

Integrated Site Assessment and Risk Assessment for a Proposed Real Estate Transaction at a PCE- impacted Drycleaner Site

by B.J. Min, M.Eng.,P.Eng and Geordie Clyde, P.Biol.
Jacques Whitford Ltd., Calgary, AB

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Presentation Outline

- Project Overview
- Background
- Introduction of Integrated Risk Based Approach and Components
- Supplementary Investigation
- Tier II Modification and Quantitative Risk Assessment
- Discussion and Conclusions



Project Overview

- Project Period - December 2004 to March 2005
- Project Initiator - Due diligence of a proposed real estate transaction and obtaining required financing and necessary Insurance
- Chemicals of Potential Concern identified from Phase I and II ESAs:

- PCE

Breakdown products:

- TCE
- DCE (cis/trans)
- VC



Background

- Previous Environmental Work - 1996 and 2003
- Phase I and II ESA – December 2004 by Jacques Whitford
- Soil stratigraphy – sand/gravel fill to 4.4. meters below grade underlain by fractured sandstone bedrock
- Land use
 - Onsite: Commercial
 - Offsite: commercial (N), commercial (E), residential (W) and Commercial/residential (S)



Background

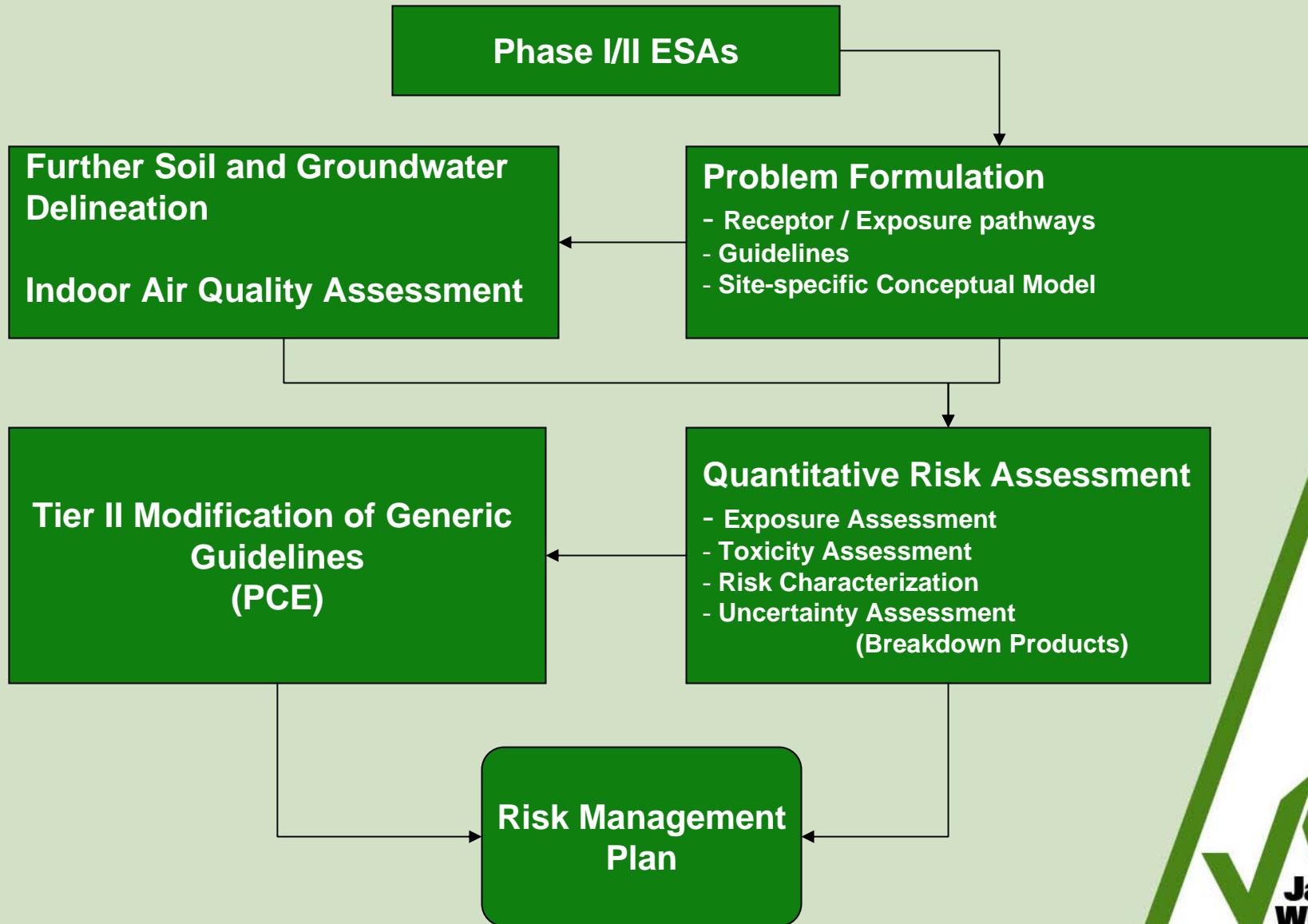
- Regional groundwater flow and nearest surface water body
 - West towards Nose Creek, 80 m west of the dry cleaner location
- PCE exceedance in soil and groundwater underneath the dry cleaner location
- Soil: at depths from 2.3 (1.26 mg/kg) to 3.8 meter below grade (2.48 mg/kg) in borehole MW 1 inside the dry cleaning premises
- Groundwater
 - 339 µg/L at MW1 inside the dry cleaner premises
 - 153 µg/L at MW2 east of the dry cleaner premises

