | | | | | **9.23** | | | | | | | | | | | |
| Julie | Friesler | | | **249 Waubesa Street** | Indoor | | | | | ND | | | | **5.88** | | | | | | | | | |
| | | | | | Sub Slab | | | | | 3.47 | | | | 5.99 | | | | | | | | | |
| Ethan | Miller | | | 250 Waubesa Street | Indoor | | | | | ND | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | | 0.324 | | | | 0.525 | | | | | | | | | |
| | | | | Background | Outdoor | | | | | | | | | ND | | | | | | | | | |

**Figure 5**
**Indoor and Sub-Slab Sample Results from Marquette and Waubesa Streets, Madison**
**Results in ppbV**

| Indoor | 0.6 |
|---|---|

| First First | First Last | Second First | Second Last | Address | Sample Type | Col: Kipp Date week 3/12 -3/17 | Col: Kipp Date week 3/26 - 3/30 | Col: Kipp Date week 4/9 - 4/13 | Col: DNR Date week 4/9-4/13 | Col:DNR Date week 4/23-4/27 | Col:Kipp Date week 5/7-5/11 | Col:DNR Date week 5/14-5/18 | Col:DNR Date week 6/4-6/8 | Col:DNR Date week 7/2-7/6 | Col:DNR Date week 7/9-7/13 | Col: Kipp Date week 7/23-7/27 | Col: DNR Date week 7/30-8/3 | Col:DNR Date week 8/20-8/24 | Col:DNR date week 9/3 - 9/7 | Col:DNR date week 9/17-9/21 | Col:DNR date week 10/1-10/5 | Col:DNR date week 10/15-10/19 | Col:DNR date week 11/12 - 11/16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carrie | Pomise | | | 253 Waubesa Street | Indoor | | | | 0.099 | | | | ND | | | | | | | | | | |
| | | | | | Sub Slab | | | | 4.9 | | | | 5.6 | | | | | | | | | | |
| Julie | Sheahan | | | **257 Waubesa Street** | Indoor | | | | 0.107 | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | **9.99** | | | | | | | | | | | | | | |
| | | | | | Mitigation | | | | | | | **3.39** | | | | | | | | | | | |
| John | Gongstad | | | 261 Waubesa Street | Indoor | | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| | Tellurian Ucan, Inc. | | | 265 Waubesa Street | Indoor | | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Ashley | Anderson | | | **266 Waubesa Street** | Indoor | | | | | | | ND | **1.31** | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | 2.54 | 3.97 | | | | | | | | | | |
| Jeffrey | Thomsen | | | 269 Waubesa Street | Indoor | | | | | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | | | | | | |
| Barry | Sahf | | | 2902 Fairview Street | Indoor | | | | 0.119 | | | | | ND | | | | | | | | | |
| | | | | | Sub-slab | | | | 0.186 | | | | | 0.183 | | | | | | | | | |
| | | | | | Duplicate | | | | | | | | | ND | | | | | | | | | |
| Braden | Jon | | | **156 Dixon Street** | Indoor | | | | | | | | | | | | **2.08** | | **1.18** | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | 4.75 | | **7.1** | | | | |
| Brown | Sylvia | | | 162 Dixon Street | Indoor | | | | | | | | | | | | | ND | | | | ND | |
| | | | | | Sub -slab | | | | | | | | | | | | | 0.193 | | | | 1.3 | |
| | | | | | Duplicate | | | | | | | | | | | | | ND | | | | 1.1 | |
| Rietz | Chris | | | 166 Dixon Street | Indoor | | | | | | | | | | ND | | | | 0.142 | | | | |
| | | | | | Sub-slab | | | | | | | | | | 0.11 | | | | 0.205 | | | | |
| Anthony | Chambers | | | 174 Dixon Street | Indoor | | | | ND | | | | | | | | | | | | | | |
| | | | | | Sub-slab | | | | ND | | | | | | | | | | | | | | |
| Green | Lance | | | 186 Dixon Street | Indoor | | | | | | | | | | | | ND | | | | ND | | |
| | | | | | Sub-slab | | | | | | | | | | | | 0.34 | | | | <0.085 | | |
| Wadsworthy | Cynthia | | | 194 Dixon Street | Indoor | | | | | | | | | | ND | | | | 0.17 | | | | |
| | | | | | Sub-slab | | | | | | | | | | 0.345 | | | | 0.366 | | | | |
| Hutchinson | James | | | 198 Dixon Street | Indoor | | | | | | | | | | | | | ND | | ND | | | |
| | | | | | Sub-slab | | | | | | | | | | | | | 0.318 | | 0.353/0.333 | | | |
| | | | | | Background 7 | | | | | | | | | | | | | ND | | | | | |
| Thorvaldsen | Guy | | | **214 Dixon Street** | Indoor | | | | | | | | | | | | | ND | | | | ND | |
| | | | | | Sub-slab | | | | | | | | | | | | | 0.201 | | | | **6.1** | |
| Carpenter | Ken | | | 218 Dixon Street | Indoor | | | | | | | | | | ND | | | | ND | | | | |
| | | | | | Sub-slab | | | | | | | | | | 0.147 | | | | 0.134 | | | | |
| Grant | Lori | | | 233 Corry Street | Indoor | | | | | | | | | | | | ND | | ND | | | | |
| | | | | | Sub-slab | | | | | | | | | | | | 0.226 | | 0.176 | | | | |