Vapor Intrusion Mitigation System (VIMS)
Design Submittal Requirements
NCDEQ Brownfields Redevelopment Section
May 2024

To more efficiently process and approve VIMS designs, the Brownfields Redevelopment Section (BRS) has standardized the format for design submittals. We have generated a checklist for ease in submittal by the prospective developer's consultant and to assist in the BRS's completeness review. The checklist below outlines the minimum requirements and submittal format under the BRS for VIMS system design considerations and reporting. All VIMS design submittals to the BRS must include this completed checklist in this required format. Strictly adhering to these design submittal requirements will allow the BRS to minimize its review time for the design and the scope of performance and pre-occupancy sampling wherever possible. However, if these requirements are not followed fully, the BRS will require a more extensive and on-going sampling protocol to ensure that the VIMS is fully protective of public health. For the purposes of these requirements, PE shall mean a Professional Engineer licensed in North Carolina.

The benefits of following these requirements include:

- Significant Professional Engineering (PE) design discretion by a PE as to the VIMS design;
- Minimal turnaround time as the BRS review will consist of a completeness check rather than a detailed design review;
- Implementation of the *Minimum Mitigation and Sampling Requirements for Reuse* (NC DEQ Division of Waste Management (May 2024) for pre- and post-occupancy sampling location and frequency minimization, and the lowest possible frequency of pre-/post-occupancy sampling to confirm system efficacy, at the BRS's discretion; and
- Potential reduction in long-term monitoring requirements and costs.

If these requirements are not followed, and the VIMS design fails a completeness check:

- Significant delays and associated costs may be incurred as the BRS conducts an in-depth review;
- Subsequent design modifications and costs of delay associated with multiple review iterations; and
- The establishment of extensive ongoing sampling requirements to ensure adequate system performance and public health protection.

Please note that this VIMS design submittal is not the end of communication with the BRS. Best practices for successful project completion and avoiding installation/construction delays include maintaining close coordination and consultation with the BRS between the PD, VIMS contractors, and all general contractors for the installation of the design. This will avoid costly construction delays and installation issues that would trigger additional monitoring requirements that otherwise would not be necessary. It is important that significant advance notification of schedules, and subsequent rescheduling as it occurs, for the following activities (at a minimum) is provided to the BRS:

- Project construction;
- Design modification/addenda;
- Installation;
- Performance testing; and
- Inspections

Note: The format below should be followed verbatim in its entirety in the VIMS design submittal to satisfy and facilitate the completeness review performed by the BRS. In addition, this document is to be completed and submitted as a checklist along with the design to ensure the necessary elements are addressed in the design.

Section 1 - Introduction

Provide a brief background of the Brownfields Property and basis for installing a VIMS (e.g. off-site migration of contaminants, on-site releases, chlorinated solvents, pre-emptive approach for residential redevelopment, etc.). Document the type of foundation design required by construction plans (e.g. waffled construction, ground floor post-tension cabling, build-to-suit construction, or other unique construction plans). Additional items to be included in the VIMS design submittal must include:

☐ Brownfield Project ID number, Parcel numbers, address(es), site history, approximate acreage of site, and contact information for the developer, consultant, VIMS installation contractor, and Brownfields Project Manager.

☐ If vapor mitigation is not proposed for all buildings (new, existing, or partial building), provide a risk-based justification for why mitigation is not needed for all buildings. Include discussion of the *Minimum Mitigation and Sampling Requirements for Reuse* (NC DEQ Division of Waste Management (May 2024) sampling requirements for occupancy. Limited building mitigation requests are subject to BRS review and approval.

☐ Discussion of proposed site redevelopment (e.g., townhomes, apartments, commercial, mixed-use, retail, etc.), and general layout of building(s), e.g., garage on first floor, with living space on second and third floors, presence of elevators, former textile mill with ground floor and basement level apartments, podium parking first floor, 10-story apartment building with podium parking on first three floors, etc.).