Components of the Integrated Site Assessments and Risk Assessment

- Supplementary Soil and Groundwater Investigation
- Indoor Air Quality Assessment
- Tier II Modification and Quantitative Human Health Risk Assessment



Integrated Site Assessments and Risk Assessment Process



Advantages of Using Risk Assessment

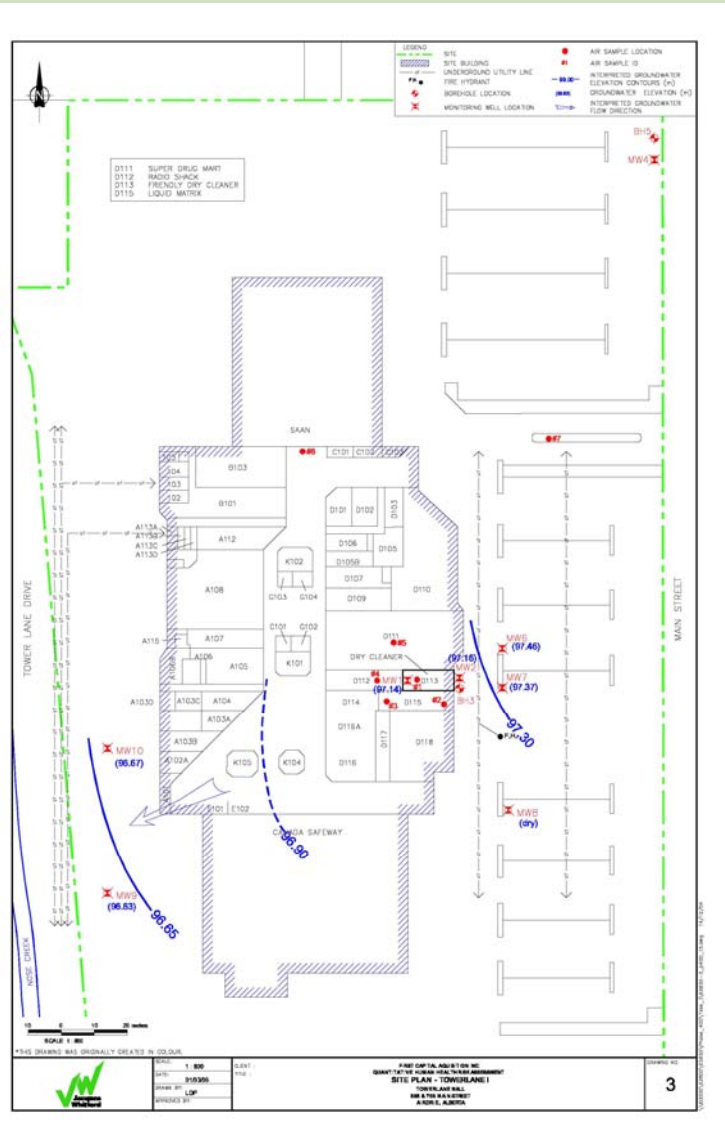
- Flexibility - risk-based approach allows an examination of management options that best fit with client or site priorities.
- Well-accepted - Process has been approved by regulators and accepted by clients and lenders.
- Remediate only those sites or areas where there is an “actual risk” to either humans or the environment.



Supplementary Investigation

- Installation of five additional monitoring wells
- CCME Commercial Soil Quality Guidelines
- CCME Drinking Water and Freshwater Aquatic Life Guidelines
- Spatial Distribution of PCE soil impact is localized primary beneath the foot print of the dry cleaning space and east towards the monitoring well location MW2 (5 m east)
- The worst case concentrations appear to exist in the shallow soil layer underlying the dry cleaning machine.

