2008

A classification system for promoting and assessing redevelopment of brownfield sites

Shovini Dasgupta
University of Windsor

A CLASSIFICATION SYSTEM FOR PROMOTING AND ASSESSING REDEVELOPMENT OF BROWNFIELD SITES

By

Shovini Dasgupta

A Dissertation
submitted to the
Faculty of Graduate Studies
through the Department of Civil and Environmental Engineering
in partial fulfillment of the requirements for the
Degree of Doctor of Philosophy at the University of Windsor

Windsor, Ontario, Canada
2008

Your file Votre référence
ISBN: 978-0-494-62767-9
Our file Notre référence
ISBN: 978-0-494-62767-9

AUTHOR'S DECLARATION OF ORIGINALITY

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that I have included copyrighted material that surpasses the bounds of fair dealing within the meaning of the Canada Copyright Act, I certify that I have obtained a written permission from the copyright owner(s) to include such material(s) in my thesis and have included copies of such copyright clearances to my appendix.

I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate Studies office, and that this thesis has not been submitted for a higher degree to any other University of Institution.

ABSTRACT

Significant economic, legal and environmental concerns present obstacles to the redevelopment of thousands of brownfields in Canada, which have the potential to stimulate economic growth, community revitalization, and urban renewal. Individually analyzing the threats and opportunities associated with redevelopment of each single site results in spending of significant amounts of resources. To overcome this limitation, the dissertation has developed a methodology for effectively classifying brownfields on the basis of a broad set of factors including contaminants, infrastructure and ecological conditions, revenue opportunities, community pressure and anticipated land uses, so that they can be analyzed categorically. Building on a review of existing classification systems, this dissertation provides a structured means for integrating the objectives of multiple stakeholders (e.g., municipality, developer, regulator, community) in a comprehensive manner. The classification system is designed to be transparent and straightforward and accounts for different redevelopment opportunities. The brownfield sites are evaluated based on attributes of the site and their suitability towards various potential redevelopment opportunities. Even though the system is applicable to all the stakeholders, municipalities are given a special emphasis as they represent a balance among various stakeholders' interests in any brownfield revitalization effort. The applicability of the developed classification is demonstrated using an illustrative example of a site entitled ABC automotive service garage with detailed calculations and flow diagrams. This classification methodology enables the greater understanding of issues specific to different brownfield scenarios, encourages the effective use of policy and resources, demonstrates the tradeoffs and has the potential to serve as an educational and communications tool.

DEDICATION

This dissertation is dedicated to my beloved husband Souvik.
Souvik, it is a challenge to be a doctoral student, but it is a much greater challenge to be the loving spouse of a doctoral student; to support and encourage her during the days of disappointment, and to share and cherish the joyous moments. All I want to say to you is "Thank you" for being my best friend, an earnest soul-mate, an honest critique of all my work, and a patient supporter of all my endeavours for four long years! I am excited to start a new phase of our lives together!

I would also like to mention the name of my late grandfather, Parimal Kumar Dasgupta. *Dadabhai*! I know you have always taken great pride in all my achievements, even when they were insignificant. I wish I could share this moment with you. Wherever you are, I know you will be very proud of me today!

Last but not least, thanks very much to my loving parents, Mr. Udit Bhanu Dasgupta and Ms. Madhumita Dasgupta, for teaching me to appreciate the value of education and knowledge above every other aspect of life.

ACKNOWLEDGEMENT

I wish to take the opportunity to thank

- My supervisor, Dr. Edwin Tam, for his technical guidance and financial support, without which it would not have been possible to complete this research successfully. Dr. Tam, I will always look up to you for your inspiration, guidance, and research insight, as well as your kindness as an individual. Thanks very much for being not only my supervisor, but also my most admirable intellectual and professional mentor.
- Our industrial partners, especially Peter Beukema and Patrick Shriner from AMEC, Marcia Wallace from the Province of Ontario, and Wendy Meininger-Dyk from Seneca College. Your practical advice and support were extremely helpful in the successful completion of this research.
- Our municipality partner, Mark Brickell from the Niagara Economic Development Corporation, for being one of the key initiators of this project to develop a brownfield classification, and for his advice, encouragement and support throughout this research. Thanks to Neil Robertson, Thom Hunt and the rest of the Planning Department staff from the City of Windsor for their invaluable advice.
- Dr. Philip Byer from the University of Toronto for his advice, suggestions and extremely valuable input to my research.
- My research partner from the University of Toronto, Nik Schruder, for taking care of a significant portion of the health risk evaluation for brownfields, and for his valuable comments and critiques during the initial phase of this research. Nik, it was a pleasure working with an energetic, kind and knowledgeable individual like you.
- My committee member, Dr. Nihar Biswas, for his insightful advice, continued guidance and support throughout my journey as a graduate student since 2002. I am grateful to him for all the help and guidance that I have received from him since the very first day I came to Canada.
- My thanks are also extended to Dr. Rajesh Seth and Dr. Phil Graniero for taking the time to review my work and participate in my examination committee.
- Special thanks to Dr. Chris Kennedy from the University of Toronto for participating in my committee and taking the time to review my dissertation.

I am thankful for the support, criticisms and suggestions of my fellow graduate students from Civil and Environmental Engineering at the University of Windsor. I would like to especially thank Susan Sawyer Beaulieu and Noor-E-Faiza Barsha for their friendship and support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A	Area of contaminated soil
BC	Backfilling cost
B_u	Backfilling cost per unit weight of soil
$C_1, C_2,.. C_T$	Cash flow in year 1, 2, ... T
CCME	Canadian Council of Minister of the Environment
CHSR	Contamination Health and Safety Risk
CIP	Community Improvement Plan
CRA	Category Requiring Action
DC	Haulage and disposal cost of soil
D_u	Haulage and disposal cost per unit weight of soil
D	Debt from bank expressed as a fraction of total revitalization cost
dc	Average depth of contaminated soil
E	Equity investment of the developer expressed as a fraction of total revitalization cost;
EC	Excavation cost
E_u	Excavation cost per unit weight of soil
ESA	Environmental Site Assessments
FMV	Fair Market Value
HES	High Ecological Sensitivity site
HRS	Hazardous Ranking System
H	High
HYGIA	Hybrid Geophysical technology for the Evaluation of Insidious contaminated Areas
I	Non refundable incentives (government) expressed as a fraction of total revitalization cost
IRR_Proj	Internal Rate of Return for the Project
L	Low interest loans expressed as a fraction of total revitalization cost
LEI	Low Ecological Impact sites
L	Low
M	Med
MARR	Minimum Attractive Rate of Return
$MARR_{riskfree}$	Risk free Minimum Attractive Rate of Return
MDL	Minimum Detectable Limit
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
NCS	National Classification System
NPV	Net Present Value
PEL	Probable Effect Level
PHCs	Petroleum hydrocarbons
PSF	Pre Submission Form
RDC	Redevelopment cost
RHAS	Rapid Hazard Assessment System
RMC	Remediation cost
RSS	Risk Screening System
RP	Risk pemium

r_o	Opportunity cost of the developer (%)
r_L	Capitalization rate on low interest loans (%)
r_p	Prime interest rate (%)
SAR	Severity of Action Required
SEE	Simplified Ecological Evaluation
SQGTG	Soil Quality Guidelines Task Group
SVOCs	Semi Volatile Organic Compounds
s	Stigma
T	Duration of the project in years
T_1	Duration of remediation
T_2	Duration of redevelopment
t	Effective Tax Rate for the project
t'	Overall tax rate in the region
t_i	Reduction in effective tax rate due to tax incentive programs
TEE	Terrestrial Ecological Evaluation
UC	Upfront cost
US EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
V	Total volume of soil to be disposed during dig and dump
VOCs	Volatile Organic Compounds
Y	Yes
ρ	Density of soil

1.0 INTRODUCTION

In Canada, there are over 30,000 brownfield sites representing significant potential in terms of economic growth, community revitalization, and urban renewal (NRTEE, 1997a). About 3900 (NRTEE, 1996) of such sites are situated in Ontario and 4200 in British Columbia (Simons, 1998). In the United States there are an estimated 425,000 brownfield sites that tarnish the urban landscapes (GAO, 1995). The US EPA estimates that there are between 500,000 and 1 million brownfields, typically in urban areas, in American communities (Bush, 2002). About 2000 such sites exist in Chicago, 5000 in Georgia and 8000 in New Jersey (Schmitter, 1998; Bartsch et al., 2001; United States Conference of Mayors, 2000). Many of these sites present opportunities to revitalize the environment, provide new jobs, increase the tax base, control urban sprawl and renew obsolete civil infrastructure (Amekudzi and Fomunung, 2004).

The redevelopment of these sites can lead to significant economic progress and ease the burden on municipalities, particularly older cities, in terms of creating new infrastructure and generating new productive lands that could be great sources of revenue for the government. A comprehensive study prepared for the NRTEE in 2002 by Royal Analytics Inc. (RAI) entitled "Economic Impact of Brownfield Redevelopment Activities in Canada" documented that every brownfield redevelopment investment dollar brings forth $3.80 in the output of various industries in the Canadian economy. In addition to this, every dollar spent on brownfields (by private or public investors) could result in an extra $0.22 in federal tax revenues (RAI, 2002). This is in addition to the original tax revenue that was being received without the brownfields being redeveloped. Another survey conducted as a part of a recent study undertaken by U.S. Conference of Mayors (2000) revealed that 179 US cities indicated that if all the brownfields were redeveloped, the responding cities would realize $5 -$13.4 M in terms of additional tax revenues per city per year. These figures clearly depict the significance of brownfield cleanups.

Despite the significant economic benefits of brownfield cleanup to the individual cities, the primary reasons these brownfield projects do not attract potential developers is because of the uncertainty in their profit margin. Complications are also posed by the most frequently cited concern of liability that the site redeveloper or owner may face from poorly assessed and controlled health risks. As a result, the tendency until recently was to prefer "greenfield" (previously undeveloped) sites for new redevelopments. This situation was exacerbated by the abundance of general information and the lack of specific information on how any particular brownfield can be approached, the unavailability of structured means to tackle important issues, and the absence of an informed policy to guide the interested stakeholders. All of these factors tend to pose challenges towards revitalizing brownfields.

As a result, evaluating brownfields and promoting their effective revitalization would benefit greatly from identifying characteristics that lead to the systematic evaluation of brownfields. This can be achieved by developing a taxonomy or classification of brownfield sites.

There continues to be significant advancement of the types of brownfields technologies available for assessing and treating contaminants, but a structured means for integrating the objectives of multiple stakeholders (e.g., municipality, developer, regulator, community) in a concise manner is still absent. No readily available classification methods exists which could differentiate among the brownfields based on an overall suite of relevant characteristics, such as community settings, site characteristics, contaminant characteristics, development potential and financial viability. Because of this, it is difficult to communicate brownfield issues to unfamiliar parties and it is necessary to continually formulate "new" strategies for recurring or categorical situations. In order to overcome this gap, this research develops a methodology for classifying brownfields in a systematic manner.

The first step for developing a systematic classification starts with identification of a common and clear definition of brownfields.

1.1 BROWNFIELD DEFINITION

There are several regulatory definitions of brownfields used across the world. The term "brownfield" is generally used to describe previously developed industrial or commercial properties, where the potential for redevelopment is complicated by the presence of real or perceived contamination (EPA, 2007).

However, from a regulatory standpoint, brownfields do not have a common definition. In United Kingdom (UK) and Australia the term brownfield simply indicates previously developed lands (Roberts *et al.*, 1998). However, the term has more specific definitions in United States (US) and Canada. In the US, the brownfield definition is found in Public Law 107-118 (H.R. 2869) - "Small Business Liability Relief and Brownfields Revitalization Act" signed into law in 2002. This defines brownfields as:

> *"Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."*

This definition was later amended to exclude certain types of severely contaminated properties that have very high concentrations of hazardous waste, such as the Superfund sites, operating facilities that are subjected to investigation/remedial-actions/cleanups and a few waste disposal/dump sites considered under waste disposal acts (EPA, 2007).

In Canada, the definition of brownfield is more general and includes severely contaminated sites as well. The first formal definition of brownfield in Canada was provided by the National Roundtable on the Environment and the Economy (NRTEE) in 2003 in a report entitled "Cleaning up the Past, Building the Future – A National Brownfields Redevelopment Strategy for Canada", which defined a "brownfield" as:

> *"An abandoned, vacant, derelict or underutilized commercial or industrial property where past actions have resulted in actual or perceived contamination and where there is an active potential for redevelopment."*

Although this definition identifies "an active potential for redevelopment" to be one of the necessary conditions of being a brownfield realistically it may not be possible to evaluate the potential without a minimal site investigation by the municipalities or the developers. In the province of Ontario (Canada) municipalities are required to define "brownfields" based on their individual specific needs and incorporate this definition into their Official Plan or Community Improvement Plan (CIP) (AR, 2007).

Therefore, from a regulatory standpoint the brownfields do not have a common definition. However, in spite of the differences, all brownfield definitions share the following key points:

- Sites are often old industrial, commercial or institutional facilities.
- Sites are often strategically located in areas where municipal services and infrastructure are in place (AR, 2007).
- Sites are abandoned/idled or underused due to real or perceived contamination (AR, 2007).

The definition of brownfield provided by NRTEE (2003) mentions all these key points and has been used as the working definition of this research. Moreover, using the definition provided by NRTEE as the starting point could enhance the applicability of this classification system to Canadian scenarios.

1.2 RECENT TRENDS AND NEED FOR A BROWNFIELD CLASSIFICATION SYSTEM

In recent years the push to redevelop abandoned sites has increased significantly to promote urban renewal, "smart growth" and return brownfield sites to more productive uses (Tam and Byer, 2004). Policies have also been developed to encourage brownfield development endeavors (Bobechko, 2005). Whether a brownfield redevelopment could promote "smart growth" and community sustainability or not depends mostly on a proper planning. Planning is based significantly on knowledge gathered from case studies, local situations and expert judgment. In some cases, it is possible to employ specific remedies that have been proven under similar discrete condition. However, a systematic classification to capture the knowledge from these different sources and to enforce a structured approach to the proper evaluation of contaminated sites is limited (Martin and Toll, 2006). Such systematic approaches to revitalizing these sites is crucial for developers, communities and the municipalities, but the available tools are generally inadequate to assist developers, authorities, and communities to understand the multiple and complex issues related to brownfields in order to make sound decisions. Practical experience and research in Canada and abroad demonstrates that if the appropriate mechanisms and decision tools can be put in place, then brownfield sites can be redeveloped and significant economic, environmental and social benefits can be realized locally, regionally and nationally (EPA, 2006).

Regulatory approaches have been recently developed that tend to facilitate brownfields development and more clearly streamline the expectations of all stakeholder groups such as property owners, potential purchasers and regulators. Recent legislative improvements, such as Bill 153 in Ontario which outlines the *Record of Site Condition* (RSC), are considered as significant advancements in encouraging brownfield redevelopment. RSC supercedes the 1996 Ministry of the Environment (MOE) Guidelines for use of contaminated sites in Ontario (Girlon et al., 2004) and incorporates the following key changes to streamline the previously practiced risk assessment process for brownfields:

Requirement of Qualified Professionals

RSC regulation created the designation of a qualified professional, based on experience and academic degree and indicated that a risk assessment be carried out under the supervision of a qualified professional. This is an attempt to improve consistency and maintain the quality of risk assessment process.

Pre-Submission Form (PSF)

Unlike 1996 MOE Guidelines, this new legislation does not require an independent third party review of the site specific risk assessment. Rather, the ministry requires the submission of a PSF prior to conducting a risk assessment to ensure that all mandatory requirements are fulfilled instead of depending on a third party evaluation, which relies on individually biased judgments, which are more variable perceptions (Girlon et al., 2004). This is an invaluable effort to streamline the risk assessment.

Ecological Risk Assessment

The new regulation mandates a comprehensive assessment of ecological risk.

However, these abovementioned regulatory changes do not necessarily help decision makers evaluate the tradeoffs among different alternatives because they are intended for compliance. Developing a systematic classification system could enable the greater understanding of issues specific to different brownfield scenarios, encourage the effective use of these new policy and resources, and serve as an educational and communication tool. Such a system would allow decision makers to consider in advance how to approach a brownfield development and promote urban renewal.

1.3 OBJECTIVE OF THE DISSERTATION

In order to advance decision making about brownfields, a research project between the University of Windsor, the University of Toronto and Seneca College has developed a system for classifying brownfields on the basis of land and infrastructure attributes, community setting, economic opportunities, and human-health risk. This dissertation develops the core methodology for this brownfields classification.

The central objective of this dissertation is to develop an expert classification system to effectively categorize brownfields that could serve as an integrative, decision support tool and offer categorical solutions for recurring brownfield scenarios. It will thus:

- Isolate the site situations where the status-quo may be questionable because of the potential hazard associated with a site.
- Identify the potential redevelopment options for hazardous sites, recognize the "limited-potential" site uses, and subsequently isolate the situations where redevelopment may be questionable.
- Demonstrate the extent of actions that should be undertaken to overcome the barriers for any given site revitalization option in terms of the following:
    - Suitability of available land, infrastructure, ecology and service resources for the proposed end use;
    - Potential for the site to generate financial (e.g., return on investment) benefits of redevelopment;
    - Effectiveness of the proposed revitalization to render community benefits;

- Likelihood of the brownfield site to pose risk to human health.
- Create a classification system to incorporate the above aspects in an efficient and step-wise manner.

1.4 USER CHARACTERISTICS

The primary purpose of the developed classification is to empower the municipalities to use this classification system in any general brownfield settings, because they represent the interest of multiple stakeholders. However, the framework is adaptable to the needs of other stakeholders and could be used by the developers, regulators and community as well for improved evaluation of brownfields.

1.5 ORGANIZATION OF THE DISSERTATION AND SPECIFIC CONTRIBUTIONS

The chapters in this dissertation are arranged as follows. Chapter 2 reviews twelve contemporary brownfield classification systems and analyzes their strengths and weaknesses. The overview of the key features of the proposed classification system is detailed in Chapter 3. A detailed description of the classification methodology and its application in an existing case study is presented in Chapters 4 through 12. Chapter 4 describes the basic methodology of classifying the sites and the different tiers of the developed classification. The first two tiers (Level 1 and Level 2) of the developed classification along with their applications are elaborated in Chapters 6 and 7. The third and fourth tiers of the classification are detailed in Chapters 8 through 12. The conclusion and recommendations for future work are drawn in Chapter 13.

Because this classification project is a collaborative effort, this thesis dissertation makes specific and significant contributions in the following aspects:

- Reviewing contemporary brownfield classification systems and analyzing their strengths and weaknesses.
- Formulating the scope of the proposed classification system (excluding health and social aspects which were undertaken by other participants).
- Developing and refining specific procedural details for Levels 1 and 2, which were outlined but not developed to the point of usability in the earlier collaboration.

- Refining the specific procedural details for Levels 3 and Level 3-Advanced, which were outlined but not developed (excluding health and social aspects).
- Fully developing the land, infrastructure and economic models from Levels 1 though Level 3-Advanced (defined in the following chapters) within this classification system.
- Integrating the health module developed by the University of Toronto into the revised classification system.
- Refining and interlinking the different levels of the *overall* classification system and bringing it to closure.

2.0 LITERATURE REVIEW

Different brownfield classification systems, scoring schemes and ranking methods have been developed in the past by various organizations in order to classify brownfields. Many of the systems are designed for a specific group of stakeholders or jurisdictions, and cannot be used to evaluate situations outside of their intended original use. Nevertheless, they provide useful starting points to consider what the desirable elements within a comprehensive classification system are. This chapter reviews twelve contemporary brownfield classification systems and analyzes their strengths and weaknesses. The chapter concludes that the lack of a multidisciplinary approach in the development of the existing classification systems limit their use on a broader scale and establishes the need for a broader multidisciplinary classification system which could serve as a basic framework for systematic decision-making.

2.1 BACKGROUND OF BROWNFIELD CLASSIFICATION SYSTEMS

A brownfield site needs to be characterized against two major categories of attributes; namely, *site-based attributes* (e.g., hydrology, topology, size, contamination, site use) and *contextual attributes* (e.g., surrounding land uses, market forces, legal regime) (DETR, 2000). These two types of attributes contribute to the evaluation of brownfields: for example, perception, liability, policy issues, legal conditions and the image of a site (Alker et al., 2000). These attributes in turn either strengthen or weaken the probability of success of any particular revitalization effort.

Several attempts have been carried out to characterize brownfields in terms of their contextual and site based attributes which have led to the development of several preliminary classifications for decision-making. However, all of these attributes are not equally important to the different groups of stakeholders involved in the process of redevelopment. As a result when individual stakeholder groups attempt to develop a classification system for brownfield sites, they only capture representative information relevant to their objectives and not necessarily all other involved stakeholders, limiting the robustness of their classification approach.

None of the classification systems examined captures both context and site-based attributes, and none consider both the attributes of an existing contaminated site as well as the future site use. Of course, some of these systems were never intended to be a comprehensive system of classification; for example, some only focus on health risk aspects. The potential downfall however, is that some of them may be used to reach conclusions about brownfields actions outside of their intended scope of analysis.

2.2 ASSESSMENT OF EXISTING CLASSIFICATION SYSTEMS

All the existing brownfield classification systems can be categorized into three major groups:

- Type 1: "Health and Risk" Based Classification Systems
- Type 2: "Financial Incentive" Based Classification Systems
- Type 3: "Relevant Critical Attribute" Based Classification Systems

These categories of classification systems and examples of each are reviewed in the following sections.

2.2.1 Type 1: "Health and Risk" Based Classification Systems

The first category of taxonomy to evaluate the brownfield sites comprises of numerically based screening tools primarily designed to assess the impacts of brownfield sites in terms of the hazard and potential hazard to human health and environment. The taxonomy employs some screening tools to rank a site and quantitatively indicate its magnitude of hazard compared to other sites. Several of such classification systems are employed by different countries to make the evaluation of contaminated sites more consistent.

Five such "Type 1" classification systems described in this section are summarized in Table 2-1. Among them, the two most important and widely used scoring mechanisms in North America are Hazardous Ranking System (HRS) developed by US EPA for the resource allocation in cleanup of superfund projects and the National Classification System (NCS) developed by the Canadian Council of Ministers of the Environment (CCME).

Table 2-1: Type 1 Classification of Brownfield Sites and their Country of Use

Available Type 1 Classification Systems	Developer	Country of Use
Hazardous Ranking System (HRS)	US EPA	USA
National Classification System (NCS)	CCME	Canada
Classification of Aquatic Contaminated sites	CCME	Canada
Rapid Hazard Assessment System (RHAS)	New Zealand Ministry of Environment	New Zealand
Risk Screening System (RSS)	New Zealand Ministry of Environment	New Zealand

Hazardous Ranking System (HRS) (EPA, 1990; 2006)

The Hazardous Ranking System (HRS) is the scoring system developed by the US Environmental Protection Agency (EPA) Superfund program to assess the relative threat associated with actual or potential releases of contaminations from a brownfield site (EPA, 1990). Based on the HRS score received, the sites are placed on a list of significantly contaminated sites called the National Priorities List (NPL). Federal funds are allocated for the cleanup of sites which are placed in NPL.

In the HRS scoring scheme, numerical values are assigned to factors grouped into three basic categories to determine the risk posed by a particular site. The three factors considered are (EPA, 1990):

- The likelihood that a site has released or has the potential to release hazardous substances into the environment;
- The characteristics of the waste –such as toxicity, mobility and waste volume;
- The receptors affected by the release.

HRS score combines four different exposure pathways which are scored based on the above mentioned three categories of factors. The pathways are: ground water migration (drinking water), surface water migration (drinking water, human food chain, sensitive environments); soil exposure (resident population, nearby population, sensitive environments); and air migration (population, sensitive environments). Each site receives four distinct scores (ranging from 1-100) for four different pathways. The final score is a combination of the four individual pathway scores. Depending on the final score of a site its position in NPL is determined.

National Classification System (NCS) (CCME, 1992)

The Canadian version of HRS Scoring system was developed by the Canadian Council of Minister and Environment (CCME) to streamline identification and cleanup of high risk contaminated sites in Canada (CCME, 1992). This scoring scheme is known as the National Classification System (NCS) and can be used as a screening tool to consistently evaluate contaminated sites for their potential to impact human health and environment.

NCS calculates the hazard and hazard potential of a site by scoring the site characteristics that can be grouped into the following three categories:

- Contaminant characteristics – the hazards from contaminant(s) present at site;
- Exposure pathway – the route through which the contaminant(s) reaches a receptor – e.g. groundwater, surface water, or air; and
- Receptor(s) – the individuals that are affected by the release.

Each site is assigned an overall score based on several attributes belonging to the above mentioned three groups. Depending upon the score the sites are categorized into five groups: Class 1- Action required, Class 2- Action likely required, Class 3- Action may be required, Class N- Action not likely required and Class I- Insufficient information.

It could be noted that the groups of factors considered in NCS is slightly different from the factors considered in HRS. Exposure pathways are considered by both systems in a different manner. In HRS, the contaminant characteristics and receptors are considered as factors which influence the four migration pathways, which are the primary means to capture the adverse effects of contaminated sites. For example, the site received four different scores from four individual pathways (ground water, surface water, surface soil and air migration), which are combined to determine the overall site score out of hundred (100). On the other hand in NCS, "migration pathway" is another factor of similar significance to the contaminant characteristics and receptors contributing to the hazard potential of a contaminated site. In NCS the contribution of migration pathways is about one third of the total score; the rest of the score is based on the type of the contamination and the receptors.

NCS scores are driven primarily by Canadian regulations. An example of scoring guidelines and evaluation factor of a site is given in Table 2-2. It is clear from the table that when the groundwater quality is evaluated, the score is assigned based on Canadian Drinking Water Guidelines (CDWG). The same is true for other attributes as well. Because of this, several experts such as Butler and Petts (2000) remarked that it is difficult to apply CCME classification to other jurisdictions as they relate to specific Canadian legislations.

The NCS does classify the contaminated sites in a rational and systematic manner, providing a consistent method for evaluating contaminated sites across Canada. This method addresses information gaps by assigning a score range as opposed to a specific score for a particular site. If only partial information is available for a site, the site may get a score range (e.g. 25-28), rather than a specific score (e.g. 27).

Table 2-2: Example Scoring Guideline for NCS (CCME, 1992)

Category	Evaluation factor: Groundwater	Scoring guideline
Exposure Pathways	• Concentration of contamination significantly exceeds CDWG by two times	11
	• Concentration between one and two times of CDWG	6
	• Meets CDWG	0

The NCS is flexible for various special conditions where the user has the option to downplay the score if the waste itself is of a higher concern but the particular site is not as adversely contaminated. For example, if there is an old contaminated site where most of the radioactive waste has decayed, the user may significantly reduce the high score assigned because of the higher concern associated with the radioactive waste (CCME, 1992).

The NCS has been an important tool for management of contaminated sites in Canada since 1992. In 2005 Soil Quality Guidelines Task Group (SQGTG) reviewed the CCME classification and recommended updating the CCME classification to limit its subjectivity, reflect more recent soil quality guidelines and include information specific to northern landscapes (CCME, 2005). Several changes were made to the original CCME classification following the SQGTG recommendations and a revised ranking system was developed (revised NCS) in 2005. This new system - the Federal Contaminated Sites Accelerated Action Plan Contaminated Site Classification System - is a revised version of the original NCS.

In the original NCS classification each site had only one final score. In case of any possible uncertainties, a site was assigned a range of score. This updated version of CCME attempts to resolve the issues of uncertainty by expressing the overall score of a site in two inbuilt components. The *uncertain part* of the score is given as the *raw potential score*, whereas the certain part of the score is given by the *raw known total score*. The *raw total score* is given by:

Raw total score = Raw known total score + Raw potential total score ....[2.1]

Moreover, the focus of this new version of CCME is more on science behind the overall risk management issues. The system made the "Qualified Professionals" responsible for justifying their decision making by providing description of their Site Specific Risk Assessment (SSRA).

The revised NCS system has also proposed to incorporate the factors specific to the proposed land use. This is an important attempt to evaluate the "future use" of a site and incorporate redevelopment potential as opposed to just human health and risk. However, the consideration is mostly limited to the exposure related characteristics. The planning, social and community wellbeing related characteristics have not been associated with the redevelopment potential.

Lastly, this revised NCS system integrates factors specific to sites located in northern regions. The system allows the user to incorporate factors outside the range of checklist questions and is adaptable to the specific needs of the users. The revised NCS has only been recently proposed and opened for public review, and its final form has not yet been released as of this writing.

Classification of Aquatic Contaminated sites (EC, 2005)

The NCS is not developed for assessment of a site with significant aquatic influence (marine sites). A method for risk ranking of contaminated marine and aquatic sites on Canadian federal properties was formulated by the Department of Fisheries and Ocean. This classification scheme relies upon the Canadian Sediment Quality Guidelines for Protection of Aquatic Life adopted by Canadian Council of Ministers of the Environment (CCME, 1998).

In order to apply this classification scheme, each attribute which contributes to the risk of a marine site is assessed numerically using a parameter called the "Probable Effect Level (PEL)". The concentrations above PEL limits are expected to produce adverse effects on biological species. With the help of a prioritization scheme proposed by Long and McDonald (1997) four relative types of aquatic contaminated sites were defined based on the PEL score of the marine sites. The Ranking scheme is given in Table 2-3. The system is analogous to the NCS scheme.

Table 2-3: Ranking Matrix for Potential Marine and Aquatic Sites of Concern (CCME, 1998)

Relative Priority Ranking	Determination of Relative Priority Ranking	NCS-type Hazard Ranking Score
Highest Priority Sites	Mean of (mean sample PEL quotients)> 2.3 and/or 21 or more PEL's exceeded	1
Medium-high Priority Sites	Mean of (mean sample PEL quotients) 1.51-2.3 and/or 6-20 PEL's exceeded	2
Medium-low Priority Sites	Mean of (mean sample PEL quotients) 0.11-1.5 and/or 1-5 PEL's exceeded	3
Lowest Priority Sites	Mean of (mean sample PEL quotients) <0.1 and/or No ISQGs exceeded	N

Rapid Hazard Assessment System (RHAS) (NZ MFE, 1993)

The Rapid Hazard Assessment System (RHAS) was designed by the New Zealand Ministry for the Environment (NZ MFE) in 1993 for evaluating brownfield sites consistently with regard to the potential environmental risk. Identical to NCS classification RHAS involves assessing contaminant characteristics, exposure pathways, and receptors at a site. This scoring is very similar to NCS and the scoring criteria and cut off scores for each class is designed based on Canadian guidelines. Minimal changes are made to make the scheme applicable to New Zealand.

Risk Screening System (RSS) (NZ MFE, 2004)

Risk Screening System (RSS) is a simplified version of RHAS published by Ministry for the Environment of New Zealand in order to avoid certain complications where rapid screening is required. RSS is designed to partially replace the RAHS discussed in the previous section. However, it was anticipated that there may be situations where RAHS may be more desirable (NZ MFE, 2004).

Similar to NSC, the RSS is a risk based screening tool. It uses a set of attributes to indicate the relative risk of a site which is expressed as a number ranging from 0-1. The three categories of brownfield sites are defined as: 1) a high-risk site, 2) a low-risk site and 3) a medium risk site based on the overall score.

Challenges of Applying Type 1 Classification Systems

All of the Type 1 Classification systems described above are established on the impact or potential impact of sites on human health and environment. The two most significant ones in North America are HRS and NCS. However, neither can address specific factors such as technological, legal, political and/or socioeconomic aspects and many other contextual attributes which are keys to any redevelopment efforts. Also, all these systems only consider the present site with contamination existing on the site but do not capture the characteristics of the future site (apart from the revised NCS which have some simplistic provisions for future use) after the redevelopment has taken place. Also, the risk based score cannot be easily translated into a form that effectively addresses liability, one of the major concerns of the developers (ECO, 2005). Therefore, Type 1 classifications can be used to prioritize remediation needs based on health risks but not redevelopment potential.

2.2.2 Type 2: "Financial Incentive" Based Classification Systems

The Type 2 classification systems were used to categorize the brownfield sites on the basis of economic status or possible financial incentives. Three such classification systems are discussed in this section.

Three-Tier Classification by NRTEE (2003)

The NRTEE report "Cleaning the Past Building the Future" (2003) emphasized market return rather than on health risk and classified the brownfields in terms of their prospects for redevelopment into three general tiers. The characteristics of these three ties of brownfield are summarized in Table 2-4.

Table 2-4: Summary of Three Tier Classification developed by NRTEE (2003)

Types	Top Tier	Bottom Tier	Middle Tier
Definition	Properties whose market values significantly exceed the costs of remediation.	Properties whose remediation cost far exceeds the market value after remediation.	Properties whose remediation cost and redevelopment potential are high.
Percent of Contaminated Sites in Canada	15 to 20 percent.	15 to 20 percent.	60 to 70 percent.
Characteristics	Redevelopment is driven by market forces.	Cleanup costs far outrun any prospects for redevelopment in the near future.	Little prospect of remediation or reuse without strategic intervention to address the barriers.
Examples	Former industrialized sites - redeveloped without any outside assistance.	Sites in rural, remote or smaller urban areas.	Sites in established urban areas and along transportation corridors, where municipal services are available.

This three tier classification system by NRTEE shows an attempt to value market forces. In other words, the context of redevelopment potential of a site was recognized, as opposed to dealing with the site as an isolated piece of land with its direct impacts on human health.

This classification is simplistic and does not outline the general principles for redevelopment or address the complicated issues of a site that is in the middle tier and therefore might have the greatest amount of uncertainty as to what should be done. Health, liability and other issues are largely absent and it has been assumed that remediation could give rebirth to any site however adverse the contamination may be. The classification system briefly touched upon the importance of a strategic location, but did not detail it. However, the movement towards considering redevelopment potential and the context (e.g., market forces) likely rendered this system more useful to developers and could be considered more "redevelopment oriented" rather than just focusing on contamination issues. The system is mostly qualitative and is not integrated with quantitative information. Lastly, the definition of middle tier for this classification is somewhat vague and contradictory. If the middle tier sites have high potential for redevelopment, it is unclear why such sites would have little prospect for remediation and reuse without strategic intervention.

Financial Classification of Brownfield by aboutREMEDIATION (AR, 2005)

Another Type 2 classification formulated by aboutREMEDIATION (AR) is based on fiscal incentives. According to AR there are three types of financial classes of brownfield sites. These are: 1) positive value; 2) negative value; and 3) neutral value sites. The characteristics of these three are summarized in Table 2-5.

A positive brownfield is the one where; the difference between present value and market value of remediated site could provide return on investments. A neutral brownfield is the one which cannot generate any return on investments without upfront government assistance, or policy changes. Although the return is negligible, such sites do have some positive features. A negative value brownfield is a site whose value is minimal and without government support there will not be any redevelopment.

This classification is very similar to the NRTEE (2003) three-tier classification scheme, but the viability is decided primarily based on remediation and does not incorporate revitalization. This classification system is inclined to overvalue fiscal components and assumes these to be the driving forces which determine the prospects for redevelopment. However, this is likely true only if the site is assessed from developers' perspective rather than from a community's perspective. The comparison to determine viability of redevelopment is carried out between "as is" value and value after remediation of the land and not after revitalization of the land.

Table 2-5: Financial Classification of Brownfield Sites (AR, 2005)

Positive Value Sites	Neutral Value Sites	Negative Value Sites
Sites those are viable and profitable. Sites possess good location and development potential and no incentives are required. Represents 10-20% of current Brownfield market.	No gain on investment without upfront incentives or policy changes. Worthwhile for governments to invest and create incentives. The property has no value to a developer without upfront assistance. Represents 60-80% of current brownfield market.	Sites that are perceived as negative value. Properties may be orphan, abandoned, escheated. Land value is often very low. Allowances are mandatory. Cannot be developed without government involvements. Environmentally, socially and economically disputed. High-risk for investors and developers. Represents 10-20% of current brownfield market.

The brownfield redevelopment process involves two stages as shown in Figure 2-1: 1) remediation/cleanup and 2) revitalization. Remediation results in a cleaned up site; however, unless it is available for end use the financial viability cannot be completely assessed. Thus, the viability of redevelopment is not completely understood after remediation. A study by Chay and Greenstone (1999) estimated the effect of Superfund clean-ups on local housing price appreciation by comparing housing price growth in the areas surrounding the first 400 hazardous waste sites to be cleaned up through the Superfund program. A follow up analysis suggests that the benefits of Superfund clean-ups as estimated through the housing market are substantially lower than the $43 million mean cost of Superfund clean-ups (Chay and Greenstone, 1999). This indicates that the effect of cleanup may not necessarily result in increase in land value unless it is revitalized. Therefore, assessing the viability of redevelopment based on the difference between present value and value after remediation could leave out the importance of revitalization on the site. As with the NRTEE approach previously, AR classification scheme overvalues the fiscal component of risk and is mostly conceptual.

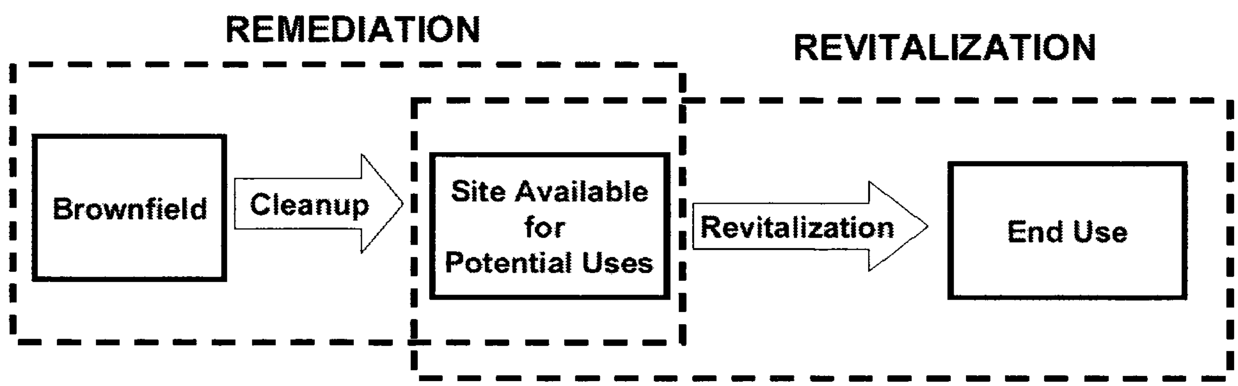


Figure 2-1: Stages of Redevelopment of a Brownfield Site

AR (2005) also stipulates that the above three site types can be moved from one classification to another depending on site conditions discovered, incentives and programs delivered, and the real estate deal struck. However, the mechanisms that could be applied to facilitate such a move are not given.

Brownfield Redevelopment Types: the A-B-C Model by CABERNET (CABERNET, 2005)

CABARNET (Concerted Action on Brownfield and Economic Regeneration Network), is a European organization that focuses on rehabilitation of brownfields in Europe. CABARNET adopts a perspective of examining the economic status of brownfield projects somewhat similar to aboutRemediation. Brownfields are divided into three major classes: A sites, B sites and C sites. The division between these sites is shown in Figure 2-2. Instead of focusing on cost and land value directly, this classification focuses on the integrated effect of cost and land value on the source of funding.

- A Sites - projects driven by private funding;
- B Sites - projects on the borderline of profitability and funded through public-private co-operation or partnerships; and
- C Sites - projects funded by mainly public sector or municipality because of the lack of profitability and low interest of any private organization to get involved

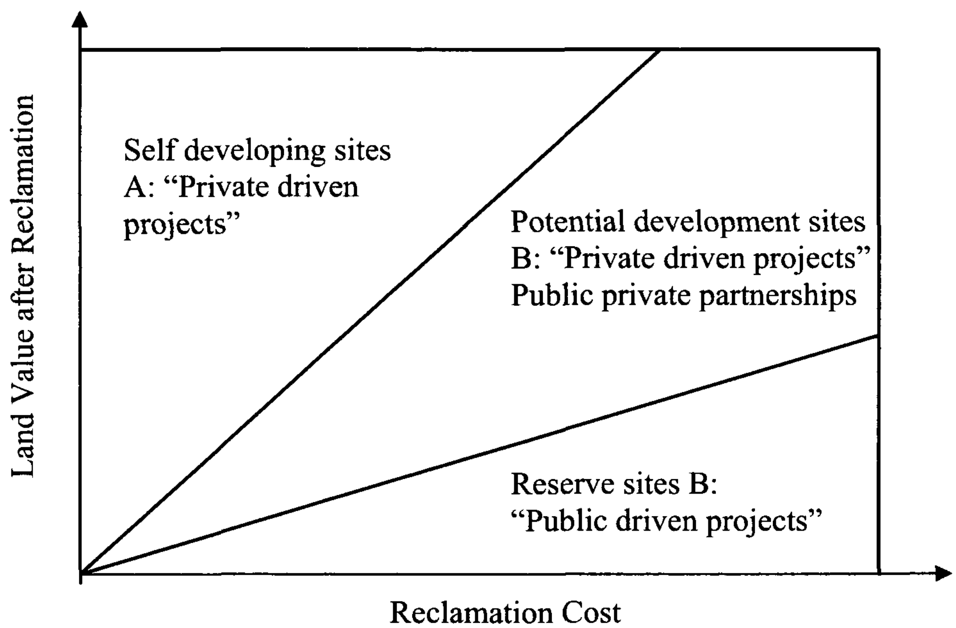


Figure 2-2: The Brownfield Redevelopment Types A-B-C Model (CABERNET, 2005)

The focus on partnership for funding makes this classification a useful tool for promoting redevelopment at a general level, particularly if it is necessary to engage with multiple stakeholders. However, the model lacks details about how to classify the existing sites, especially those that may lie within the transition zones between the different classes.

Challenges of Applying Type 2 Classification Systems

Type 2 classification systems attempt to capture the financial issues influencing the redevelopment process as the basis for classification as opposed to the attributes at the brownfield site. The underlying principles rely on comparing present value, remediation/redevelopment cost, and the value of the site after revitalization. While economics is a major driving force for redevelopment of any brownfield project, it is an oversimplification to use only the remediation cost and the land value. None of the Type 2 classification system could attempt to capture the offsite economic benefits of the redevelopment. For example, the economic benefit of rejuvenating a brownfield site may be minimal but the increase in tax base in the surrounding areas because of its rejuvenation may be quite significant. Furthermore, the Type 2 classification systems remain mostly qualitative as opposed to being data driven and do not incorporate social issues such as stigma in the post cleanup values of the land. This limits the scope for their extensive practical application. Health is also outside the scope of these classifications. They mostly focus on the fiscal component of all the incentives associated with the entire redevelopment process.

2.2.3 Type 3: Relevant and Critical Attribute Based Classification Systems

These are basically classification systems that do not fall under the Type 1 or 2 categories. This third category of brownfield classification systems involve attributes which could include but not limited to the effects of contaminants on human health and environment and financial incentives. These systems cover a diverse range of site based attributes such as geology, subsurface characterizations, and contextual attributes such as potential for redevelopment, past use or state of present use. The classification schemes are primarily established based on some critical attributes: the reoccurrence of these attributes results in some common redevelopment patterns, financial gains, and risk reduction and liability protection. However, in most of the cases the classifications are conceptual and qualitative and are not supported by quantitative screening methodologies and rigorous data analysis.

Examples of Type 3 systems include:

- Classification scheme based on subsurface characterization by HYGIA- an European R&D Project
- Typology of potentially contaminated sites by NRTEE
- Typology implied in the definition of a brownfield provided by NRTEE in 2003
- UK Based Classification System by Urban mines Ltd.

Classification Scheme Based on Subsurface Characterization by HYGIA- A European R&D Project (HYGIA, 2002)

This classification system is developed based on the subsurface characterization of brownfield sites. The project HYGIA (Hybrid Geophysical technology for the Evaluation of Insidious Contaminated Areas) was a European project to develop, test and apply innovative instruments and software for assessing brownfield sites. A portion of this project involved analyzing brownfield typologies and classified brownfields based on the past use of the land, typology of soil, geology and contaminants. Based on data from 206 sites, they grouped the site types and characteristics which occurred at a high frequency to develop a typology. The typology is essentially based on the current use of the site and is given in Table 2-6.

Table 2-6: The Selection of Typologies Identified by HYGIA Project (HYGIA, 2002)

Current Uses	Past Uses	Geology	GW table depth	Permeability	Soil Containment Depth	Main Containments
Abandoned Industry	Active Industry	Sedimentary	2	1.00E-01	1.8	TPH
	Agricultural	Fractured			0.85	Pesticides
	Refinery	Sedimentary	5-7.5/6-10	8.64E+00	5	Hydrocarbons
Petrol station	Petrol station	Sedimentary	5.25	5.00E-01	10.7	TPH, monoaromatic HCs
		Fractured	7	1.00E-02	1	Monoaromatic HCs
Residential	Active-industry	Sedimentary	22	1.00E+00	1	Mineral oils, metals
Commercial	Agricultural	Fractured		1.00E+03	8.75	TPH, monoaromatic HCs

Geologically relevant characteristics may reoccur and thus brownfields sites with similar characteristics could be grouped together and expected to have similar circumstances. However, in this case the choice of sites depended on the types of land use the project team encountered and found suitable for the project. Consequently, there is a possibility that the classification system could be biased and constrained. Also, it is strictly limited to site specific attributes and issues such as market forces; surrounding land use has no significance in this typology. The issues of future site use were not incorporated within the classification scheme.