Include references to the following figures (to be included in the Figures section outlined below):

☐ Site vicinity map

☐ Figures detailing <u>all</u> existing and/or proposed buildings overlain on historical sampling locations/known impacts.

☐ Figures detailing the approximate ground floor square footage, including square footage of area proposed for mitigation (if different), of relative buildings and their proposed use per floor. Include footprint of planned demolition or retention of existing buildings.

☐ Locations of thickened footers, separate slabs, etc. that may hinder communication between slab segments.

☐ Locations of relevant mitigation features (including but not limited to extent of vapor barrier, suction lines, risers, extraction points, pressure monitoring points, etc.).

☐ Locations of vertical walls in contact with soils (and a statement regarding whether any such features exist or not).

☐ The design and any figures as appropriate have a PE Seal using the following language:

> "The Vapor Intrusion Mitigation System (VIMS) detailed herein is designed to mitigate the intrusion of subsurface vapors into building features in accordance with the most recent and applicable DWM Vapor Intrusion Guidance, Interstate Technology & Regulatory Council (ITRC) guidance, and American National Standards Institute (ANSI)/American Association of

Radon Scientists and Technologists (AARST) standards, or alternative standards approved in writing in advance by DEQ, and that a professional engineer licensed in North Carolina, as evidenced by said engineer's professional seal, is satisfied that the system has been designed **[add "and installed" for use in an installation report]** so as to be fully protective of public health within the meaning of NCGS 130A-310.32 (a)(2), from known Brownfields Property contaminants."

Note: If a VIMS is not installed for certain portions of a Brownfields Property due to open-air 'podium' construction or parking decks, a VIMS may still be required for enclosed features such as elevator shafts, stairwells, and/or areas with utility penetrations that exchange air with occupied areas. Confirmatory sampling of enclosed features and occupied spaces potentially affected by utility penetrations may be required during post construction/renovation.

Section 2. Design Basis

Specify which type(s) of VIMS is intended for the planned structures, selecting which is appropriate, and explaining the basis for the selection:

☐Passive System. Note for all passive systems, a mechanism/process shall be established (to be approved by the BRS) by which the system can be made active, which may include a reliance on information from pressure measurements, soil gas and/or indoor air sampling, or changes in site conditions. A passive system should be designed and installed such that if activation is required, the system is fully effective at preventing vapor intrusion.

☐Active System. Note a pressure differential resulting in depressurization below the slab of 4 pascals or greater at remote extents of each VIMS area is considered sufficiently depressurized. Low pressure readings such as 1 pascal will be acceptable if employed with continuous (multiple pressure readings per hour) data logged pressure measurements during varied HVAC situations, weather events, and climate for winter and summer months from sub-slab ports that are at or have a lineal correlation with values from a permanent port that is located at the outer extent of the negative pressure field. An overview of the alarm system that informs appropriate parties in the event the system malfunctions should be included. Refer to Section 4 below for more information on pilot testing.

☐Alternate System. Mitigation systems that are not designed to induce target depressurization thresholds below a slab, such as sub-slab ventilation systems (i.e., systems designed primarily to dilute sub-slab vapor concentrations by inducing air flow below the slab, sometimes referred to as "sweep" systems), may be allowable on a case-by-case basis following alternative monitoring strategies (e.g., air flow, tracer testing, sub-slab vapor chemical data, indoor air data, etc.) subject to review and approval from the BRS.

Note: Pressure monitoring points are to be placed at locations remotely distant from where each suction point transitions to below the slab in addition to locations positioned near each suction point and associated horizontal piping. If monitoring points are not installed at remote locations, future sampling requirements may necessitate installation of additional monitoring locations or an evaluation of indoor air quality.

For all system designs, the following design specifications must be included as exhibits:

☐ Sub-slab Venting Construction Materials and Installation. Design specifications must be

included as an exhibit (see Section 8 below). All above-slab piping, including above a roof line must be labeled at intervals no greater than 10 linear feet permanently labeled with "Vapor Intrusion Mitigation System" with contact information for questions or repairs.