Supplementary Investigation



Indoor Air Quality Assessment

- Indoor air samples were collected using a SKC Universal XR sample pump and thermal desorption tubes
- Risk based reference values indicating concentrations of the parameters showing no human health adverse effects
- Occupational Health and Safety Guidelines (8 hr Threshold Limit Value)
- Detectable PCE concentrations were recorded in the dry cleaner premises and adjoining tenant locations

Tier II Modification & Quantitative Risk Assessment

- Alberta Environment allows modification of generic regulatory guidelines by replacing generic parameters with site-specific information
- Modification of generic guidelines is also known as the Tier II approach
- Tier II modification uses similar methods and assumptions as those used to develop the Canadian Soil Quality Guidelines
- The modified criteria must be protective of both current and reasonably foreseeable future land uses

Tier II Modification & Quantitative Risk Assessment

- Chemicals of Potential Concern identified from Phase I and II ESAs

Chemicals of Potential Concern					
Chemicals of Concern	Potential Source	Maximum Measured Concentration			Carried Forward in Risk Assessment
		Indoor Air (mg/m ³)	Soil (mg/kg)	Groundwater (mg/L)	
PCE	Operations associated with the on-site dry cleaner.	0.056	2.48	0.339	Yes
TCE		< 0.002	< 0.03	0.003	Yes
1,1-DCE		NS	< 0.03	< 0.002	Yes
cis-1,2-DCE		< 0.002 ¹	< 0.03	< 0.002	Yes
Trans-1,2-DCE			< 0.03	< 0.002	Yes
Vinyl Chloride		< 0.003	< 0.03	< 0.002	Yes

Receptor Identification

- Human Receptors
 - Non-carcinogens – Toddler (6 months – 4 years)
 - Carcinogens – Adult Worker (56 years)
 - Receptors assumed to be on the site 10 hr/day, 5 day/yr, 48 wks/yr
- Ecological Receptors
 - Based on site conditions no ecological receptors are anticipated to be impacted by the CoPCs
 - Ecological receptors were not assessed further