Typology of Potentially Contaminated Sites by NRTEE (1997b)

In the background documents prepared by NRTEE on "Improving Site-Specific Data of Contaminated Sites" (1997b), they distinguished between contaminated and potentially contaminated sites. Contaminated sites were defined as the sites that are known to exceed certain environmental quality standards. Potentially contaminated sites were defined as those that have not yet been subjected to scientific measurement but, because of some indirect evidence such as past use, have a higher probability of showing contamination if investigations were conducted (NRTEE, 1997b).

In 1997 NRTEE classified all the contaminated/potentially contaminated sites into three basic categories: designated sites, non designated sites, and brownfield sites. It should be noted from above that that designated and non designated sites did not fit under the definition of "Brownfield" sites despite having the potential to become contaminated. The definitions of designated, non-designated and brownfield sites are as follows:

- **Designated sites** are defined as the designated waste disposal sites, including municipal and hazardous wastes and dredge spoils.
- **Non-designated sites** are defined as the properties that have not been used for waste disposal but because of their past or present land use are possibly contaminated.
- **Brownfield sites** are under-utilized or abandoned industrial and commercial sites.

Examples of these three major types of potentially contaminated sites, possible types of wastes, data and the risk associated with each of these individual contaminated sites are summarized in Table 2-7. The focus for this classification was investigating historical records, which is probably the most tangible and easy way of investigating and classifying a site.

Table 2-7: Examples of Potentially Contaminated Sites and an Initial Estimation of Information Availability and Risk Associated with them (NRTEE, 1997b)

Type of Site	Examples	Types of Wastes	Relative Risk
Designated Sites			
Disposal sites for industrial chemicals and wastes	Sainte- Marie Salome, Quebec	Refinery and other industrial wastes	Medium
Toxic and hazardous waste disposal sites	Ville Mercier, Quebec	Waste oils and solvents	High
Radio-active waste disposal/storage site		Radioactive hospital wastes	Medium
Non-Designated Sites			
Primary Industries (Agriculture, Fishing, Forestry and Mining)			
Mining sites	Deloro Mine Site, Deloro, Ontario, Weedon Mine, Fountainbleau, Quebec	Arsenic, acid water, heavy metals, waste rocks and mill tailings	Medium
Manufacturing Industries			
Manufacturing sites (general)	Cooksville Quarry, Mississauga, Ontario;	Petrolium by-products, hazardous industrial wastes; heavy metals, creosote, benzene, copper, lead, oil and mineral greases.	Medium
Oil refinery sites	Port Credit, Mississauga, Ontario	Organic compounds, petroleum	Medium
Transportation, communication, Services			
Road salt storage area		Road salts (could contaminate surface and ground water)	Low
Gas stations		Petroleum and petroleum by-products	Medium
Brownfield Sites			
Abandoned or underused industrial sites	Abandoned mines, industrial sites, oil wells	Mine tailings, hazardous chemicals	Medium
Abandoned or underused commercial sites	Former gas site stations, laundries	Gasoline	Medium

The classification touched upon briefly on some of the commonalities between contaminated sites with similar past use, in terms of the presence or absence of contaminations and risk. This strongly suggests that commonalities do exist between different contaminated sites with similar histories and a systematic taxonomy could identify these common characteristics and subsequently suggest common approaches to remediation and revitalization.

However, NRTEE acknowledged that sometimes it is difficult to link a source of contamination with the affected site, and admitted the importance of considering space and time dimensions for some of these contaminated sites (NRTEE, 1997b). For example, a hazardous release at one location can result in contamination of groundwater at another location. However, they did not extend their analysis to incorporate such offsite migration issues.

2.2.4 Typology Implied in the Definition of Brownfield Provided by NRTEE in 2003

In 2003, the NRTEE published a new report titled "Cleaning the Past and Building the Future" in which they defined brownfield more specifically as compared to the 1997 backgrounder reports described in previous section. Brownfields were now defined as:

> *Abandoned, idle or underutilized commercial or industrial properties where past actions have caused known or suspected environmental contamination, but where there is an active potential for redevelopment.*

The definition of brownfield was extended to both sites with known contamination and suspected contamination. They were also linked with an "active potential for redevelopment". However, the report did not define what was meant by "active potential for redevelopment". The definition itself indicates that there could be twelve possible combinations of three sets of attributes included in this definition, such as the state of usage, ownership, and presence of contamination. These are depicted graphically in Figure 2-3, and can be summarized as:

- Abandoned commercial sites with known contamination
- Abandoned industrial sites with known contamination
- Abandoned commercial sites with suspected contamination
- Abandoned industrial sites with suspected contamination
- Idle commercial sites with known contamination

- Idle industrial sites with known contamination
- Idle commercial sites with suspected contamination
- Idle industrial sites with suspected contamination
- Underutilized commercial sites with known contamination
- Underutilized industrial sites with known contamination
- Underutilized commercial sites with suspected contamination
- Underutilized industrial sites with suspected contamination

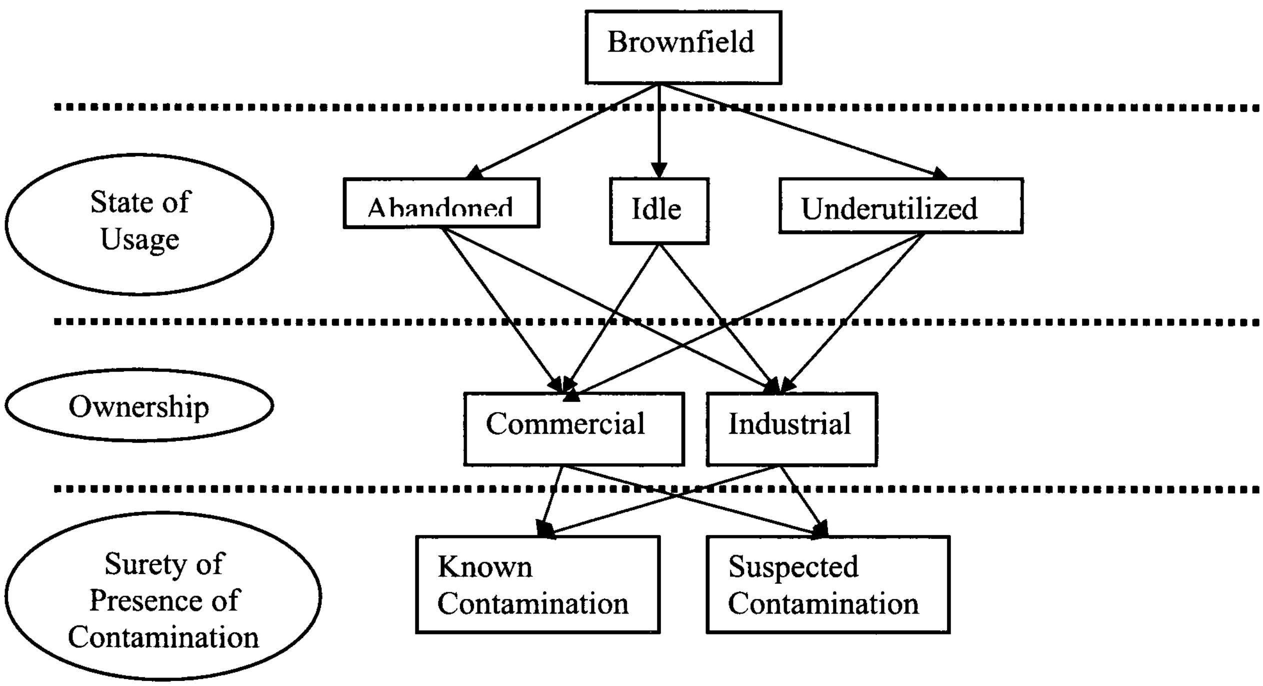


Figure 2-3: Brownfield Typology as per NRTEE Definition (2003)

This is a straightforward and simple method of classifying the contaminated sites, however the definitions of underutilized and idled were not clearly specified. The difference between abandoned, idled and underutilized could be confusing. However, in this dissertation the "abandoned" sites were considered as the ones that have not been used for several years and left derelict by former users or owners. The "idled" sites are the properties that have been recently rendered inactive, but not necessarily for a significant period of time and the owners or tenants have not necessarily left. There is also the expectation that the site could returned to productive use in the near future. The "underutilized" sites are the ones that are still being used but not at capacity; as a result, these sites could be idled or abandoned in the future.

In summary, the system is too simplistic and cannot be used to promote redevelopment or prioritize remediation.

UK Based Classification System of Contaminated sites by Urban Mines Limited (Alker et al., 2000)

This system was developed by Urban Mines Ltd. in the UK to classify the brownfield sites in terms of a wide range of characteristics according to the typology shown in Table 2-8 and against 38 site specific characteristics listed in Table 2-9.

Table 2-8: Typology of Brownfield Sites –Urban Mines Ltd. (Alker et al., 2000)

Type	Description
I	Vacant, available for immediate use
II	Vacant, partially occupied or utilized, available for immediate use
III	Vacant, requiring intervention
IV	Derelict, requiring intervention
V	Contaminated, requiring intervention
VI	Vacant and derelict, requiring intervention
VII	Vacant and contaminated, requiring intervention
VIII	Vacant, derelict and contaminated, requiring intervention
IX	Derelict and contaminated, requiring intervention
X	Vacant, partially occupied or utilized, requiring intervention
XI	Derelict, partially occupied or utilized, requiring intervention
XII	Contaminated, partially occupied or utilized, requiring intervention
XIII	Vacant and derelict, partially occupied or utilized, requiring intervention
XIV	Vacant and contaminated, partially occupied or utilized, requiring intervention
XV	Vacant, derelict and contaminated, partially occupied or utilized, requiring intervention
XVI	Derelict and contaminated, partially occupied or utilized, requiring intervention

Stakeholders surrounding the individual brownfield sites were surveyed to determine their opinions about the thirty eight characteristics associated with a site, as illustrated in Table 2-9. Based on this survey, the weight was assigned within a multi-objective evaluation analysis to determine which of these attributes are critical for any particular site. At the end of the evaluation process, a site is of one type and can have any number of these thirty-eight attributes. For example, site “A” could be of type of Type I of Table 2-8 (vacant and available for immediate use) and out of the thirty eight characteristics only “geological” and "pollution" could be the critical attributes for the site. This is the first classification scheme encountered which attempts to classify the sites using such an extensive set of attributes.

Table 2-9: Critical Characteristics of Brownfield sites - Urban Mines Ltd. (Alker et al., 2000)

Category	Characteristics
Environmental	• Ecological • Geological • Geotechnical • Pollution • Renovation and Reclamation • Topology • Water quality and supply
Economics	• Economic outlook • Economics of infrastructure • Economics of remediation • Economics of site development • Investment supply • Monetary incentives • Site economics
Social	• Community interaction • Crime • Demographic information • Education and training • Employment opportunities • Heritage • Recreation and leisure • Urban capacity
Overlapping	• Benefits • Costs • Development issues • Uses of sites • Infrastructure liabilities • Location • Perception • Planning instruments • Policy instruments • Post development impacts • Pre development impacts • Risk • Regional variations • Site availability • Statutory/ regulatory control

However, the classification scheme cannot be universally accepted as the stakeholders were specific to the given survey area. The local stakeholders picked some of the critical characteristics from a list provided to them for each of the brownfield investigated, and the classification was developed based on their opinion.

Like most other classification systems, it also does not take into consideration the attributes of future site uses after the site is cleaned up and revitalized.

Challenges of Applying Type 3 Classification Systems

Type 3 systems have a diverse basis for defining classes of brownfields, and these are compared in Table 2-10.

Table 2-10: Comprehensive List of Basis for Comparison for Type 3 Classifications

Typology	Basis for Comparison
Typology of Potentially Contaminated Sites by National Round Table on the Environment and Economy (NRTEE) in 1997)	• Past use
Typology Implied in the Definition of Brownfields Provided by NRTEE	• Stage of usage • Past use • Surety of presence of contamination
Classification Scheme Based on Subsurface Characterization by HYGIA	• Subsurface characters
UK Based Classification System by Urban mines Ltd.	• Availability • Degree of contamination • Necessity of intervention • Social attributes • Economic attribute • Environmental attributes

Most of the Type 3 classification systems identify the basis for comparison and outline the definition of different classes. However, none detail the methods for actually classifying brownfields and the possible action requirements as outlined in Type 1 systems where risk is the basis for the classification. All of the systems are somewhat subjective and are at a development stage.

2.3 SUMMARY OF AVAILABLE BROWNFIELD CLASSIFICATIONS

Type 1 classification systems provide a rational and systematic ranking method for brownfields based on their potential impacts on human health and environment. These rating processes, based on the respective national regulations, are achieved by screening the contaminated sites in terms of their potential to impact human health and environment and the associated risks (CCME, 1992).

However, Type 1 systems do not consider the many technological, social, economic and legal aspects associated with brownfields. Focusing primarily on risk reduction, this type of classification systems fail to incorporate many other significant contextual issues. However, the contribution of Type 1 classification systems can not be ignored in the development of more comprehensive taxonomy as they provide significant and relevant risk related information. The classifications can be used to prioritize remediation needs but not redevelopment potential.

Type 2 classification systems rely on the economics of redevelopment. However they are mostly qualitative. In most cases, they emphasize the fiscal component of redevelopment. Some of them ignore revitalization cost and only consider cost of remediation and post cleanup value of the land. However the land value after revitalization is a function of the end use, legal framework, social structure, community needs and many other issues which were not considered in the defined classes.

Type 3 systems differ from Type 1 or 2 systems which use a specific basis for comparison (e.g., risk, financial gain). These classification systems often have their own distinct basis for comparison, ranging from the present state of usage, to geophysical characteristics, to the degree of certainty of contamination.

Classification approaches based on contextual characteristics such as remediated value and as-is value (Type 2) require incorporating contamination, risk and liability issues, while a risk based classification requires more appreciation for the social and economic issues driving or hindering brownfield redevelopment. One of the major concerns of redevelopment of contaminated sites are the social issues such as community revitalization, community cohesion, job creation, increase in tax base, rejuvenation of the area etc. that are associated with the revitalization efforts. Deciding how to remediate and redevelop brownfield involves more than just remediation. Tam and Byer (2002) suggests that the owners and their consultants also need to understand aspects such as alternative site uses. Surprisingly, none of the existing classification systems incorporate the social dimensions of a redevelopment scenario to any significant degree. Lastly, most of these classification systems do not outline clearly the degree of information that is required in order to classify the contaminated sites according to the respective schemes. Only "risk" based classifications identified the information and investigations that are required to classify the sites. Other schemes did not outline with clarity the information needs and how the information is processed in order to classify the sites according to the concepts developed.

Developing a straightforward and useful classification scheme which incorporates more complexities into the system based on the amount of data available and the degree of multidisciplinary investigation carried out on site attributes should aid developers, municipalities, regulators and community to successfully better evaluate brownfield sites and promote their revitalization.

2.4 CLASSIFICATION APPROACH DERIVED FROM THE LITERATURE REVIEW

This investigation into existing classification systems and their diverse basis strongly suggests developing a rational and useful classification system for contaminated sites requires a multi-disciplinary and multi-stage approach. This could integrate a more diverse array of attributes within the same classification system. Incorporating social attributes into a comprehensive classification system could also be very valuable. Most of the existing classification systems do not outline clearly the degree of information that is required in order to classify the contaminated sites according to the respective schemes. In all likelihood, a user of any classification system will only have minimal or selective information to begin with and will subsequently "work through" increasing detailed levels of analysis. Developing a straightforward and useful classification scheme which incorporates more complexities into the system based on the amount of data available and the degree of multidisciplinary investigation carried out on site attributes should aid developers, municipalities, regulators and community to successfully better evaluate brownfield sites and promote their revitalization.

Based on the review of advantages and limitations of the available classification systems and the industrial partners' feedback, the proposed classification system is designed to have the following basic characteristics:

- Consider the views of different stakeholders, and can be used by them;
- Consider alternative end uses;
- Consider minimal information requirements.

The overall purpose is to develop a classification that allows for prioritization and tradeoffs, identifies barriers to redevelopment and enables the municipalities to use the system in any general brownfield situation to promote redevelopment. It was also recognized that the information availability can vary from very basic visual inspection to extensive site assessment reports and the classification system is designed to proceed from minimal/basic information requirement to detailed data analysis.

3.0 BASIC CHARACTERISTICS OF THE CLASSIFICATION SYSTEM

3.1 SUMMARY OF BASIC CHARACHTERISTICS OF THE CLASSIFICATION SYSTEM

3.1.1 Expectations of the Expert System

As discussed in Chapter 1 the central purpose of this research is to develop an expert classification system to effectively categorize brownfields and offer categorical solutions for repetitive brownfield scenarios without individual assessments. Unlike existing systems, this methodology has been specifically developed to serve as a tool to promote redevelopment. Because of that, instead of classifying the brownfield sites based on physical attributes (e.g., soil, geological profile, and contaminant concentration) they are categorized for their suitability towards various proposed redevelopment opportunities. The attempt is to capture the barriers associated with redeveloping the sites into different end uses, and to then categorize the sites based on how severe these existing barriers are and the extent of actions that are required to remove those barriers and subsequently promote successful redevelopments. The system is designed to be defensible and easy to use and takes into account different redevelopment opportunities. The brownfield sites are evaluated based on attributes of the site and their suitability towards various potential redevelopment opportunities. Even though the system is applicable to all the stakeholders, municipalities are given a special emphasis as they will likely represent the greatest number of stakeholders' interests in any brownfield revitalization effort. In short, it is assumed that a municipality's interests will represent to a reasonable extent a balance of interests of its residents, businesses, community groups, and other stakeholders.

3.1.2 Adapting a Tiered Approach to Overcome Data-gaps

Several of the existing brownfield classification and ranking systems require significantly large amounts of site information and analytical data as inputs. If a data gap occurs, in most cases the classification systems are substantially affected because in most situations the overall categorizations are sensitive to a lack of information. For example, the HRS score for a given brownfield cannot be evaluated when there is insufficient supporting data (Schruder, 2007). To overcome this limitation, the proposed classification system uses a tiered approach and incorporates three different levels to assess the information of three different levels of precision.

Under this tiered approach, the very first level is used to process the basic site information about a brownfield, when resources available are limited for carrying out an individual investigation. However, the higher levels of this framework prompt the user to input increased amounts of site information and analytical data for more refined categorization. Adapting a tiered approach allows the user of the classification system to begin (the first level) with minimal or selective information and subsequently "work through" increasing detailed levels of analysis under the reasonable assumption that correspondingly more information becomes available.

3.1.3 Non Numerical Approach in Overall Rating

As indicated in Chapter 2, most of the health and risk based classification systems use a numerical/quantitative approach that translates site attributes into a common score which is indicative of the potential contaminant-pathway-receptor scenarios (Petts et al., 1997). On the other hand most classifications that consider contextual attributes such as economic dimensions as the basis for categorization of brownfield are qualitative and descriptive.

Although a quantitative approach is preferred when the aim is an accurate and detailed description of the brownfield situation, a qualitative grounding becomes applicable when subjective data and individuals' interpretation of issues and situations (e.g. social perception, market forces, community cohesion) are significant (Creswell, 1994 and Neill, 2007), which is the case for brownfield categorization. Moreover, this classification system intends to be comprehensive and incorporates multi-disciplinary dimensions such as health, economics, social cohesion and infrastructure issues. Because of this, in many cases the site information is received in the form of situations, words and perceptions (Creswell, 1994), rather than in the form of numbers and statistics and as a result, a qualitative scoring method was more appropriately used. However, in several situations, especially in economics and health risk, a combination of quantitative calculations and qualitative approaches were used side by side in intermediate steps prior to arriving at the final descriptive score. In later chapters, a descriptive score is used at the final level of evaluations (e.g. risk, community) of this classification to maintain consistency during the evaluation of multidisciplinary attributes. This is also consistent with what the research partners have done previously in relation to the larger research project that this thesis is integrated into.

In this classification, the multidisciplinary attributes are grouped into four different categories (detailed in Chapter 4): land and infrastructure, economics, social/community, health. When there are barriers present in the respective categories, the corresponding categories are identified as the *Category Requiring Action* (CRA) and are eventually consigned an explanatory score of "high" (H), "medium" (M) or "low" (L) to indicate the extent of actions required to overcome the barriers associated with each of those categories of attributes that may prohibit a successful redevelopment. When there are no barriers associated with a site for proposed redevelopment it means that the given category of attributes already supports the proposed redevelopment and is designated as "Yes".

The "L" CRA score is assigned when there is a minimal barrier associated with redevelopment. For example, for health a score of "L" means that the site poses minimal health effects to the humans. Similarly, a score of "L" in economics means that the site has minimal economic barriers and a limited financial incentive can make the proposed redevelopment economically viable. On the other hand, an "H" score means there is a potential for significant negative barriers for redevelopment. For example, an "H" health score implicates a severe potential for harm to human health and corrective actions such as extensive remediation efforts should be undertaken. An "H" score for economics means significant amounts of economic incentives are required to ensure the financial benefit to the developer from the proposed redevelopment. The intermediate level between "H" and "L" scores is an "M" score. This means that the corresponding category requires moderate levels of action for the proposed redevelopment.

3.1.4 Time Dimension

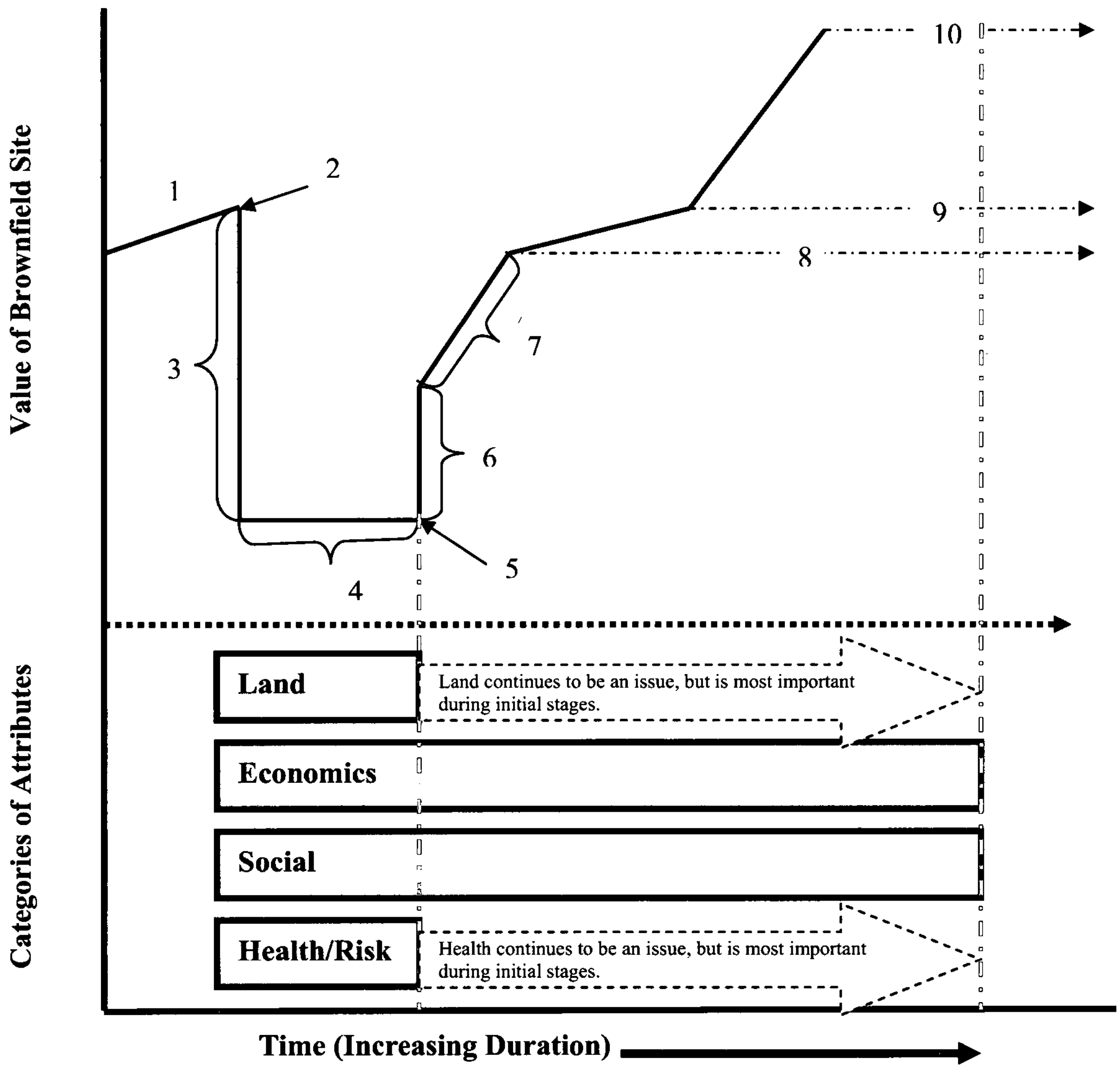
A brownfield redevelopment involves the long term use of an abandoned/idled/ underutilized property and the process of redevelopment is complex and time consuming (Lange and

McNeil, 2004). Any method for evaluation of brownfields should therefore be able to account for the dynamics of time. The upper portion of Figure 3-1 illustrates the range of site values obtained for different durations in time following the redevelopment effort (Mundy, 2001). Mundy (2001) suggests that after initial identification of the property as a brownfield, the property loses its market value. The loss of market value is based on assumption that the contamination is in its most adverse form. This is eventually overcome when the Environmental Site Assessments (ESAs) are conducted and environmental risk is quantified. At this point (referred as"5" in Figure 3-1) the value recovers to a point commensurate with the remediation cost and risk. The worse the contamination is, the lesser the amount of recovery (length of "6"). If the contamination is evaluated to be extremely adverse there may be no recovery of the value at this point. The value of the property increases during the remediation efforts and remains stable after the amount of contamination is decreased by remedial efforts. The attributes that are investigated in this classification lie in different points of time during this entire process of redevelopment.

As detailed in the subsequent chapters, in this classification, the multidisciplinary attributes are grouped into four different categories: land and infrastructure, economics, social/community, health. These attributes change significantly as the contaminant effects change over time. However, for the purpose of the proposed classification, we focus on these attributes only at that specific duration in time when they pose maximum barrier towards redevelopment. Despite the fact that the multidisciplinary attributes are evaluated within the same framework, some attributes are more important during the initial stages of redevelopment, while others span from beginning till the end of the redevelopment.

In Figure 3-1, the health, land and infrastructure evaluation in this study mainly signifies the conditions of attributes during the time span when the contamination problem is identified and the environmental risks are documented. During this period human-health risk and land/infrastructure attributes pose maximum barrier for redevelopment. On the other hand the economic and social evaluations carried out in this classification consider the market and community behavior for the entire time span extending up to the entire redevelopment effort.

The fact that health and land are considered to be an issue at the initial stages of redevelopment (Figure 3.1) does not mean that they cease after environmental investigation.



1. Normal value trend
2. Contamination problem - property looses marketability
3. Value drop
4. Uncertainty, difficult to quantify values
5. Environmental investigation complete, costs and risk documented
6. Value recovers to point commensurate with remediation cost and risk
7. Remediation program underway, value recovers as the amount of contamination decreases.
8. Property value stabilizes, permanent stigma retains the value below the normal
9. Temporary stigma, value returns to normal
10. Increase in value due to redevelopment

Figure 3-1: Influence of Time Dimension on the Proposed Brownfield Classification [Adapted from Mundy (2001)]

Rather, they pose the maximum barrier during that phase, and therefore the classification considers the evaluation of those two categories during the initial phase rather than evaluating them throughout the entire span of redevelopment.

3.1.5 Recognizing General versus Specific Scenarios by Raising Red Flags

The classification system recognizes that there are a number of brownfield situations that are so unique that it is not feasible to give them a generic trait-based feedback using the brownfield classification. These are the scenarios that are unique rather than recurring or categorical. For such situations an evaluation based on general principles and rules developed in this classification may not be appropriate. These types of unique situations are identified as the "Red Flag"s by the proposed framework. If the decision pathway leads the user to a "Red Flag", the user is recommended to proceed for expert opinions for the site evaluation, rather than carrying on an evaluation following the generic rules and decision pathways developed in this classification. All the algorithms laid out in this framework are for recurring situations and cannot be used "as-is" for very unique scenarios. Further investigations are recommended on the decision pathways that lead to a possible "Red Flag" issues.

3.1.6 Use of Default Values for Decision Making

Many of the benchmark values used for making decision (area, contaminant concentration etc.) have been adapted from available published documents or expert elicitations (e.g. discussions with experts). For many of these, little to no rationale was given to justify the industry practices/published values of these benchmarks. However, because of lack of information and research conducted in these fields, these benchmark values are used as default values. North American and Canadian standards have been used as standards benchmarks, if available, assuming it would be more practical for use if this classification system is applied for North American brownfields. However, the intention was to keep the key algorithms of the decision methodology as generic as possible so that its applicability is not limited to the geographical boundary.

3.2 CLASSIFICATION RESEARCH SCOPE AND BOUNDARIES

- This brownfield classification has been developed for evaluation of single use sites and cannot be used directly for evaluation of multiple use sites (more than one type of end uses). This situation will likely occur when the brownfield spans a very large area (e.g., multiple city blocks). When a multiple-use scenario needs to be evaluated using this system, they should be divided into several single use land parcels as shown in Figure 3-2 and each of these land parcels should be evaluated separately. However, in such situations the synergistic effects of the end-uses are overlooked by the system. For example if a site is used for development of a high density residential complex and a commercial store, the commercial development may have benefits of the new customer base created by the residential use. On the other hand, the residential units may increase in value because of the presence of a commercial store in the vicinity, as opposed to a stand alone residential unit in the same location. However, this classification system does not take this into account.
- Evaluation of sites contaminated with radiation is beyond the scope of this classification system. The public perception of radioactive sites is a complex area of investigation and involves concerns about the future generation as well as the generation of more contaminated waste. Therefore, such situations are beyond the scope of the proposed classification system, although elements of this system may prove useful in such situations.
- Brownfields that physically overlap with certain development resistant geographic and infrastructure features, such as wetlands, floodplains, airport operating areas, environmentally protected habitats are identified as *development constrained* sites and are only evaluated up to Level 2 and not beyond. Such sites are already subject to extenuating circumstances and need to be assessed on a case by case basis by experts. However, the majority of conventional brownfields (as defined by NRTEE) are not subject to such extenuating circumstances, as in most cases they have already been used for industrial or commercial applications in the past.
- The evaluation of severity of health risk within this classification system limits itself to the evaluation of effect of the single chemical compound found on site in its pure form that is likely to cause the greatest harm. This is an approach that intends to

capture the "worst *single* case" scenario. However, the consideration of synergistic or antagonistic effects of multiple chemical contaminants is beyond the scope of the proposed classification system. This is because the health effect of the toxicology of contaminant mixtures is not well understood (Asante-Duah, 1996). Furthermore, the inability to reduce health risk to a single, understandable parameter could render this brownfields classification too complex to be practically usable, and using a single contaminant reflects realistic practices currently. However, building in synergistic effects into the classification system is a future possibility.

- The ecological evaluation of brownfields is limited to terrestrial ecology. The evaluation of impacts on aquatic ecosystems is beyond the scope of this classification. Although certain extended brownfield sites in the vicinity of aquatic bodies may influence the neighboring aquatic ecosystems, it was assumed that most single use sites are of small to medium size and the ecological impacts of such sites would be more pronounced for the terrestrial ecosystem as opposed to the neighboring aquatic ecosystems. Moreover, most sites with significant potential to impact aquatic ecosystems (e.g., shorelines and flood plains) come under "development constrained sites" which are beyond the scope of advanced tiers in this classification system.
- Economic evaluation was carried out considering sites were sold after redevelopment and not "as is" or after "assessment only". Later chapters will show that this methodology could also be modified and applied to evaluate the economics of sites that are sold directly after cleanup and the outcome may not be same as when the sites are sold after redevelopment. However, it was recommended that the sites be evaluated assuming they were sold after redevelopment rather than when they are sold after cleanup. It can be reasonably assumed that the evaluation of sites sold after redevelopment are capable of providing the "true worth" of the site, independent of how the transactions may occur during the span of clean up and redevelopment.
- The social issues are integrated within the framework at a generic level. The classification system recommends the social indicators that should be used for the evaluation. However, detailed investigations on how those individual indicators should be combined are beyond the scope of the classification system. A separate research project is being conducted for that purpose.

3.3 ILLUSTRATIVE EXAMPLE

Each of the Chapters 5 through 11 illustrates distinct components of the proposed methodology, and the applicability of each of this particular component to the illustrative example (ABC Automotive Service Garage) is demonstrated with detailed calculations and flow diagrams at the end of the corresponding chapters.

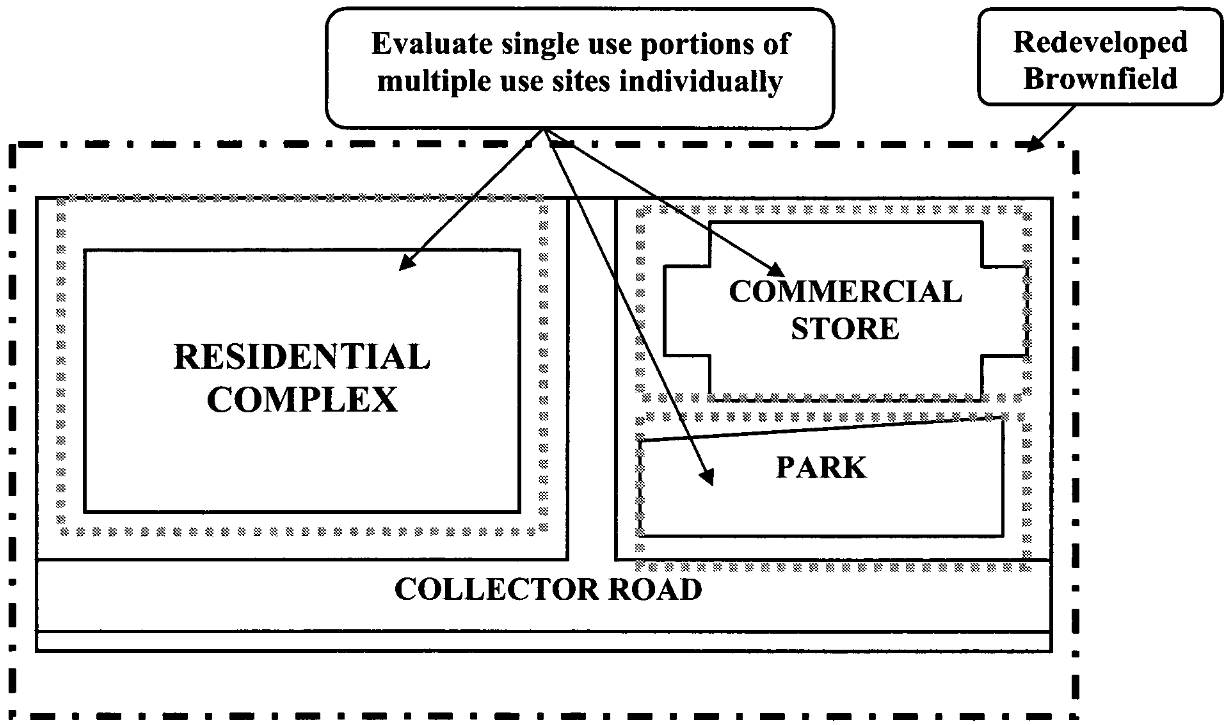


Figure 3-2 Single Use versus Multiple Use Sites

The site assessment results were provided from an actual Ontario case study, which were then combined with two hypothetical redevelopment options to establish realistic conditions of input-data used for an example site entitled ABC Automotive Service Garage. In some cases the available data were altered to better illustrate the applicability of the proposed classification system. In limited cases, no actual data were available so hypothetical values were used. Despite these modifications most data were gathered from Phase I and II ESA results from a real case study. Appendix A summarizes the key ESA results and redevelopment options that were used to generate the input data required for evaluating the illustrative example of ABC Automotive Service Garage.

4.0 METHODOLOGY

4.1 OVERVIEW OF APPROACH

In order to plan and promote redevelopment of brownfield properties within a municipality or a jurisdiction, the following three key questions should be addressed sequentially:

- *Which are the sites (known/potential brownfields) within a municipality that needs to be considered for improvement?*
- *What types of potential redevelopment could be considered for these "candidate" sites?*
- *If a potential revitalization option is pursued, what barriers need to be overcome in order to make the redevelopment effort a success?*

The proposed classification system attempts to answer these key questions by formulating three individual levels within the framework:

1) *Level 1: Screening the Status-quo Option.*
2) *Level 2: Screening the Limited Potential Site Uses.*
3) *Level 3: Classifying the Site Based on Basic End Uses.*

The complexity of information requirement increases from one level to the next. The multilevel classification system proposed in this research is shown schematically in Figure 4-1 and the objectives accomplished in each of these levels are detailed through an illustrative example in Figure 4-2. When increased information is available, an additional fourth level (Level 3-Advanced) could also be developed, which further refines the classification of brownfields derived at Level 3 as shown in Figure 4-1. A brief description of these levels, their objectives and methodology are illustrated in subsequent sections. Four hypothetical sites (site A, site B, site C and site D) have been used to better illustrate the various levels of this classification and their applicability for a given set of sites.

4.2 INDIVIDUAL LEVELS WITHIN THE FRAMEWORK

4.2.1 Level 1: Screening the Status-quo Option

The first key question outlined in the previous section is:

- *Which are the sites (known potential brownfields) within a municipality that needs to be considered for improvement?*

The first course of action that needs to be taken by a municipality is to prepare an inventory of any undesignated sites (including known/potential contaminated sites and idled/underutilized properties), that pose hazard to the local community or have characteristics that are dissimilar to generic situations (e.g. tax sale, generate lower taxes, economically undervalued compared to neighborhood sites). The very first level (Level 1) of the classification system deals with preparing this inventory and providing a broad classification of numerous undesignated sites to delineate action.

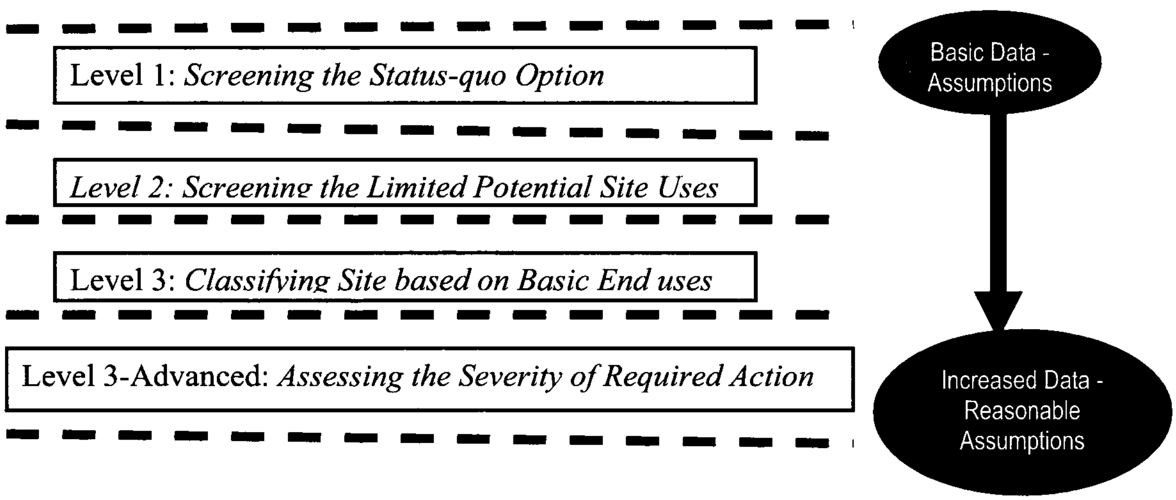


Figure 4-1: Levels of the Proposed Classification System

During Level 1 sites are screened for the status-quo option. This is essentially a non-intrusive rapid screening which could be carried out based on a site visit, historical maps or records of complaints and past assessments (if available to the municipalities). The screening is essentially done based on a straightforward checklist. The level leads to a broad classification of undesignated sites in order to prioritize redevelopment needs. The red square in Figure 4-2 schematically represents Level 1.

It could be observed from the Figure 4-2 that based on the answers to a checklist, in Level 1, the undesignated sites are categorized into two major groups: 1) *No Action Required* or *Status-quo Possible* and 2) *Action Required.* The sites under *Action Required* inventory are the ones that are recommended for further investigation for improvement. These sites are

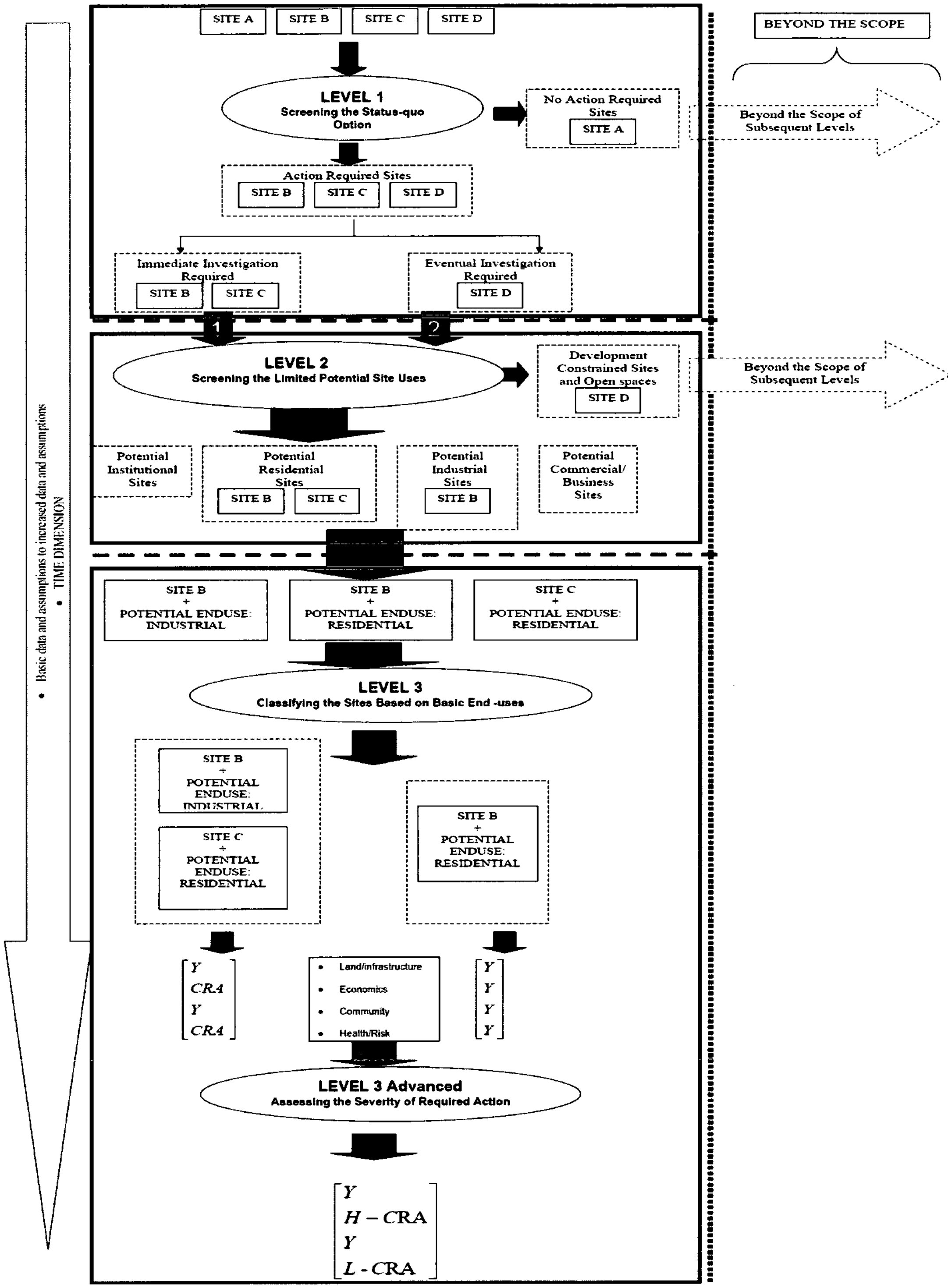


Figure 4-2: Classification System for Assessing and Promoting Redevelopment of Brownfield Sites

further classified into two sub-classes- i) *Immediate Investigation* sites and ii) *Eventual Investigation* sites. *Immediate Investigation* sites are the ones where the hazards could be potentially adverse and an investigation in the immediate timeframe for improvement is proposed. *Eventual Investigation* sites are the ones in which improvement needs should be considered in sequence following the immediate investigation sites.

In Figure 4-2, out of the four example undesignated sites (Site A, B, C and D), after Level 1 screening site A is designated as *No Action Required.* Sites B, C and D are chosen as *Action Required* sites. Among these three sites, B and C are the ones for which *Immediate Investigation* is proposed. For site D an *Eventual Investigation* is proposed.