☐ Membrane Vapor Barrier Construction Materials and Installation. Design specifications must be included as an exhibit (see Section 8 below). Particular attention should be paid to the design and diagrams for sealing barriers at slab penetrations and edges. Note: Brownfields Property contaminants of concern (COCs) must not be present in building materials.

Note: BRS relies on the design engineer's professional opinion that the materials selected for the vapor intrusion system have been considered for compatibility and resistance to chemicals that may come into contact with the system. If materials are proposed that are not specifically rated for chemical resistance to specific site contaminants of concern, this may have a bearing on the BRS' determination of performance testing requirements following construction. Specification documentation should be provided for all materials utilized as part of the VIMS.

Note: *Utility backfill material can have a higher permeability to air relative to the surrounding subsurface soil. The utility backfill material may act as a potential pathway for contaminant vapor to migrate from beyond the building footprint to below the building slab. Therefore, whenever VIMS are designed for brownfields properties with hazard indices (HIs) over 1.0, trench dams must be included in VIMS design documents for all utility penetrations that enter the building envelope below the foundation to manage potential vapor transport along utility backfill. Such trench dams are recommended for brownfields properties with HIs between 0.1 and less than 1.0.* Include details on trench dam installation as part of system design.

Section 3. Quality Assurance / Quality Control

☐ Details on planned inspections are **required** for all gravel and piping prior to installing the vapor barrier, and are **required** for all sections of the vapor barrier prior to pouring the slab. These inspections must be conducted by qualified personnel under the supervision of the design PE and include field logs and photographs.

☐ A statement committing to provide a minimum of 2 business days' advance notification to the BRS prior to inspections should be included.

☐ Smoke Testing and/or Thickness (Coupon) Measurements: Smoke testing is strongly recommended for both *roll-out* and spray applied barriers. Coupon testing will be required on spray application barriers only.

Note: Completion of quality assurance/quality control measures such as adequate inspections and if conducted, smoke and coupon testing are lines of evidence to verify the VIMS is effective at meeting its design objectives. Failure to collect such lines of evidence may have a bearing on the BRS' determination of performance testing requirements following construction (e.g., in the event of sampling data inconsistency, such as outlier events, failure to inspect the gravel layer or conduct smoke testing would create uncertainty as to system effectiveness to fully protect public health and may require additional confirmatory sampling).

Section 4. Post-Construction / Pre-Occupancy Effectiveness Testing

☐ Discussion of Pilot/Influence Testing is **required for passive and active systems prior to**

occupancy with the objective being to document that all areas below the slab can be effectively influenced by the current piping network. Timing for pilot testing is critical; pilot testing shortly after a slab pour and before any vertical construction can provide crucial information while still being able to make limited modification or corrections, the **minimum required pilot testing information should be conducted with the building envelope completed and indoor air handling performing as it will be when occupied with HVAC(s) operational**. Testing details should include, at a minimum:

- ☐ Pressure monitoring points: Note based on pilot testing results and review by the BRS, the number of pressure monitoring points installed for pilot testing may ultimately reduce the number of permanent pressure monitoring points.
- ☐ Pressure monitoring points are placed at locations that are demonstrated to be remotely distant from where each suction point transitions and are located at the extents of the area of influence below the slab in addition to locations near each suction point and associated horizontal piping.
- ☐ Sub-slab vacuum monitoring and/or sample collection points: Note these should be installed PRIOR to installation of floor slab(s). Drilling through concrete slabs and VIMS barriers after a concrete slab is in place may result in significant issues regarding the sealing of the sampling point to the VI barrier once the concrete slab has been poured.
- ☐ A statement committing to provide a minimum of 2 business days' advance notification to the BRS prior to inspections should be included.