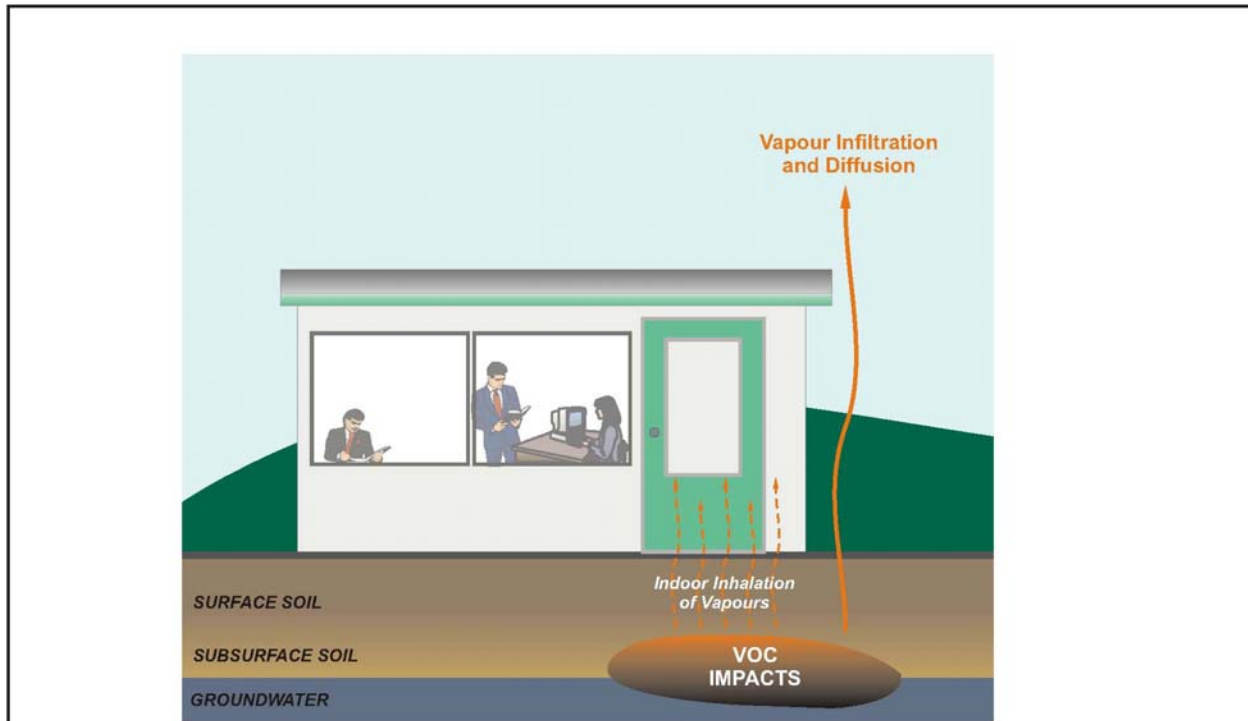
Exposure Pathway Evaluation

Potential Exposure Scenarios			
Exposure Pathway Description (On-site and Off-site)	Likelihood of Exposure	Carried Forward for Quantitative Analysis?	Justification
Inhalation of subsurface soil vapours indoors	Possible on-site	Yes	<ul style="list-style-type: none"> •soil & groundwater vapours may migrate into the on-site buildings
Inhalation of groundwater vapours indoors	Nothing off-site.		
Inhalation of subsurface soil vapours outdoors	Unlikely	No	<ul style="list-style-type: none"> •soil & groundwater vapours may migrate into outdoor air becoming diluted •exposure minimal when compared to indoor air
Inhalation of groundwater vapours outdoors			

Exposure Pathway Evaluation

Potential Exposure Scenarios Considered Very Unlikely		
Exposure Pathway Description (On-site and Off-site)	Carried Forward for Further Analysis?	Justification
Ingestion, Dermal Contact, Inhalation of surface soil/dust	No	<ul style="list-style-type: none"> •Site is Covered •CoPCs at a depth of 2.0 m
Ingestion, Dermal Contact of surface water	No	<ul style="list-style-type: none"> •no surface water bodies on-site •transport to surface water is not expected •closest surface water is Nose Creek
Ingestion, Dermal Contact of groundwater	No	<ul style="list-style-type: none"> •Groundwater not used as a potable drinking water source.
Ingestion of vegetation, garden produce	No	<ul style="list-style-type: none"> •soil and groundwater impacts below the root uptake zone •commercial site with no grown produce

Conceptual Exposure Model



CONCEPTUAL EXPOSURE MODEL
ON-SITE COMMERCIAL SCENARIO - INDOOR INHALATION OF VAPOURS



THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOUR

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Tier II Modification & Quantitative Risk Assessment

- Conceptual Exposure Model
 - VOC vapours from the impacted soil and groundwater diffuse upward through the soil and into the dry cleaner building through cracks in the floor slab. On-site receptors may inhale the vapours in indoor air.

Tier II Modification Procedures – Indoor Inhalation Pathway

$$SQG_{II} = \frac{(RfC - C_a) \times \left(\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + \left(\frac{H}{RT} \times \theta_a \right) \right) SAF \times DF_i \times 10^3 \text{ g/kg}}{\frac{H}{RT} \times \rho_b \times 10^6 \text{ cm}^3/\text{m}^3 \times ET} + BSC$$

Where:

SQGII	= soil quality guideline by indoor infiltration for volatiles using RfC	mg/kg
RfC	= reference air concentration	mg/m ³
Ca	= background indoor/outdoor air concentration	mg/m ³
SAF	= soil allocation factor	unitless
θa	= vapour filled porosity	unitless
θw	= moisture filled porosity	unitless
Koc	= organic carbon partition coefficient	mL/g
foc	= soil organic carbon fraction in contaminant partitioning zone	g/g
ρb	= soil dry bulk density in contaminant partitioning zone	g/cm ³
H	= Henry's Law Constant	atm-m ³ /mol
R	= universal gas constant	atm-m ³ /mol-K
T	= annual average soil temperature	K
DFi	= dilution factor from soil gas to indoor air	unitless
ET	= exposure term (8/24*5/7*48/52)	unitless
BSC	= background soil concentration (CCME, 1996b)	mg/kg



Tier II Modification

- Maximum concentrations of PCE in both soil and groundwater were below Risk Based Quality Guidelines (RBQG)

Modified Risk-Based Soil and Groundwater Quality Guidelines for Inhalation of Vapours in Indoor Air

Parameter	Soil (mg/kg)		Groundwater (mg/L)	
	Maximum Measured Concentration	RBQG	Maximum Measured Concentration	RBQG
PCE	2.48	18	0.339	22