4.2.2 Level 2: Screening the Limited Potential Site Uses

Once the inventory of *Action Required* sites have been identified in Level 1, the course of action for the municipality is to identify what are the potential revitalization options for these *Action Required* sites and identify the "Limited Potential" alternatives. The primary objective is to answer the second key question:

> *What types of potential redevelopment options can be considered for these "candidate" sites?*

Level 2 has been developed to identify the range of generally considered potential site uses for individual *Action Required* sites based on a municipality-designated standards and protocols. An initial set of siting standards and protocols have been extracted from the official master plans of Ontario and US cities for each of the following possible broad categories of end uses: industrial, commercial, residential, institutional, assembly and development constrained sites. The section within the blue square in Figure 4-2 schematically represents Level 2.

All the *Action Required* sites identified in Level 1 are screened for possible revitalization options and designated as *potential*:

- residential sites;
- commercial/business sites;
- industrial sites;

- assembly sites;
- institutional sites;
- As a combination of more than one of these based on the screening.

The sites may also be classified as development constrained sites or open spaces. The evaluation of these two site classes, are limited to Level 2 and not beyond.

Based on Figure 4-2, among the three *Action Required* sites (B, C and D), Site D, for example, is a development constrained site. Site B has two potential end uses – residential and industrial. Site C has only one potential end use – residential use. The evaluation of the development constrained sites (Site D in this case), stops after Level 2 and is beyond the scope of subsequent levels of this classification as previously discussed in Chapter 3.

The focus of Level 2 is to narrow the investigation in Level 3 so that when the possible barriers of redevelopment on a particular site is evaluated in Level 3, the user only works through site and end use combinations that offer significant potential in terms of redevelopment, rather than all possible site uses. However, it should be noted that under special situations it is still possible to have a "limited-potential" site use. However, such situations would likely require significant and perhaps extraordinary measures to facilitate such land use arrangements. This is further detailed with examples in Chapter 6.

4.2.3 Level 3: Classifying Sites Based on Basic End Uses

Once the potential combinations of *Action Required* sites and their potential end uses have been identified, it is essential to identify the barriers for any potential combination. In other words, the key question is:

> *If the potential revitalization option is pursued, what are the barriers that must be overcome to make the redevelopment effort a success?*

This is done by analyzing the individual site and each potential end use. The objective of Level 3 is to identify the suitability of a site for a proposed end use. The viability of a particular end use for a given site is assessed based on a series of deciding factors. These factors are grouped into following four major categories:

- Land and Infrastructure

- Economics
- Social/Community
- Health

Each of these categories is evaluated to determine if the corresponding category already supports the proposed end use ("Y" or yes), or if some action is required to remove the existing barriers of the respective category in order to achieve the targeted end use. If the system evaluates that some action is required to overcome the barriers associated with a particular category, that category is designated as a *Category Requiring Action* (CRA). An example of required action might be a grant or low interest loan designed to specifically provide more incentives to redevelop a brownfield site and overcome its economic barriers. For such a brownfield site, the category economics will be designated as a CRA.

The end result can be represented by a 4 x 1 matrix that signifies how suitable the site is for a proposed end use. As an example, the previous Figure 4-2 shows the following site and end use combinations as the classification system moves from Level 2 to Level 3:

- Site B with Potential End-use: Residential
- Site B with Potential End-use: Industrial
- Site C with Potential End-use: Residential

In Level 3 each of these above combinations are evaluated for their barriers and corresponding action requirements in the four individual categories and results in the matrices given in Table 4-1. The process flow diagram for Level 3 is illustrated within the green square in Figure 4-2. The resulting matrices are given in Table 4-1 and these matrices decide the class/characteristic combination of a particular brownfield site. For example, Site B with industrial and Site C with residential end use lead to the same class or characteristic combination $\begin{bmatrix} Y \\ CRA \\ Y \\ CRA \end{bmatrix}$ where land/infrastructure and community support the end use. However, there are barriers associated with economics and health that needs to be overcome and these are categories requiring actions. The action required to change economics from "CRA" to "Y" could be providing some government grants. Similarly, for the second "CRA", health, some remedial actions may be suggested.

Table 4-1: Example Output-Matrix of Level 3

Output Matrix for Level 3	Site B with Potential End-use: Residential	Site B with Potential End-use: Industrial	Site C with Potential End-use: Residential
Land and Infrastructure	*Y*	*Y*	*Y*
Economics	*Y*	*CRA*	*CRA*
Social / Comunity	*Y*	*Y*	*Y*
Health	*Y*	*CRA*	*CRA*

Site B with the potential residential end use is the best situation with four "Y" s, which means the proposed end use has no barriers; the worst is if there are all four "CRA"s. If a developer intends to use this classification system and has already decided to have a proposed end use, he can start at Level 3 rather than Level 1 or 2, identify the categories that require action, and plan and promote appropriate actions to improve those categories for a successful redevelopment. This classification system, however, should not be used to justify predetermined end uses. Instead, it is for assessing the situation from a general perspective that can reveal important tradeoffs among all potential redevelopment scenarios.

4.2.4 Level 3-Advanced: Assessing the Severity of Required Action

When a potential site and end use combination is evaluated using the Level 3 of this classification system and a particular category is evaluated to be a "CRA", the extent of action required is not evident. That severity of action required could be extensive or minimal. For example, a "CRA" in the category of economics may signify that there is a minor barrier and a limited government grant or tax breaks can make the category of economics a "Y". On the other hand, it may signify that the project is of limited economic viability and extensive government assistance and continued support is required to push economics to "Y". This limitation of Level 3 prompts an additional level (Level 3-Advanced) for assessing the degree of required action. Level 3-Advanced further refines the classes and assesses whether the categories designated as a CRA require a "high" (H), "medium" (M), "low" (L) severity of action.

The classification system as a whole identifies the barriers for a successful brownfield redevelopment and categorizes them based on what needs to be done to promote successful redevelopment, so that proper action plans can be developed in order to plan and promote revitalization. Knowing the categories requiring action and extent of barriers that need to be removed in order to carry out a successful redevelopment can persuade developers to investigate the available resources, and municipalities to understand the status of the brownfields in their jurisdiction. Each of the above levels is explained in detail in Chapters 5 through 11 along with their illustrative examples.

4.3 EXPECTATIONS OF INFORMATION REQUIRED

Unlike the existing classification systems, the proposed classification system requires limited information to use Levels 1 and 2. Level 1 requires available information about historical site uses, potential physical and chemical hazards, zoning of the site and adjacent properties and information on any harm that is suspected to have been cauused by the site. Level 2 requires information about site location and accessibility. However, Level 3 and Level 3-Advanced require a complete Phase I and II ESA (including an estimate of remediation cost) and information about specific redevelopment options. These are further elaborated in Chapters 5 through 11.

4.4 APPLICABILITY OF THE PROPOSED CLASSIFICATION SYSTEM

There are expected similarities among brownfields in terms of infrastructure, health, subsurface conditions, revenue opportunities, community pressure and anticipated land uses: analyzing these circumstances should give rise to categories of brownfields which can be grouped according to common characteristics that lead to similar barriers for redevelopment. The ability to undertake such an interdisciplinary classification would be a significant advance in itself because it would render generally applicable data into circumstance driven categories.

In summary this expert classification system would serve as an integrative, decision support tool and:

- Demonstrate the financial (e.g., economics) and non-financial (e.g., community, health) benefits of development;
- Isolate situations where development may be questionable; and
- Offer categorical solutions for recurring brownfield scenarios.

Moreover, developing such a classification scheme for brownfields based on the need of action would assist in more effective and efficient redevelopment strategy selection for both the municipalities and the developers. When redevelopment strategies are selected often the tradeoffs become inevitable. By investigating the action requirements this classification system would provide useful information about the tradeoffs and enable different parties to articulate their concerns with reference to clearly and commonly laid out terms.

5.0 LEVEL 1: SCREENING THE STATUS-QUO OPTION

This chapter presents the classification methodology for the first of the four levels, the *Level 1: Screening the Status-quo Option* as well as an illustrative example to demonstrate its use.

5.1 OVERVIEW OF LEVEL 1

In order to plan and promote redevelopment of brownfield properties within a municipality, the municipalities need to identify:

> *Which are the sites (known/potential brownfields) within their jurisdiction that needs to be considered for improvement?*

Therefore, the first course of action that needs to be pursued by a municipality is to prepare an inventory of any undesignated sites (including known/potential contaminated sites and abandoned/idle/underutilized properties) that pose hazard to the local community or have characteristics that are dissimilar to typical site circumstances (e.g., tax sale, generate lower taxes, economically undervalued compared to neighborhood sites). The purpose of creating this inventory is to eliminate the sites that do not require immediate attention, and to instead focus on immediate and potentially hazardous sites and efficient resource management.

The output of Level 1 is an inventory of properties identified for improvement in order to delineate action and can include sites without environmental issues/concerns but it is *not* a brownfields inventory because it is expected that there is insufficient proof at this stage to substantiate contamination, physical hazard etc. and designate the site as a brownfield. To designate a property identified for improvement on a "brownfield inventory" at Level 1 without proof may lead to legal recourse and contempt from the property owner and community (AR, 2005).

Level 1 of the classification system deals with preparing the above mentioned inventory and screens the sites for the status-quo option. Level 1 screening uses information from site visits, historical maps or records of complaints and past assessments (only if available to the municipalities) and compares them against a checklist. The level leads to a broad classification of undesignated sites in order to prioritize redevelopment needs and this process is shown in Figure 5-1. Based on the answers to the checklist, the undesignated sites are categorized into two major groups: 1) *No Action Required* or *Status-quo Acceptable* and 2) *Action Required.* The sites under *Action Required* inventory are the ones that are recommended for further investigation for improvement. These sites are further classified into two sub-classes: i) *Immediate Investigation* sites, and ii) *Eventual Investigation* sites. *Immediate Investigation* sites are the ones where the hazards could be potentially adverse in the immediate timeframe or right away and an immediate investigation for improvement is therefore proposed. *Eventual Investigation* sites are the ones in which improvement needs should be considered in sequence following the *Immediate Investigation* sites.

Based on the limited information gathered from the checklist, Level 1 also predicts (within limited reliability) the major groups of contaminant that are likely to be present in the *Action Required* sites, so that the municipalities could be guided to screen the possible investigation and remedial technologies based on the existing information, if and when required. However, Level 1 is not designed to be used as the sole basis for identifying the nature of the potential contamination of an *Action Required* site. This information should be used only as guidance if/when future investigation is planned by the respective municipalities. Since the information collected at this stage is a readily available subset of Phase I Environmental Site Assessments (ESA), more comprehensive information surrounding a site should lead to a more dependable site classification.

In summary, the objective of Level 1 is to:

- Screen the numerous undesignated sites within a municipality for status-quo option and prepare an inventory of any undesignated sites that could create hazards to the local community.
- Provide a perspective on the major groups of contaminants that are likely to be present at those inventoried properties where status quo is unacceptable.

5.2 INFORMATION REQUIREMENT

Level 1 functions as a "desktop study" and requires the following information:

- A complete identification of the site – street address, location.

- Previous and current use and zoning.
- Current use (if any) and zoning of adjacent premises.
- Records of complaints from the local residents received by the municipality.
- Results of any earlier site assessments (if available).
- Information on any environmental/regulatory orders/complains against the site.
- Detailed photograph/visual inspection of hazardous substance, physical features that are likely to be present because of the historical uses/site activities/infrastructure/offsite migration of chemicals through the environment (e.g., odors, wells, pits, ponds or lagoons, surface pools of liquids, drums or storage containers, stressed vegetation, piles of solid wastes).

The information required is essentially a subset of the information collected during a *Phase I ESA*. The details required are based primarily on available data and that is already known to the municipalities, or can be acquired without extensive field sampling or the intensive involvement of a qualified assessor.

5.3 DECISION CRITERIA AND ASSESSMENT

5.3.1 Level 1 Checklist

The obtained information is used to complete the two page "Level 1" checklist which has been developed in this research and shown in Figure 5-1. It has two sections:

- Section I: Site Information - This section uniquely identifies the site that is being assessed and certain criteria specific to the site for assessing the impacts of hazard (e.g. site accessibility, past use).
- Section II: Likelihood of Potential Hazard - This section outlines the nature of potential chemical/physical hazards that are likely to be present at the site based on available information related to historical use, site activity or infrastructure. It includes information about the substances that may have been disposed, deposited and stored at the site because of past activities.

Figure 5-1: Level 1 User Checklist

PART I

I. SITE INFORMATION

1. Site Name:

2. Street Address:

3. City/County: **4. Postal Code:**

5. Known Historical Use(s) of Site:

- ☐ Agricultural
- ☐ Battery recycling and disposal
- ☐ Chemical and Dye manufacturing
- ☐ Chlor-alkali manufacturing
- ☐ Cosmetics manufacturing
- ☐ Drum recycling
- ☐ Dry cleaning
- ☐ Gasoline stations
- ☐ Glass manufacturing
- ☐ Hospitals
- ☐ Incinerators
- ☐ Landfills/ dumps
- ☐ Leather manufacturing
- ☐ Machine shops and metal fabrication
- ☐ Manufactured gas plants and coal
- ☐ Gasification
- ☐ Marine maintenance
- ☐ Metal plating and finishing
- ☐ Metal recycling and automobile salvage
- ☐ Munition manufacturing and ordinances
- ☐ Mining
- ☐ Painting and automobile body repair
- ☐ Pesticide manufacturing and use
- ☐ Petroleum refining and use
- ☐ Pharmaceuticals manufacturing
- ☐ Photographic film manufacturing and development
- ☐ Plastic manufacturing
- ☐ Printing ink manufacturing
- ☐ Railroad yards
- ☐ Research and educational instituitions
- ☐ Semiconductor manufacturing
- ☐ Smelter operation
- ☐ Underground storage tank
- ☐ Vehicle maintenance
- ☐ Wood preservation
- ☐ Wood, pulp and paper manufacturing
- ☐ Other industrial/ commercial, Please specify_________
- ☐ No past industrial/commercial occupancy
- ☐ Vacant

6. Current Use of the Site:

☐ Parklands ☐ Industrial ☐ Commercial
☐ Institutional ☐ Agricultural ☐ Residential
☐ Childcare pre/primary school ☐ Other, specify__________

7. Status of Current Use: ☐ Abandoned ☐ Idled ☐ Underutilized ☐ Active Use

8. Future Use of the Site (if known):

9. Land Use/Zoning of Adjacent Properties May Include (you may chose more than one):

☐ Parklands ☐ Industrial ☐ Commercial
☐ Institutional ☐ Agricultural ☐ Residential
☐ Childcare pre/primary school ☐ Other, specify__________

10.Accessibility of the Site : ☐ Controlled access
☐ Uncontrolled access

11. Neighborhood Type: ☐ Rural ☐ Urban ☐ Semi-urban

12. Location is Strategic with a Potential for Redevelopment
☐ Quite likely ☐ Not Likely

13.Tax sale*: ☐ Yes ☐ No

*Properties available for sale due to tax arrears.

PART II

II. LIKELIHOOD OF POTENTIAL HAZARDS

1. POTENTIAL CHEMICAL HAZARD

Chemicals suspected to be disposed, stored, deposited, used at the site:

	Quite Likely	Not Likely
Acids and bases	☐	☐
Batteries	☐	☐
Cleaning products	☐	☐
Coal tar	☐	☐
Solvents/degreasing agents	☐	☐
Petroleum products (diesel fuels, gasoline, motor oil, oil sludge and waste oil)	☐	☐
Dyes, pigments and inks	☐	☐
Explosives and ordinances	☐	☐
Fertilizers	☐	☐
Insulations	☐	☐
Paints	☐	☐
Plastics	☐	☐
Polymers and epoxy compounds	☐	☐
Pesticides (herbicides and insecticides)	☐	☐
Refrigerants and coolants	☐	☐
Soaps	☐	☐
Surfactants	☐	☐
Waxes	☐	☐
Hydraulic fluids and lubricants	☐	☐
Others, specify	☐	☐

Suspected potential sources of contaminant:

	Quite Likely	Not Likely
Surface spill or discharge	☐	☐
Dumping/ burial of waste	☐	☐
Drums/ storage containers	☐	☐
Septic tank/lateral field	☐	☐
Underground tank/piping	☐	☐
Aboveground tank/piping	☐	☐
Lagoon or ponds	☐	☐
Adjacent property	☐	☐
Pipeline release	☐	☐
Seepage pit / dry wall	☐	☐
Others, specify	☐	☐

2. POTENTIAL PHYSICAL HAZARDS*

	Quite Likely	Not Likely
☐Unstable stacked material	☐	☐
☐Sharp objects	☐	☐
☐Old or exposed wiring	☐	☐
☐Uncovered or unmarked holes/pits	☐	☐
☐Unsafe/crumbling infrastructures	☐	☐
☐Confined spaces	☐	☐

3. ANY HARM THAT ARE SUSPECTED TO HAVE BEEN CAUSED BY THE SITE

☐Reported/known cases of illness or health impairment among people
☐ Reported/known lower growth of vegetation
☐Reported/known cases of animals dying at the site

* Physical hazards have been adapted from public safety pathways of Schruder (2007)

The user has two options for specifying the potential hazards:

- *Quite Likely*: There is a *substantial* chance based on past activities, known/reported events or existing infrastructure features that the given hazard is likely present at the site.
- *Not Likely*: There is only a *limited* chance based on past activities, known/reported events or existing infrastructure features that the given hazard may be present at the site.

The intent of using "Quite Likely" and "Not Likely" as opposed to "Yes" and "No" is to address the possible uncertainty because during Level 1 the information available may not be as accurate or complete.

5.3.2 Sorting the Checklist Information and Level 1 Grouping

The information obtained from checklist is grouped into two categories: evidence of potential hazard, and impact escalator.

Evidence of Potential Hazard

This evidence consists of information or observations that lead to the potential presence of a physical or chemical hazard (e.g., visual or olfactory perception, known information are designated as the evidence of potential hazards). The chemical hazard could be from historical uses (described in Part I of checklist), activities, or infrastructure (described in Part II of the checklist). A potential hazard exists if any of the following scenarios is true:

- Any of the answers to Part II questions are chosen to be "Quite likely"; that is, one of the following are selected:
    - Any potential chemical hazard;
    - Any potential physical hazard;
    - Any harm that is suspected to have been caused by the site; and
    - Any one of the specified site use options listed in Field 5 of Part I other than "No past industrial/commercial occupancy"; or "Vacant" are chosen.

If one of the above criteria is true the classification system assumes the presence of potential hazard and the site is now considered an *Action Required* site.

Impact Escalators

An *Impact Escalators* is site information that does not confirm the presence of hazard by itself; however when combined with the evidence of potential hazard, it significantly escalates the impacts posed by that hazard. The site is believed to meet impact escalator criteria if any of the following are true:

- Field 9 of Section 1 indicates that the land use/zoning of adjacent properties may include –agricultural, residential, pre/primary school, child care, and institutional.
- Field 10 of Section 1 designates - the accessibility of the site is "uncontrolled"
- Field 11 of Section 1 identifies the neighborhood as "urban and semi-urban".
- Field 12 of Section 1 indicates that the site is located at a strategic location with potential for redevelopment.
- Field 13 in Section 1 indicates the site is at "Tax sale"

If there is any of the above impact escalator criteria present at an *Action Required* site, the site is designated as *Immediate Investigation* site; otherwise the site is designated as *Eventual Investigation* site. Once the presence/absence of evidence of potential hazard and the impact escalators have been obtained from the checklist, the decision could be made on the category of the site. Figure 5-2 illustrates the decision criteria for Level 1. Figure 5-2 also shows that potential hazards themselves are insufficient to lead to an *Immediate Investigation*. Only when they are combined with an impact escalator does a site achieve an *Immediate Investigation* designation.

As an example, in Figure 5-3, out of the four undesignated sites (Site A, B, C and D) and after Level 1 screening, site A is designated as a *No-Action Required/Status-quo Acceptable* site. Sites B, C and D are chosen as *Action Required* sites. Among these three sites, B and C are the ones for which immediate investigation is proposed. For site D an eventual investigation is suggested. The output from Level 1 therefore results in a broad categorization of sites.

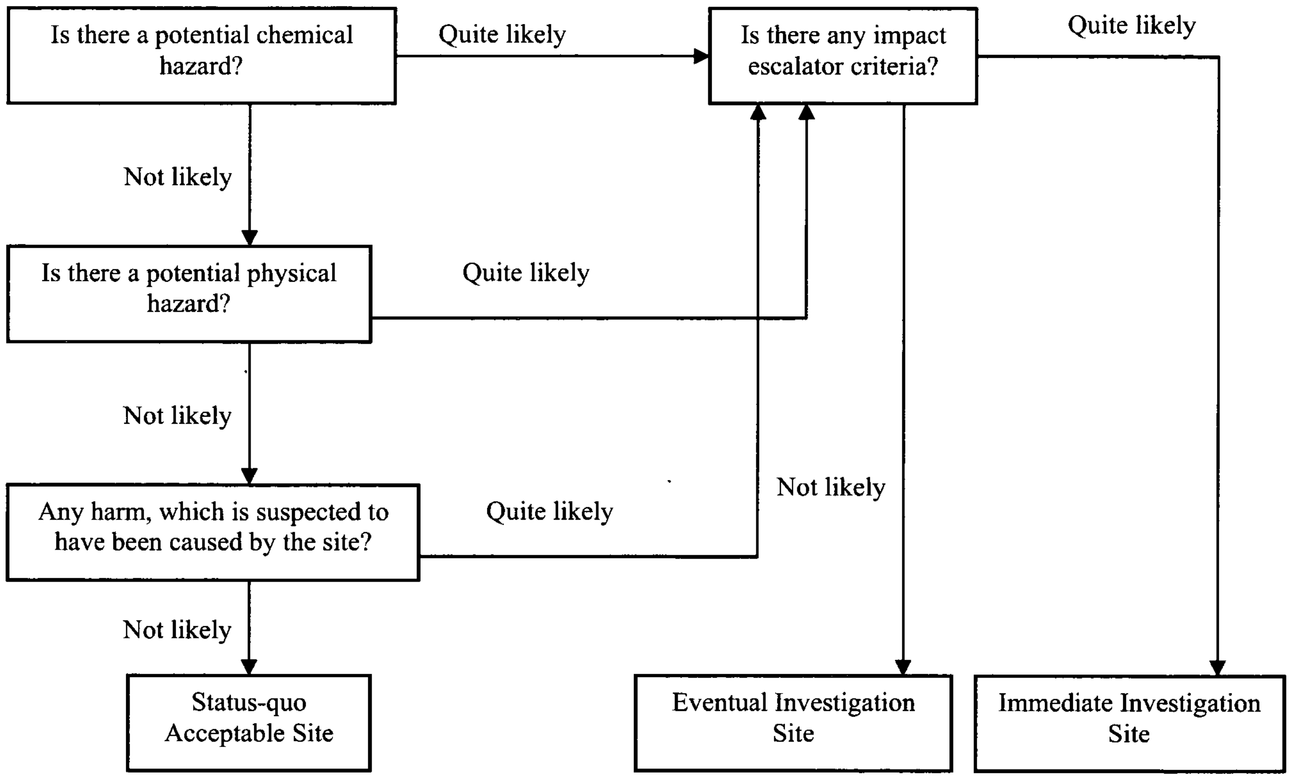


Figure 5-2 Decision Criteria for Level 1

5.3.3 Contaminant Perspective on Sites with Potential Chemical Hazard

If the information or observations gathered from Level 1 checklist lead to a potential evidence of presence of a chemical hazard, based on historical case studies Level 1 can also suggest the groups of contaminants that are likely to be present as a result of the activities that are carried out or chemicals that are disposed at the site. This could be determined if one of the enlisted historical use(s) are selected for the site and/or any of the enlisted chemical products are selected from Part II. At this level potential contaminants are grouped into seven major categories (FRTR, 2005 and US EPA, 2005):

- Nonhalogenated volatile organic compounds (VOCs).
- Halogenated volatile organic compounds.
- Nonhalogenated semivolatile organic compounds (SVOCs).
- Halogenated semivolatile organic compounds

- Fuels.
- Metals and metalloids.
- Explosives.

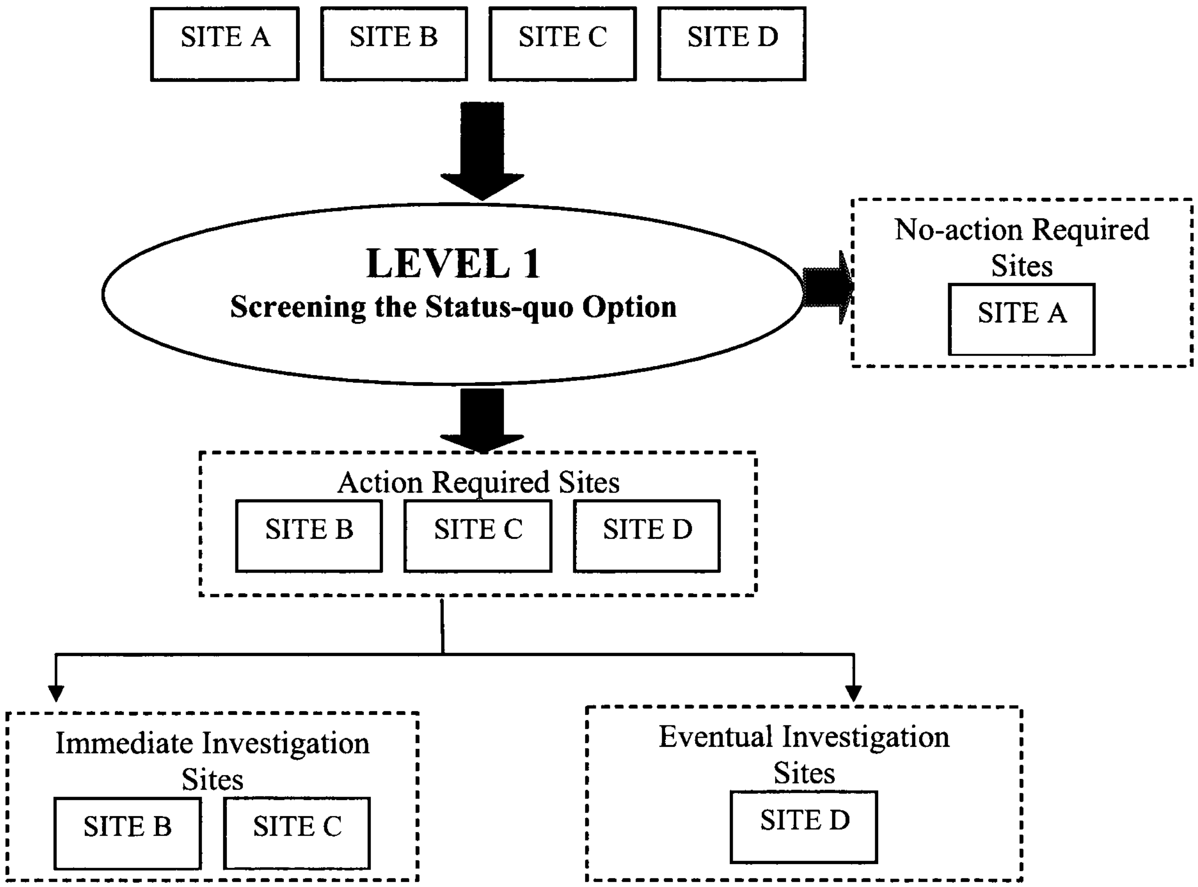


Figure 5-3: Level 1: Screening the Status-quo Option

Appendix B enlists the specific contaminants that are considered under each of these potential contamination categories. The tables in Appendix C list:

- The contaminant groups (given above) that are expected to be associated with each of the common historical site uses.
- Chemicals products that might be present because of the activities or infrastructure and whether they contribute to the seven major groups of contaminants. These chemical products contribute to the contaminants as well.

The information given in the tables are used by the classification system to summarize the contaminations that are likely to be present in the site that is being evaluated in Level 1. By scoping the possible groups of contamination, Level 1 helps in selecting suitable investigation procedures and remedial alternatives. In the end, Level 1 provides a broad categorization of numerous undesignated sites possessed by the municipalities. It also identifies the major group of potential contaminants that are likely to be present based on the site activities and historical uses at the site and provides a better understanding of the hazard associated with them. The exception to this is when the user does not identify the specific historical end use and selects the option "Other industrial/commercial end use" in Part I (historical uses).

5.4 SUMMARY

The Level 1 assessment is a rapid screening checklist approach and its output provides the municipalities with an estimate of the scope and extent of potential brownfield sites without extensive investigation. The objective is to provide a broad categorization of undesignated sites within a municipality based on available information so that municipalities can focus on the sites that need attention in immediate time span and subsequently promote improved resource management. The user/municipalities are expected to fill out a 2-page checklist based on easily acquirable/already available information and the checklist is processed to provide a better understanding of the hazard associated with the site. Incomplete or incorrect input information may influence the accuracy of the output of Level 1. However, when resources are limited this assessment guides the municipalities to eliminate the sites that do not need attention and focus on the sites that pose immediate hazards.

5.5 ILLUSTRATIVE EXAMPLE: LEVEL 1

5.5.1 Site Description

The following section shows an example Level 1 checklist for the case study considered in this dissertation entitled ***ABC Automotive Service Garage***.

5.5.2 Checklist

Based on the information the municipalities have, the historical uses of ABC Automotive Service Garage include:

- Painting and auto parts repair and vehicle maintenance.
- Gasoline station.

The following information on the site conditions was also available from Appendix A:

- The site is underutilized and is located at a mixed residential/commercial neighborhood in an urban location.
- No harm has been suspected to have been caused by the site.
- The site is not likely to have any physical hazard.

The completed Level 1 checklist is shown in Figure 5-4.

5.5.3 Decision Methodology

Evidence of Potential Hazard

After completing the checklist as shown in Figure 5-4, the answers to Part II questions are chosen to be "Quite Likely". Therefore there is a potential chemical hazard and ABC Automotive Services is considered to be an *Action Required* site.

Figure 5-4: Example Level 1 Checklist for ABC Automotive Service Garage

PART I

I. SITE INFORMATION

1. Site Name: ABC AUTOMOTIVE SERVICE GARAGE

2. Street Address: XXXXXXXXXXXX

3. City/County: Ontario **4. Postal Code: XXX XXX**

5. Known Historical Use(s) of Site: Gasoline station/Vehicle maintenance

- ☐ Agricultural
- ☐ Battery recycling and disposal
- ☐ Chemical and Dye manufacturing
- ☐ Chlor-alkali manufacturing
- ☐ Cosmetics manufacturing
- ☐ Drum recycling
- ☐ Dry cleaning
- ☒ Gasoline stations
- ☐ Glass manufacturing
- ☐ Hospitals
- ☐ Incinerators
- ☐ Landfills/ dumps
- ☐ Leather manufacturing
- ☐ Machine shops and metal fabrication
- ☐ Manufactured gas plants and coal
- ☐ Gasification
- ☐ Marine maintenance
- ☐ Metal plating and finishing
- ☐ Metal recycling and automobile salvage
- ☐ Munition manufacturing and ordinances
- ☐ Mining
- ☒ Painting and automobile body repair
- ☐ Pesticide manufacturing and use
- ☐ Petroleum refining and use
- ☐ Pharmaceuticals manufacturing
- ☐ Photographic film manufacturing and development
- ☐ Plastic manufacturing
- ☐ Printing ink manufacturing
- ☐ Railroad yards
- ☐ Research and educational instituitions
- ☐ Semiconductor manufacturing
- ☐ Smelter operation
- ☐ Underground storage tank
- ☒ Vehicle maintenance
- ☐ Wood preservation
- ☐ Wood, pulp and paper manufacturing
- ☐ Other industrial/ commercial, Please specify_________
- ☐ No past industrial/commercial occupancy
- ☐ Vacant

6. Current Use of the Site:

☐ Parklands	☐ Industrial	☒ Commercial
☐ Institutional	☐ Agricultural	☐ Residential
☐ Childcare pre/primary school	☐ Other, specify__________	

7. Status of Current Use: ☐ Abandoned ☐ Idled ☒ Underutilized ☐ Active Use

8. Future Use of the Site (if known):

9. Land Use/Zoning of Adjacent Properties May Include (you may chose more than one):

☐ Parklands	☐ Industrial	☒ Commercial
☐ Institutional	☐ Agricultural	☒ Residential
☐ Childcare pre/primary school	☐ Other, specify__________	

10.Accessibility of the Site : ☐ Controlled access ☒ Uncontrolled access

11. Neighborhood Type: ☐ Rural ☒ Urban ☐ Semi-urban

12. Location is Strategic with a Potential for Redevelopment ☒ Quite likely ☐ Not Likely

13.Tax Sale: ☐ Yes ☒ No

PART II

II. LIKELIHOOD OF POTENTIAL HAZARDS

1. POTENTIAL CHEMICAL HAZARD

Chemicals suspected to be disposed, stored, deposited, used at the site:

	Quite Likely	Not Likely
Acids and bases	☐	☒
Batteries	☐	☒
Cleaning products	☐	☒
Coal tar	☐	☒
Solvents/degreasing agents	☐	☒
Petroleum products (diesel fuels, gasoline, motor oil, oil sludge and waste oil)	☒	☐
Dyes, pigments and inks	☐	☒
Explosives and ordinances	☐	☒
Fertilizers	☐	☒
Insulations	☐	☒
Paints	☒	☐
Plastics	☒	☐
Polymers and epoxy compounds	☐	☒
Pesticides (herbicides and insecticides)	☐	☒
Refrigerants and coolants	☐	☒
Soaps	☐	☒
Surfactants	☐	☒
Waxes	☐	☒
Hydraulic fluids and lubricants	☒	☐
Others, specify	☐	☒

Suspected potential sources of contaminant:

	Quite Likely	Not Likely
Surface spill or discharge	☐	☒
Dumping/ burial of waste	☐	☒
Drums/ storage containers	☐	☒
Septic tank/lateral field	☐	☒
Underground tank/piping	☒	☐
Aboveground tank/piping	☒	☐
Lagoon or ponds	☐	☒
Adjacent property	☐	☒
Pipeline release	☐	☒
Seepage pit / dry wall	☐	☒
Others, specify	☐	☒

2. POTENTIAL PHYSICAL HAZARDS*

	Quite Likely	Not Likely
☐Unstable stacked material	☐	☒
☐Sharp objects	☐	☒
☐Old or exposed wiring	☐	☒
☐Uncovered or unmarked holes/pits	☐	☒
☐Unsafe/crumbling infrastructures	☐	☒
☐Confined spaces	☐	☒

3. ANY HARM THAT ARE SUSPECTED TO HAVE BEEN CAUSED BY THE SITE

☐Reported/known cases of illness or health impairment among people

☐ Reported/known lower growth of vegetation

☐Reported/known cases of animals dying at the site

* Some of the physical hazards have been adapted from public safety pathways of Schruder (2007)

Impact Escalators

Field 9 of Section 1 indicates that the land use/zoning of adjacent properties may include residential areas. This is an impact escalator. Therefore, the site is designated as an *Immediate Investigation* site. Because there is a potential chemical hazard, the Level 1 analysis reveals the potential chemical contamination by evaluating the historical uses and chemical products.

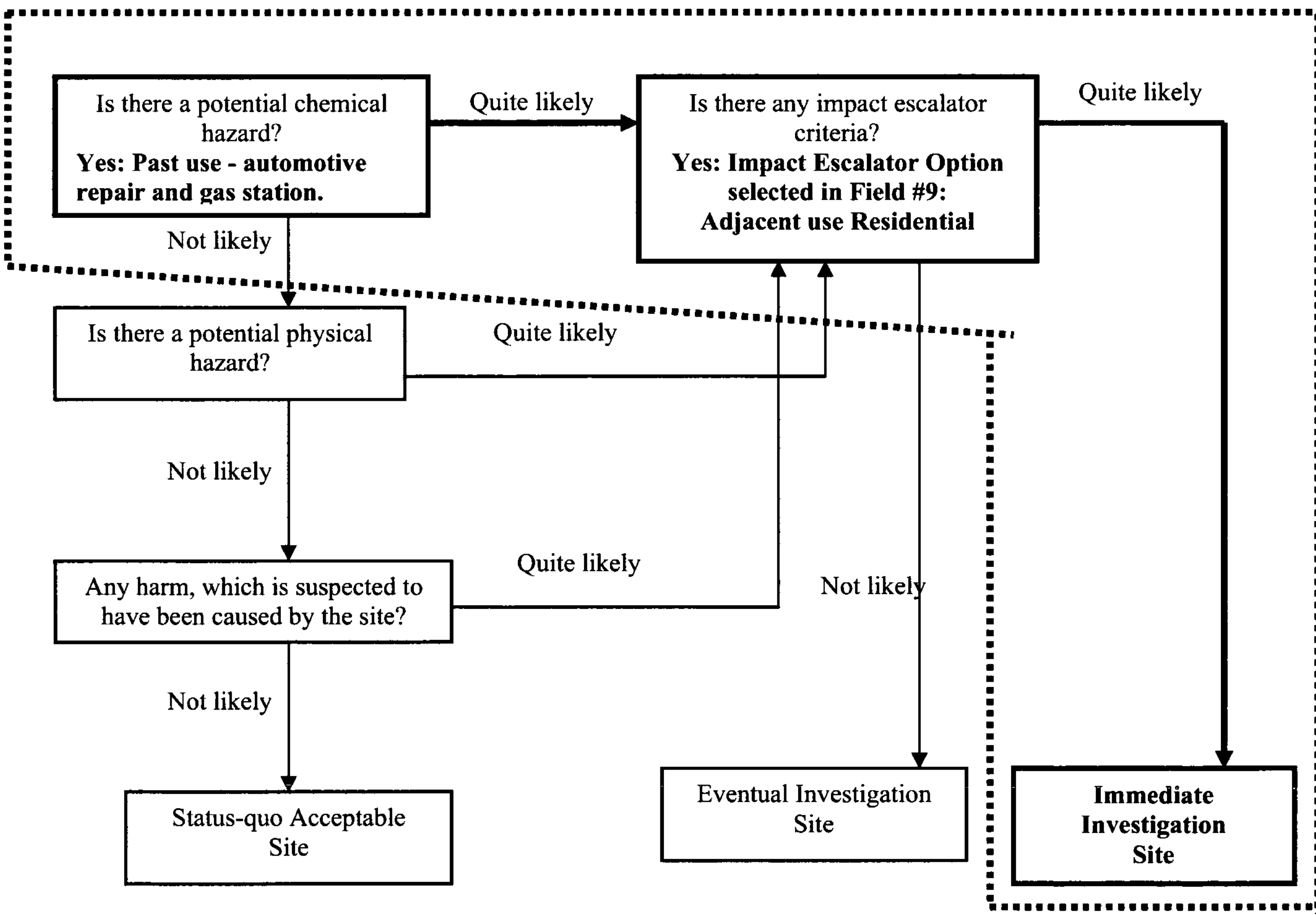


Figure 5-5 Decision Flow for ABC Automotive Service Garage.

From Part II, it could be anticipated that the chemical products that are likely to be present are paints, plastics, hydraulic fluids and lubricants and petroleum products. Based on the historical information and the potential chemical hazard and using Table 1 and 2 of Appendix C, the potential contaminants were determined. These are summarized in Table 5-1.

Table 5-1 Contaminant Groups Present in ABC Automotive Service Garage

	Contaminant Groups that could be Potentially Present							
	Halogenated VOCs	Non-halogeated VOCs	Halogenated SVOCs	Non-halogeated SVOCs	Fuels	Metals and Metalloids	Explosives	Source of Information
Potential Chemical Hazards								
Hydraulic fluids and lubricants	√	√			√	√		**Table 1 (APPENDIX C)**
Paints	√	√			√	√		
Plastics	√	√		√		√		
Petroleum products	√	√			√	√		
Historical Uses								
Gasoline stations		√		√	√	√		**Table 2 (APPENDIX C)**
Painting and automobile body repair	√	√			√	√		
Vehicle maintenance	√	√			√	√		

Based on Table 5-1, nonhalogenated volatile organic compounds (VOCs), halogenated volatile organic compounds., non halogenated SVOCs, fuels and metals and metalloids are likely to be present at the site.

5.5.4 Output: Level 1

The output from the Level 1 assessment is as follows:

- ABC Automotive Service Garage is an *Action Required* site. Due to the presence of impact escalator criteria it is an *Immediate Investigation* site. This implicates an action needs to be undertaken in an immediate time span and it is a potential hazard to the community. Based on the available information, the following groups of contaminants are expected to be present at the site:

- Halogenated VOCs;
- Non-halogenated VOCs;
- Non haloganeted SVOCs;
- Fuels; and
- Metals and metalloids.

5.5.5 Discussion

The output from Level 1 analysis of ABC Automotive Service Garage indicates that this site requires an attention immediately and the municipality should now proceed to the next level and investigate what could be the potential options for improving this site. The information about the contaminations may provide some guidance on the investigation techniques that should be applied and scope the remedial alternatives. For example "in-situ physical and chemical treatment" could be a quite efficient tool to remove the contaminants that are likely to be present at ABC Automotive Service Garage. However while scoping the remedial alternatives based on the group of contaminants the user should be cautious because, the level of effectiveness of remedial alternatives may often depend significantly on the specific type (not the group) and distribution of contaminants and how efficiently a technology is applied (FRTR, 2005).

6.0 LEVEL 2: SCREENING THE LIMITED POTENTIAL SITE USES

This chapter presents the classification methodology for the second of the four levels or *Level 2: Screening the Limited Potential Site Uses*, and demonstrates its use through the ***ABC Automotive Service Garage*** illustrative example at the end.

6.1 OVERVIEW OF LEVEL 2

Once an inventory of *Action Required* sites have been identified in Level 1, the municipality next identifies the potential revitalization options for these *Action Required* sites and screens out the redevelopment alternatives that have limited potential. In particular:

- A site use is considered a *potential site use* if it meets the accepted protocols for a given type of end use as set out by the municipality as a part of their land use planning.
- A site use is screened out as a *limited potential site use* if it is infeasible to have the given site use without overcoming significant barriers such as:
    - Violating reasonable standards or protocols for a given site use.
    - Carrying out significant physical changes beyond the boundary of the site (e.g., new roadways/railway lines have to be constructed; a new, expansive buffer zone needs to be created next to the site).

For example, developing a residential unit adjacent to a landfill is screened out as a "limited potential" use by the system. Although it is apparently infeasible to site a residential unit beside a landfill, there are situations when such siting occurs. However, this would be a violation of the nominal protocols of land use planning and involves a significant modification in the overall region, and would necessitate extraordinary effort. For example, there is a need for acquisition of adjacent properties to create a buffer zone and/or relocate the landfill.

Conventional siting protocols applicable to broad categories of end uses (e.g., residential, industrial, institutional, assembly, commercial/business) and development constrained sites have been extracted from the official master plans of several North American cities (Windsor, ON; Toronto,ON; Kansan, USA; Welland, ON etc.) for this framework.

The objective of the Level 2 is to screen the *Action Required* sites from Level 1 for potential revitalization options and to further categorize them into *potential*:

- residential sites
- industrial sites
- institutional sites
- assembly sites
- commercial/business sites
- As a combination of more than one of these based on the screening.

The definition of each of these site uses have been adapted from the National Building Code of Canada (NBCC, 2005) and is given in Table 6-1.

Table 6-1: Description of Categories of End Uses Considered in Level 2 (NBCC, 2005)

Potential End Use	Definition
Assembly Occupancy	Use that involves gathering of persons for civic, political, social, recreational, travel, religious or other purposes, such as schools, arenas, open air theatres, cafeterias, etc.
Institutional Occupancy	Use where persons are involuntarily detained due to age, mental, physical conditions, such as hospitals or jails.
Residential Occupancy	Used as sleeping accommodation for persons who are not involuntarily detained.
Business Occupancy*	Used for transaction of business, rendering and receiving professional and personal services.
Commercial Occupancy*	Used for displaying or selling of retail goods, wares or mercantile (this is defined as Mercantile occupancy in NBCC (1995)
Industrial Occupancy	Use of buildings for assembling, fabricating, manufacturing, processing, reporting or sorting goods and materials.

* These two occupancies have been considered together in Level 2.

The site may also be classified as a development constrained site, or as strictly an open space. The evaluations of these two classes are limited to Level 2 and not beyond. These sites need to be assessed on a case by case basis by experts. Based on their circumstances other special measures could be undertaken to consider them for further redevelopment options.

6.2 INFORMATION REQUIREMENTS

Additional data is required to conduct a Level 2 evaluation. These include following information about the site location:

- Existing and potential access to roads and highways;
- Existing and potential access to municipal services;
- Available area of the site;
- Availability of transportation; and
- The compatibility of the use with the surrounding areas in terms of scale, massing, height, siting, traffic orientation, landscape.

This classification system does not explicitly consider mixed-use buildings. However, one approach to assessing buildings of multiple uses (e.g., a condominium with a ground level store front) would be to consider the use with the greatest sensitivity or potential problems. The information outlined in this section is used for Level 2 Screening following the decision methodology illustrated in section 6.3.

6.3 DECISION METHODOLOGY

6.3.1 Summary of Decision Methodology

Figure 6.1 illustrates the decision methodology for Level 2.