☐ Discussion of pour back areas including:

- ☐ Statements and details that any modifications or repairs to the VIMS shall be conducted under oversight of the original VIMS engineer or an alternate VIMS design engineer.
- ☐ Protection of and testing following completion: Note if concrete pour back areas for future tenants are included in the VIMS design or if slab modifications are made in the future, communication testing will be required, and analytical sampling may be required, after completion of the concrete slab pour. Further, if ongoing tenant upfit activities result in damage to the VI barrier, inspections and communication testing will be required following repair of the VI barrier and patching of the slab. Finally, in the instance TCE is present in subsurface soil gas above acceptable risk-based thresholds, temporary mitigation measures (e.g., installing temporary ventilation of the space) will be required to be conducted prior to performing tenant upfit activities as reviewed and approved by BRS.
- ☐ Commitment to BRS notification of a minimum of 2 business days prior to the start of tenant up-fit activities.
- ☐ Discussion regarding sampling/protective measures that will be taken if a building is occupied during up-fit activities.

Note: Section 3 (Quality Assurance/Quality Control) above will apply to all future pour backs and slab modifications that breach the installed vapor barrier; these requirements apply to all system or slab modifications regardless of the size of the altered area. If pour-back area communication testing is not deemed sufficient prior to floor slab being poured, this will result in the need for additional sampling. Alteration of pour back areas or alteration of slabs in the future may necessitate future sampling of the site buildings.

☐ Discussion of protection, access restrictions, and inspection of exposed systems (including pour back areas): During any time that the system is left exposed (i.e. without a concrete/wooden cover in place), protective measures must be implemented, as noted above, and scheduled inspections of the exposed system are required. In addition to the pre-occupancy testing, during the time that the system is left exposed, monitoring, including vapor intrusion assessment, will be conducted in the subject building including the pour back area. If PCE, TCE, and/or select daughter products are present at the Brownfields Property, indoor air sampling will be required.

☐ Discussion of pre-occupancy sub-slab and/or indoor air sampling in accordance with the *Minimum Mitigation and Sampling Requirements for Reuse* (NC DEQ Division of Waste Management (May 2024) guidance document.

Note: Unlike the remainder of this document, which has significant PE discretion in design; soil gas/indoor air sampling frequency and locations (which, for consistency, has been set forth in the *Minimum Mitigation and Sampling Requirements for Reuse* (NC DEQ Division of Waste Management (May 2024) guidance document) is subject to the sole discretion of the BRS.

Note: Pilot/Influence Testing, Soil Gas, and/or Indoor Air Sampling must be submitted to the BRS for conditional occupancy considerations as per standard Brownfields VI provisions.

Section 5. Post-Occupancy Effectiveness Testing– Should be specified with the design submittal and not at a later date.

☐ Discussion of On-going Pressure Testing: Note this is **required for active systems** to be conducted on a monthly basis for the first year with collected information submitted to the BRS on a quarterly basis (or via telemetry data submittals on a basis as pre-approved by the BRS). Telemetry data should come from sub-slab ports that correlate with values from a port that is located at the outer extent of the negative pressure field. Based on the first year of pressure readings, and with approval of the BRS, pressure testing may be collected quarterly (see below) and data would be submitted with the annual Land Use Restriction Update (LURU) following the first year of data collection. Note that the BRS utilizes a 'sliding scale' of pressure reading collection frequency vs. the stated depressurization goal or observed depressurization (e.g., if a VIMS is designed (or observed) to obtain a pressure differential less than 4 pascals, more frequent depressurization measurements will be necessary and may include continuous (multiple pressure readings per hour) data logging for a BRS-determined period of time; or an upgrade to the VIMS to increase pressure differentials may be necessary). Pressure readings shall be maintained and stored by the owner of the VIMS in accordance with applicable Brownfields Agreement requirements for records retention for the site.

☐ Discussion of proposed post-occupancy sub slab vapor and/or indoor air sampling: Sampling is to be completed post occupancy and the data will be compared to applicable DEQ screening criteria. Include discussion of resampling in the event that impacts are identified above applicable screening criteria.