Tier II Modification vs. Generic Guidelines

Comparison of Generic to Modified Risk-Based Quality Guidelines

Parameter	Generic		Modified Risk Based
	Guideline	Source	
Subsurface Soil (mg/kg)			
PCE	0.5 ¹	CCME, 2004 Soil Quality Guidelines for Commercial Land Use	18
Groundwater (mg/L)			
PCE	0.111	CCME, 2004 Canadian Guidelines for Freshwater Aquatic Life	22

Quantitative Risk Assessment

- Conducted to derive risk based remediation criteria (RBRC) for PCE breakdown products
- Assumed maximum CoPC concentrations in soil and groundwater present beneath the entire floor slab
- Predicted indoor air concentrations were greater than measured indoor air concentrations indicating the conservatism of the modelling

Dose-Response Assessment

Toxicity Reference Values		
Chemical	RfC (inhalation) (mg/m ³)	RSC (inhalation) (mg/m ³)
TCE	NA	1.64E-02 ^c
cis-1,2-DCE	1.77E-02 ^b	NA
trans-1,2-DCE	3.55E-02 ^a	NA
1,1-DCE	2.00E-01 ^a	NA
Vinyl Chloride	NA	2.30E-03 ^a

Notes:

^a US EPA IRIS database, 2004

^b US EPA PPRTV, 2002

^c Health Canada, 2003



Estimation of Receptor Dose

$$CDI = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

Where

CDI = Chronic Daily Intake (mg per kg of body weight per day)

C = Exposure Point Concentration (e.g. mg/L or mg/kg)

CR = Contact rate (e.g. L/day or m³/day)

EF = Exposure frequency (days/year)

BW = Body weight (kg)

AT = Average time (days)

Hazard Assessment (non-carcinogens)

$$\text{Hazard Quotient (HQ)} = \frac{\text{Chronic Daily Intake (CDI)}}{\text{Tolerable Daily Intake (TDI)}}$$

Acceptable Hazard Levels

HQ < 1.0 if all pathways are considered, then the intake is not considered to pose a health threat.

HQ < 0.2 to account for 80% of exposure to a CoPC from the background environment.



Hazard Assessment (Carcinogens)

Incremental Life Cancer Risk (ILCR)

= Lifetime Average Daily Dose x Cancer Slope Factor

The ILCR is typically expressed:

e.g. 3×10^{-6} for three additional cases in a million

- Acceptable level of risk
 - 1 additional cancer case in 100 000 people (1×10^{-5})
- NOTE: 1 in 3 Canadians will get cancer in their lifetime so risk assessment allows for 0.40001 instead of 0.40000 cases in a population

SUMMARY OF RISK ESTIMATES

Summary of Risk Estimates		
Parameter	HQ	ILCR
Total		
TCE	NA	8.57E-08
cis-1,2-DCE	1.01E-02	NA
trans-1,2-DCE	8.58E-03	NA
1,1-DCE	3.41E-03	NA
Vinyl Chloride	NA	5.31E-06

Risk Based Soil and Groundwater Criteria

Risk Based Soil and Groundwater Remediation Criteria ¹

Parameter	Non-Carcinogen		Carcinogen	
	Maximum Measured Concentration	RBRC	Maximum Measured Concentration	RBRC
Sub-Surface Soil (mg/kg)				
TCE	NA		ND	2.06
cis-1,2-DCE	ND	1.10	NA	
trans-1,2-DCE	ND	1.30	NA	
1,1-DCE	ND	3.30	NA	
Vinyl Chloride	NA		ND	0.029
Groundwater (mg/L)				
TCE	NA		0.003	2.4
cis-1,2-DCE	ND	4.51	NA	
trans-1,2-DCE	ND	3.79	NA	
1,1-DCE	ND	7.35	NA	
Vinyl Chloride	NA		ND	0.10

Notes:

¹ based on HI of 0.2 and ILCR of 1E-05 targets in coarse-grained soil.

NA – not applicable

ND – not detected



Conclusions

- Use of site-specific data to generate modified risk-based guidelines resulted in an increase of the generic guidelines.
- QRA did not predict unacceptable risks to receptors at the site under current land use scenario for any of the CoPCs.
- Using conservative assumptions presented in this report, there are no potential adverse health effects associated with the exposure of receptors to the maximum concentrations of CoPCs measured to date.

Project Postscript

- The integrated site assessment and risk assessment approach was successfully implemented to meet project stakeholders' needs.
- The end result was “Win-Win” as the real estate transaction was completed and the purchaser was successful in obtaining the necessary insurance and financing to complete the transaction.
- A Risk Management Plan including groundwater monitoring and ventilation upgrading, was developed and is being implemented.



Questions?

Thank you!