- As indicated in Figure 6-1, the first step in Level 2 is to investigate if the future development is complicated because the site overlaps with certain geographic or infrastructural features, such as wetlands, floodplains or airport operating areas. Section 6.3.2 provides a comprehensive list of such features. If one such feature exists, it is designated as a development constrained site and needs to be evaluated on a case by case basis by experts outside this classification system.
- If the site is not a development constrained site it needs to be checked if the site area is >10 m^2. As per Ontario Building Code Act (1992), a "building" that includes plumbing, works, walls and roofs should at least have a structure of >10m^2. The limiting gross areas are much higher for industrial buildings and vary significantly

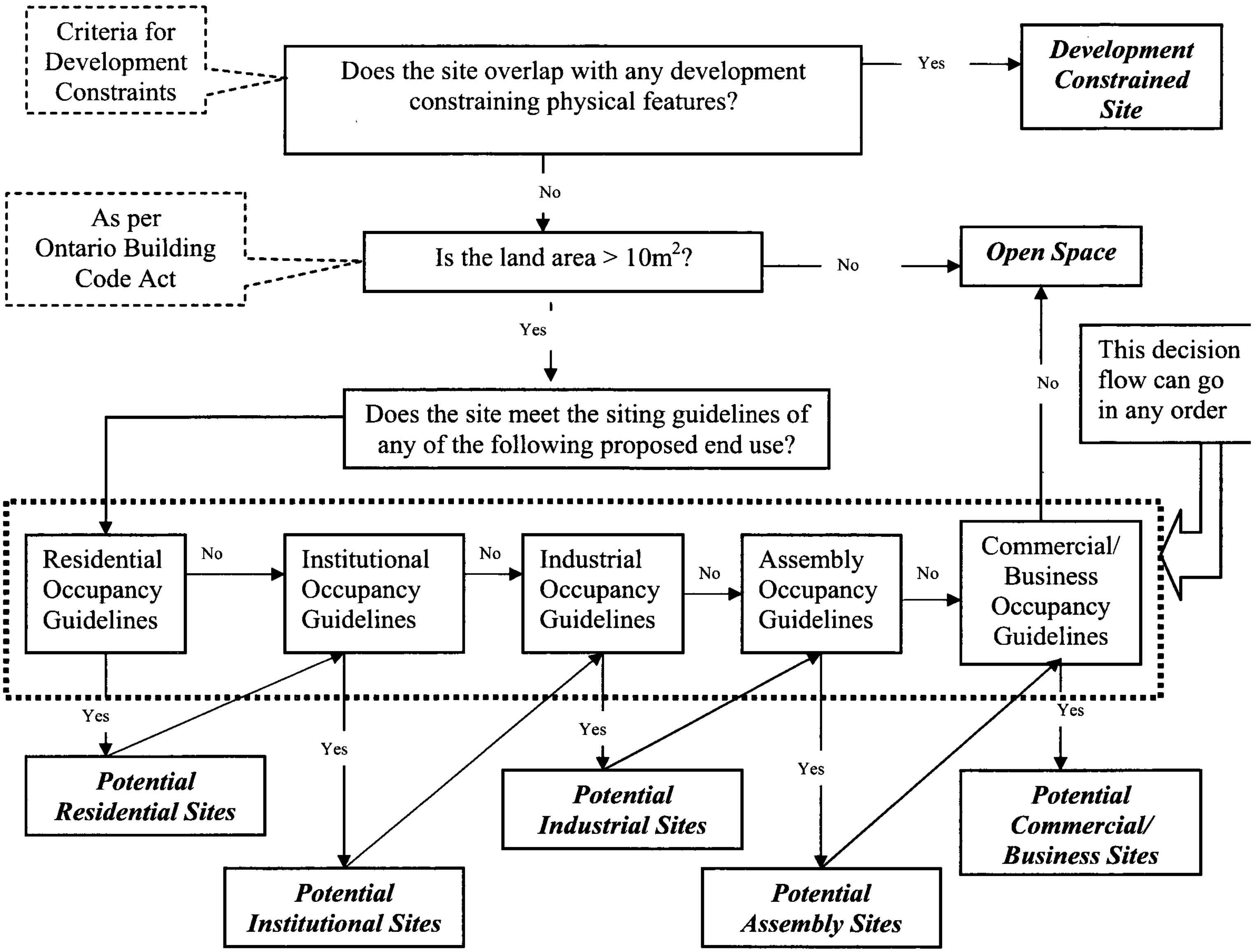


Figure 6-1: Decision Criteria for Level 2

from jurisdiction to jurisdiction. Moreover, there are a number of other factors that need to be considered for limiting area requirement, such as the floor space index and the maximum area of the site that can be occupied by a building. For example, the city of Hamilton requires a minimum area of 280 m^2 for industrial and assembly use. However, since building permits are required for buildings having the area > 10 m^2, this was considered to be the minimum threshold area required for redevelopment. Sites smaller than this are thus considered too small for carrying out any redevelopment and are designated as potential open space. For such situations the user is recommended to consider combining the site with other neighboring sites, using it as a neighborhood park, open space, parking lot, or leaving vacant and containing any hazard as appropriate.

If the site is neither screened out as a potential open space site, nor as a development constrained site, it is examined to determine the potential end uses for the site. This is carried out on the basis of certain reasonable standards or protocols. Section 6.4.3 provides a comprehensive list of standard siting protocols for different end use categories. Based on the user's preferences this screening may be carried out for a limited set of end uses and not the entire set (e.g. residential, commercial etc.). It should be noted that some of these siting guidelines for different end uses overlap (e.g., the sites found to be potential residential are often potential commercial sites as well). The siting guidelines for industrial and residential end use are least overlapping. Therefore, although the site in the example was screened for the entire set of potential end uses the illustrative example for this chapter includes discussions on screening the site for industrial and residential end use to best illustrate the applicability of this method. Appendix F includes the tables for Level 2 screenings of the remaining potential revitalization options (e.g.: institutional, assembly, commercial/business). The outcome from all of these screenings is provided at the end of this chapter.

6.3.2 List of Development Constraints

If the site overlaps with any of the areas listed in Table 6-2 the site is considered to be a development constrained site.

If the site is not a development constrained site and the area is more than 10 m^2, then the potential site uses are examined. Otherwise, a development project that does fall under these two criteria would generally be prohibited or prevented from taking place.

6.3.3 Siting Protocols for Various End Uses

A list of protocols or various end uses is given in Table 6-3. If any of these protocols for an end use is not met, then that particular end use will be identified as a limited potential scenario: there may be a physical or other incompatibility between a site and a particular end use. The reason behind these protocols is primarily physical incompatibility. Appendix D illustrates how the default values for minimal area of each of the proposed end uses have been estimated. These values could be modified depending on the standard practices of the different municipalities and jurisdictions. A portion of these conventional protocols have been compiled from the City of Windsor Master Plan, which is assumed to represent conditions in most Ontario municipalities.

Table 6-2 List of Development Resistant Features (City of Windsor, 2006)

Does the site overlap with the followings?	Yes	No
Natural heritage or candidate natural heritage areas	☐	☐
Environmental policy areas	☐	☐
o Special geological features.		
o Places were migratory species rest		
o Ecological community		
Floodplains	☐	☐
Shorelines	☐	☐
Mining sites	☐	☐
Airport operating areas	☐	☐
Part of a proposed greenway system	☐	☐
Waterway corridors	☐	☐
Community/regional parks	☐	☐

6.4 SUMMARY

Level 2 distinguishes the potential revitalization options for the *Action Required* sites identified from Level 1 and screens out the redevelopment alternative for which the conventional protocols/practices are not met. For example, if a municipality/jurisdiction has hundred 100 *Action Required* sites, the Level 2 investigation may further categorize fifty (50) of them as potential residential sites, twenty (20) of them as potential commercial sites, thirty (30) as both potential residential and commercial sites. It is still possible for a municipality to develop a "limited-potential" end use that is screened out by Level 2. For example, although a residential end use for a brownfield next to a landfill is not identified as a "potential end use", there are situations when such siting occurs. However, such situations would run counter to nominal protocols of land use planning and a significant modification in the overall region beyond the physical boundary of the site would be required.

Table 6-3: Standard Siting Protocols for Various End uses

Potential Use	Standard Siting Protocols	Quite Likely	Not Likely
Residential	• The site includes the minimum land area required for the construction of a residential unit.(default value 23 m^2)*	☐	☐
	• Access to a collector or arterial road.*1	☐	☐
	• Full municipal physical services can be provided.	☐	☐
	• Adequate community services and open spaces are available or planned.	☐	☐
	• Public transportation services can be provided.	☐	☐
	• Sufficient buffers are provided to separate the area from adverse effects of non residential communities. (1 km default value)	☐	☐
Industrial	• The site includes the minimum land area required for the construction of a industrial unit. (default value: 175 m^2)*	☐	☐
	• Sufficiently separated and/or buffered from sensitive land uses (1 km)	☐	☐
	• Access to an arterial road.*1	☐	☐
	• Full municipal physical services can be provided.	☐	☐
	• Industry related traffic can be directed away from residential areas.	☐	☐
	• Peak period public transportation service can be provided.	☐	☐
	• Access to designated truck routes.	☐	☐
Commercial/ Business*	• The site includes the minimum land area required for the construction of a commercial unit .(default value 50 m^2).*	☐	☐
	• Direct access to Class I or Class II Arterial Roads.*1	☐	☐
	• Full municipal physical services can be provided.	☐	☐
	• Public transportation service can be provided.	☐	☐
Institutional	• The site includes the minimum land area required for the construction of a institutional unit.(default value 23 m^2)	☐	☐
	• Direct access to a Class II Arterial Road or Class I or Class II Collector Road.*1	☐	☐
	• Public transportation service can be provided.	☐	☐
	• The size of the property provides opportunities for expansion.	☐	☐
	• Full municipal physical services can be provided.	☐	☐
	• Traffic can be directed away from residential areas.	☐	☐
Assembly	• Direct access to Arterial or Collector Roads.*1	☐	☐
	• The site includes the minimum land area required for the construction of an assembly occupancy.(default value 37 m^2)*	☐	☐
	• Full municipal physical services and emergency services, can be provided as appropriate.	☐ ☐	☐ ☐
	• Public transportation service can be provided.	☐	☐
	• The use will be compatible with the surrounding area in terms of scale, massing, height, siting, orientation, setbacks and landscaped areas.	☐	☐
	• Adequate off-street parking can be provided.	☐	☐

*The default values of minimum area requirements are calculated using methods provided in Appendix D

*1 Definitions of different types of roads are provided in Appendix E

6.5 ILLUSTRATIVE EXAMPLE: LEVEL 2

6.5.1 Site Location and Objectives

The following section shows the Level 2 evaluation for the ABC Automotive Service Garage illustrative example. The example evaluates the garage site to determine if it is a potential residential site and/or a potential industrial site because the siting protocols for industrial and residential end use have minimal overlapping and thus it is easier to see how the classification system works at this level. The screenings carried out for the remaining end use categories (e.g. commercial, institutional, and assembly) are detailed in Appendix F.

In this case the information about the site and the surrounding properties were determined using publicly available GIS software such as "Yahoo Map" and ESA results given in Appendix A. Figure 6-2 illustrates the location of the site determined using the Yahoo Map. It could be observed from the Figure that the site is located on an arterial road AR1.

6.5.2 List of Development Resistant Features

As per the ESA results, "… there were no areas of natural significance or condition in the vicinity of the site, which would cause the site to be classified as potentially sensitive according to the Ministry of Natural Resources (MNR)' Natural Heritage Club Website." Moreover, Phase I ESA results indicate it is an old commercial building and not a community/ regional park.

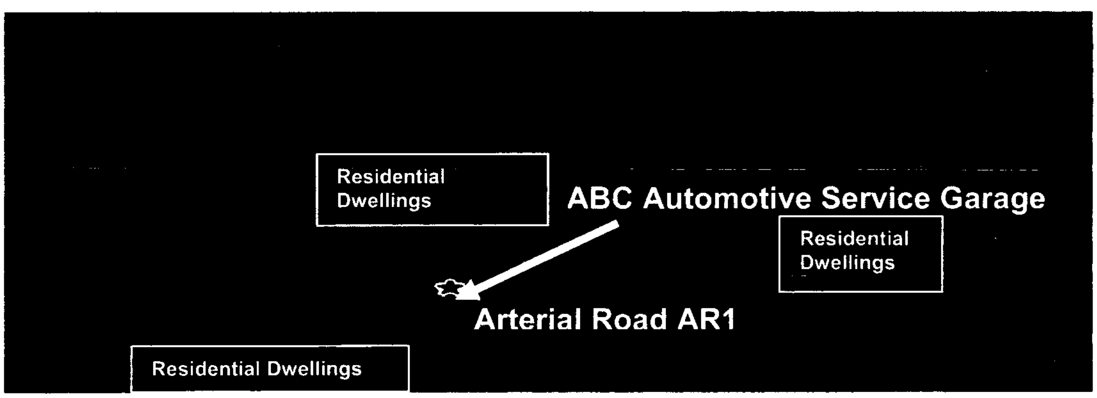


Figure 6-2: Location of ABC Automotive Service Garage

The completed development constraint checklist for the site is provided in Table 6-4, and concludes that the site can be considered for further development.

Table 6-4: List of Development Constraining Features for ABC Automotive Service Garage

Does ABC Automotive Service Garage Overlap with the Followings?	Yes	No
Natural heritage or candidate natural heritage sites	☐	☒
Environmental policy areas o Special geological features. o Places were migratory species rest o Ecological community	☐	☒
Floodplains	☐	☒
Shorelines	☐	☒
Mining sites	☐	☒
Airport operating areas	☐	☒
Part of a proposed greenway systems	☐	☒
Waterway corridors	☐	☒
Community or regional parks	☐	☒

6.5.3 Minimal Area Requirement

The total site area for ABC Automotive services is approximately 15,000 m^2 (Appendix A) which is much greater than 10 m^2. Thus, the site is not restricted to open space use.

6.5.4 Standard Siting Protocols for Residential End Use

This section illustrates how the siting protocols for residential end use are checked in this example. Table 6-5 outlines the practiced siting protocols for residential use extracted from Table 6-3 and the source of information that was used to determine if the guidelines were met.

Table 6-5 shows that:

- The area of ABC Automotive Services exceeds the minimum land area requirement for a residential end use (23 m^2).
- From Figure 6-2, obtained using Yahoo Maps it could be observed that the site has an access to Class II arterial road AR#1.
- The Phase 1 ESA (Appendix A) indicates that the site has access to full municipal and community services.

- The availability of public transport can be determined using the transit map. Figure 6-3 illustrates the bus route map for the city. It could be observed that the site is located close to the bus routes, and so public transit should be readily available.

Table 6-5: Standard Siting Protocol Checklist for ABC Automotive Service Garage – Residential

Potential Use	Standard Siting Protocols	Information Source	Quite Likely	Not Likely
Residential	• The site includes minimum land area required for the construction of a residential unit.(default value 23 m^2)* - **15,000 m^2**	Phase I ESA/ Municipality records	☒	☐
	• Access to a collector or arterial road. - **(Access to Class II arterial road AR#1)**	Publicly available GIS based software Figure 6-2	☒	☐
	• Full municipal physical services can be provided. - **Site connected to municipal water supply** - **Storm water is discharged into municipal swear system**	Phase I ESA	☒	☐
	• Adequate community services and open spaces are available or planned. - **North of site residential dwellings** - **Commercial stores available next to it** - **Residential dwelling/community services available**	Phase I ESA/ neighborhood survey	☒	☐
	• Public transportation services can be provided. - **Refer to the map – nearby transit routes**	Transit map obtained from the website of the city Figure 6-3	☒	☐
	• Sufficient buffers are provided to separate the area from adverse effects of non residential communities (1km default value) - **No industrial zone in the vicinity** - **No landfill/waste disposal sites in the vicinity**	Publicly available GIS based software Figure 6-4, 6-5	☒	☐

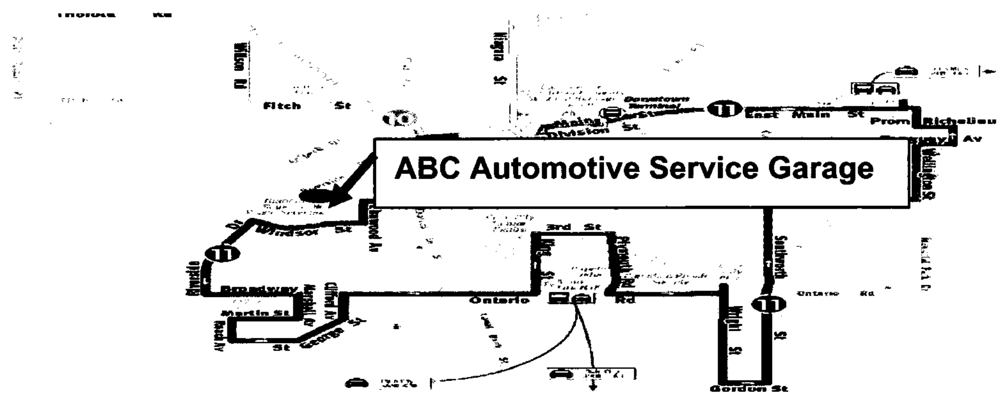


Figure 6-3 Availability of Public Transportation Services for ABC Automotive Service Garage

Two more searches were conducted using the publicly available maps and GIS systems to determine the locations of neighborhood factories and industries, landfill and disposal facilities.

- Figure 6-4 illustrates the locations of neighborhood factories and industries as shown by the black circles and Figure 6-5 illustrates the location of neighborhood landfills, and disposal facilities. These are all located several kilometers away from the site. Therefore, the residential development on this site is not restricted by the presence of inadequate buffer between industrial and other hazardous uses.

From the above evaluation this site is considered a "potential residential site".

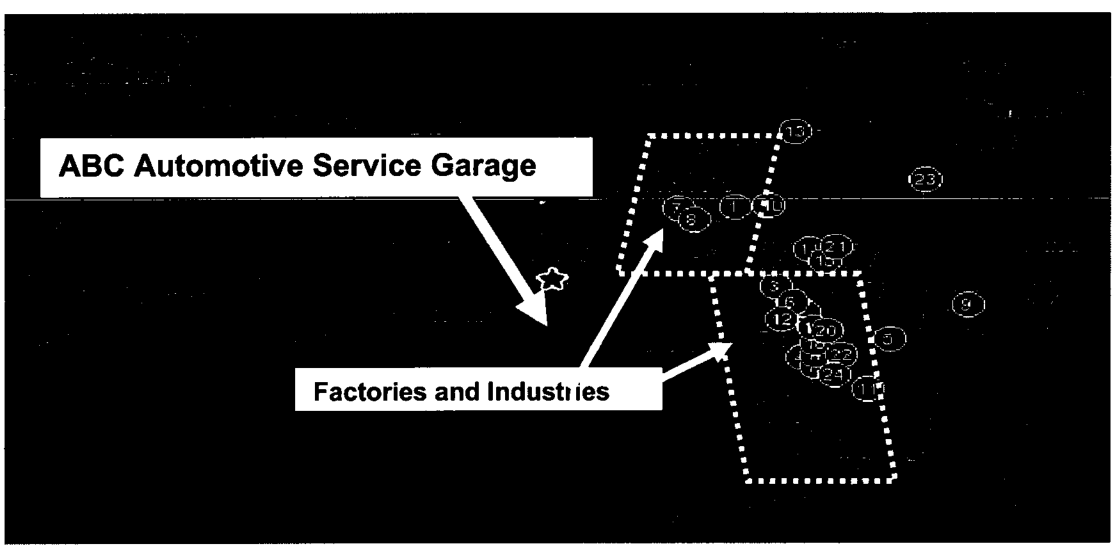


Figure 6-4: Factories and Industries near ABC Automotive Service Garage

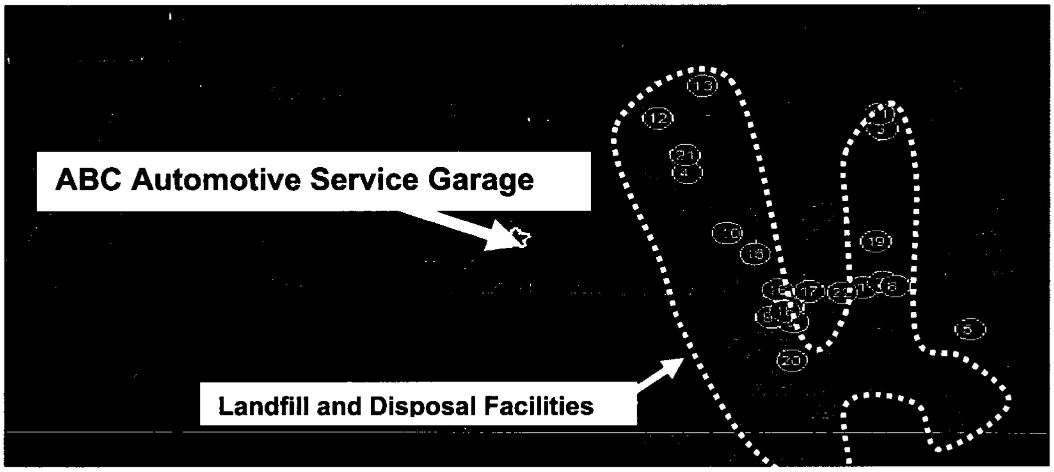


Figure 6-5: Landfill and Disposal Facilities Near ABC Automotive Service Garage

6.5.5 Standard Siting Protocols for Industrial End Use

This section illustrates how the siting protocols for industrial end use are checked. Table 6-6 outlines the siting protocols for industrial use extracted from Table 6-2 and the source of information that was used to determine if the guidelines were met.

Table 6-6: Standard Siting Protocols Checklist for ABC Automotive Service Garage - Industrial

Potential Use	Standard Siting Protocols	Information Source	Quite Likely	Not Likely
Industrial	• The site includes minimum land area required for the construction of a industrial unit..(default value: **15,000 m²**)* **- Yes (15,000 m²)**	Phase I ESA	☒	☐
	• Sufficiently separated and/or buffered from sensitive land uses (1km). **- No, Residential use is adjacent to the site**	Figure 6-2/GIS, Phase I ESA	☐	☒
	• Access to an arterial road; **- Yes**	Figure 6-2/ GIS	☒	☐

The rationale for the decisions made in Table 6-6 is further elaborated in the following description:

- ABC Automotive Service Garage meets the minimum land area requirement for an industrial development (> 175 m²).

- Based on Figure 6-2 and also the ESA results, the site has a residential end use immediately adjacent to it.
- From Figure 6-2 the site does have access to an arterial road.

Since one of the criteria are not met, ABC Automotive Service Garage is not considered a potential industrial site

The standard siting protocol checklists for remaining three categories of end uses (institutional, business/commercial, assembly) have been included in Appendix F and the results of the overall Level 2 investigation have been discussed in the following section.

6.5.6 Output: Level 2

The output of Level 2 investigation is as follows:

- ABC Automotive Service Garage is a *potential*
    - residential site.
    - commercial/business site.
- ABC Automotive Service Garage is <u>not</u> a *potential*
    - industrial site.
    - institutional site.
    - assembly site.

Within reasonable courses of action these end uses are not feasible. Extraordinary efforts would be required to carry out these end uses.

Therefore, if a municipality requires more residential/commercial units, they can consider a follow-up investigation on this brownfield. The next step is to proceed to Level 3 and Level 3-Advanced to evaluate what are the barriers that need to be overcome for a potential residential development and a potential commercial development. The specific information required for a commercial and a residential redevelopment option are given in Appendix A.

7.0 LEVEL 3 AND LEVEL 3-ADVANCED

This chapter presents the main approach of the classification methodology for the third and the fourth levels: *Level 3: Classifying the Sites Based on Basic End Uses* and *Level 3-Advanced: Assessing the Severity of Required Action.*

7.1 LEVEL 3: CLASSIFYING SITES BASED ON BASIC END USES

After the *Action Required* sites are identified in Level 1 and their potential end use alternatives have been selected in Level 2, municipalities need to identify what barriers should be overcome for any potential site and end use combination to succeed. The essential issue to resolve is:

> *If a potential revitalization option is pursued, what barriers need to be overcome in order to make the redevelopment effort a success?*

Answering this question requires the user to examine the suitability of the site for a potential end use. The suitability of a particular end use for a given site is assessed based on a series of deciding factors grouped into following four major categories:

- Land and Infrastructure
- Economics
- Health
- Social/Community

Each of these categories is evaluated separately for the individual site and potential end use combinations.

In each of these categories, the site characteristics are evaluated as:

- If the site characteristics in a corresponding category in their current conditions, supports the proposed end use, then the category is "yes" (Y).
- If some action is required to remove existing barriers that prevent the end use, then the corresponding category is a "Category Requiring Action" (CRA).
- If any given category is a CRA, the system then further evaluates if it is a "high" (H), "medium" (M) or "low" (L) CRA.

Whether a category is a "Y" or a "CRA" is assessed in Level 3 and the severity of action is evaluated in Level 3–Advanced. These two levels (Level 3 and Level 3-Advanced) overlap significantly and are therefore discussed sequentially in the appropriate chapters.

The critical questions considered under each of the abovementioned four categories (e.g., land and infrastructure, economics, social, health) are listed in Table 7-1.

Table 7-1: Categories Considered for Level 3 Assessment of Classification

Category	Question	Possible Answers	Category Status
Land and Infrastructure	Is the available land, ecology and service resources fully adequate for the end use?	☐ Yes →	Y (Yes)
		☐ No →	CRA (Category Requiring Action)
Economics	Do the onsite economic benefits and costs support this end use?	☐ Yes →	Y (Yes)
		☐ No →	CRA (Category Requiring Action)
Social/ Community	Does the community support this end use?	☐ Yes →	Y (Yes)
		☐ No →	CRA (Category Requiring Action)
Health	Is the onsite and offsite contamination below accepted standards for the end use?	☐ Yes →	Y (Yes)
		☐ No →	CRA (Category Requiring Action)

The questions listed in Table 7-1 are answered based on several decision criteria developed further in this research. The decision criteria considered under each of the categories are further divided into different individual modules and are covered in Chapters 8 through 11. These modules are assigned intermediate scores entitled SAR (Severity of Action Required). There are four possible SAR scores (high, medium, low and none) that indicate the severity of actions required for *any given module* (Figure 7-1). As with the CRA score, a "high" SAR score indicates a high severity of action required for the given module, a "med" SAR score indicates a moderate level of action in the given module, and a "low" SAR score indicates minimal actions for a given module. A SAR score of "none" indicates that the module already supports the redevelopment in its present condition. SAR scores from individual modules within a category are the intermediate scores that are combined to evaluate if the *overall* category is a "Y" or a "CRA", and also to evaluate whether the severity of a category requiring action (CRA) is an H, M or L. The end result can be represented by a 4 x 1 matrix that signifies how suitable the site is for a potential end use. Therefore, the high, medium and low scores for the modules representing SAR scores are designated "high", "med" and "low" within the text. The high, medium and low scores for the categories (which are the combinations of several modules) are designated by capital letters: "H", "M" and "L". The different typology for SAR scores and CRA scores are used to avoid confusion.

Figure 7-1 illustrates an example Level 3 evaluation process for land and infrastructure and Table 7-2 illustrates the modules that are considered under the individual categories, except for economics. Unlike the three other categories, because of the quantitative nature of the criteria, economics is not evaluated using a modular approach. However, the outcome for economics is also translated to a "Y" or a "CRA" to be consistent with the overall framework. The end result of Level 3 can be represented by a 4 x 1 matrix that signifies how suitable the site is for a proposed end use.

For example, if both residential and industrial end uses are "potential uses" for a brownfield site "A", the resulting example matrices may look like the ones illustrated in Figure 7-3. These matrices determine the characterization of a particular brownfield site. As illustrated in Figure 7-3, site A with an industrial end use is defined as $\begin{bmatrix} Y \\ Y \\ CRA \\ Y \end{bmatrix}$, which means the categories of land and infrastructure, health risk and economics support an industrially oriented redevelopment, while social is considered a category requiring action.

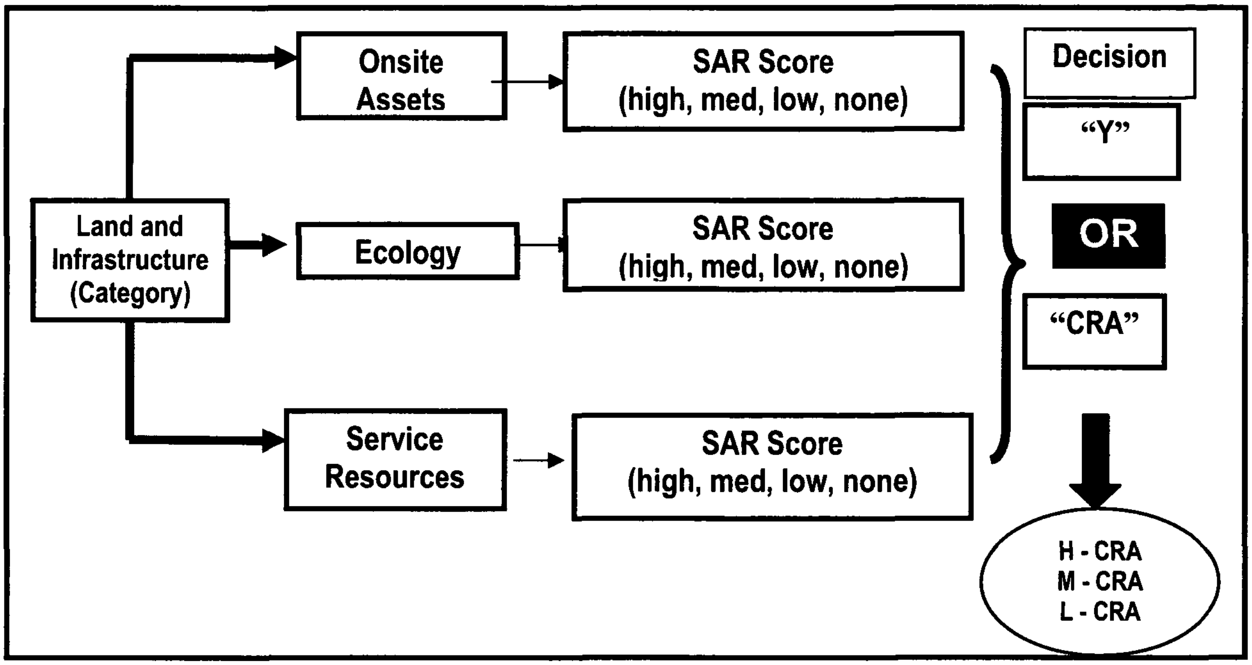


Figure 7-1 Example Framework for Level 3 Evaluation (Land and Infrastructure)

Table 7-2: Evaluation Modules Considered Under Individual Categories

Category	Modules
Land and Infrastructure	• Onsite Assets • Terrestrial Ecology • Site Accessibility
Health	• Surface water pathway • Groundwater Pathway • Vapor intrusion pathway
Social/ Community	• Community concerns • Community needs • Tax-base

Based on above discussion, sixteen (2^4) output matrices could be possible, giving rise to sixteen characterization combinations of brownfields in Level 3. These possible combinations are given in Table 7-3. The "best" combination is the situation when all four categories are "Yes", which means the existing conditions already support the potential end use, while the worst is if all four categories are CRAs.

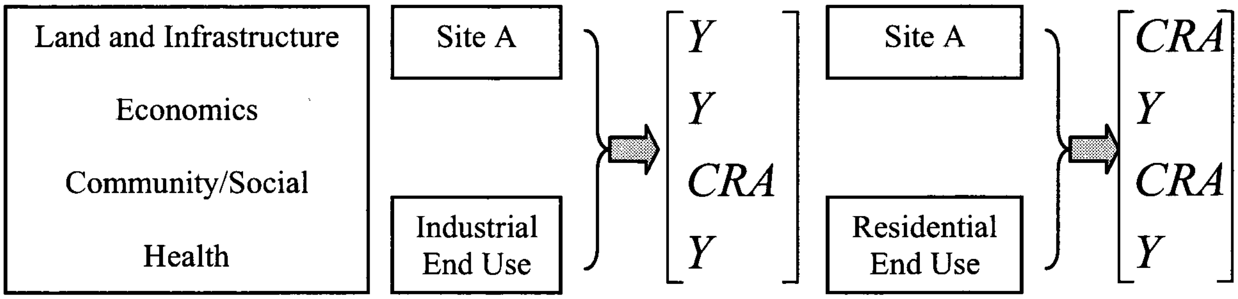


Figure 7-2: Sample Output Matrix for Level 3 Classification of Brownfield Sites

If a developer/municipality intends to use this classification system and decides to evaluate a proposed end use for which they have adequate information, the developer can start at Level 3 instead of the Level 1 or 2, identify the CRAs, and then focus on the appropriate actions required for a successful redevelopment. However, it should be noted that this classification system should not be used to justify a predetermined course of action but could be used in limited situations to demonstrate the trade-offs of a given course of action by starting at Level 3.

Table 7-3: Possible Output Matrices from Level 3

Characterization Combination	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**
Land	*Y*	*CRA*	*Y*	*Y*	*Y*	*CRA*	*Y*	*Y*
Economics	*Y*	*Y*	*CRA*	*Y*	*Y*	*CRA*	*CRA*	*Y*
Social	*Y*	*Y*	*Y*	*CRA*	*Y*	*Y*	*CRA*	*CRA*
Health	*Y*	*Y*	*Y*	*Y*	*CRA*	*Y*	*Y*	*CRA*

Characterization Combination	**#9**	**#10**	**#11**	**#12**	**#13**	**#14**	**#15**	**#16**
Land	*CRA*	*CRA*	*Y*	*CRA*	*CRA*	*CRA*	*Y*	*CRA*
Economics	*Y*	*Y*	*CRA*	*CRA*	*CRA*	*Y*	*CRA*	*CRA*
Social	*Y*	*CRA*	*Y*	*CRA*	*Y*	*CRA*	*CRA*	*CRA*
Health	*CRA*	*Y*	*CRA*	*Y*	*CRA*	*CRA*	*CRA*	*CRA*

7.2 LEVEL 3-ADVANCED: ASSESSING THE SEVERITY OF REQUIRED ACTION

When a site and a potential end use combination are evaluated in Level 3 and a particular category is identified as a "CRA", it is not clear whether the action required is extensive or minimal. Therefore the decision criteria are designed so that the system further evaluates if a CRA is an "H", "M" or "L" using Level 3-Advanced. Level 3 and Level 3-Advanced evaluations overlap in some situations and are carried out simultaneously; however, more detailed information is required for Level 3-Advanced. When the information is inadequate, the evaluation ceases at Level 3. In the following chapters, both Level 3 and Level 3-Advanced evaluations for the four given categories are described along with the illustrative example.

8.0 LAND AND INFRASTRUCTURE: LEVEL 3 AND LEVEL 3- ADVANCED

8.1 OVERVIEW OF LAND AND INFRASTRUCTURE

This section outlines the methodology for evaluating the land and infrastructure criteria for brownfields sites and a proposed redevelopment by characterizing this overall category as:

- Land and Infrastructure is "Y" (Yes) –land, ecology and service resources are adequate for the proposed end use.
- Land and Infrastructure is a "CRA" (Category Requiring Action) –land, ecology and service resources are not adequate for the proposed end use and some actions need to be undertaken to enable this use.

The general approach (as described in Figure 8-1) involves evaluating the land and infrastructure criteria, through three different modules:

- Onsite Assets;
- Ecology; and
- Site Accessibility.

As discussed in Chapter 7, each of these three modules is assessed for its suitability for the proposed end use and is designated an "SAR" score of "high", "med", "low" or "none". The scores are based on benchmarks found in available literature and expert opinions.

Once the three modules are evaluated for their SAR scores, these scores are combined to evaluate if the *overall* land and infrastructure is "Y" or "CRA". If the land and infrastructure is a category requiring action (CRA), the SAR scores are further used to specify if this category should be eventually assigned a description of "high" (H), "medium" (M) or "low" (L). This indicates the extent actions required to overcome the barriers in land and infrastructure that can hinder the proposed redevelopment. As discussed in Chapter 3, the "L" severity score is assigned when there is a minimal barrier associated with the land and infrastructure. In such situations, very limited or no arrangements are required for removal of onsite assets, ecological barriers or provide accessibility for the proposed redevelopment. Conversely, an "H" score means there is a potential for significant negative barriers for redevelopment due to the existing conditions of onsite assets, ecological features and service resources. This implies significant efforts are needed to modify the land and infrastructure for the proposed end use. An "M" score means that the land and infrastructure attributes are of moderate concern.

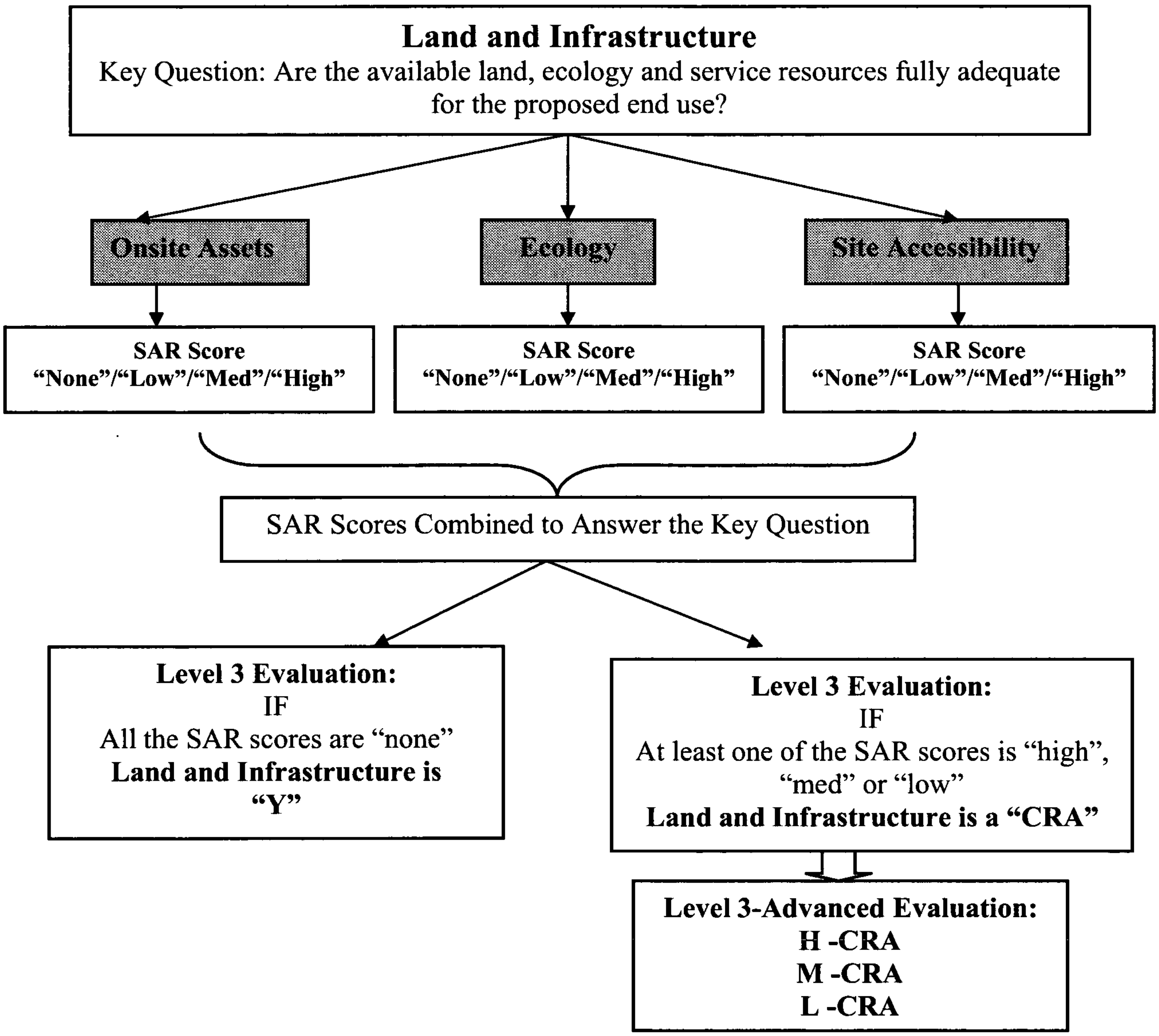


Figure 8-1: Evaluation of Land and Infrastructure for Brownfield Classification

In summary:

- "H-CRA": Extensive actions need to be undertaken to make land, ecology and service resources fully adequate for the proposed end use.
- "M-CRA": Moderate actions need to be undertaken to make land, ecology and service resources fully adequate for the proposed end use.

- "L-CRA": Minimal action can make land, ecology and service resources fully adequate for the proposed end use.

The subsequent sections discuss the steps for evaluating the SAR scores for each of these modules and how the individual scores of the three modules are combined to evaluate the land and infrastructure category of Level 3 and Level 3-Advanced.

8.2 INFORMATION REQUIREMENTS

The following is a list of information required for Level 3 and Level 3-Advanced evaluation of land and infrastructure:

- Phase I and II ESA.
- Information about the proposed end use:
  - Area required;
  - Compatibility with the existing neighborhood (e.g. compliance of the proposed end use with existing zoning ordinances, master plans etc.);
  - Whether the redevelopment involves reuse/renovation of existing onsite assets or requires a complete/partial demolition; and
  - Utility and structural infrastructure capacity needed for the proposed redevelopment.

8.3 ONSITE ASSETS MODULE

This module determines if the onsite assets and attributes are readily available, fully functional and usable (ready to be used for redevelopment) when needed or do they require special precautions and arrangements with regards to the site demolition and renovation for the proposed redevelopment option. This module analyzes the extent of such precautions and arrangements. The following criteria are considered under the conditions of onsite assets:

- Land area;
- Compatibility with zoning ordinances and master plan (if applicable);
- Building materials of concern; and
- Regulated building equipments of concern.

The steps for evaluating the SAR score for onsite assets are described in the following sections:

8.3.1 Step 1: Availability Assessment

The evaluation of onsite assets starts with investigating the availability of the site for its intended end use. This investigates if the land is readily available and usable when needed by analyzing the zoning compliances, compatibility with the master plan, and the land-area requirements. Figure 8-2 summarizes the first step of onsite assets module – identified as availability assessment. The SAR score of "high" is assigned to the availability assessment module if the land is unavailable. If the proposed use complies with zoning ordinances with some reservations, the decision pathway leads to a "Red Flag". In such situations, an individual investigation becomes essential.

This availability assessment should not be confused with the Level 2 evaluation. In Level 2 the criteria for area requirement, zoning etc. are considered at a very generic level from a municipality perspective. In Level 3, the evaluation of compatibility is performed at a much more specific level. As discussed before, this level requires an increased amount of information as compared to Level 1 and Level 2.

If the site use is compatible with the local master plan, zoning and area requirements it is considered available and the user is guided to proceed to Step 2 to assess the Onsite Assets Hazard Potential.

8.3.2 Step 2: Onsite Assets Hazard Potential

This section outlines the methods of investigating the onsite assets hazard potential to determine the overall SAR score for the Onsite Assets module as shown by Figure 8-3.