Note: Unlike the remainder of this document, which has significant PE discretion in design; sub slab vapor/indoor air sampling frequency and locations (which, for consistency, has been set forth in the *Minimum Mitigation and Sampling Requirements for Reuse* (NC DEQ Division of Waste Management (May 2024) guidance document) is subject to the sole discretion of the BRS**.**

Note: In addition to these requirements, townhomes remain subject to the sampling requirements outlined in the *Minimum Requirements for Townhome Developments* (NC Brownfields Program, May 2020) located at **www.ncbrownfields.org**. Ensure that townhome redevelopment has been approved by the BRS in advance of redevelopment planning.

Section 6. Future Tenants & Building Uses

☐ This section must address plans to notify future tenants of the presence of a VIMS and to prevent future tenants or occupants from exposing/damaging the VIMS without the oversight of a qualified P.E. Note that if the VIMS is exposed (for installation of new utilities, etc.), the same inspection requirements and reporting as for initial installation is required.

Section 7. Reporting

This section must discuss reporting deliverables within 60 days following completion of initial post-construction testing as outlined in Sections 4 and 5 above and a commitment to include all of the following in the final deliverable:

☐ A report prepared and submitted to the BRS under PE seal.

☐ Summary of the installation, QA/QC measures, and post-construction/pre-occupancy system effectiveness testing.

☐ A statement from the PE providing an opinion of whether the VIMS was delivered in a condition consistent with the VIMS design and objectives. **Note**: Certain components of these reporting requirements, including pressure measurements, sub slab vapor sampling, and indoor air sampling, can be conducted and reported under a NC Licensed Geologist seal.

☐ Appendices to include at a minimum:

☐ As-built drawings (also signed/sealed by a PE);

☐ All inspection logs including photographs and field logs. Note that the inspection logs do not need to be addressed in the text of the report unless information pertinent to the operation of the VIMS was discovered; and

☐ An index of, and individual safety data sheets for, any materials used during construction that could contribute to background indoor air contamination.

☐ PE sealed statement regarding the system effectiveness **verbatim** as follows:

> "The Vapor Intrusion Mitigation System (VIMS) detailed herein is designed to mitigate the intrusion of subsurface vapors into building features in accordance with the most recent and applicable DWM Vapor Intrusion Guidance, Interstate Technology & Regulatory Council (ITRC) guidance, and American National Standards Institute (ANSI)/American Association of Radon Scientists and Technologists (AARST) standards, or alternative standards approved in writing in advance by DEQ, and that a professional engineer licensed in North Carolina, as evidenced by said engineer's professional seal, is satisfied that the system has been designed **[add "and installed" for use in an installation report]** so as to be fully protective of

public health within the meaning of NCGS 130A-310.32 (a)(2), from known Brownfields Property contaminants."

Section 8. Design Submittal Exhibits

Drawings to be included:

☐ General Site Location Map (to include a scale and north arrow)

☐ Site Figure that includes:

☐ The Brownfields Property boundary and immediately adjacent properties or landmarks such as streets;

☐ Graphic scale and north arrow;

☐ Historical sampling locations and known impacts (groundwater, soil, soil-gas, subs-slab, indoor air, and if available on-site or adjacent surface water locations) relative to existing and proposed structures; and

☐ Reference to table(s) in the VIMS Plan where analytical results are provided. These results should be compared to the appropriate screening criteria (residential or non-residential IASL's, etc.).

☐ Design Specifications: Sub-Slab Venting Construction Materials and Installation; Membrane Vapor Barrier Construction Materials and Installation

☐ Material Specification Sheets for all items associated with the VIMS (vapor barrier, piping, mastic, tape, sealants, cleaners, etc.)

