# MODELLING VAPOUR INTRUSION IN WET BASEMENT CONSTRUCTION SCENARIOS

Victoria Lazenby

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# Overview

- The ‘wet basement’ conceptual site model
- Current approaches to modelling vapour intrusion into wet basements:
  - Johnson & Ettinger
  - WATER9
- An alternative method…

# Vapour Intrusion into a Basement

From: ITRC www.itrcweb.org

# Vapour Intrusion into a Basement

# Johnson & Ettinger

- *Not recommended for modelling a 'wet basement'*
- Calculates volatilisation from groundwater into soil and migration through slab
  - A vapour conc. 'above' the groundwater is calculated
  - J&E attenuation factor is calculated and applied to the calculated vapour conc.
- If adapted to model a wet basement scenario:
  - The J&E attenuation factor is very low (i.e. predicted indoor conc's are high) when the capillary fringe and vadose zone are set to 0 m
  - A capillary fringe of ~1cm needs to be modelled
  - Reduced infiltration area should be applied (e.g. upgradient wall only)

# WATER9

Developed to predict concentrations of volatile chemicals above quiescent wastewater ponds

$$\mathrm{E} = \mathrm{K} \ x\ \mathrm{A} \ x\ \mathrm{C_L}$$

E = emission rate of the contaminant from the water body surface (g/s)

K = overall mass transfer coefficient (m/s), calculated as per equation below.

A = liquid surface area ($m^2$)

C = concentration of contaminant in liquid ($g/m^3 \equiv mg/L$)

$$K = \left[\frac{1}{K_L} + \frac{1}{K_g K_{eq}}\right]^{-1}$$

$K_L$ = liquid phase mass transfer coefficient (m/s)

$K_g$ = gas phase mass transfer coefficient (m/s)

$K_{eq}$ = equilibrium constant or partition coefficient

# WATER9

When adapted for a wet basement:

- 'Area' and 'depth' of 'quiescent water body' based on thin drains along basement walls
- Wind speed based on air exchange rates
- Water flow rate in $K_L$ generally calculated based on aquifer properties
  - Aquifer hydraulic parameters used to calculate seepage velocity (conductivity, porosity, gradient)
  - Volume of flow assumed to be all groundwater adjacent to basement wall (e.g. 15 m long and 2 m high wall area)
  - Water inflow values of ~1 x $10^{-8}$ to ~1 x $10^{-5}$ $m^3/s$ (~0.86 to 860 L/day) can be calculated based on aquifer properties
  - Equates to values of approx. 0.001 to 0.00001 m/s flow rate of water in drain

Emission rate (g/s) converted to indoor air concentration ($mg/m^3$) based on basement volume ($m^3$) and air exchange rates ($hr^{-1}$)

# Concrete Seepage Approach

$$E = C_w \; x \; S \; x \; A$$

Where:

E = Emissions rate in mg/hr

$C_w$ = Concentration in groundwater in mg/L

S = Seepage rate in L/m$^2$/hr

A = Area of seepage of contaminated groundwater in m$^2$

Seepage rate (‘S’) through concrete can be calculated based on:

- Concrete permeability coefficients
  - Can be adapted to account for different concrete types
- Darcy’s velocity – estimates flow through a porous medium
- Site specific factors, such as:
  - Concrete thickness
  - Porosity, etc.

# Comparing Predicted Concentrations

Based on a source of *1 mg/L benzene* into a *generic residential* basement with a *1.5m x 15m seepage area* in the basement:

- J&E calculates approximately 1 $mg/m^3$ benzene in basement air
- WATER9 calculates approximately 0.005 $mg/m^3$ benzene in basement air
- Concrete seepage method calculates approximately 0.0001 $mg/m^3$ benzene in basement air

*Am currently collating real world data – any examples of post-construction basement air sampling that can be shared will be appreciated!*

# Conclusions

Understanding of the conceptual approach behind any model is required if a model is to be relied upon

This includes a need to understand limitations, uncertainties, and sensitivities

Models are only as good as the data that goes into them – Rubbish In, Rubbish Out!

With greater complexity comes greater potential for uncertainty

Real world data is generally best…

and where that isn't possible, models should be validated with real world data

*Journal article with full methodological details is forthcoming!*

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# QUESTIONS?

victoria.lazenby@arcadis.com