At first it is evaluated if there are any existing onsite assets that need to be disposed from the site. A Phase I ESA can provide information about the number of buildings, stories and ancillary structures (STC, 2006). For example, the information about onsite assets could also come from a geophysical map generated using a Ground Penetrating Radar (GPR) (Kenneth

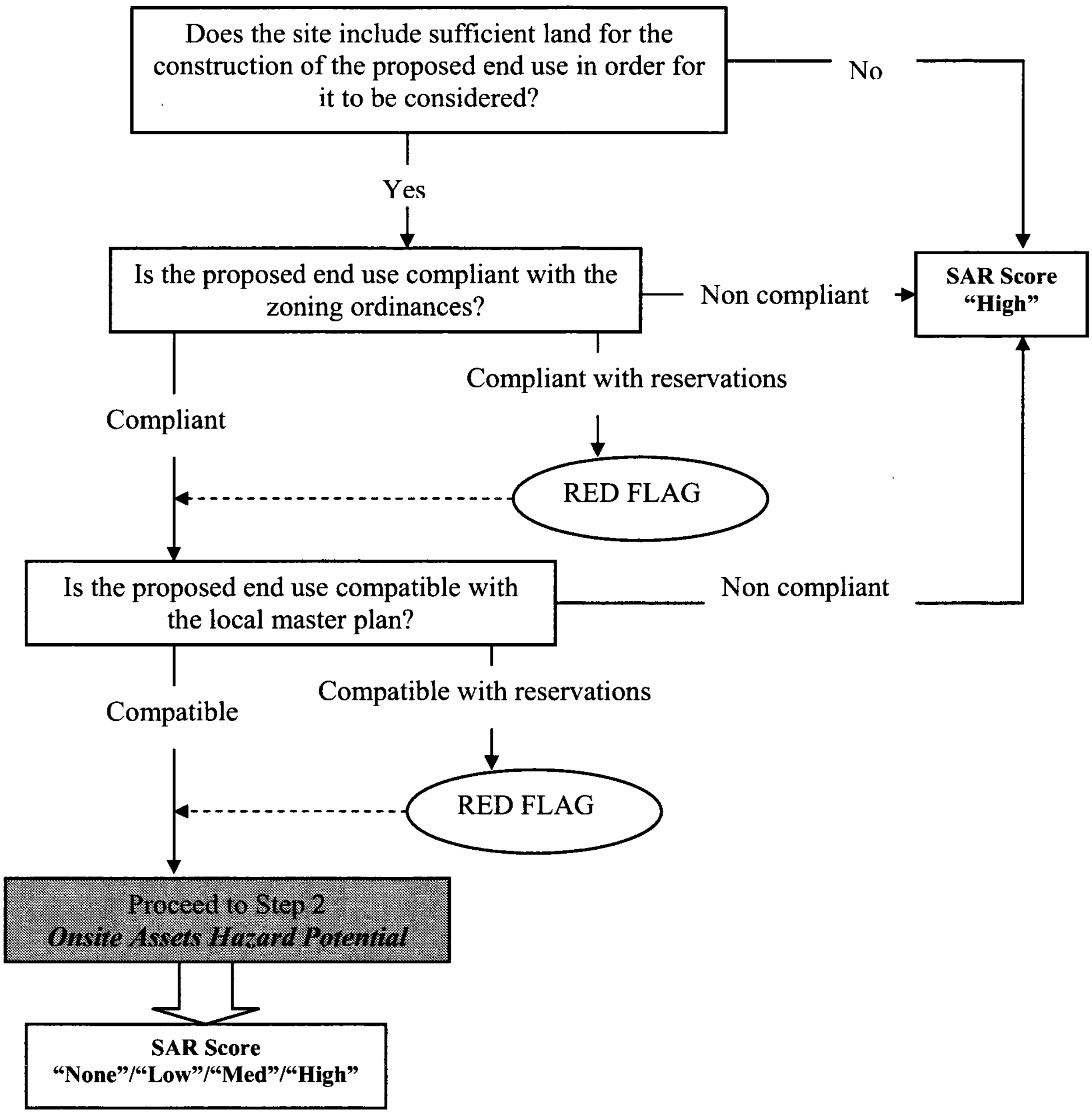


Figure 8-2: Onsite Assets Module: Step 1- Compatibility Assessment

and Earnest, 2006). As illustrated in Figure 8-3, three groups of onsite assets are evaluated separately to determine the SAR score based on onsite asset hazard potential.

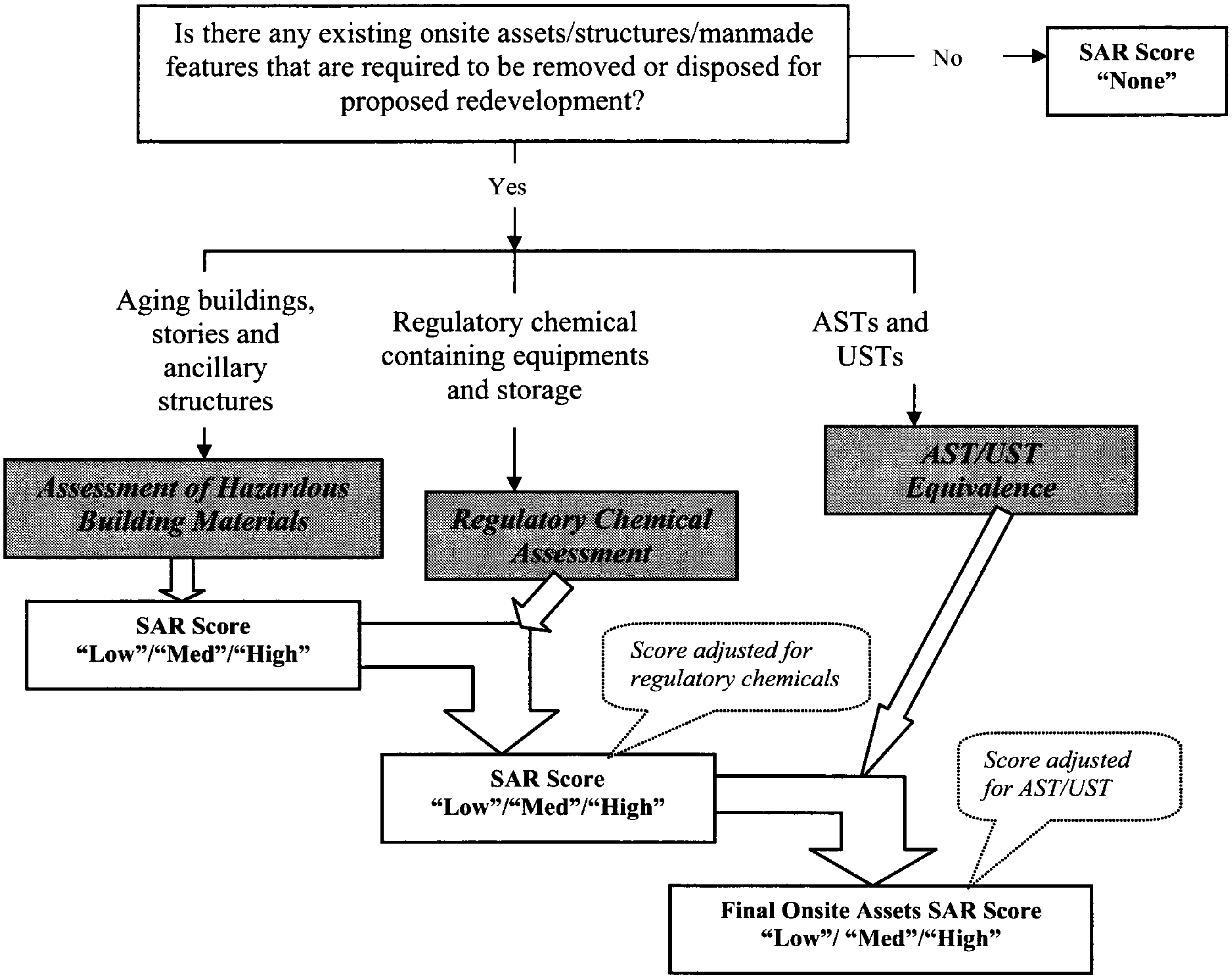


Figure 8-3: Onsite Assets Module Step 2: Onsite Assets Hazard Potential

The assets in Figure 8-3 are:

- Aging buildings, stories and ancillary structures: includes the buildings ramps, substructures and foundations of aging structures that are required to be removed.
- Regulatory chemical containing equipments and storage: includes the hazardous and regulatory waste storage and equipment containing regulatory wastes such as PCBs and mercury that require special reporting and regulatory compliance.
- AST/UST: aboveground storage tanks and underground storage tanks.

The assets are evaluated in the order shown in Figure 8-3.

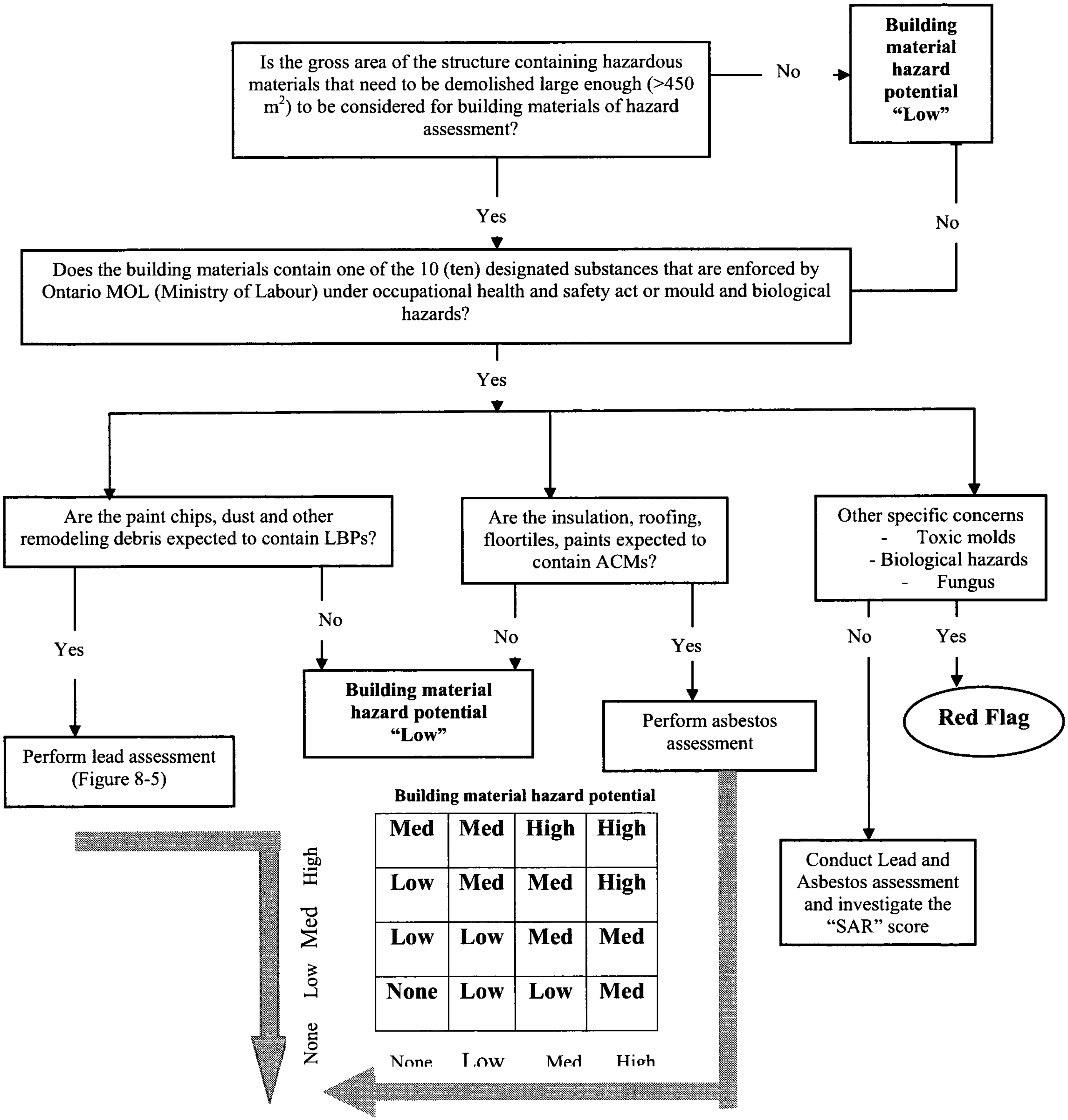
8.3.2.A Assessing Hazardous Building Materials

Figure 8-4 summarizes the methodology for assessing hazardous building materials. When aging buildings, stories and ancillary structures are identified in the site, the user needs to determine whether the gross area of the structures being demolished are above a threshold value of gross area to require special arrangements and precautions during the removal process. If the gross area that need to be demolished is below 450 m^2 (GSG, 2005) the SAR score is assumed to be "low" and it is concluded that even if hazardous materials are present, their presence will only cause limited barrier for the proposed redevelopment. If the gross area is > 450 m^2, the presence of hazardous materials for the aging buildings is investigated. This benchmark was accepted from a scoring scheme developed by Chicago (GSG, 2005) as a part of their smart growth initiatives in which they assigned a significantly low score for the buildings for initial brownfield screening when the gross area was approximately <450 m^2.

The next step is to investigate the presence of onsite designated substances that prohibit, limit or restrict the exposure of workers and require specific disposal procedures. Under Ontario Occupational Health and Safety Act (1990), there is a list of eleven such designated substances of which 10 are considered for evaluation:

- Asbestos
- Arsenic
- Lead
- Ethylene oxide
- Silica
- Vinyl chloride
- Benzene
- Coke oven emissions
- Acrilonitrite
- Isocyanates

Although mercury is the eleventh designated substance, it is not considered under this module and is rather considered under *equipment of concern* because in most cases mercury is associated with fixtures such as lamps and other electrical components rather than the building materials themselves.



Med	Med	High	High
Low	Med	Med	High
Low	Low	Med	Med
None	Low	Low	Med

Figure 8-4: Assessments of Hazardous Building Materials

Although all the above ten materials are investigated for concern, the onsite buildings are investigated in this classification system for two generic hazardous materials: lead and asbestos. Most aging buildings that are demolished have common concerns involving asbestos and lead that result in a significant amount of health and safety concerns. These hazards arise from the demolition activity, and lead and asbestos are the two major contaminated building materials that become regulated wastes when removed from the building and infrastructure (Gallant and Blickle, 2005). The other eight substances and toxic molds, biological materials, debris and fungus could also pose barriers to the land and infrastructure category. However, these are more specific and the classification system identifies such situations as "Red Flags" and prompts the users to investigate them on a case by case basis. If the visual site reviews reveal the obvious presence of extensive amounts molds, fecal material and biological hazards or one of the eight designated substance (other than lead and asbestos) the situation should be investigated as a special case. The investigation of lead and asbestos are few of the most common additional services requested in demolition assessments before building decommissioning. Note that the *health effect* for their presence is evaluated under "health" section. The *occupational risk* and the severity of hazard associated with site preparation are investigated in this module.

Lead

In the past lead was usually added to paint pigments to enhance the paint durability. Several publicized health studies of lead published in 1970s prompted the public for limiting the lead exposure. Lead was banned in U.S. from house paint from 1978. Most of the aging buildings built prior to banning lead based products have risks associated with Lead Based Paints (LBPs)(Kenneth and Earnest, 2006). According to Health Canada (2005), in Canada:

- "If a building was built before 1960, it probably contains lead based paint."
- "If a building was built after 1980, interior paints may not contain leads but there may be lead in the exterior."
- "If a building was built after 1992, the lead concern may be limited because all consumer paints produced in Canada and the U.S. by that time was virtually lead-free."

The dust and remodeling debris are expected to contain lead if one of the following conditions is true:

- The expected age of dwelling indicates that it was built prior to banning the use of lead within the jurisdiction;
- The site was a generator of lead bearing waste or in the vicinity of a generator for lead bearing waste; or
- There was a history of child sickness. Because of the critical role of dust as an exposure pathway, children have a much significant risk for lead poisoning (Kinder, 2007).

If one of the above is true, the user is prompted to investigate the quality of lead as per the method illustrated in Figure 8-5.

- If none of the criteria that indicate that the dust and remodeling debris are expected to contain lead is satisfied then it is assumed that the score is "none".
- If any one of the criteria is satisfied, the next step is to investigate the results from past health assessments (if available).

It should be noted that this classification system was designed to be used for any jurisdiction, and if a particular jurisdiction had not banned lead from paint, there will always be a lead hazard, even if the building is relatively new.

If the past results indicate that there is no "lead contamination" the score is "none". Otherwise, the user is guided to investigate the maximum total lead concentration for paint and other coatings used in the interior and exterior walls of the building and determine if the intermediate SAR score is "high", "medium" or "low".

The maximum total lead concentration that is permitted to be used in exterior or interior surfaces of any building from Hazardous Products Regulations (liquid and coating materials) is 600mg/kg or 600ppm (0.06% of dry wt) (SOR, 2005). The difference between the ranges of 0-600mg/kg has been divided into four quartiles to establish the benchmarks. The benchmarks are established such that if concentration is below 150 ppm (which is the first quartile between 0-600mg/kg), the score is "low"; if the concentration is between 150-450ppm, the score is "medium"; and if greater than 450ppm, the score is considered "high".

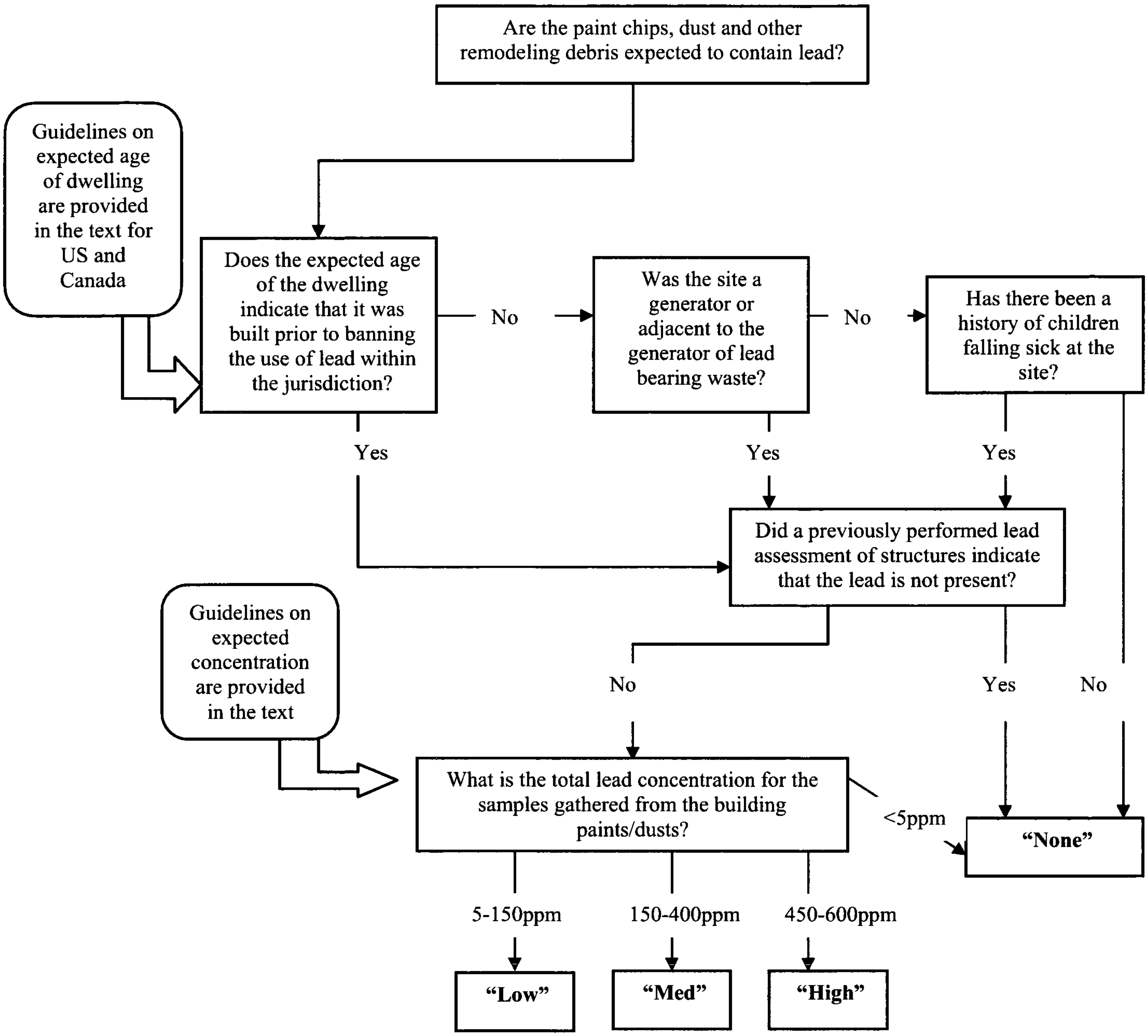


Figure 8-5: Methodology for Assessment of the Lead Score

Several jurisdictions in US and Canada allow the waste to be exempt from being treated as hazardous waste if the lead concentration is below 5ppm. Moreover the MDL (Maximum Detectable Limit) for standard lead assessment procedures is 5ppm. Therefore, the score is "none" if < 5ppm concentration is encountered.

Asbestos Containing Materials (ACMs)

The other generic building material of hazard that is evaluated within the framework is asbestos. Asbestos is one of the major concerns associated with site preparation. Because of its insulating properties and tensile strength, asbestos is found in heating system insulation, vinyl floor tiles and sheet flooring, roofing paper and shingles, cement siding shingles, and a suite of other building construction products (NHDES, 2007). The cost of abatement of asbestos sometimes exceeds the cost of building demolition itself (Kenneth and Earnest, 2006). Appendix G provides a list of suspect ACMs, which are common in buildings/infrastructures.

The score for asbestos is assigned based on if the asbestos removal activities that are potentially involved for demolition, restoration or removal of ACMs are a potential type 1, type 2 or a type 3 activity classified by Ontario Reg. 278/05. This classification assigns a score of "low", "med" or "high". The guidelines for identifying the potential category of work involved is developed based on guidelines from Ontario Reg. 278/05 and are given below:

Criteria for potential type 1 operation – Score "low"

- Only ceiling tiles are ACMs covering an area < 7.5 m^2 – removal is possible without the material being broken, cut, drilled, rubbed off, ground or vibrated.
- Non-friable ACMs present, other than ceiling tiles; material could be removed without being broken, cut, drilled, rubbed off, ground, sanded or vibrated.
- Removal of less than 1 m^2 of drywall in which asbestos-containing material have been used as joint filling compounds.

Criteria for potential type 2 operation – Score "med"

- ACMs to be renovated/removed is present in only a part of false ceiling and are likely to be placed on the surface of the false ceiling.
- 1 m^2 or less of friable ACMs needs to be demolished.

- Site preparation involves enclosing friable ACM or applying tape or a sealant or other covering to insulations that may consist of ACMs.

- Ceiling tiles are composed of ACMs covering an area > 7.5 m^2 removal is possible without the material being broken, cut, drilled, rubbed off, ground, sanded or vibrated.

- Removal of > 1 m^2 of drywall in which ACM have been used as joint filling compounds.

- Removing insulation that may consist of ACMs from a pipeline or conduit.

Criteria for potential type 3 operation – Score "high"

- ACM removal method is not type 1 or 2 and may lead to asbestos exposure.

- Removal of more than 1 m^2 of friable ACM.

- Removal of air-handling equipment in a building that has been sprayed with fireproofing containing asbestos.

- Repair, alteration or demolition of a furnace made of asbestos-containing refractory materials.

The scores for lead and asbestos assessments are combined as shown in Figure 8-4 to determine the overall SAR score for asbestos and lead. It can be observed here that a "high" lead score and a "low" asbestos score gives a "med" score as opposed a "high" score. A "medium" score is a balance between a "high" and a "low" and have been considered instead of the highest of the two scores or the "worst" score to avoid an over conservative approach. However, when the *final* module scores were combined the worst of the two or three SAR scores were considered because the module with the hardest score is the most difficult one to achieve. Choosing the worst scores at each intermediate step, whenever the scores are being combined and also at the final step would have significantly compounded the conservativeness of the evaluation.

8.3.2.B Regulatory Chemicals Containing Equipment and Storage Assessment

Another set of onsite assets can significantly increase the severity of action required. This set consists of equipment and storage containing regulated chemicals such as PCB transformers, PCB-containing light ballasts, fixtures, mercury containing equipment. Removing such equipment – especially in old industrial/commercial brownfield sites significantly increases the severity of barriers associated with the land and infrastructure category. After identifying such equipment and storage, the severity of SAR score is adjusted as shown in Table 8-1. This section is generally more applicable for old industrial sites.

Table 8-1: Adjusted Intermediate SAR Score

Criteria	Scoring
Presence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure.	Increase the severity of SAR score.
Absence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure.	Continue with the intermediate SAR score derived from onsite assets module.

8.3.2.C Storage Tank Equivalence Assessment

The last level of adjustment of a SAR score is based on the presence of Underground Storage Tanks (USTs) and Aboveground Storage Tanks (ASTs). Tanks used to contain regulated substance for which 10% of the volume including the pipes is below the ground surface is termed as an UST (Kenneth and Earnest, 2006). When less than 10% is below the ground they are termed as ASTs. The storage facilities included in this section includes hazardous waste pipelines and tanks for storing oil for commercial purposes. Storm-water collection systems, surface impoundments and pits or lagoons are excluded. The cumulative volume of storage tanks present at the site is scaled to the number *of equivalents* of UST/AST. Table 8-2 summarizes how the number of equivalents of UST/AST is estimated. This concept of using equivalents of USTs and ASTs was developed by modifying the quantitative schemes developed by Chicago (GSG, 2005) for screening their brownfields.

The information on ASTs and USTs can be collected from site surveys using a radar and registration documents on storage tanks submitted to appropriate federal departments (AFDs)

(EC, 2007). The volumes of ASTs and USTs present are normalized to a scale that was developed by investigating existing scoring schemes for USTs and ASTs (GSG, 2005) used within other evaluation systems. The normalized AST/UST score contributes to the *overall* onsite assets "SAR" score as follows:

- Severity of SAR score is increased by one degree if there is >10 equivalents of ASTs and USTs.
- Severity of SAR score is unchanged if there is <10 equivalents of ASTs and USTs.

This adjustment to SAR score is made because >10 equivalents of ASTs and USTs is considered to pose a barrier – extensive enough to reflect on the overall onsite assets "SAR" score

Table 8-2: UST/ AST/ Underground Structure Equivalents

UST/AST / Underground structure equivalents	
<750 L	1 equivalent of UST
750-1,500 L	2 equivalents of UST
1,501-4,000 L	4 equivalents of UST
4,001-15,000 L	8 equivalents of UST
>15,000L	12 equivalents of UST

After the final SAR score is assigned to the onsite assets for ASTs and USTs the user proceeds to the next module on ecological evaluations.

8.4 ECOLOGY MODULE

This module determines the potential for natural resource impacts that could be caused by the site and assigns a SAR score to the site's ecological features. The evaluation process is adapted from principles of the Terrestrial Ecological Evaluation (TEE) process developed by the Washington Department of Ecology (WSDE, 2007), which has been adapted to this overall classification system. Specific and significant modifications are made in the following aspects of WSDE framework to enhance its applicability to the proposed classification system:

- The process flow diagrams were refashioned to fit with the overall classification system.
- The outcomes were modified to be consistent with the modular approach.
- The questions were recast to reflect the physical changes associated with the different redevelopment situations and can be answered based on Phase I and II ESAs.

The ecological evaluation determines if the site will likely to be a threat and pose a risk to wildlife or plants or affect the soil biota if no remediation takes place. Figure 8-6 summarizes the process flow diagram for ecological evaluation. The following sections illustrate the methodology for ecological evaluation.

8.4.1 Step 1: Excluding Low Ecological Impact (LEI) Sites from Ecological Evaluation

Certain site circumstances exclude the site from any further ecological evaluation because the contaminants have no pathway to reach the topsoil and damage the plants, animals or biota. These are:

- The contaminants are contained deep in the ground and sufficient physical barriers exist that could limit the contamination from vertical movement to the top layer of soil and impact the ecology.
- There is no habitat where plants or animals live/will live near the contamination.
- The contamination concentrations are lower than what is usually found naturally occurring in the area.

As illustrated in Figure 8-6 (Step 1):

- If a site meets any one of the above criteria (answers to any of the questions listed in Table 8-3 are "Yes"), then the site is considered to have a Low Ecological Impact (LEI) and SAR score of "none" is assigned to the ecological module. Such sites are considered to not harm the terrestrial ecological features. Table 8-3 lists the criteria for qualifying as an LEI site discussed above.
- If a site is not designated as LEI site, the evaluation process continues to step 2.

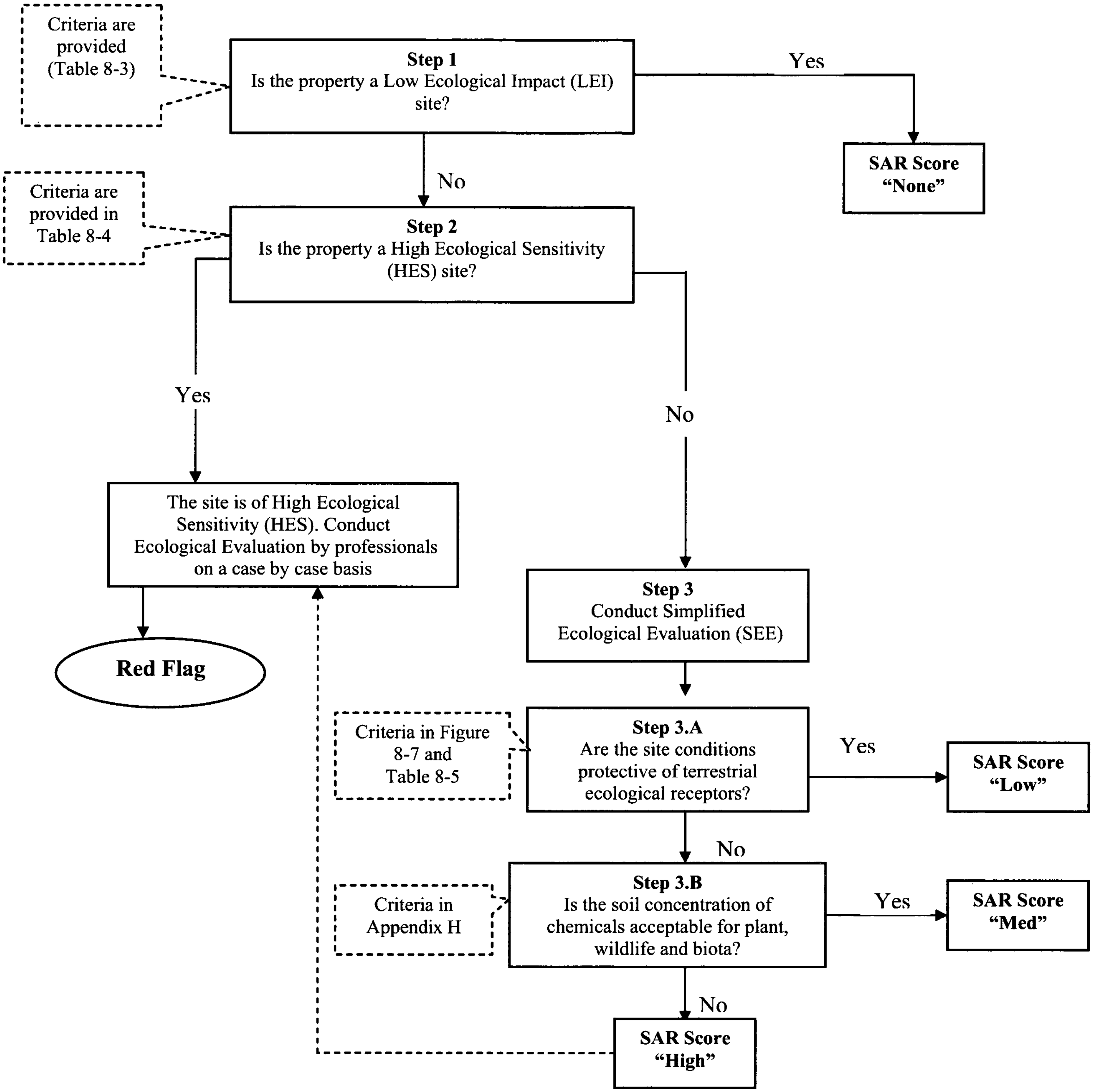


Figure 8-6: Ecological Evaluation Module

Table 8-3: Criteria for Qualifying as a Low Ecological Impact (LEI) site

Criteria for Exclusion	Answer
1. Is soil contamination located below and will remain below (during redevelopment) a certain depth through out the site? • At least 5m beneath the surface. • Between 2 to 5m and acceptable containments are present which will remain in place even if redevelopment is carried out (culvert/instructions)	☐Yes ☐No/ Unknown
2. Will soil contamination be covered/capped by buildings, paved roads, pavement, or other physical barriers after redevelopment that will prevent plants or wildlife from being exposed to contamination?	☐Yes ☐No/Unknown
3. Are the sites contaminated with hazardous substances other than those listed in Appendix H and there is less than 6000 m^2 of adjacent undeveloped land on the site, or within 150m of any area of the site?	☐Yes ☐No/Unknown
4. Are the sites contaminated with hazardous substances listed in Appendix H, there is less than 1000 m^2 of adjacent undeveloped land on or within 500 feet of any area of the site?	☐Yes ☐No/Unknown

8.4.2 Step 2: Criteria to be Considered as a High Ecological Sensitivity (HES) Site

Certain sites have a Higher Ecological Sensitivity (HES) and individual evaluations by professionals on a case by case basis is recommended (Red Flag) for such sites. There are four criteria outlined in Table 8-4 that designate if the property is an HES site. If any of these criteria are met (i.e., answers to any of the questions in Table 8-4 is "Yes"), the site ecology is identified as a "Red Flag" and a site specific ecological evaluation by a professional is recommended. If none of the criteria in Table 8-4 are met the site qualifies for a simplified ecological evaluation (SEE) and the system proceeds to step 3 to evaluate the site ecology based on simplified ecological evaluation scheme adapted from WSDE (2007).

Table 8-4: Criteria for Qualifying as a High Ecological Sensitivity (HES) site

Criteria	Answer
1. Is the site located on or directly adjacent to an area where management or land use plans maintains/will maintain or restore vegetation? E.g. green-belts, protected wetlands, forestlands, locally designated environmentally sensitive areas, parks or outdoor recreation areas.	☐Yes ☐No
2. Is the site used by a threatened or endangered plant or animal species	☐Yes ☐No
3. Is the site located on a property that contains at least 40,000 m^2 of native vegetation within 150 m of the site? Do not include vegetation beyond the site.	☐Yes ☐No
4. Does any assessment indicate that the site may present any risk to the significant wildlife populations?	☐Yes ☐No

8.4.3 Step 3: Simplified Ecological Evaluation (SEE)

If the site is not an HES site, then the next step is to perform a generic SEE. The SEE methodology is outlined in Figure 8-7 in conjunction with Table 8-5. This scheme has been developed by modifying the SEE scoring criteria of Washington State Department of Ecology. To complement the overall classification system being developed, the quantitative scoring scheme developed by the Washington State Department was modified and translated into a qualitative scoring scheme.

In SEE, the brownfield sites are categorized into three major groups depending on the area of contiguous (connected) undeveloped land on the site or within 150 m of any area of the site to the nearest 2,000 m^2. As shown in Figure 8-7 the first, second and third group are considered to have 1,000 to 8,000 m^2; 8,000 m^2 to 16,000 m^2; and 16,000 m^2 to 40,000 m^2 of land respectively.

Figure 8-7: Simplified Ecological Evaluation (Step 3.A)

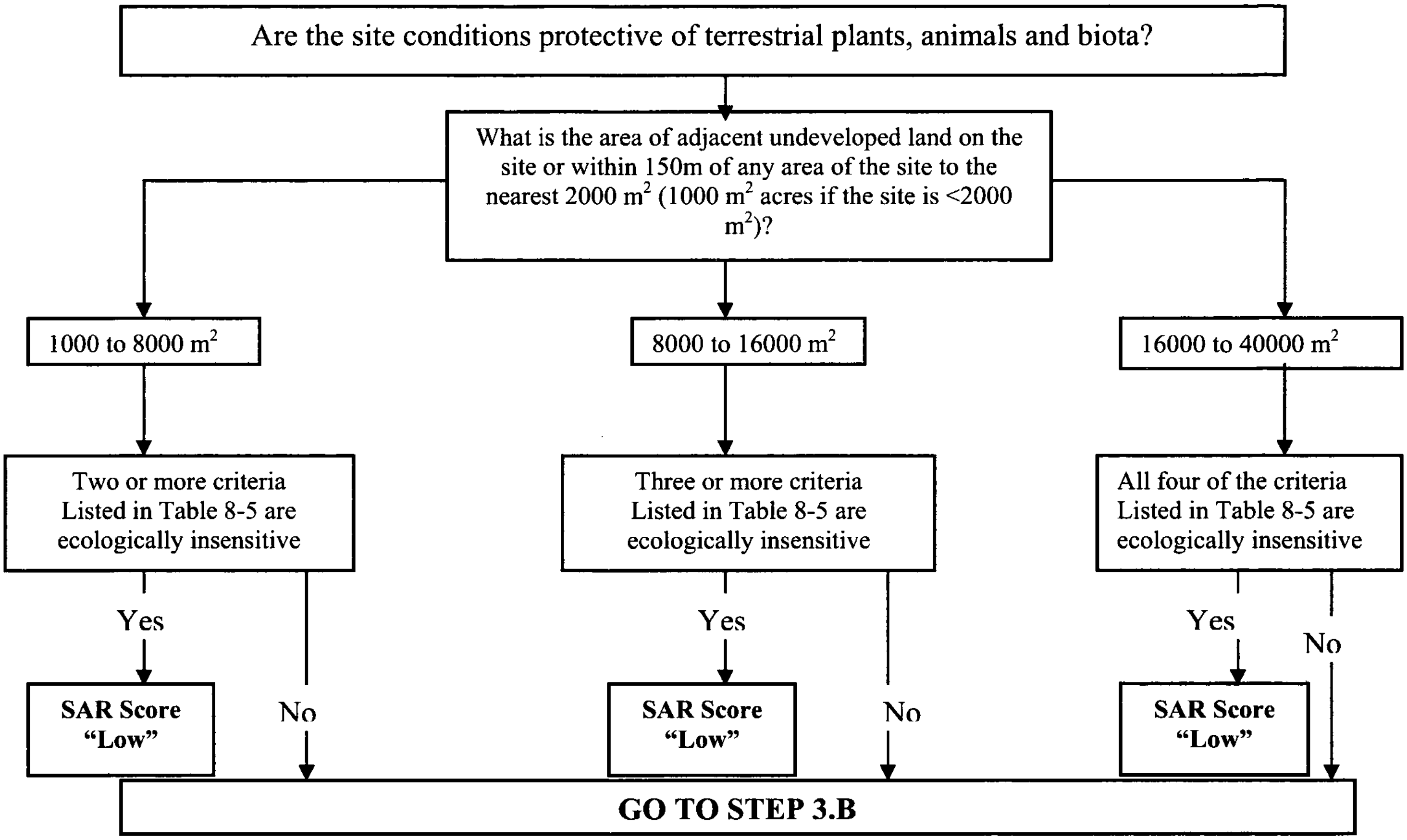


Table 8-5: Ecological Sensitivity of Site Attributes (WSDE, 2007)

Criteria	Ecologically Insensitive	Ecologically Sensitive
Past use What is the past use of the site?	Industrial/commercial	Residential/park/open space
Habitat Quality What is the habitat quality of the site?	Vegetation is predominately noxious plant species or weeds	High species diversity, used by uncommon/rare species
Wild life attraction Is the undeveloped land likely to attract wildlife?	No	Yes
Presence of ecologically adverse contamination Are any of the soil contaminants listed in Appendix H present?	Yes	No

After appropriate grouping, the sites are then investigated for four possible criteria outlined in Table 8-5 to evaluate their ecological sensitivity. These criteria are:

- Past use;
- Habitat quality;
- Wildlife attraction; and
- Presence of ecologically adverse contamination.

As illustrated in Table 8-5, the above mentioned criteria are considered ecologically insensitive if;

- The past use is industrial or commercial;
- Vegetation is predominately noxious and non-active, exotic plant species or weeds;
- The undeveloped land is not expected to attract wildlife; and
- There are contaminants that are listed in Appendix H.

A SAR Score of "low" is assigned if one of the following is true:

- The site/contiguous underdeveloped land area is between 1,000 to 8,000 m^2 and at least *two* of the criteria listed in Table 8-5 are ecologically insensitive.
- The site/adjacent underdeveloped land area is between 8,000 to 16,000 m^2 and at-least *three* of the criteria listed in Table 8-5 are ecologically insensitive.
- The site/adjacent underdeveloped land area is between 16,000 to 40,000 m^2 and all *four* of the criteria listed in Table 8-5 are ecologically insensitive

If the SAR score is not "low" the classification system proceeds to the next part of SEE (Step 3.B) to investigate if the soil concentration of chemicals is acceptable for plant, wildlife and biota. This is investigated by checking the ecological acceptability criteria provided in Appendix I.

- If none of the limits of contaminations exceed the limits specified in Appendix I, the SAR score is "med".
- If any of the contamination concentrations exceeds the limits provided, an SAR score of "high" is assigned to the site. However, if an SAR score for ecological evaluation is "high" the system also raises a "Red Flag" and recommends the user to confirm the exact ecological status as it is done in the case of an HES site by conducting an individual evaluation before further considering redevelopment.

After evaluating the SAR score from ecological evaluation, the next step is to investigate the site accessibility.

8.5 SITE ACCESSIBILITY MODULE

This module determines if the site has access to the transportation and service resources. It analyzes the extent of effort required to make provisions for utilities, site services, transportation and process resources (this is especially important for some industrial uses; for example, the automotive industry would require access to metal castings) for the proposed redevelopment. The following criteria are considered under site accessibility:

- Utility infrastructure;
- Telecommunication infrastructure;
- Transportation infrastructure; and
- Proximity to process resources.

Unlike the other modules, this module depends on user preferences. At this module the user is expected to select the set of criteria given in the Table 8-6 which are relevant for the proposed end use. For example, the public space and park may be relevant for a residential use, but may not be of importance for a commercial end use. The highest score for all of these required criteria is considered to be the overall accessibility score. This is because the highest score is received by the accessibility criterion that is the most difficult to achieve.

8.6 OVERALL LEVEL 3 AND LEVEL 3-ADVANCED SCORE

The SAR scores from three modules are finally combined to determine the overall land and infrastructure score as shown in Figure 8-8. The scores are combined to obtain the Level 3 evaluation as follows:

- If all of the SAR scores from the three modules is "none" – land and infrastructure is "Y".
- If at least one of the SAR scores is "high", "med" or "low", land is a "CRA".

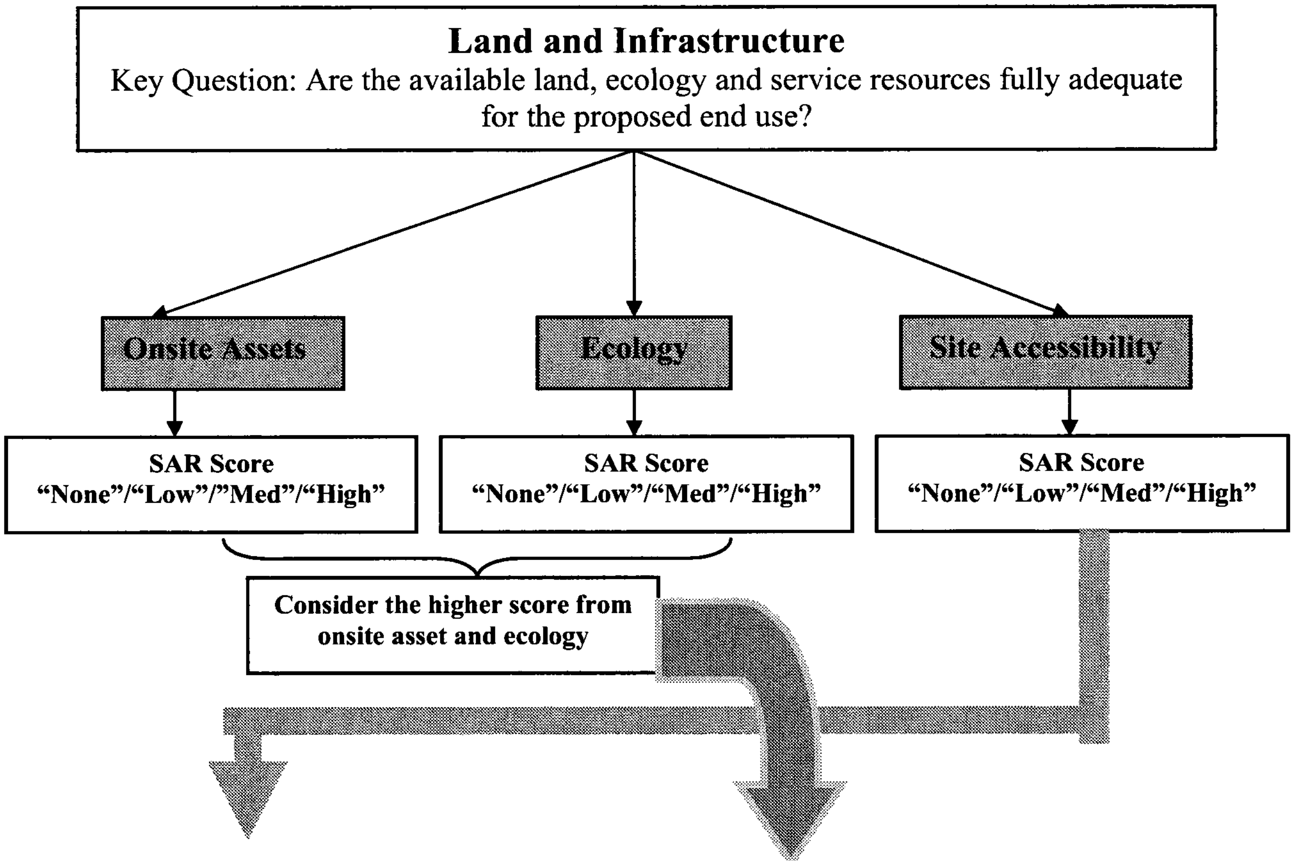
If land and infrastructure is a CRA the next level of evaluation is conducted to obtain the Level 3-Advanced score as follows:

- The highest SAR score from *Onsite Assests* and *Ecology* module is selected.