Section 9. Special Considerations for Retrofits

To the extent practical, the following details will need to be provided in advance to the BRS for its review for a planned retrofit of existing buildings (and if not available, state why):

☐ Complete explanation of subsurface structural conditions on all site buildings, including those buildings that are not proposed for mitigation but will remain on-site including but not limited to details on the presence or absence of the following:

☐ Basements/crawlspaces;

☐ Vertical walls in contact with soil;

☐ Details on slab thickness and underlying conditions (i.e. slab on gravel, slab on grade, slab over crawlspace, etc.);

☐ Details on number of slabs per building that are connected that have differing thicknesses or thickened footer separations or sub-walls that would create isolated slab areas for consideration, or would hinder overall VIMS influence;

☐ Obvious issues with slab integrity such as cracks or voids, etc.;

☐ Presence of sub-slab utility conduits, trenches, or tunnels that could act as preferential pathways and the need to mitigate (e.g. installation of trench dams, anti-seep collars, etc.);

☐ Sumps;

☐ Elevator pits; and

☐ Other applicable subsurface building features.

☐ Details on proposed sealing/repairs of obvious/existing concrete slab from minor caulking of floor cracks/expansion joints, and VIMS core drilled suction points, to possible VIMS saw cut trench sealing or specialized coatings for entire floor slab (e.g. Retro-Coat™ or other

similar coatings).

☐ Details on radius of influence in pilot/communication testing planned.

☐ Existing buildings to remain as part of redevelopment and/or proposed buildings shown on the Site Plan should be accurate and complete. At a minimum, plans should provide the following details:

☐ Detailed foundation plans - In addition to displaying piping network and proposed monitoring point locations, foundation plans should show, to the extent practical, all footers, grade beams, and other sub-slab features that could affect vacuum communication. This would also include sub-grade crawl spaces, basements, tunnels, walk-out basements, elevator pits, and other situations where soil is in contact with side walls of structure in addition to below the footprint of the building slab. Provide details on any vertical walls in contact with soil and the planned mitigation of such.

☐ Drawings shall be provided of each VIMS barrier sealing detail, including piping layout (transition from slotted PVC, terra vent, etc. to solid piping through grade beams for example), and examples of these detail drawings should be called out on VIMS layout drawing. When possible, drawings should be provided in color so that VIMS piping, extents of proposed vapor barrier, proposed sample/vacuum monitoring locations and other features can be easily distinguished.

☐ Detailed drawings, to the extent practical, of grade beams, thickened slabs, footers, and other sub-slab features that could affect VIMS influence must be clearly defined and easily discernable from existing or proposed interior walls that are above the floor slab (which would have no effect on vacuum influence below the slab).

☐ NOTE: Include references to any guidance/documents used or referenced by the PE during design of the VIMS.

Useful Reference(s):

Division of Waste Management (March 2018, Version 2) - "DWM Vapor Intrusion Guidance", which is currently under revision.
DWM Vapor Intrusion Guidance

Note: this document also contains in Appendix H the "Preliminary NCDEQ Brownfields Program Guidance, Vapor Intrusion Mitigation System (VIMS) Design Submittal, New Construction Minimum Requirements Checklist", which is replaced for BRS' purposes by this document "VIMS Design Submittal Requirements, May 2024".

Minimum Mitigation and Sampling Requirements for Reuse, NC DEQ Division of Waste Management (May 2024)
https://deq.nc.gov/about/divisions/waste-management/bf/statutes

"North Carolina Brownfields Program, Minimum Requirements for Townhome Developments" (May 2020)
https://deq.nc.gov/about/divisions/waste-management/bf/statutes

ITRC Guidance Website - “Technical Resources for Vapor Intrusion Mitigation”
Vapor Intrusion - ITRC (itrcweb.org)

ANSI/AARST CC-1000, “Soil Gas Control Systems in New Construction of Buildings”.
Note: The CC-1000 companion guidance publication includes informational content only and is not part of the standard.
ANSI/AARST CC-1000

ASTM, “Standard Guide for Development of Long-Term Monitoring Plans for Vapor Mitigation Systems” (ASTM 7CD8408/D8408M-21)
ASTM Standards