Table 8-6: Criteria for Site Accessibility Module

Criteria	SAR Score "high"	SAR Score "med"	SAR Score "low"
Utility infrastructure capacity	>800 m away	200 m – 800 m away	Available onsite or < 200 m
Transportation infrastructure	Secondary or country roads	Class A/primary or state highway	Interstate access/ rail/airport
Telecommunication Infrastructure	Proposed 2-5 years	Proposed 1-2 years	High tech fiber optics installed
Walk-able community	> 400 m	200 to 400 m	Within 200 m
Access to public transportation	> 400 m	200 to 400 m	Within 200 m
Adjacent Parking availability	Away/ elsewhere	On street	In rear, within unit or at surface lot
Possible conflict with surrounding land uses	Severe conflicts	Conflicts with reservations	No- conflicts
Public spaces park	> 400 m	200 to 400 m	Within 200 m

- If the *Accessibility* score is "high" – the highest of the SAR scores from *Onsite Assets* or *Ecology* is increased by one degree. This score is the final CRA score for Level 3-Advanced.
- If the *Accessibility* score is "med" – the highest of the SAR scores from *Onsite Assets* and *Ecology* is the final CRA score for Level 3-Advanced.
- If the *Accessibility* score is "low"/"none"– the highest of the SAR scores from *Onsite Assets* and *Ecology* is decreased by one degree. This is the final CRA score for Level 3-Advanced.



Criteria	Final CRA Score
If site accessibility SAR score is "none" or "low"	Decrease the severity of higher score from onsite assets and ecology by one degree
If site accessibility SAR score is "med"	Continue with highest of the scores from onsite assets and ecology
If site accessibility SAR score is "high"	Increase the severity of highest score from onsite assets and ecology by one degree

Figure 8-8: Evaluation of Land and Infrastructure for Brownfield Classification

The rationale for adjusting the scores is dependent on the relative ease to overcome each barrier and its relative importance. Among the three different modules considered under land and infrastructure, ecology and onsite asset related barriers are much difficult to overcome compared to site accessibility related barriers. Ecological features are the characteristics of a site acquired over several years. Onsite assets already exist and their removal may involve significant amounts of efforts.

Conversely, accessibility features (e.g. roads, telecommunications) are mostly controlled by human needs and can be provided as a part of overall redevelopment process. Therefore, instead of considering accessibility "SAR" score independently like onsite assets and ecology the influence of accessibility features was assumed to escalate or diminish the overall land and infrastructure score (which is the highest of the *Onsite Assets* and *Ecology* score).

8.7 ILLUSTRATIVE EXAMPLE: LEVEL 3 AND LEVEL 3-ADVANCED - LAND AND INFRASTRUCTURE

This section evaluates the site ABC Automotive Service Garage for Level 3 and Level 3-Advanced land and infrastructure. The following sections illustrate the information from Phase I and II ESA and the methodology for processing the available information.

8.7.1 Information Requirement for the Illustrative Example

The following information is excerpts from the Phase I and II site assessments that are used for evaluating the ABC Automotive Service Garage illustrative example. The complete information is given in Appendix A.

- The site is located in a small city (under 50,000) in Ontario, in a mixed residential and commercial neighborhood.
- The owner has been occupying the 15,000 m^2 property since 1971 as an automotive dealership and service garage, with major operations including vehicle repair and maintenance and an automotive showroom/car lot. The site is an irregular shaped 15,000 m^2 property occupied by three commercial buildings:
    - The southern building has a footprint of 2250 m^2
    - The northern building has a footprint of 140 m^2
    - The eastern building has a footprint of 250 m^2
- Two steel USTs (one 3785L and one 11356L) were removed from the ground and disposed.

- No active or closed waste disposal site was listed within 1 km of the site by the Waste Management Branch of the Ontario Ministry of the Environment (MOE).
- No coal tar or waste sites were listed as being present within 1km of the site by "Inventory of Coal Gasification Plant" by MOE.
- The site and surrounding sites is not a registered PCB waste storage site. Light ballasts were tested for PCB and the concentration was below acceptable standards.
- The site is not a registered waste generator based in the MOE database.
- The site was well maintained and no amounts of debris, uncontrolled chemical storage or waste storage were observed at the site.
- The following descriptions highlight the status of any designated hazardous substances:
    - Some of the interiors and exterior walls of the site building contained painted surfaces. The site building was approximately constructed in 1950s and given the date, it is possible that lead based paint (LBP) might be present. LBP was verified using sampling and the concentration was <0.05 mg/L. This is below the MDL for LBP concentration (threshold value for LBP score of "none").
    - Based on the date of the construction of site building (i.e. beginning of 1950s), friable asbestos containing materials (ACMs) may be present at the site as the use of friable ACMs was not discontinued until early 1980. However, a survey was carried out only in the readily accessible areas of the existing building and no asbestos was found.
    - No other designated substances were identified at the site.
- There was no area of natural significance or condition in the vicinity of the site, which would cause the site to be classified as potentially sensitive according to the Ministry of Natural Resources (MNR)' Natural Heritage Club website.
- The MNR has been contacted regarding the presence of a 'threatened'/'other' species in the vicinity of the site and no concern was received.
- The site is connected to municipal water supply. Sanitary wastewater is discharged to municipal sewer system. Storm water flows to catch basins are located across the site and into municipal storm water system. Electrical services are supplied to the site through

aboveground and underground service cables. Pad and pole mounted transformers are present adjacent to the site. The locations nearby have fiber optic cables available.

The two potential redevelopment options are considered for the site. One is a residential and the other is a commercial development. From Level 2, the site is both a potential commercial as well as a potential residential site. The following information is available specific to these two redevelopment options:

8.7.1.A Potential Residential Use

For the first redevelopment alternative, a developer who has an established company with a strong and stable cash flow intends to remediate the entire property, demolish the buildings and develop it into a set of town homes.

8.7.1.B Potential Commercial Use

For the second redevelopment alternative, the existing owner plans to renovate the existing buildings and use it as a business/commercial property. Renovating the property would involve the following:

- Encapsulating the contaminant using barrier walls to prevent any offsite and vertical migration of the contaminant.
- Renovating of the existing buildings and developing them as follows:
    - Renovating the southern and northern buildings to commercial stores.
    - Demolishing the eastern building (250 m^2).
    - Removing all of the ASTs and USTs.

8.7.2 Land and Infrastructure Evaluation for Potential Residential Use

This section evaluates the land and infrastructure Level 3 and Level 3-Advanced for the potential residential use.

8.7.2.A Onsite Assets Module - Residential

The following sections detail the steps used for determining the SAR score of the Onsite Assets Module of ABC Automotive Service Garage.

Step 1: Availability Assessment

Figure 8-9 evaluates the first step of onsite assets module – the availability assessment. The results obtained are shown through bolded arrows and bolded responses in the flow diagrams from Figures 8-9 to 8-12.

- It was determined that the 80 town houses that are planned require < 15,000 m^2 of area. Therefore the land included sufficient area for the construction.
- Because the site is a mixed residential neighborhood, the proposed zoning is compliant with the housing end use.
- The master plan was evaluated and it also indicates that the area could be compatible for residential use. There is thus some assurance that this proposed end use is not inconsistent with the surrounding land matrix.

The results shown in Figure 8-9 guides the user to proceed to the onsite assets hazard potential.

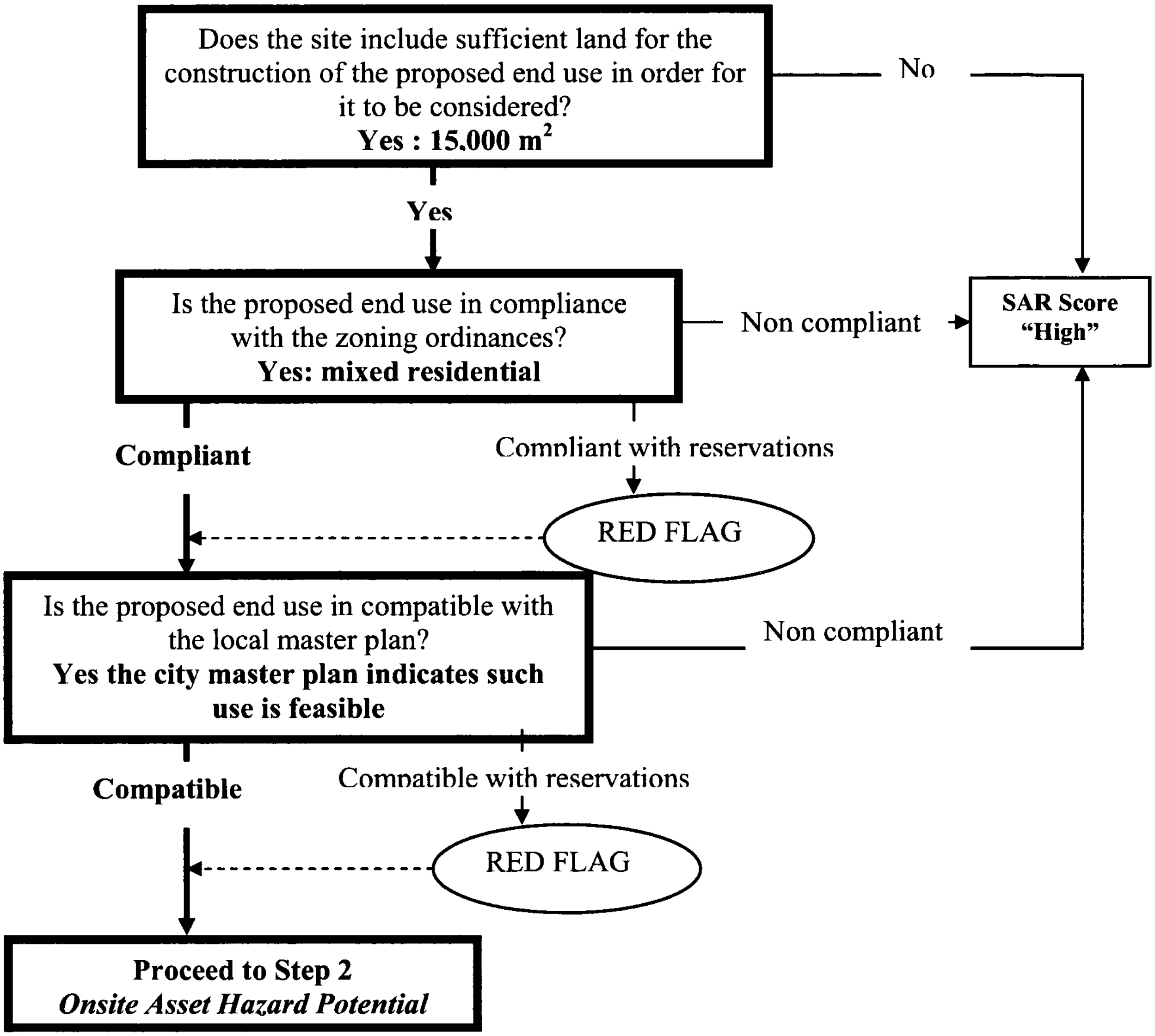


Figure 8-9: Compatibility Assessment for ABC Automotive Service Garage – Residential Use

Step 2: Onsite Assets Hazard Potential

Figure 8-10 illustrates the evaluation of the onsite assets hazard potential. Because there are buildings on the site and also there are USTs, the user is guided through the building materials of hazard assessment, regulatory chemical containing equipment and storage assessment, and AST/UST assessment.

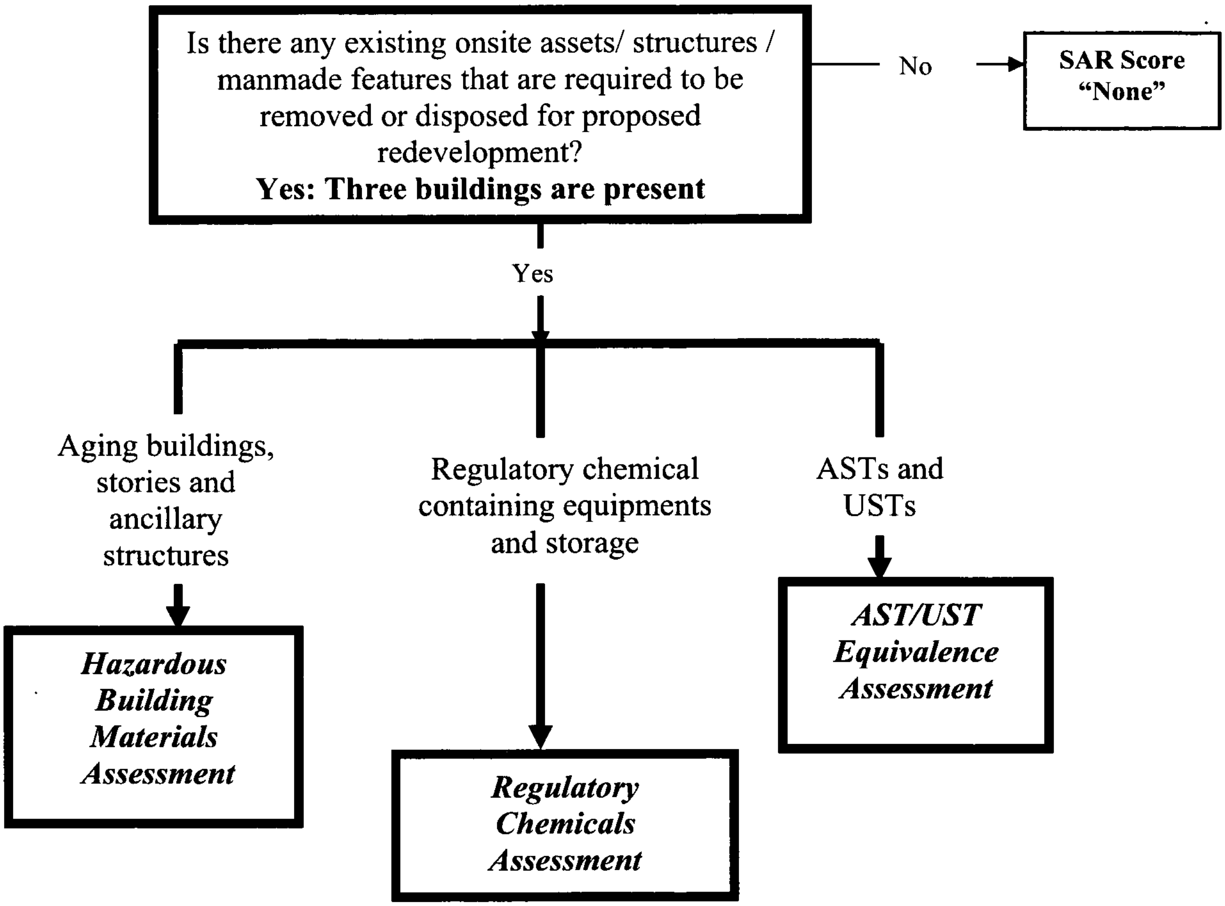


Figure 8-10: Onsite Assets Module Step 2: Onsite Assets Hazard Potential – Residential Use

Assessment of Hazardous Building Materials

Figure 8-11 summarizes the assessment of hazardous building materials. The gross area of the footprint of buildings is 2640 m^2 or (2250+140+250) m^2 >> 450 m^2. Based on the construction date of the building (early 1950s), the building material is expected to contain LBPs and ACMs. However, no other designated substances are observed in the site. As per Figure 8-11 the user is therefore guided to perform a lead and an asbestos assessment.

Lead

Figure 8-12 illustrates the decision path for lead assessment. The lead concentration in the samples from Phase II ESA was found to be <5ppm (mg/L), which is the MDL for lead: this leads to a score of "none".

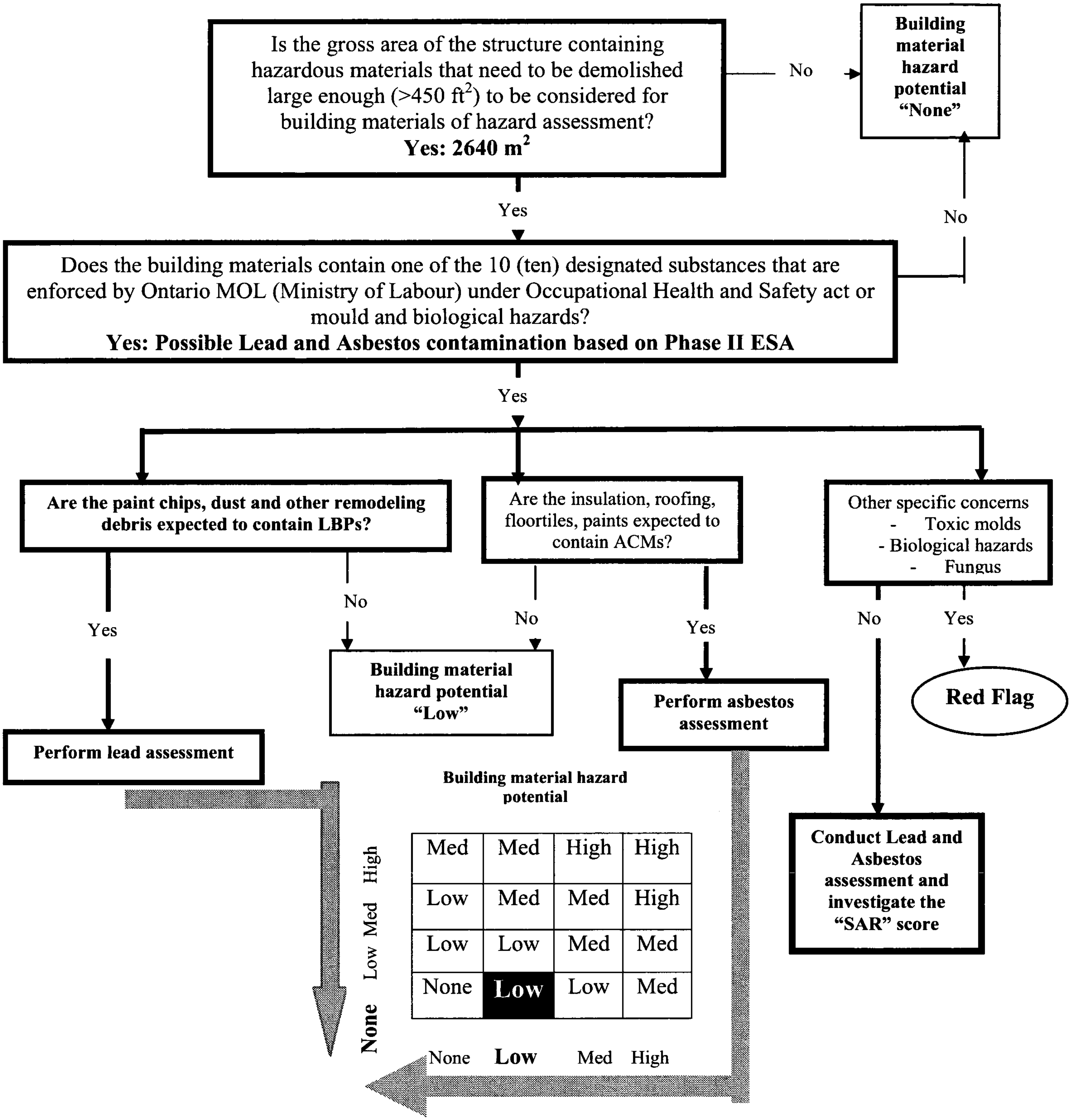


Figure 8-11: Assessment of Hazardous Building Materials – ABC Automotive Service Garage- Residential Use

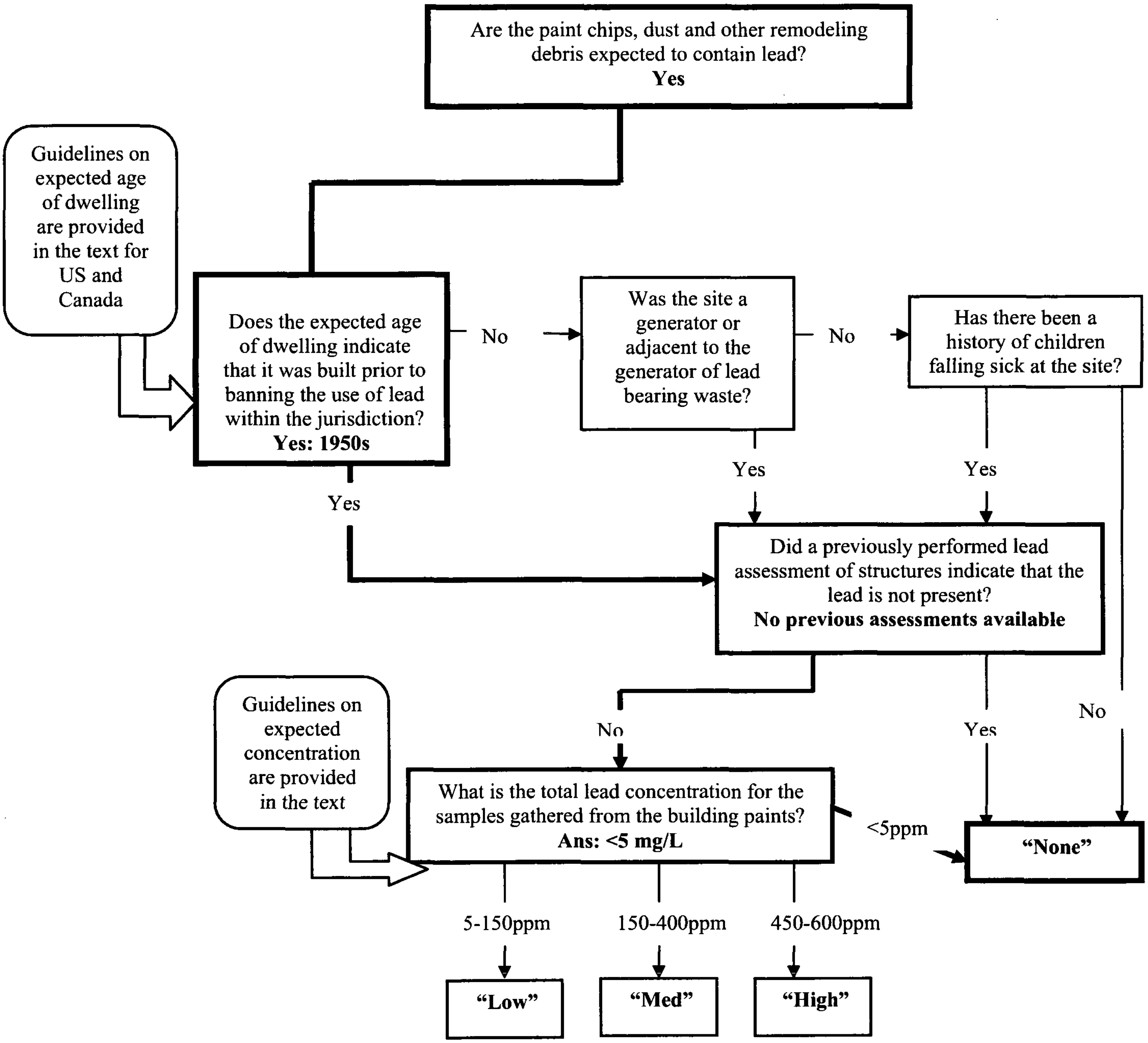


Figure 8-12: Methodology for Assessment of the Lead Score– ABC Automotive Service Garage- Residential Use

ACMs

Although the building is expected to contain asbestos the ESA indicates that the site reconnaissance did not find any presence of friable asbestos in the accessible areas. Therefore the classification considers the asbestos present to be non-friable. This leads to a "type-1" activity and a "low" score is assigned. Figure 8-11 indicates the overall building material of hazard score and it could be observed that the site is assigned an intermediate SAR score of "low". This score is further adjusted due to the presence of regulatory chemicals, ASTs and USTs as shown in the following sections.

Presence of Regulatory Chemical Containing Equipment and Storage

Since the buildings were mostly used for commercial purposes, no PCB/other regulatory chemical containing equipment were present. Moreover as pointed out previously, Phase I ESA indicates:

- No active or closed waste disposal site was listed within 1 km of the site by the Waste Manage Branch of the MOE.
- No coal tar or waste sites were listed as being present within 1 km of the site by "Inventory of Coal Gasification Plant" by MOE.
- The site and surrounding sites is not registered PCB waste storage site.
- The site is not a registered waste generator based on MOE database.
- The site was well maintained and no amounts of debris, uncontrolled chemical storage or waste storage were observed at the site.

Therefore the Building Material Hazard Score is adjusted as shown in Table 8-7. The user is guided to continue with the same SAR score of "low" and moves to the next step of AST and UST assessment.

Table 8-7: Adjustment of Score for Regulated Chemical Storage/Equipment

Criteria	Scoring
Presence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure	Increase the severity of score
Absence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure	**Continue with the same intermediate SAR score from Onsite Assets module Low →Low**

AST/UST Assessment

Two steel USTs (one 3785L and one 11356L) were removed from the ground and disposed. Based on Table 8-10

- 3785 L UST translates to → 4 equivalents of standard UST.
- 11,356 L translates to → 8 equivalents of standard UST.

Therefore, there are a total 12 equivalents (>10 equivalents) of UST that need to be removed. The severity of SAR score is thus increased by one degree (from "low" to "med") if there are >10 equivalents of ASTs and USTs. Thus, from the above assessment the final SAR Score for Onsite Assets Module is "medium".

8.7.2.B Ecology Module - Residential

Excluding Low Ecological Impact (LEI) Sites from Ecological Evaluation

Table 8-8 summarizes the criteria for to determine if the brownfield is an LEI site and the responses for ABC Automotive Service Garage. Since all the answers chosen are "No/ Unknown", this is not an LEI site and thus an ecological evaluation is required for the site.

Criteria to be Considered to Designate a Site as an HES Site

Table 8-9 summarizes the criteria of ABC Automotive Service Garage for being designated as an HES site. As all the answers are "No" for the criteria given in Table 8-9, this is not an HES site and an SEE can be conducted based on generic criteria.

Simplified Ecological Evaluation (SEE)

Figure 8-13 in conjunction with Table 8-10 illustrates Part 3.A of SEE. By having 75% of 15,000 m^2 land undeveloped, the site could be considered within the grouping of 8000 m^2 to 16000 m^2 sites. Table 8-10 highlights the criteria that are chosen for the site in bold letters. Three of the criteria in Table 8-10 are ecologically insensitive and thus the site ecology receives an SAR score of "low". Figure 8-14 summarizes the overall ecological evaluation for ABC Automotive Service Garage and the decision pathways are shown with bold arrows based on above discussion.

Table 8-8: Criteria for Qualifying as a Low Ecological Impact (LEI) Site- Residential Use

Criteria for Exclusion	Answer
1. Is soil contamination located below a certain depth through out the site? • At least 5 m beneath the surface. • Between 2 to 5m and acceptable containments are present which will remain in place even if redevelopment is carried out (culvert/instructions). **Unknown. Phase I and II results do not confirm this.**	☐Yes ☒No/ Unknown
2. Will soil contamination be covered by buildings, paved roads, pavement, or other physical barriers after redevelopment that will prevent plants or wildlife from being exposed to contamination? **No. It is unsure whether the physical barrier will be there or not for the residential development.**	☐Yes ☒No/Unknown
3. Are the sites contaminated with hazardous substances other than those listed in Appendix H and there is less than 6000 m^2 of adjacent undeveloped land on the site, or within 150m of any area of the site affected by the hazardous substances? **No. The site itself contains 15,000 m^2 (>>6000 m^2) of undeveloped land of which only 25% has buildings and ancillary structures. Therefore, the undeveloped area is 11,750 m^2.**	☐Yes ☒No/Unknown
4. Are the sites contaminated with hazardous substances listed in Appendix H, there is less than 1000 m^2 of contiguous undeveloped land on or within 150 m of any area of the site affected by those hazardous substances? **No, the site is not contaminated with one of the substances listed in Appendix H.**	☐Yes ☒No/Unknown

Table 8-9: Criteria for Qualifying as an HES site – Residential Use

Criteria	Answer
1. Is the site is located on or directly adjacent to an area where management or land use plans will maintain or restore native or semi-native vegetation? **No. There was no area of natural significance or condition in the vicinity of the site, which would cause the site to be classified as potentially sensitive according to the Ministry of Natural Resources (MNR)' Natural heritage club website.**	☐Yes ☒No
2. Is the site used by a threatened or endangered plant or animal species? **No. MNR has been contacted regarding the presence of a 'threatened'/ 'other' species in the vicinity of the site and no concern was received.**	☐Yes ☒No
3. Is the site (area where the contamination is located) located on a property that contains at least ten acres of native vegetation within 150 m of the site (where the contamination is located)? **No. It is in the mixed residential neighborhood and does not have at least 40,000 m^2 of vegetation within 10 m of a property boundary.**	☐Yes ☒No
4. Does any assessment indicate that the site may present any risk to the significant wildlife populations? **No such assessments were available.**	☐Yes ☒No

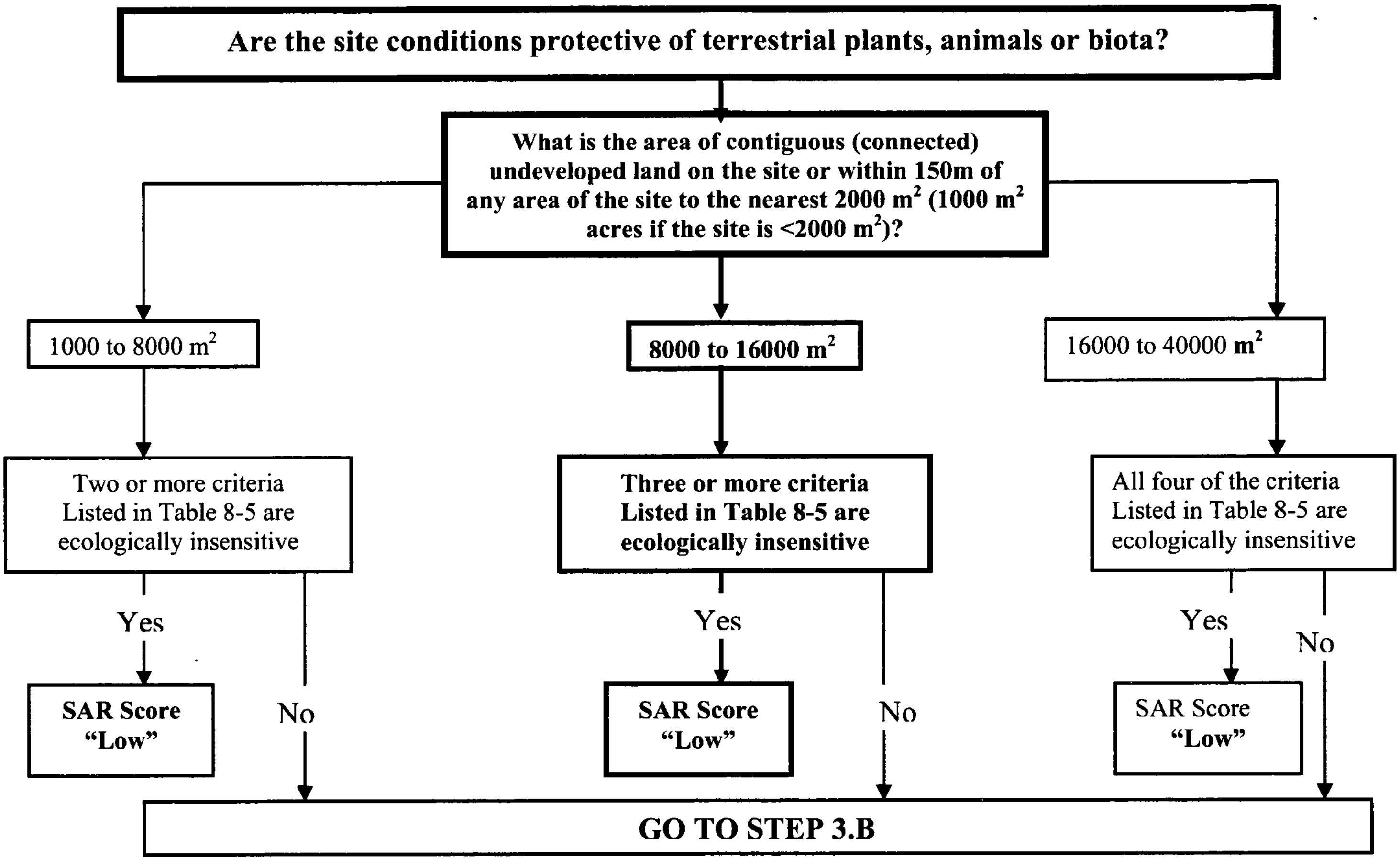


Figure 8-13: Simplified Ecological Evaluation (Step 3.A) – Residential Use

Table 8-10: Ecologically Sensitive Site Attributes of ABC Automotive Service Garage – Residential Use

Criteria	Possibly Ecologically Insensitive	Possibly Ecologically Sensitive
Past use What is the past use of the site?	**Industrial/ commercial**	Residential/ park/ Open space
Habitat Quality What is the habitat quality of the site?	**Low: Vegetation is predominately noxious plant species or weeds**	High: Relatively high species diversity, used by uncommon/ rare species
Wild life attraction Is the undeveloped land likely to attract wildlife?	**No**	Yes
Presence of ecologically adverse contamination Are any of the soil contaminants listed in Appendix I present?	Yes	**No**

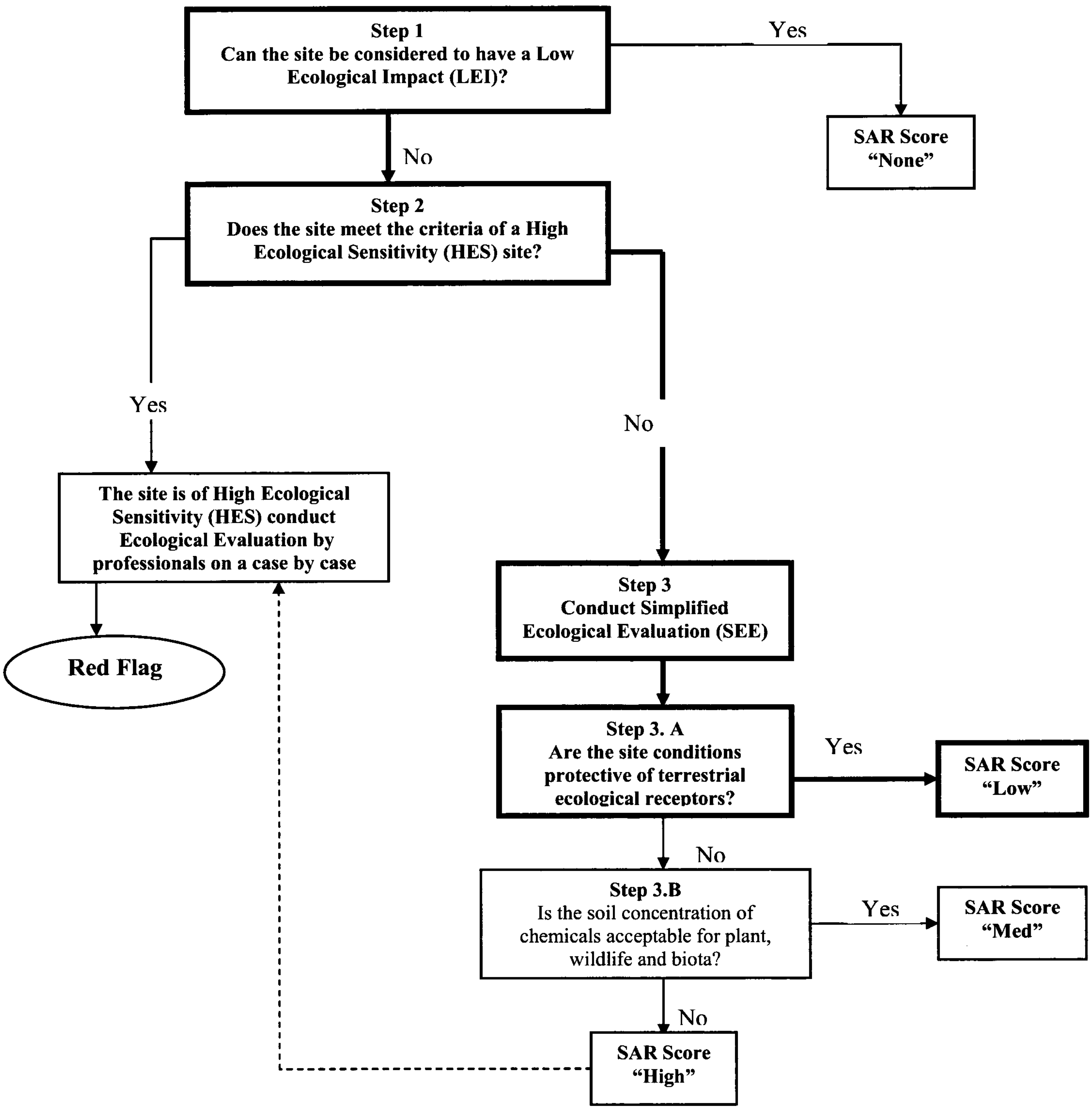


Figure 8-14: Ecological Evaluation Module – Residential Use

8.7.2.C Accessibility Module – Residential

Table 8-11 summarizes the site accessibility criteria for ABC Automotive Service Garage. The criteria preferred by the user are shown using checked boxes and corresponding SAR scores are indicated with bold letters. The rationale for choosing the SAR scores are provided in the "Comments" column.

Table 8-11: Site Accessibility Score for ABC Automotive Service Garage –Residential Use

Criteria	**User preference**	**SAR Score "high"**	**SAR Score "med"**	**SAR Score "low"**	**Comments**
Utility infrastructure capacity	☒	>800 m away	200 m – 800 m away	***Available onsite or < 200 m***	Phase I ESA indicates that the site is connected to municipal utility
Transportation infrastructure	☒	Seconda ry or country roads	***Arterial/ primary or state highway***	Interstate access/ rail/ airport	The site has access to arterial
Telecommunication infrastructure	☒	Propose d 2-5 years	Proposed 1-2 years	High tech fiber optics installed	Phase I ESA indicate that is available
Walk-able community	☒	> 400 m	200 to 400 m	***Within 200 m***	Nearby mixed residential neighborhood is present
Access to public transportation	☒	> 400 m	200 to 400 m	***Within 200 m***	Adjacent to the site the transit route is present
Adjacent parking availability	☒	Away/ elsewher e	On street	***In rear, within unit or at surface lot***	Parking will be available within the site once the redevelopment takes place
Possible conflict with surrounding land uses	☐	Severe conflicts	Conflicts with reservations	No- conflicts	N/A, not a referred criteria as per user choice
Public spaces park	☐	> 400 m	200 to 400 m	Within 200 m	N/A, not a referred criteria as per user choice

Based on the above assessment, the highest of the scores for the accessibility criteria listed in Table 8-11 is “med”. Thus, final SAR Score of *Accessibility* Module is “med”. Next the user is guided to determine the overall score for land and Infrastructure.

8.7.2.D Overall Land and Infrastructure Score for Residential Use

Figure 8-15 illustrates the overall land and infrastructure score for brownfield classification. The following are the SAR scores for the three modules:

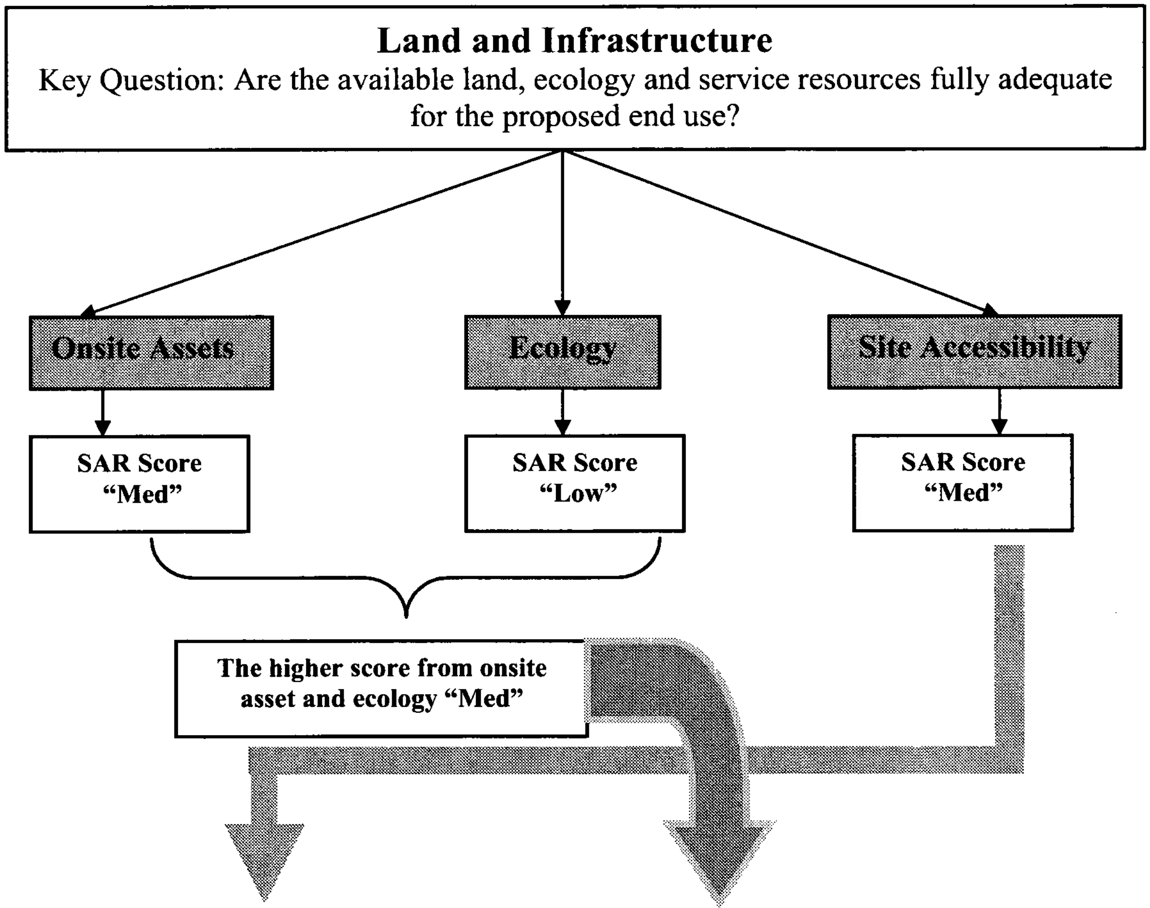
- The SAR score for onsite assets module is “med”.
- The SAR score for ecology module is “low”.
- The SAR score for accessibility module is “med”.

Because, none of these scores are “none”, the Level 3 evaluation identifies that land and infrastructure is a “CRA” for the residential use.

For the purpose of determining Level 3-Advanced score:

- First, the user determines the highest score from ecology and onsite assets module which is “med” in this case.
- Next, the user adjusts this score based on the accessibility module. As illustrated in Figure 8-15, if the accessibility SAR score is “med” the user continues with the highest of onsite assets and ecology score. In this case, the final score remains “med”.

As a result, the Level 3-Advanced score for the site for residential use is M-CRA, which means a moderate degree of action is required in order to remediate and develop the site into residential town homes.



Criteria	Final CRA Score
If site accessibility SAR score is "none" or "low"	Decrease the severity of higher score from onsite assets and ecology by one degree
If site accessibility SAR score is "med"	**Continue with highest of the sores from onsite assets and ecology "MED"**
If site accessibility SAR score is "high"	Increase the severity of highest score from onsite assets and ecology by one degree

Figure 8-15: Evaluation of Land and Infrastructure for Brownfield Classification - Residential

8.7.3 Land and Infrastructure Evaluation for Potential Commercial Use

8.7.3.A Onsite Assets Module -Commercial

The following sections elaborate the onsite assets evaluation for commercial use.

Step 1: Availability Assessment

Figure 8-16 evaluates the first step of onsite assets module – the availability assessment for commercial end use. The results obtained are shown through bolded arrows and bolded responses in the flow diagrams.

- It was determined that the commercial end use would use the existing buildings after renovation.
- Because the site is a mixed residential neighborhood, the proposed zoning is compliant with the commercial end use.
- The master plan was evaluated and it also indicated that the area could be used for commercial

The results shown in Figure 8-16 guides the user to proceed to the onsite assets hazard potential.

Step 2: Onsite Assets Hazard Potential

Figure 8-17 illustrates the evaluation of the onsite assets hazard potential and the user is guided through the building materials of hazard assessment, regulatory chemical containing equipment and storage assessment, and AST/UST assessment.

Building Materials of Hazard Assessment

The gross area of the footprint of buildings is 2640 m^2 of which only the eastern building will be demolished and the rest will be renovated for commercial purposes. The gross area of the eastern building is 250 m^2, which is much less than 450 m^2. Therefore the building material hazard potential is "none". This is because for the proposed commercial end use very limited demolition is needed for aging buildings.

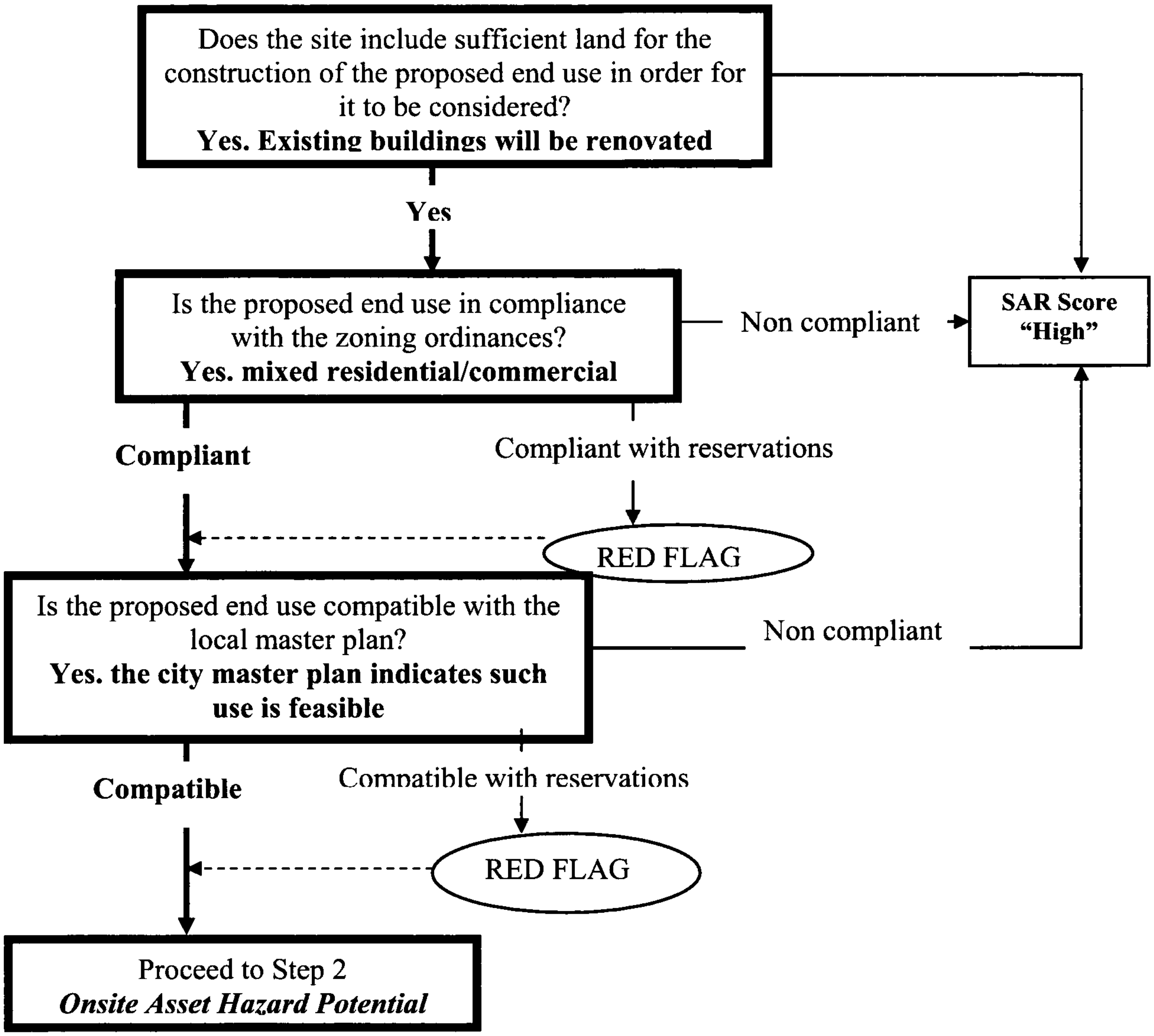


Figure 8-16: Compatibility Assessment for ABC Automotive Service Garage-Commercial Use.

Presence of Regulatory Chemical Containing Equipment and Storage

There is no regulated chemical-containing equipment and storage. Thus, this score is "none" in Table 8-12.

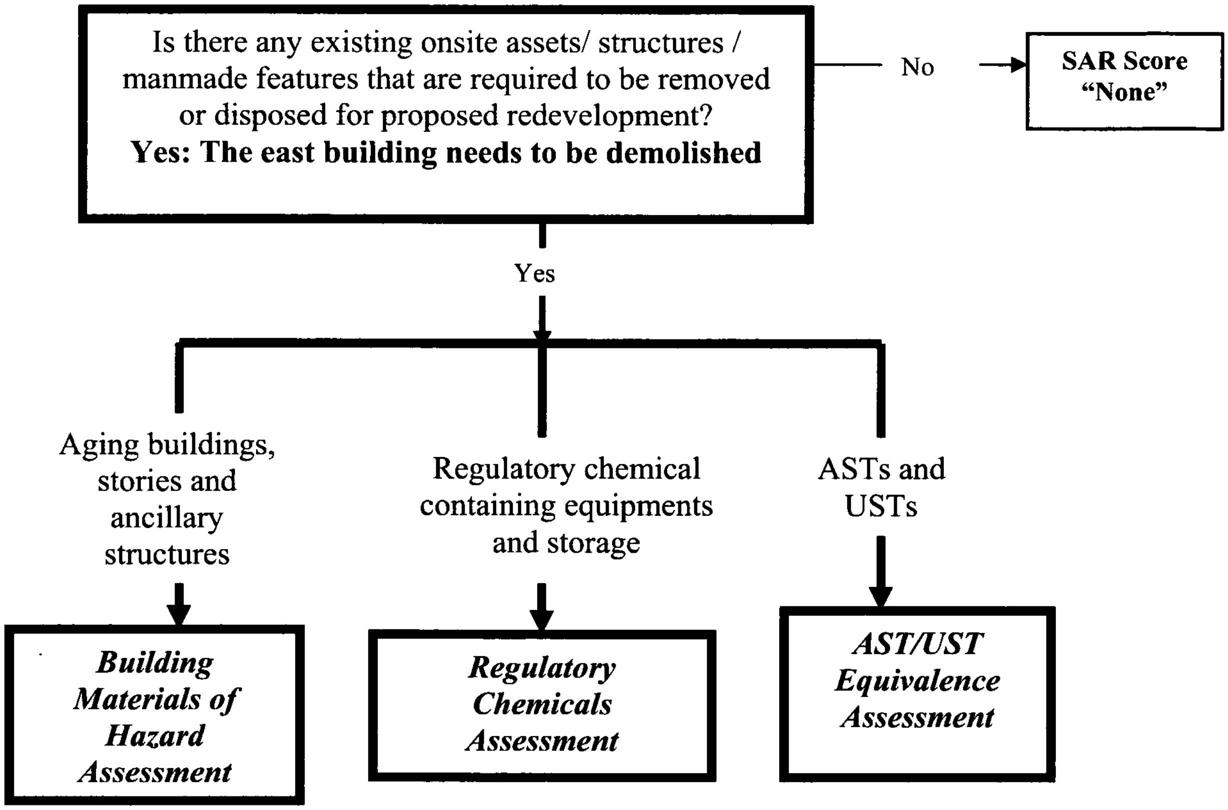


Figure 8-17: Onsite Assets Module Step 2: Onsite Assets Hazard Potential – Commercial Use

Table 8-12: Adjustment of Score for Regulated Chemical Storage/Equipment

Criteria	Scoring
Presence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure	Increase the severity of score
Absence of regulated chemical containing equipments and storages/waste inside/adjacent to the buildings/stories/ancillary structure	**Continue with the same intermediate score None →None**

AST/UST Assessment

For the commercial end use also the two steel USTs (one 3785L and one 11356L) should be removed from the ground and disposed. As with the residential end use, a total of 12 equivalents (>10 equivalents) of UST need to be removed. Therefore, the severity of SAR score is increased by one degree (from "none" to "low"). The final SAR Score for Onsite

Assets Module is "low" for the proposed commercial end use. Next, the user is guided to the ecology module.

8.7.3.B Ecology Module - Commercial

Table 8-13 summarizes the criteria to determine if the brownfield is an LEI site and the responses for ABC Automotive Service Garage. Since one of the answers is chosen "Yes", this site could be considered and LEI if the proposed commercial end use is carried out. The developer will provide containment to the site to limit migration of any contamination. If the site is considered an LEI, a SAR of "none" is assigned for ecology.

Table 8-13: Criteria for Qualifying as a Low Ecological Impact (LEI) site

Criteria for Exclusion	Answer
1. Is soil contamination located below a certain depth through out the site? • At least 5 m beneath the surface. • Between 2 to 5 m and acceptable institutional control is present which will remain in place even if redevelopment is carried out(culvert/ instructions) **Unknown. Phase I and II results does not confirm this.**	☐Yes ☒No/ Unknown
2. Will soil contamination be covered by buildings, paved roads, pavement, or other physical barriers after redevelopment that will prevent plants or wildlife from being exposed to contamination? **Yes. If the commercial end use is carried out containment will be provided to prevent vertical and offsite migration of the chemicals.**	☒Yes ☐No/Unknown
3. Are the sites contaminated with hazardous substances other than those listed in Appendix H and there is less than 6000 m^2 of adjacent undeveloped land on the site, or within 150m of any area of the site affected by the hazardous substances? **No. The site itself encompasses 15,000 m^2 of undeveloped land of which only 25% has buildings and ancillary structures.**	☐Yes ☒No/Unknown
4. Are the sites contaminated with hazardous substances listed in Appendix H, there is less than 1000 m^2 of adjacent undeveloped land on or within 150 m of any area of the site affected by those hazardous substances? **No. The site is not contaminated with one of the substances listed in Appendix H.**	☐Yes ☒No/Unknown

8.7.3.C Accessibility Module - Commercial

Table 8-14 summarizes the site accessibility criteria for ABC Automotive Service Garage. The criteria preferred by the user are shown using checked boxes and corresponding SAR scores are indicated with bold letters.

Table 8-14: Site Accessibility Score for ABC Automotive Service Garage- Commercial Use

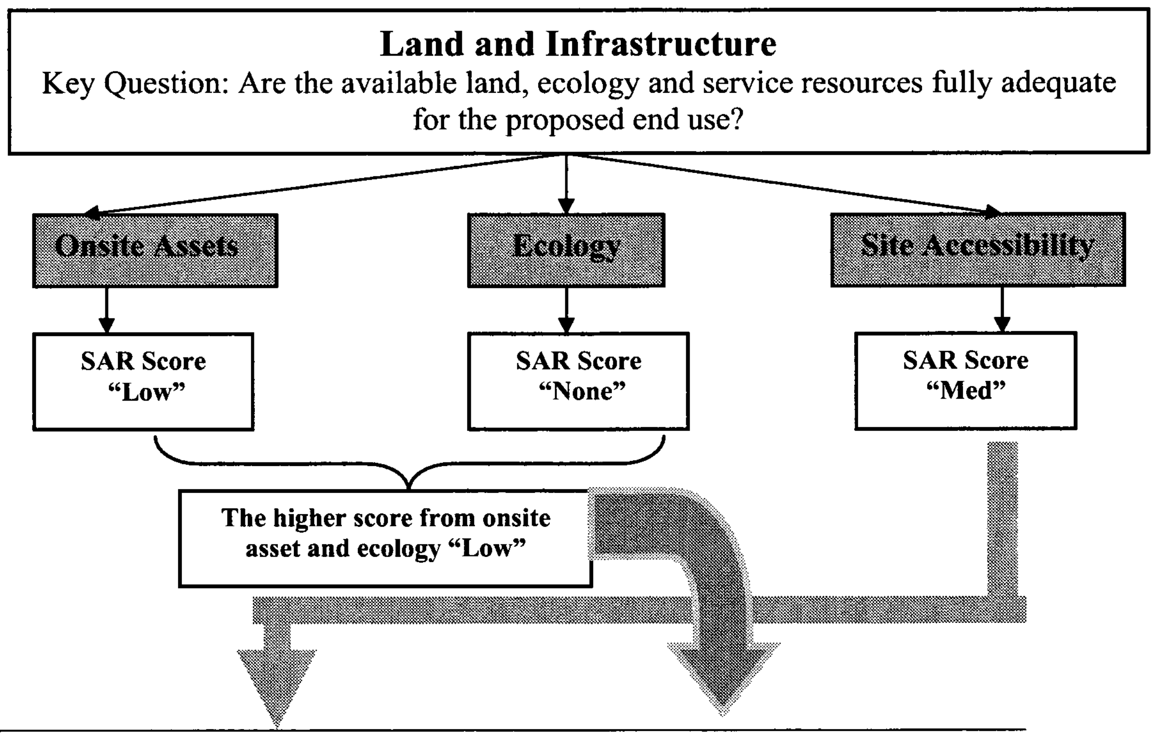
Criteria	User preference	SAR Score "high"	SAR Score "med"	SAR Score "low"	Comments
Utility infrastructure capacity	☒	>800 m away	200 m – 800 m away	***Available onsite or < 200 m***	Phase I ESA indicates that the site is connected to municipal utility
Transportation infrastructure	☒	Secondary or country roads	***Class A/ primary or state highway***	Interstate access/ rail/ airport	The site has access to class A roads
Telecommunication infrastructure	☒	Proposed 2-5 years	Proposed 1-2 years	High tech fiber optics installed	Phase I ESA indicate that is available
Walk-able community	☒	> 400 m	200 to 400 m	***Within 200 m***	Nearby mixed residential neighborhood is present
Access to public transportation	☒	> 400 m	200 to 400 m	***Within 200 m***	Adjacent to the site the transit route is present
Adjacent parking availability	☒	Away/ elsewhere	On street	***In rear, within unit or at surface lot***	Parking will be available within the site once the redevelopment takes place
Possible conflict with surrounding land uses	☒	Severe conflicts	**Conflicts with reservations**	No-conflicts	
Public spaces park	☐	> 400 m	200 to 400 m	Within 200 m	N/A. Not a referred criteria as per user choice

It should be noted that for commercial end use, an additional criteria "possible conflict with surrounding land uses" has been checked in addition to the criteria considered for residential end use. This is because there is a limited probability that the additional traffic might create some conflict with the surrounding community.

Based on the above assessment, the highest of the scores for the accessibility criteria listed in Table 8-14 is “med”. Thus, final SAR Score for Accessibility Module is “med”.

8.7.3.D Overall Land and Infrastructure Score for Commercial Use

Figure 8-18 illustrates the overall land and infrastructure score of brownfield classification for commercial use.



Criteria	Final CRA Score
If site accessibility SAR score is “none” or “low”	Decrease the severity of higher score from onsite assets and ecology by one degree
If site accessibility SAR score is “med”	**Continue with highest of the sores from onsite assets and ecology “LOW”**
If site accessibility SAR score is “high”	Increase the severity of highest score from onsite assets and ecology by one degree

Figure 8-18: Evaluation of Land and Infrastructure for Brownfield Classification - Commercial

The followings are the SAR scores for the three modules:

- The SAR score for onsite assets module is "low".
- The SAR score for ecology module is "none".
- The SAR score for accessibility module is "med".

Because, two of these scores are "none", the Level 3 evaluation identifies that land is a "CRA".

For Level 3-Advanced score, the highest score from ecology and onsite assets module - "low" for the proposed commercial development was chosen. No adjustments were made to this score because the accessibility score was "med". Because the Level 3-Advanced score for the site for the proposed commercial use is L-CRA, a low degree of action is required in land and infrastructure category to carry out the proposed commercial development.

8.8 CONCLUSION

This category evaluates the brownfield based on the suitability of the available land, ecology and service resources for the proposed end use. The evaluations of the onsite assets and ecology focus on existing situations, whereas accessibility focuses on future needs. Although modules consider different points in time, their focus is on the actions required for site preparation. The considerations incorporated into occupational health risk associated with some of the onsite assets should not be confused with health module. Health evaluations as described in the chapter 10 do not focus on actions required for site preparation and development but deal with existing site conditions.

From the above example, the different redevelopment options may require varying degrees of actions to make land, infrastructure suitable for the proposed redevelopment. As illustrated in the above discussion for a residential end use a complete demolition of the existing structure was anticipated and therefore the land was evaluated to be an M-CRA. On the contrary, the commercial end use involved only partial renovation of the infrastructure and containment of the contamination rather than a complete remediation. This resulted in a land score of L-CRA. Similar evaluations for the two site uses for the other categories of Level-3 are carried out in the subsequent sections.

9.0 ECONOMICS - LEVEL 3 AND LEVEL 3 ADVANCED*

9.1 OVERVIEW OF ECONOMICS

This section outlines the method to evaluate the financial benefits of a brownfield redevelopment effort for the developer and helps in prioritizing redevelopment by grouping the sites as:

- "Likely economically viable" and then the category of economics is designated as "Y" (Yes); and
- "With economic barriers" and then the category of economics is designated as "CRA" (Category Requiring Action).

The primary reason some brownfield cleanup projects do not attract potential developers is because of the challenges associated with their economic viability. When a parcel of land has relatively high value and limited degree of contamination, the return on investment can be lucrative. Such brownfield sites are usually traded in private transactions, especially when the expected revenue after cleanup is high. However, if the environmental features are repellant, upsetting and disruptive because of perceived contamination, the property values are hindered by community dissatisfaction or environmental "stigma" even after the site has been remediated adequately (Mundy, 2001). In complex contamination scenarios, lower fair market value and "stigma" are instrumental in significantly reducing the economic viability of some redevelopment efforts.

The existing approaches for measuring the financial feasibility of brownfield redevelopment are mostly qualitative and limited in terms of their applicability. In the proposed methodology, whether the economic component of a site and end use combination is "Y" or "CRA" depends on quantitative assessment of fair market value of the property, remediation cost, tax revenue, and the internal rate of return. This methodology examines how alternative site uses can affect the economic viability of the project. A decision pathway developed for this purpose is shown schematically in Figure 9-1.

* Part of this chapter was presented by Dasgupta, S.; Tam, E. "A Framework for Assessing the Economic Viability of Brownfield Sites" in OttawaGeo2007 Diamond Jubilee Canadian Geotechnical Conference and the 8th Joint CGS/IAH-CNC Groundwater Conference, Ottawa, October 21-24, 2007.

Unlike other categories (e.g. land, health, social), the economic evaluation is not conducted by dividing the category into separate modules. Economics is evaluated in quantitative terms because of the numeric nature of the inputs. However, the decisions are later translated to qualitative "high" (H), "med" (M) or "low" (L) scores consistent with the overall classification system.

The economic evaluation in Level 3 investigates a diverse array of factors such as the fair market value (FMV), remediation and redevelopment cost, the time of cleanup, and minimum attractive rate of return (MARR) of the developer. This methodology also introduces an alternative parameter, the "risk premium", to account for the influence of uncertainty associated with the nature and the type of contamination. A procedure has been adapted to work within the framework to help compare alternative end uses and identify the likely economically viable or "Yes" options. For the brownfields that have economic barriers, this methodology can also predict the magnitude for the incentives: these are low-interest loans, tax incentives, or grants (private or government) required to bring economic viability to a proposed redevelopment effort. An illustrative example using ***ABC Automotive Service Garage*** is presented at the end for two potential redevelopment alternatives.

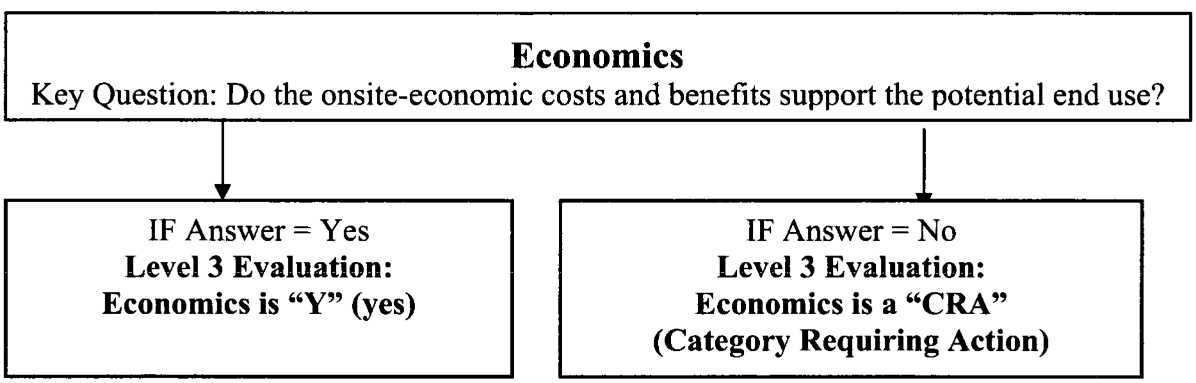


Figure 9-1 Level 3 Economic Evaluation of Brownfield Sites

9.2 INFORMATION REQUIREMENTS

The following information is required for economic evaluation of brownfields:

- **Remediation Cost (RMC)**

This could be either a user input or could be estimated using the area and depth of soil as described in section 9.3.3.

- **Redevelopment Cost (RDC)**

This is a user input based on the type of redevelopment. If the redevelopment cost is not readily available, the user can evaluate the economics assuming the transaction is a "sale after cleanup" for which the redevelopment cost is "zero". This is further discussed in section 9.3.1.

- **Fair Market Value (FMV) of the property after redevelopment**

This could be estimated by comparing the values of similar properties using real-estate appraisal methods (e.g. by comparison) and may be discounted for the anticipated stigma.

- **Type (e.g. loans, tax incentives, grants) and amount of outside incentives that might be available**
    - Three different types of incentives have been incorporated at different stages of the framework:
        - Non refundable upfront incentives;
        - Low interest loans;
        - Tax incentives.
- **Duration of the project (T) in years**
- **Debt and equity investments for the project**
- **Prime interest rate in the region**

It is assumed by the system that the cost of borrowed money for the debt portion of the project investment is equal to the prime interest rate in the region and the developer is capable of securing the required funds. If the amount of equity investment is not available, the municipalities can carry out the evaluation assuming 100% debt. This is further detailed in section 9.3.

- **Risk Premium (RP)**

This is an additional premium which is a function of brownfield uncertainty and the risk adverse of the developer. The default values for risk premium has been provided in this thesis; however the user may input their own values if they have further information.

9.3 DECISION METHODOLOGY

9.3.1 Importance of Exit Strategies

The brownfield owner/developer can decide at what point during the redevelopment to transfer ownership. The strategy/plan to sell the property and complete the deal at a given time is the *exit strategy*. Breggin et al. (1999) outlined four individual exit strategies that could be considered for brownfields:

- Sale "As is";
- Sale after assessment;
- Sale after site preparation (assessment and cleanup, handling liability);
- Sale after redevelopment;

The preferred exit strategy of the developer/owner significantly influences the perceived economic viability of a redevelopment. Although in reality there could be various exit strategies, this methodology evaluates the economic viability when the site is sold after both remediation and redevelopment because this course of action provides the most insight into the true worth of the site in terms of redevelopment opportunities. Therefore, this research limits itself in evaluating the economic viability of the brownfields that are retained by the developer throughout the entire redeveloped.

This same method can also be applied when the site is sold after preparation if the redevelopment cost is not readily available and the FMV after redevelopment is not known. Alternatively, in some cases, the developer may choose to only remediate the site as well. This is basically a subset of the methodology developed for "sale after redevelopment". In such cases, the FMV of the property will be the land value of the clean site, rather than the redeveloped site and the redevelopment cost is not required. However, if a site economics is evaluated without considering redevelopment, the true or "entire" worth of the site may not be captured through this framework.

9.3.2 Decision Methodology for Sale after Redevelopment

This research evaluates the economic viability when the property transaction takes place after both remediation and redevelopment. The general approach relies on the answer to the following key question for economics of a proposed site:

Do the onsite economic costs and benefits support this proposed end use?

Based on the answers, the economics of a site and end use combination could be identified as "Y" or "CRA" respectively. Each brownfield site and end use combination is vetted against a large set of attributes including FMV of the property, remediation cost, tax revenue and redevelopment cost which in turn contribute to the internal rate of return.

The criteria influencing economic viability of a redevelopment effort contributes to two distinct rates of return: the *Internal Rate of Return* for the project (IRR_Proj) and the *Minimum Attractive Rate of Return* (MARR) for the developer.

For decision-making purposes, the IRR_Proj is compared to a benchmark discount rate for accepting and rejecting the project. The term MARR has been used as the benchmark with which IRR_Proj is compared in order to designate a project as economically viable. Thus, the economic viability of any project is determined by comparing the estimated MARR with the IRR_Proj. The decision rule for an investment project is as follows:

- IRR_Proj > MARR, project economics is "Y"
- IRR_Proj < MARR, project is likely to have economic barriers and economics is a "CRA"

The subsequent section describes in detail how different estimate parameters could be derived and these two individual rates (IRR_Proj and MARR) could be estimated and compared for a given redevelopment project.

9.3.3 Estimating the Internal Rate of Return from the Project (IRR_Proj)

IRR_Proj is the internal rate of return of a brownfield project or interest at which the Net Present Value (NPV) of the project becomes zero. This concept is often used in capital budgeting (Investopedia, 2007) which also concludes that the higher a project's internal rate of return, the more worthy the project is (Investopedia, 2007). The internal rate of return is one of the most commonly used tools to evaluate investment project investments (Lexa and Berlin, 2005) and assuming all other factors are equal among the various projects, the IRR_Proj can itself be used to decide which alternative project should be undertaken first. However, in this methodology, the objective is not only to select from a group of viable projects, but also to make a decision on the viability of an individual/standalone redevelopment project. Therefore, IRR_Proj is used as a tool for comparison instead of a decision tool on its own. It is compared to the minimum rate required by a developer when taking up a brownfield redevelopment project. To estimate IRR_Proj the user requires input on remediation cost, redevelopment cost, project duration, upfront cost and FMV of the property. The following sections discuss the steps of evaluating the IRR_Proj and how to obtain/estimate the input parameters using readily available information. This internal rate of return is "before tax" and does not take into account the effective tax rate.

Step A: Remediation Cost (RMC)

The industrial partners of this research project indicated that the Phase II ESA can include a rough estimate of the remediation cost upon request from clients; as a result, cost estimates may actually be available depending on the circumstances.

In case the site preparation cost is not available a default value is calculated by the classification system using the average cost of remediation by "dig and dump" method as suggested by the industry practitioners. In this method the total volume of soil to be disposed is estimated and the cost of remediation is assumed to be the summation of the cost of excavation (EC), haulage and disposal (HC) and backfilling (BC). This is estimated as follows:

$$RMC = EC + HC + BC \quad [9.1]$$

$$EC = E_u \times V \times \rho = E_u \times A \times d_c \times \rho \quad [9.2]$$

$$HC = H_u \times V \times \rho = H_u \times A \times d_c \times \rho \quad [9.3]$$

$$BC = B_u \times V \times \rho = B_u \times A \times d_c \times \rho \quad [9.4]$$

Where:

RMC = Remediation cost

EC= Excavation cost

E_u= Excavation cost per unit weight of soil

HC= Haulage cost

H_u =Haulage and disposal cost per unit weight of soil

BC= Backfilling cost

B_u = Backfilling cost per unit weight of soil

V= Total volume of soil disposed

A= Area of contaminated soil (if not known total area the area of the site can be used)

d_c= Average depth of contaminated soil.

ρ= Density of soil

The default values of the excavation, disposal and backfilling cost provided by industrial partners are as follows:

E_u = \$5/tonne

H_u = \$35-\$65/tonne (can be narrowed down further with user's input value) – approximately 75% of the cost

B_u = \$15/tonne

Therefore, the cost for dig and dump is \$55-\$85/tonne of soil. It is advised that the user takes the highest value to be conservative. When there are limited information available to the municipalities these default values, the area of land (A), and the depth of contamination (d_c) can be used for a rough estimate of RMC.

However, for the situations of offsite contamination (when the contamination spreads beyond the property boundary of the brownfield under consideration and clean up is required for the neighboring sites as well), this default value can be inaccurate and expert input is required. Moreover, there could be inaccuracy in the default value because of uncertainty in the depth of contamination (d_c) and expert inputs may be required for this parameter. If expert input is unavailable, the user can consult the examples from remediation technology cost compendium included in Appendix J (EPA, 2000) and select the remediation cost as appropriate.

Step B: Redevelopment Cost (RDC)

This is a user input based on the type of redevelopment. If the redevelopment cost is not readily available and municipalities have limited information about redevelopment, the user can evaluate the economics assuming the transaction is a "sale after cleanup" for which the redevelopment cost is "zero" as discussed in section 9.3.1.

Step C: Duration of the Project (T) in years

A delay in the project results in re-evaluation of the economic viability. The results obtained for particular project duration is not valid when there is an unanticipated delay. T is composed of two separate durations T_1 and T_2, where T_1 is the duration of remediation and T_2 is the duration for redevelopment in years. Remediation and redevelopment activities may overlap during some years as well.

Step D: Fair Market Value (FMV)

FMV could be estimated by comparing the values of similar properties using real-estate appraisal methods (e.g. by comparison) and may be discounted for the anticipated stigma. The FMV depends of the value of the comparable clean properties in the neighborhood. After discounting for stigma, the FMV could be estimated using the traditional real estate valuation methods such as sales comparison approach, income approach or cost approach, whichever is applicable (Varner, 2005 and Canning, 2005) for the redevelopment alternatives. Municipalities can also review the real estate prices in the region and substitute an appropriate price of a similar redeveloped property for FMV.

Depending on the public perception, stigma reduces the value by 0-90% of the FMV. (Note that in the illustrative example, stigma is assumed to be negligible to improve the clarity of the example.)

FMV can be estimated by:

$$FMV = V_{clean}\,(1-s) \qquad [9.5]$$

Where V_{clean}= value of comparable clean properties in the neighborhood or the expected value of the property obtained by reviewing real estate prices without considering the effect of stigma. s= Anticipated percent reduction in FMV due to stigma (%). If s=0, as in the case of the illustrative example, then $FMV=V_{clean}$.

Step E: Internal Rate of Return from the Project (IRR_Proj)

The next step is to determine IRR_Proj. Equation [9.6] is used to determine IRR_Proj:

$$NPV = UC + C_1/(1+IRR\_Proj) + C_2/(1+IRR\_Proj)^2 + C_3/(1+IRR\_Proj)^3 + \ldots + C_T/(1+IRR\_Proj)^T \qquad [9.6]$$

Where,

NPV= Net Present Value of the project

UC= Upfront Cost

$C_1, C_2, .. C_T$ = Cash flow in year 1, 2, ... T

T= Duration of the project in years

The cash flow in a given year (year 1, 2,...T) is a function of the site preparation cost, redevelopment cost and the FMV of the property. During the years when remediation takes place, the cash flow is obtained by dividing RMC by the duration of remediation and C_i is given by:

$$C_i = RMC/T_1 \quad \text{[9.7]}$$

During the years when redevelopment takes place, the cash flow is obtained by dividing RDC by the duration of redevelopment and C_i is given by:

$$C_i = RDC/T_2 \quad \text{[9.8]}$$

If in a given year both remediation and redevelopment go side by side:

$$C_i = RMC/T_1 + RDC/T_2 \quad \text{[9.9]}$$

The return is expected to be received at the very last year and therefore FMV is assumed to be in the last year's cashflow by this methodology, unless otherwise specified. The value of IRR_Proj could be determined by substituting NPV = 0 in equation [9.6] and appropriately substituting C_1, C_2, C_3, etc., and then solving the above equation. The terms, C_1, C_2 are positive if there is a positive cash flow/cash inflow (e.g. revenue) and negative if there is a cash outflow from the project.

9.3.4 ESTIMATING MINIMUM ATTRACTIVE RATE OF RETURN (MARR)

MARR is determined based on the cost of capital and available investment options for an individual or a company. It reflects the investment opportunities that are available. The MARR varies for investments to account for different levels of risk. In this methodology the MARR is expressed as a function of two distinct rate parameters namely $MARR_{riskfree}$ and Risk Premium.

- $MARR_{riskfree}$ accounts for the present market conditions, demand and availability of funds.

- The RP accounts for the influence of uncertainty associated with the nature and the type of contamination.

The MARR could be estimated by the following the steps summarized schematically in Figure 9-2.

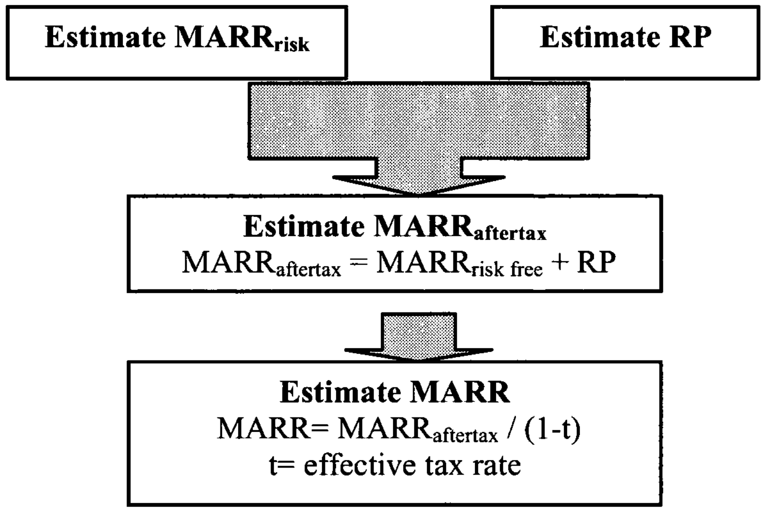


Figure 9-2: Schematic Diagram for Estimating MARR

Step F: Risk Free Minimum Attractive Rate of Return ($MARR_{riskfree}$)

This is the cost of capital that is expected by the developer irrespective of the project and depends on the overall portfolio of the developer represented by the opportunity cost (r_o) and the cost of borrowed money. This is estimated as a weighted average of the cost of borrowed money and the opportunity cost of equity investment.

The financial incentives such as non refundable government incentives/grants (I) and low interest loans (L) are also factored while calculating the cost of borrowed money as a weighted average of capital contributions. $MARR_{riskfree}$ can be calculated using equation [9.11] given below:

$$MARR_{riskfree} = \frac{(I \times r_i + L \times r_L + E \times r_o + D \times r_p)}{100} \qquad [9.10]$$

Where,

I= Non refundable incentives (government) expressed as a fraction of total revitalization cost;

L= Low interest loans expressed as a fraction of total revitalization cost;

E= Equity investment of the developer expressed as a fraction of total revitalization cost;

D= Debt from bank expressed as a fraction of total revitalization cost;

$r_i = 0$; as no interest is considered for non refundable incentives (%);

r_L = Interest rate on low interest grants (%);

r_o = Opportunity cost (%);

r_p = Prime interest rate (%);

The financial incentives (I) reduce the required $MARR_{riskfree}$ if and when such incentives are available (because interest rate for them $r_i = 0$). This helps the user to assess the sensitivity of the MARR (and also the overall economic viability) to grants, loans that might be available and tax incentives. The use of this methodology could help the municipalities to decide on the magnitude of the grants, low interest loans or incentives that are required for a given redevelopment.

When the municipalities have limited information, and are unaware of the opportunity cost (r_o) of the developer, the upfront government incentives and the low interest loans available, $MARR_{riskfree}$ is assumed to be equal to the cost of borrowed money which is equal to the prime interest rate in the region.

$$MARR_{riskfree} = r_p \quad \text{[9.11]}$$

Step G: Risk Premium (RP)

The risk premium depends on several factors that contribute towards the uncertainty of a proposed redevelopment effort and includes available risk transfer mechanisms, type of contaminant, uncertainty related to stigma, indemnification, available risk transfer mechanisms and several other parameters. The risk premium can be thought of as the "additional" value the developer wants in exchange for undertaking a "riskier" venture (e.g., contamination). This concept does exist in other financial applications, but interestingly, has not been exclusively applied in brownfields cases. In this research, the risk premium concept is developed to add greater clarity to the economics analysis.

In the absence of available risk transfer mechanisms, risk premium is assumed to be a function of the type of developer/company involved in the project and the risks/uncertainties associated with different types of contaminants. In this research we have assumed the risk premium to be a step function of the lenders risk ratings of various contaminants suggested by a nationwide research conducted by Mundy and Associates and the types of organizations as shown in Figure 9-3.

This risk-rating data is based on eighty-eight (88) interviews conducted with national, regional and local lenders, where the lenders rated the concerns of different types of contaminations in a scale of 1 to 10 (Mundy, 2001). The target values for the risk premium are obtained by combining the expected range of gross returns for different levels of companies derived from expert elicitations and dividing the available ranges into equal intervals. The default values of risk premium for established companies based on the lender's risk ratings are provided in Table 9-1. The default values in Table 9-1 are provided for illustrative purposes. Further investigation is recommended to be carried out to finalize the risk premium values.

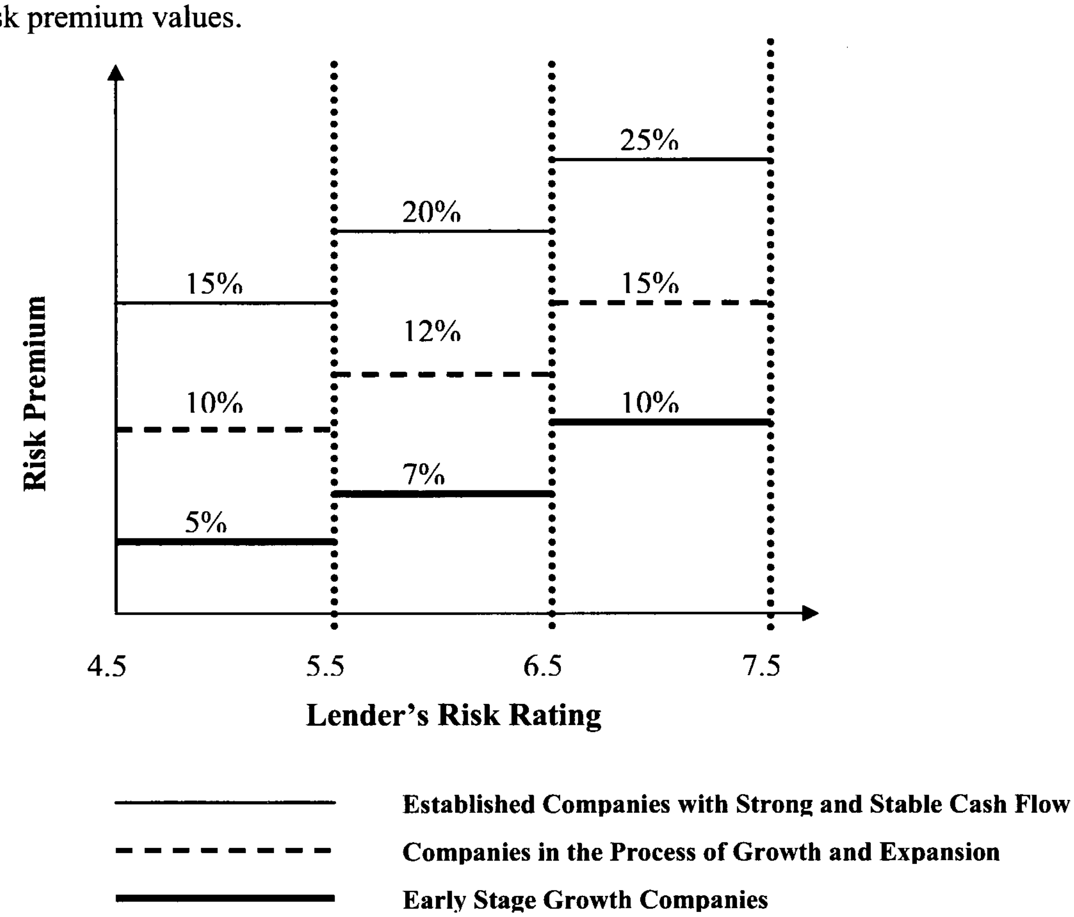


Figure 9-3: Distribution of Risk Premium

Table 9-1: Example values of Risk Premium [risk ratings are adapted from Mundy (2001)].

Contaminant	Risk Rating (Mundy, 2001)	Risk Premiums for Established Companies with Strong and Stable Cash Flow	Risk Premiums for Companies in the Process of Growth and Expansion	Risk Premiums for Early Stage Growth Companies
Encapsulated asbestos	5.4	5%	10%	15%
Electric transmission lines	6.4			
Gaseous	6.6	7%	12%	20%
Chemical	7.6			
Un-encapsulated asbestos	7.6	10%	15%	25%
Crude waterborne	7.7			
Other petroleum	7.8			
Heavy metal	8.5			

Moreover, the presence of risk transfer mechanisms (insurances, indemnification, covenant not to sue) can significantly reduce the risk premium. However, the quantitative investigation of their influence on risk premium could not be estimated because of the lack of publicly available data. The risk premiums considered here are the after-tax premiums. If in special situations, the risk premium provided is "before tax" they should converted to after tax risk premiums by multiplying the values by (1-t), where t is the effective tax rate.

In this evaluation it was assumed that the "cost of borrowed money" remains same for all the projects, and the additional "risk premium" is considered by the developers on the entire investment and not by the lenders. However, the individual shareholders, equity holder(s) and lenders(s) may consider their own risk premiums when investing in a given brownfield project and the generic algorithm can be extended as shown in section 9.3.7.

Step H: Estimating $MARR_{aftertax}$

The next step as per Figure 9-3 is to estimate the $MARR_{aftertax.}$ This is estimated by adding up the two individual components from two previous sections; that is:

$$MARR_{aftertax} = MARR_{riskfree} + RP \qquad [9.12]$$

This quantity does not take into consideration the tax.

Step I: Effective Tax Rate

If there is any tax incentive program present at the region that reduces the tax rate for brownfield redevelopments, the effective tax rate could be calculated using equation [9.13]

$$t = t' - t_i \quad [9.13]$$

t= effective tax rate

t'= tax rate in the region

t_i = reduction in effective tax rate due to tax incentive programs

If the information is not available about tax incentives, t_i is then assumed to be "zero".

Step J: Estimating Minimum Attractive Rate of Return (MARR)

The rate ($MARR_{aftertax}$) is further adjusted for the effective tax rate and tax incentive programs to determine the benchmark value of MARR, so that the developer retains the minimum return after paying the taxes.

Where,

$$MARR = MARR_{aftertax}/(1-t) \quad [9.14]$$

t being the effective tax rate.

This MARR derived in step J is essentially the minimum attractive rate of return that a developer would expect from a project and should be less than or equal to the IRR_Proj for a project to meet the minimum requirement of a developer. Different developers may have their individual and specific expectations in terms of the minimal profit that they require. When the individual developers use this model, they can add that additional expectation to the $MARR_{aftertax}$ to reflect their specific case instead of using the generic model. By doing so, this approach considers what would normally be considered "profit". In this classification system, profit is above and beyond the "yes" outcome; once a "yes" condition is met, the scenario has met the minimum economic conditions for success, and it is up to the developer to incorporate the additional income they desire.

9.3.5 Level 3 Evaluations for Economics

The economic viability of any project is determined by comparing the estimated MARR with the IRR_Proj following the decision rule:

- IRR_Proj > MARR, project economics is "Y"
- IRR_Proj < MARR, project economics is a "CRA"

9.3.6 Level 3-Advanced: Assessing the Degree of CRA for Economics

When the economic analysis results in a "CRA", the difference between IRR_Proj and MARR provides a rough estimate of the magnitude of economic barriers. The difference between the maximum and minimum default values of risk premium (RP) is 20% (25% minus 5%). This range is divided into four quartiles to set out the benchmarks for H, M and L.

It is therefore recommended that:

- If MARR minus IRR_Proj is less than 5% (which is the first quartile of the range between the maximum and minimum values of RP), the project economics is an "L-CRA"
- If MARR minus IRR_Proj is between 5% to 15% (which is the inter quartile range between the maximum and minimum values of RP), the project economics is an "M-CRA"
- If MARR minus IRR_Proj is more than 15% (which is the fourth quartile of the range between the maximum and minimum values of RP), the project economics is "H-CRA".

However, more research is necessary to finalize these benchmarks. Modifying the effective tax rate (t) or the government incentives could reduce the MARR and is capable of making a project viable without changing the IRR_Proj. The methodology outlined here is illustrated through the example evaluation for ABC Automotive Service Garage in the subsequent section.

The entire Level 3 economic evaluation is summarized in Figure 9-4.

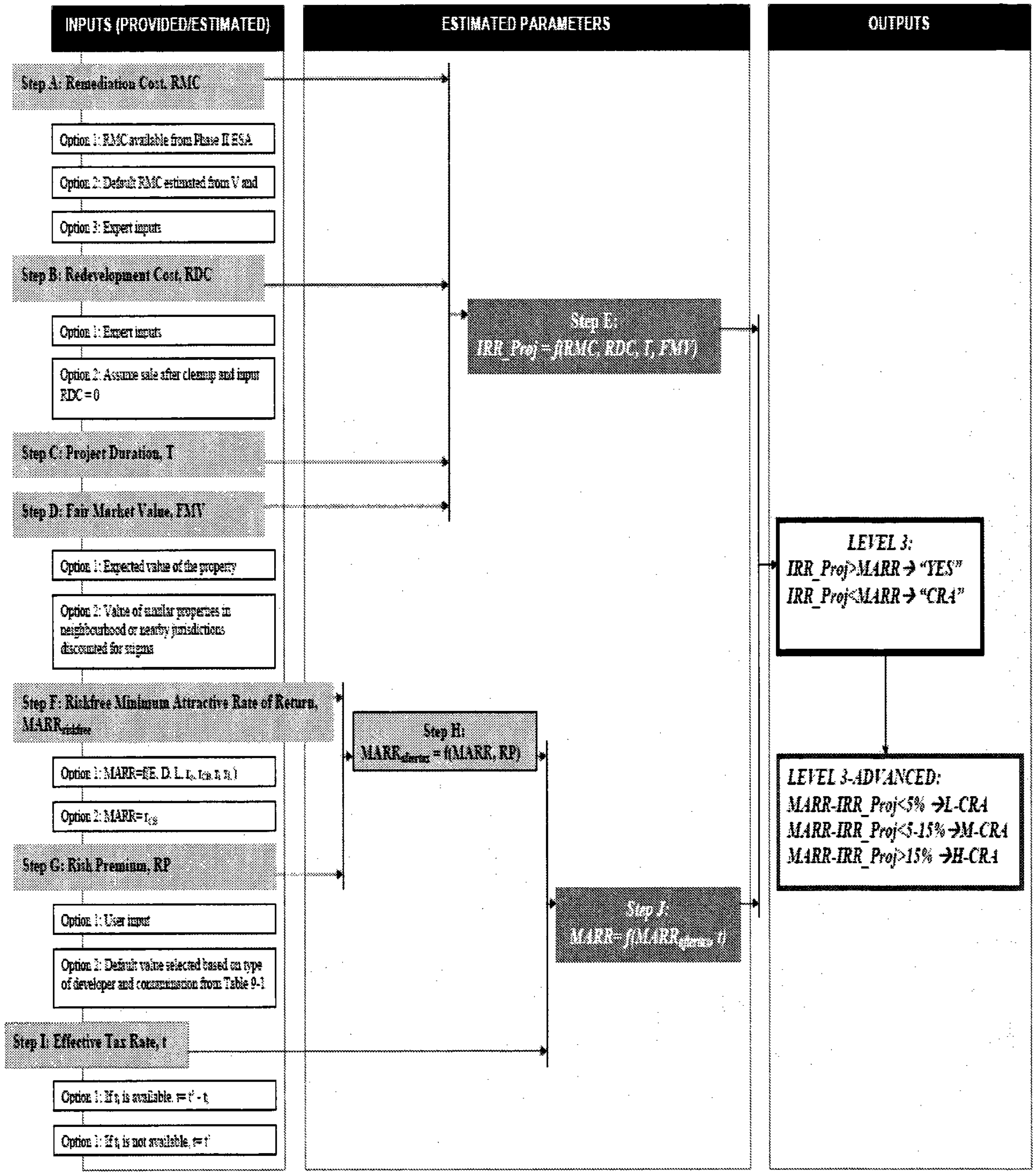


Figure 9-4: Parameters Involved In Level 3 and Level 3-Advanced Economic Evaluations

9.3.7 Opprtunities for Extending the Concept of Risk Premium and Tax Rate

Equity holders and the lending institutes may already have their own individual risk premiums. If the equity holders and the lenders consider their own risk premums, the MARR can be determined as follows:

$$MARR = E*r_{o'} + D*r_{p'}, \qquad [9.15]$$

Where $r_{o'}$ and $r_{p'}$ are the expected before tax returns on equity and debt including the risk premium values (both $r_{o'}$ and $r_{p'}$ being the before tax rates). However, based on the discussions with Canadian banks during the development of this framework it was determined that the banks are likely not to consider any separate risk premium for brownfields. Instead, they may reject any brownfield projects unless the developer has an acceptable track record based on prior relationships. Therefore, it is more practical to use the single risk premium that is considered by the developers themselves as shown in the previous sections to express risk because the lender's risk premium – if it does exists – may not be readily identifiable at all. If the lender itself has an identifiable risk premium, it would be preferable that this premium is split out and added to the risk premium term shown in equation 9.12. In this way, risk is more explicitly acknowledged, as opposed to being "buried" within the other terms. From a practical perspective, if the lender cannot articulate its risk premium as a separate term or even identify, then there may be no choice but to assume that the lender's rate has both nominal and risk-related factors built in.

The algorithm can be further extended for the situations, where the jurisdictions do not tax on debt portion of the investment. In such cases, equation 9.15 could be further modified to equation 9.16 to account for the fact that the debt portion is not taxed.

$$MARR = E*r_{o'} + D*r_{p'}(1-t) \qquad [9.16]$$

These are the specific circumstances and the base model developed here could be customized based on the individual needs.

9.4 ILLUSTRATIVE EXAMPLE: LEVEL 3 AND LEVEL 3-ADVANCED - ECONOMICS

9.4.1 Information Requirement

As in case of "Land and Infrastructure", ABC Automotive Service Garage is assumed to represent a brownfield in Ontario, and the municipality is willing to proceed for a residential or commercial development at ABC Automotive Service Garage. The following information from Appendix A are used to evaluate the site economics.

The Phase I and II ESA provides the following information:

- Major types of contaminant: metals, metalloids and hydrocarbons.
- The following information are available about groundwater:
    - Petroleum hydrocarbons ("PHCs") and benzene, toluene, ethylbenzene and xylenes ("BTEX") were not identified above justified criteria in the groundwater samples analyzed from any of the boreholes/ monitoring wells, UST excavation or test pits at the Site, with the exception of PHCs in a borehole located below the northern building.
    - Volatile Organic Compounds ("VOCs"), including BTEX and heavy metals were not identified above the criteria in groundwater samples analyzed from any of the boreholes/monitoring wells at the site.

The two possible redevelopment options as developed previously:

The Residential Redevelopment Option:

- The developer is an established company with a strong and stable cash flow. The opportunity cost estimated for the developer is 10% and the assessors estimate the acceptable range of risk premium is between 5-10%.
- The upfront cost for property purchase and other legal considerations was $1M.
- 20% of the investments come from government grants and 60% of the funding is expected to come from a bank at an interest rate of 8%.
- The proposed end use is 80 residential town houses each having an estimated FMV of $0.2 M and the project is to be completed in 3 yrs and the town houses are to be available for sale at the fourth year. There is no reduction anticipated because of stigma.
- The effective tax rate at the region is 40%.

- The redevelopment cost is estimated to be $8.2M. This was estimated using building costing software (Buildcost, 2007).

The Commercial Redevelopment Option:

- The developer is the existing owner in the process of expanding the brownfields business. The developer proposes to encapsulate the contaminated portions and renovating the buildings.
- The upfront cost for property is $0M as they already own the site.
- 80% of the funding is expected to come from a bank at an interest rate of 8%. Rest is the equity investment. Availability of government grants is unsure at this point.
- The proposed end use is two commercial buildings with estimated total FMV of $2.5M and the renovation project is to be completed in 2 years and the property is to be available for sale at the third year.
- The effective tax rate at the region is 40%.
- The cost of providing encapsulation was assumed to be $1M and renovation cost was assumed to be another $1M.

In this illustrative example the economic evaluation for residential (section 9.4.2.A) and commercial (section 9.4.2.B) options are conducted separately.

A third evaluation is conducted assuming the site is sold after remediation up to residential standards (section 9.4.2.C). This is a subset of overall economic evaluation for "sale after redevelopment" and can be carried out when the FMV for redeveloped property and redevelopment costs are not available to the municipalities. It is assumed that if the property is remediated up to the residential standards, it would sell at $4.1M. However, the outcome considering "sale after remediation" may not reflect the true worth of the property if redevelopment is not considered.

9.4.2 Decision Methodology

9.4.2.A Residential Redevelopment Option

This section illustrates the economic evaluation if the potential residential development is undertaken.

1. ESTIMATING THE RATE OF RETURN FROM THE PROJECT (IRR_PROJ

Step A: Remediation Cost (RMC)

There are several methods of estimating remediation cost. Expert input could be useful in approximating the remediation cost. However, in this example, the remediation cost is assumed to be directly proportional to the weight of soil that might be removed using "dig and dump". The default method described in section 9.3.3 is therefore used for estimating the remediation cost. This assumption is valid because the Phase II ESA results indicated the groundwater contaminations were below the accepted standards.

Most brownfields use "dig and dump" as the preferred remediation approach for contaminated soils, due to time constraints and the simplicity of the approach. Professionals from industrial partners and publicly available case studies confirm this course of action, although it is acknowledged that "dig and dump" may not be the most progressive remediation method.

Based on industry experience and assuming a dig and dump approach, a rough estimate of the remediation cost was obtained by summing the costs of excavation (EC), haulage and disposal (HC) and backfilling (BC). However, expert input in Phase II ESA based on the site assessment provides more accurate assumptions on remediation cost. Appendix J can be consulted for a guideline on remedial cost, when expert inputs are not available.

For the given case study the default value of the cost estimate was conducted using the generic data from industrial partners as default values:

1. Excavation cost per unit , E_u = \$5/tonne
2. Haulage and disposal, H_u = \$35-\$65/tonne (can be narrowed down further with user's input value) – approximately 75% of the cost
3. Backfilling (if required), B_u = \$15/tonne

Therefore, the cost for dig and dump is \$55-\$85/tonne of soil.

Assuming contamination reaches down to 0.8 m on average, and thus d_c = 0.8m, the total volume and mass of soil estimated to be removed is:

$= A^* \, d_c * \rho$ tonnes

$= (3.84*4046*0.8) \, m^3 * 2$ tonnes/m^3

$= 25 * 10^3$ tonnes [the assumed soil density, ρ= 2 tonnes/m^3]

Using equation [9.1] and substituting the values of E_u, H_u and B_u, an approximate remediation cost estimate is between $1.3 to $2.1 M, and the higher value of $2.1 M is assumed conservatively as the RMC.

Step B: Redevelopment Cost (RDC)

The redevelopment cost was estimated to be $8.2 M. This was estimated using building costing software (Buildcost, 2007). The revenue generated from the sale of the buildings after 4 years was estimated to be $16.0 M.

Step C: Project Duration (T)

Assuming the entire redevelopment is completed in three years and the site sold after the fourth year, T is therefore 4 years. The remediation cost is assumed to be distributed uniformly between first three years (T_1=3 years) and the redevelopment is assumed to take place in the third year (T_2 =1 year). Also, it is considered that the FMV is generated at the fourth year after the redevelopment is completed. Note that IRR_Proj is subject to change when any delay occurs in the project.

Step D: Fair Market Value (FMV)

In this example FMV is provided as $16M.

Step E: IRR_Proj

Substituting into equation [9.6] using the following input data:

- Upfront cost, UC= -1 M
- Cashflow in year 1, $C_1 = RMC/T_1$ = - 0.7M (one third of remediation cost)
- Cashflow in year 2, $C_2 = RMC/T_1$ = -0.7M (one third of remediation cost)
- Cashflow in year 3, $C_3 = RMC/T_1 + RDC/T_2$ = -(0.7 + 8.2) M = 8.9 M
- Cashflow in year 4, C_4= FMV=16M (estimated FMV of the property)

The IRR_Proj was found to be 25% using equation [9.6]

2. Estimating the Minimum Attractive Rate of Return for the Developer (MARR)

Step F: Minimum Attractive Rate of Return ($MARR_{riskfree}$)

$MARR_{riskfree}$ is the cost of borrowed money for the redevelopment effort and is a function of market conditions, such as debt, equity and non refundable government grants. $MARR_{riskfree}$ is estimated by determining the weighted average of the interest rates. Table 9-2 illustrates the source of funding for the project in this case and divides it into debt (D) from financial instituitions, equity (E) and non refundable government incentives (I). The $MARR_{riskfree}$ is estimated as a weighted average of the individual interest rates. In this case, $MARR_{riskfree}$ is estimated to be 6.8% using equation [9.11].

Table 9-2: Possible Sources of Funding for the Residential Redevelopment Project

Sources	Percentage capitalization	Interest rate
Debt (D)	D=60%	$r_p = 8\%$
Government grants (I) (non-refundable)	I=20%	$r_i = 0\%$
Equity (E)	E=20%	$r_o = 10\%$ (The opportunity cost is taken as the interest rate on the equity, or else the user inputs a number)

Step G: Risk Premium (RP)

From Table 9-1 the risk premium of 10% was selected for PHC (petroleum) contamination.

Step H: Estimating $MARR_{aftertax}$

$MARR_{aftertax}$ was estimated to be 16.8% (10% + 6.8%) using equation [9.12].

Step I and J: Estimating the Adjustment for Effective Tax Rate

The sum of risk premium $MARR_{riskfree}$ was adjusted substituting the effective tax rate, t= 40% using equation [9-14]. The MARR determined was 28%, which is higher than the IRR_Proj of 25%. Therefore the project economics is a Category Requiring Action (CRA) for the potential residential redevelopment. The magnitude of difference between the two rates (28% versus 25%) provides a measure of the extent of the economic barrier.

3. Level 3-Advanced Evaluation - Residential

As discussed before, MARR minus IRR_Proj equals 3%, which is less than 5%. Therefore the economics for residential development is an "L- CRA".

4. Modifying the Economic Outcomes by Providing Extra Incentives

The following scenarios illustrate how the possible residential redevelopment efforts could be economically viable:

- **Scenario I:**

  If government was willing to provide a tax incentive (t_i =20%) so that the effective tax rate was reduced to 20% as per equation [9-13], the resulting MARR could be 21% [21% = 16.8/(1-0.2)%] < IRR_Proj (25%). This could have made the project economics into a "Yes" category.

- **Scenario II:**

  Instead of tax incentives the government may be able to provide, for example, an additional 10% low interest loan (L), with an interest rate of 3%, reducing the economic load on the developer in terms of equity investment. Table 9-3 illustrates this alternative funding scenario. For scenario II, the new $MARR_{riskfree}$ estimated using equation [9.11] is 6.3%. $MARR_{aftertax}$ for scenario 2 is 16.3% and MARR is 27% > 25% (IRR_Proj). Therefore, for scenario 2 economics is a "CRA". Thus, even though a 10% low interest loan may have thought to have been helpful, this loan amount still cannot make economics of this example viable.

The above scenarios reflect the flexibility of the proposed model to deal with different tax rates and various government incentives. None of the existing tools that are publicly available today are capable of depicting the influence of various forms of government/private incentives. Further refining this model will allow it to depict the influence of government grants and provide a magnitude of the incentives required to make the redevelopment effort economically viable.

Table 9-3: Alternative Funding Scenario for the Residential Redevelopment Project – Scenario II

Sources	Percentage capitalization	Interest rate
Debt	D=50%	r_p =8%
Low interest Government Loans	L=10%	r_L =3%
Government grants (non-refundable)	I=20%	r_i =0%
Equity	E=20%	r_o =10% (The opportunity cost is taken as the interest rate on the equity, or else the user inputs a number)

9.4.2.B Commercial Redevelopment Option

1. Estimating the Rate of Return from the Project (IRR_Proj)

In this case, the cost of providing encapsulation was RMC = \$1 M and renovation cost RDC was another \$1M. The revenue generated (i.e. benefit) from the sale of the buildings at the third year was \$2.5 M. Substituting into equation [9.6] using the following inputs:

- Upfront Cost, UC = 0 M
- Cashflow in year 1, C_1= RMC/T_1 = -\$0.5 M
- Cashflow in year 2, C_2 = -\$1.5 M
- Cashflow in year 3, C_3= \$2.5

The IRR_Proj was found to be 19%.

2. Estimating the Minimum Attractive Rate of Return for the Developer (MARR)

Minimum Attractive Rate of Return ($MARR_{riskfree}$)

Because for commercial development it is unsure whether any government incentives would be available, $MARR_{riskfree}$ can be estimated by determining the weighted average of the interest rate for debt and equity. $MARR_{riskfree}$ is estimated to be 8.4%.

Table 9-4: Possible Sources of Funding for the Commercial Redevelopment Project

Sources	Percentage capitalization	Interest rate
Debt	D=80%	r_p =8%
Equity	E=20%	r_o =10% (The opportunity cost is taken as the interest rate on the equity, or else the user inputs a number)

Risk Premium (RP)

Since the developer is new in the brownfield redevelopment business, and is assumed to be in the process of growth and expansion, a risk premium of 15% was selected for petroleum products contamination.

Estimating $MARR_{aftertax}$

$MARR_{aftertax}$ was estimated to be 23.4% (15% + 8.4%).

Estimating the Adjustment for Effective Tax Rate

The sum of risk premium $MARR_{riskfree}$ was adjusted based on the effective tax rate, t= 40% using equation [9-13]. The MARR determined was 39%, which is much higher than the IRR_Proj of 19%. Therefore the project economics is a Category Requiring Action (CRA).

Level 3 Advanced Evaluation

As discussed before, MARR minus IRR_Proj is equal to 20%, which is greater than 15%. Therefore, the economics for commercial development is an "H- CRA". Therefore the economic outcome for a residential use is an L-CRA, whereas for commercial it is an H-CRA. Limited tax cuts and incentives can push economics to "Y" for residential use.

9.4.2.C Sale After Remediation

As discussed in the previous sections, this methodology for economic evaluation considers that the developer retains the site until redevelopment is completed. However, this same method can also be applied for evaluating the sites that are sold after cleanup, when redevelopment options are not clear. The following example illustrates the economic evaluation, assuming the site is sold after remediation as vacant residential lots. If the site is remediated up to the residential standards the remediation cost is considered to be \$2.1M (same as before).

Assuming the vacant lot for residential development has an FMV of \$4.1M (higher than commercial as only a portion of the lot was renovated for commercial use), the following steps are carried out to conduct economic evaluation for sale after cleanup.

1. Estimating the Rate of Return from the Project (IRR_Proj)

In this case the cost of remediating the land was assumed to be \$2.1 M. By substituting the following inputs into equation [9.6]:

- Upfront Cost, UC= -1 M
- Cashflow in year 1, C_1= RMC/T_1 = -0.7 M (one third of remediation cost)
- Cashflow in year 2, C_2= -0.7 M (one third of remediation cost)
- Cashflow in year 3, C_3= -0.7M
- Cashflow in year 4, C_4= 4.1 M

The IRR_Proj was found to be 11%.

2. Estimating the Minimum Attractive Rate of Return for the Developer (MARR)

The MARR determined was 28%, just as it was with the sale after redevelopment. This is much higher than the IRR_Proj of 11%. Therefore the project economics is a Category Requiring Action (CRA).

<u>Level 3 Advanced Evaluation</u>

As discussed before, MARR minus IRR_Proj equals 17%, which is greater than 15% (benchmark for H-CRA). Therefore, the economics for the commercial use option is an "H-CRA". The economics is "H-CRA" if the site is sold after remediation as opposed to redevelopment, in which case it is an "L-CRA".

9.4.3 Discussion

The methodology relies upon comparing the two different interest rates from a financial standpoint. However, if the project investments and returns are received at too many irregular intervals the IRR concept can generate multiple IRR values for the same project, making it difficult to decide which IRR is the true value. To avoid these scenarios, it is best to apply the IRR concept only to projects or investments having positive cash flows throughout their lifetimes (Odellion, 2007).

Moreover, IRR_Proj deals only with the rate and does not take into account the magnitude of absolute benefit. Therefore, a particular redevelopment option may appear to be very appealing because IRR_Proj is high; however, the actual amounts of benefits from the other projects may be higher.

Working with interest rates transforms a future value to a present value and as a result, it can often be misinterpreted as the actual return from the project. This method is a financial tool that is capable of handling the time value for money, but any delay in project can have a significant effect on the outcome. The classification system assumes that the project meets the anticipated timeline. In reality, this is not the case for a number of redevelopment processes. However, having such a tool could clearly indicate the impact of not being able to maintain the project timeline. Lastly, there are several exit strategies that are taken up by the developers involved in redevelopment of brownfields and the economic viability of a brownfield site for developer significantly depends on the corresponding exit strategy. A brownfield developer has a number of options for timing the sale (ELI, 1999). The owner can attempt to sell the property immediately after cleanup or follow through with the entire redevelopment. In this classification the economic scenario is evaluated for sites that are sold after cleanup and redevelopment, rather than the ones sold "as is" or "after assessment". A successfully completed project offers a much higher return than simply selling the brownfield. However, this method does not incorporate the economic implications associated with exit strategies other than the one in which the developer retains the site for entire redevelopment process. Lastly, it should be noted that the provided default value of the remediation cost is only a rough estimate and the user is strongly encouraged to provide information about the remediation cost.

9.5 CONCLUSION

This portion of the classification project models the economic viability of the project. The advantage of using IRR is that it considers a project's risk and the time value of money. This model provides an opportunity to reflect the influence of government incentives in various forms (e.g., non refundable loans, tax cuts, upfront cost), and demonstrates their impacts on the return expected from the project. The results obtained within this classification system are sensitive to the incentives available from government. In fact, the incentives could reflect a shift of decision points based on tax cuts or government roles. This gives a rough estimate of the magnitude and the type of government incentives capable of making a brownfield redevelopment viable. The model works for single use sites to identify economic viability; however, given the limitations presented in the previous section, it is advisable to combine the analysis with more comprehensive financial evaluation tools, such as NPV, especially if the cases are such that the difference between the two rates, MARR and RR_Proj are quite low, or the situations when both the rates are very low themselves in magnitude (e.g. IRR_Proj <10%). Although this economic evaluation is a part of the proposed Level 3 evaluation, it could be considered as a standalone tool useful for making decisions on the economic viability of brownfield redevelopment projects.

10.0 HEALTH - LEVEL 3 AND LEVEL 3-ADVANCED*

This category evaluates the brownfields based on the human health risks associated with them. The category of health is judged by reapplying the basic CHSR (Contamination Health and Safety Risk) methodology developed at University of Toronto (Schruder, 2007). This chapter integrates the previously developed CHSR methodology into the proposed classification system so that its consideration of different potential end uses is consistent with the overall classification approach by describing the following:

- A brief overview of CHSR methodology developed by Schruder (2007);
- Minor modifications which are made to the CHSR methodology to make it consistent with the overall classification system; and
- The outcomes from the health evaluation for the illustrative example, ***ABC Automotive Service Garage.***

10.1 USE OF CHSR METHODOLOGY TO EVALUATE HEALTH

The framework for human health groups brownfield sites as:

- Health is "Y" (Yes) – these are the brownfield sites where the hazard-potentials associated with human-health risk are lower than the acceptable standards.
- Health is a "CRA" (Category Requiring Action) – these are sites where hazard potential associated with human health are higher than the acceptable standards and a clean up/remediation action needs to be carried out to lower the health risk associated with the existing site conditions.

Figure 10-1 summarizes the methodology for evaluating the health risk. This evaluation is conducted primarily by using the CHSR methodology developed by Schruder (2007). CHSR methodology is a screening procedure for the human-health risk associated with brownfields based on the hazard and exposure related to four individual migration pathways: ground water pathway, surface water pathway, surface soil pathway, and vapor intrusion pathway. The public safety pathway considered in the original CHSR methodology was excluded from Level 3 because the sites that have public safety concerns are already identified at Level 1.

* This section of the thesis has been adapted from Schruder, N. (2007). "Methods for Classifying Human - health and Safety Risks of Brownfield Sites." M.A.Sc. Thesis, University of Toronto.

Minor modifications are made to the CHSR flow diagrams to make provisions for the exposures of not only the people that are present at the site, but also the future site users. These modifications change the final CHSR outcomes only if the flow diagrams lead up to the "receptor" module. In the original CHSR methodology the exposure was considered limited if there was no existing users. However, for the classification framework a higher score is assigned even if there is a potential for human exposure to the release of contaminants because of nature of the proposed redevelopment. The outcome is not changed based on different end uses if the flow charts do not lead to user to the receptor module at all as in the case of the illustrative example.

As illustrated in Figure 10-1 the risk score for each individual pathways determined using the CHSR system is translated to a severity ranking (SAR score) of "none", "low", "medium" or "high". Next, the SAR scores from each of these four modules are combined to determine if the overall health is "Yes" or a "CRA". If health risk is a CRA the SAR scores are used to evaluate if the severity is an "H", "M" or "L".

10.2 SCORING THE SEVERITY OF RISK USING CHSR METHODOLOGY

The basic methodology for CHSR evaluation involves investigating the four modules: groundwater pathway, surface-water pathway, surface soil pathway and vapor intrusion pathway. Each of these abovementioned pathways are evaluated for the severity of risk associated with them. Appendix K illustrates the flow diagrams of CHSR methodology (Schruder, 2007) for determining severity of risk scores. As discussed before, the receptor module of the flow diagrams are slightly modified to account for the future users.

10.2.1 Ground-water Pathway

This module evaluates the severity of risk posed by a brownfield in terms of its potential to contaminate groundwater. Contamination that infiltrates into the groundwater as a leachate often spreads beyond the physical boundary of the property and results in significant amounts of liability to the developer. The severity of health risk posed by groundwater pathway is evaluated using the groundwater module of CHSR methodology and is given a risk score of "high", "med" or "low".

10.2.2 Surface-water Pathway

This module evaluates the potential of the brownfields to pose risk through all naturally occurring perennial water bodies, artificially made and intermittently flowing surface water bodies; for example, streams, rivers, lakes, oceans, and certain ditches are surface water bodies (US EPA, 1992). The module indicates the potential of the brownfields to contaminate surface water and lead to human exposure. The severity of surface water risk is investigated by applying the surface water module of CHSR system and is given a score of "high", "med" or "low".

10.2.3 Surface-soil Pathway

This module evaluates the potential of the brownfields to pose a health risk through surface soil exposure (referred to as the top 1.5 m soil layer) (MOE, 2004). This module evaluates on-site exposures resulting from dermal contact or ingestion of contaminated surface soil. According to Schruder (2007) contamination in the surface soil has a greater exposure potential than subsurface soil to pose health risk because they are more likely to be potentially inhaled or ingested as dust, particulates and vapors from the soil. As with other pathways, the severity of risk is evaluated using CHSR methodology to be "high", "med" or "low". It should be noted that this pathway concentrates on evaluating risk from surface soil on human health only; the "terrestrial ecology" module described under the category of "Land and Infrastructure" evaluates the influence of surface soil on flora and fauna. Because the evaluation criteria and threshold values of chemical concentrations are different for human receptors and flora or fauna the two evaluations are carried out separately.

10.2.4 Vapor Intrusion Pathway

This module evaluates the severity of risk posed when contaminants vaporize from the soil and groundwater immediately under a structure and migrate through abandoned sewers, underground utility lines and other similar routes (US EPA, 2002). This puts humans at risk of inhaling noxious vapors. Like the other pathways, the vapour intrusion pathway is evaluated and a risk score of "high", "med" or "low" is determined for the pathway. The details of this evaluation method can be obtained from Schruder (2007).

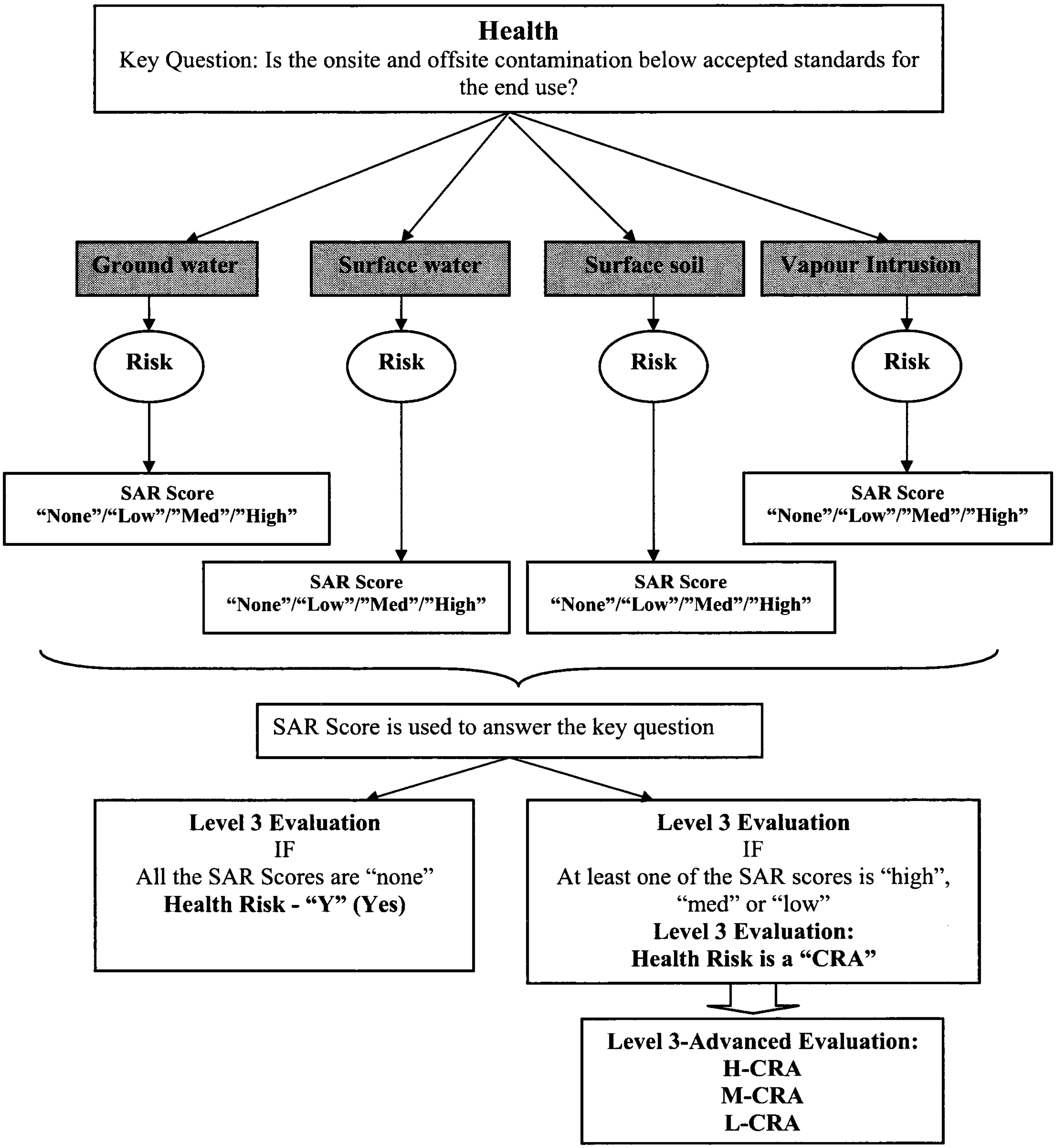


Figure 10-1: Evaluation of Health for Brownfield Classification

10.3 SAR (SEVERITY OF ACTION REQUIRED) SCORE FOR EACH MODULE

A SAR Score is assigned to each of the above mentioned pathways. It is assumed that the severity of action required is directly related to the severity of risk. The correlation between "risk score" from CHSR and "SAR" score is as follows:

- A "high" risk score for a pathway translates to a "high" SAR score.
- A "med" risk score for a pathway translates to a "med" SAR score.
- A "low" risk score for a pathway translates to a "low" SAR score.
- A "N/A" for a pathway translates to a "none" SAR score.

10.4 LEVEL 3 EVALUATIONS FOR HEALTH

As discussed in the previous sections the Level 3 decision rule for health is as follows:

- If SAR score for all the pathways is "none" the category of health is "Yes"
- If SAR score of at least one of the four pathways is "high", "med" or "low" then the health is a CRA.
- The highest of all the individual SAR scores indicate the *overall* CRA score. For example, for a site if followings are the SAR scores,
  - Ground water pathway has a SAR score "low".
  - Surface water pathway has an SAR score "med".
  - Surface soil pathway has an SAR score "high".
  - Vapor intrusion pathway has an SAR score "med".

The highest of the four scores is "high" (surface soil pathway score), and the over all score is an "H- CRA".

10.5 ILLUSTRATIVE EXAMPLE: LEVEL 3 AND LEVEL 3-ADVANCED- HEALTH

Chapter 9 of Schruder (2007) evaluates the severity of risk associated with each of the four modules for ABC Automotive Service Garage. Results from Schruder (2007) were adapted to suit the ongoing illustrative example. The evaluations in Schruder (2007) were conducted using Phase I ESA and Phase II ESA results separately and the outcomes were different. Here the outcomes from Phase II ESA have been considered as Phase II ESA is more accurate than Phase I.

The outcomes of CHSR are identical for the proposed residential and commercial end use. Although the CHSR flow charts have been modified to account for the number of potential users, in this case, the concentration of contamination was below the acceptable standards and flow charts did not lead the user to the receptor module.

Table 10-1 illustrates the risk associated with each individual module determined using the CHSR methodology and the corresponding SAR scores determined using the rules set out in section 10.3. As illustrated in section 10.3

- A "low" risk score for a pathway translates to a "low" SAR score.
- A "N/A" for a pathway translates to a "none" SAR score.

Table 10-1 Summary of the Results from CHSR Based on Information Provided from the Phase II ESA

Exposure Pathway	Severity of Risk -Residential	Corresponding SAR Score	Severity of Risk -Commercial	Corresponding SAR Score
Surface Water	**LOW**	**Low**	**LOW**	**Low**
Groundwater	**N/A**	**None**	**N/A**	**None**
Surface Soil	**N/A**	**None**	**N/A**	**None**
Vapour Intrusion	**N/A**	**None**	**N/A**	**None**

As illustrated in Section 10-3 because one of the "SAR" scores is "low", health and risk is a "CRA" (for both residential and commercial).

The *overall* CRA score is the highest of the SAR scores obtained from the four modules. In this case the CRA score is "L". Figure 10-2 illustrates the flow diagram for health evaluation. It could be concluded from the above discussion that the site has a health score of "L-CRA" for both residential and commercial end use.

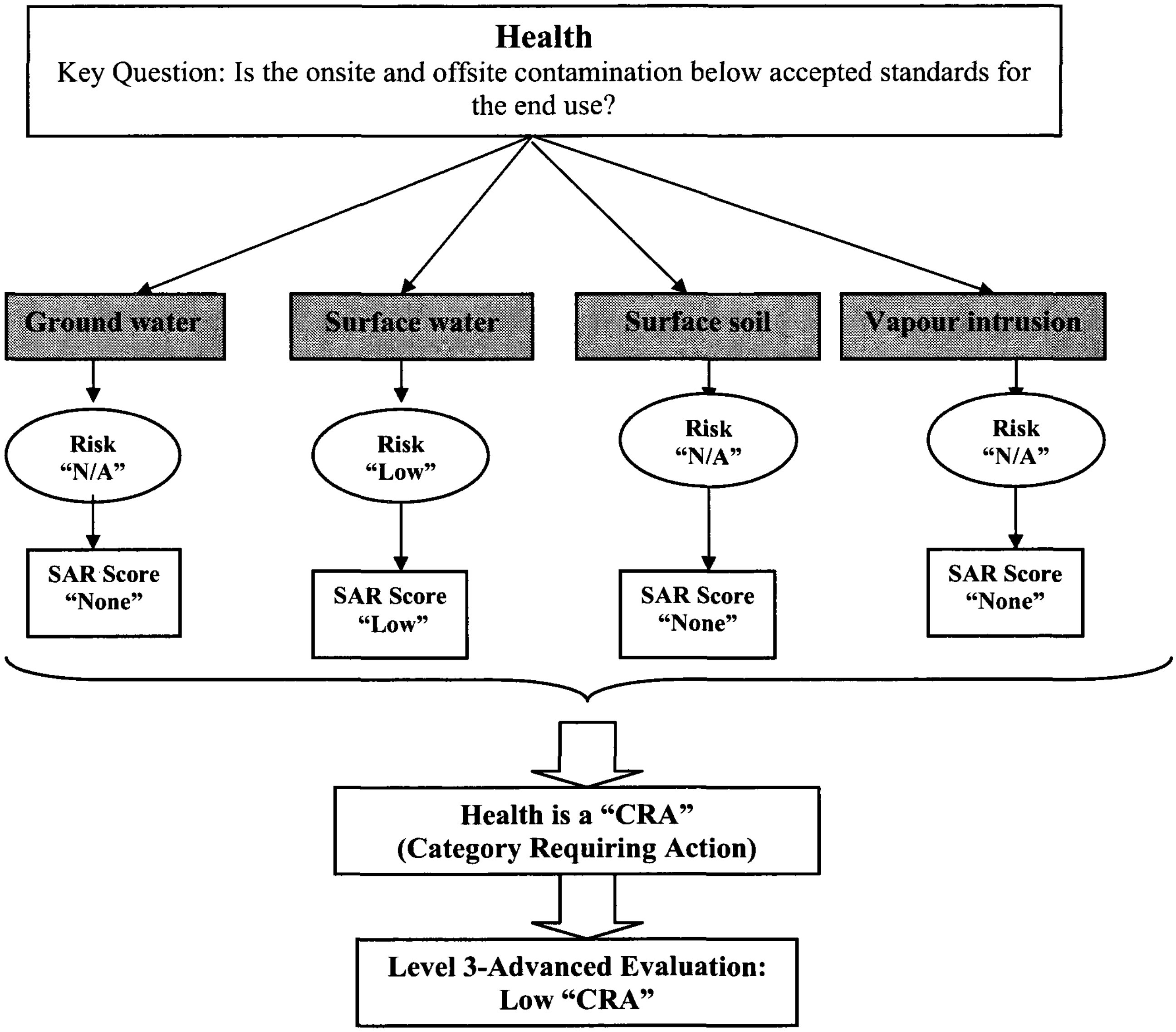


Figure 10-2: Evaluation of Health for Brownfield Classification- ABC Automotive Service Garage – both Residential and Commercial Options

11.0 SOCIAL/COMMUNITY- LEVEL 3 AND LEVEL 3-ADVANCED

As discussed in the previous sections this category classifies the brownfields based on the social and community criteria. Evaluating the community needs is a complex process and extensively involves stakeholders at various stages. In this dissertation, the overall framework for evaluation of community support is described at a generic level, in order to place social issues in the context presented by this classification system. However, more research is required.

11.1 OVERVIEW OF COMMUNITY

Many revitalization projects can lead to community renewal. The long term benefits of these projects may be job creation and improved community image. Because revitalization is almost always a part of a larger infrastructure effort, it is important to know the extent of support from the surrounding community. The community readiness is one of the most important aspects that should be evaluated. Building on the ideas developed by the Seneca College effort, the classification system suggests that the community be evaluated based on three modules:

- Community concerns;
- Community needs for the end use; and
- Increase in tax base.

11.1.1 Community Concerns

Brownfields are often situated in the core of depressed or declining communities and in commercial, retail or residential areas rather than in isolated locations (Attoh-Okine, 2001). The support from a given community on a redevelopment often depends on the perception of the community about the risk of developing a brownfield site and the health and safety risk associated with the status-quo (Thomas, 2003). Thomas (2003) suggests that in most situations communities are concerned over the following:

- Environmental conditions on the site;
- Redevelopment options for the site;
- Relative risks to local residents if the site is not remediated;

- Relative risks to local residents while redevelopment is occurring; and
- Relative risks to local residents from the operation of proposed alternative developments.

11.1.2 Community Need for the End Use

The *community need* includes assessing the need for green-space, schools, recreational facilities or other reuse needs that address community desires. The assessment of community desires involve evaluating community opinions, needs and key issues that are encountered by a community. Certain individuals or organizations (public or private) within the community may have an active role in decision-making for the potential site uses. Community needs could be quantified based on indicators such as inventory of existing assets, desire of the community for other assets, vacancy rate, per-capita availability of recreational space/green space and community needs for a proposed end use.

11.1.3 Tax Base

The economic evaluation of the proposed framework is limited to evaluating the onsite benefit of a brownfield. However, there can be significant offsite economic benefit that could be associated with a proposed brownfield redevelopment. In the event of a brownfield redevelopment the tax base at all the three tiers of government tends to increase significantly along with the job creation and productive use of a former abandoned site. Therefore, the increase in tax base can be significant indicator of the community revitalization.

Similar to other categories, the framework proposes evaluating brownfields in social terms by evaluating SAR scores for each of the modules is illustrated in Figure 11-1.

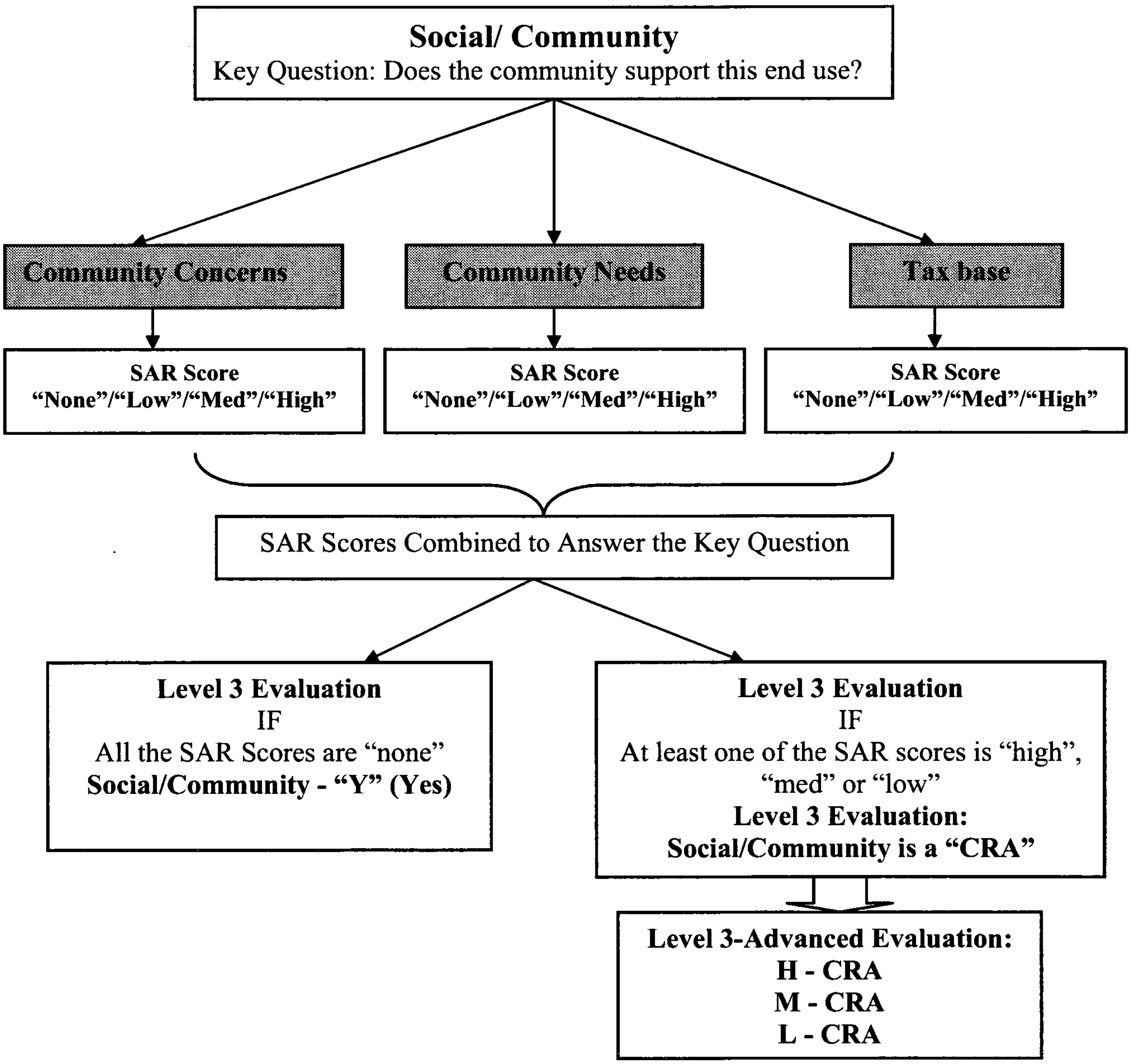


Figure 11-1: Social/Community Evaluation for Brownfield Classification

11.2 CONCLUSION

Unlike other categories (e.g., land, economics), the social evaluation is limited currently to a generic level assessment. The social evaluation of a brownfield is a complex and detailed analysis by itself. Considerably more research will be needed to complete the evaluation method for the community and social aspects within this classification system. For the purpose of our illustrative example for ABC Automotive Service Garage, it is assumed that:

- The community is supportive of residential redevelopment (i.e. the community is "Yes" for the proposed residential end use).
- The community is an "L-CRA" for the proposed commercial end use.

12.0 SUMMARY OF OUTSPUTS FROM THE OVERALL CLASSIFICATION

12.1 OUTPUT FROM THE OVERALL CLASSIFICATION SYSTEM

To help demonstrate how the outputs of this classification system fit together, this chapter first summarizes the illustrative example used throughout this dissertation. Table 12-1 lists the results of the example, ***ABC Automotive Service Garage***, for the two proposed redevelopment options. As shown in Table 12-1:

- Level 1 evaluation concludes that the site ABC Automotive Service Garage is an *Action Required* site (sub category: *Immediate Investigation* site), which means that the site has the potential to pose an immediate threat to the community.
- Level 2 evaluation concludes that the site has two potential uses: residential and commercial. The remaining end uses have "limited potential".
- Level 3 concludes that for the residential end use the site could be described by the characterization combination indicated by the matrix $\begin{bmatrix} CRA \\ CRA \\ Y \\ CRA \end{bmatrix}$ where land, economics and health are the three categories which are CRAs (Categories Requiring Action). Social is a "Yes" (i.e. supportive of the proposed residential development). On the other hand, for the commercial end use the site could be described by the characterization combination indicated by the matrix $\begin{bmatrix} CRA \\ CRA \\ CRA \\ CRA \end{bmatrix}$ where some actions are required for all the categories of end uses.

Table 12-1: Summary of Outputs Obtained at Each Level of the Classification System for the ABC Automotive Service Garage

Levels	When is it evaluated?	Output	
Level 1: Screening the Status-quo Option	Municipalities are investigating whether ABC Automotive Service Garage has the potential to pose an immediate threat to the community	• This is an Action Required Site. - The sub category is Immediate Investigation site. Therefore an investigation needs to be conducted at an immediate time-span. • The following contaminants are likely to be present at the site: - Halogenated VOCs - Non-halogenated VOCs - Non haloganeted SVOCs - Fuels - Metals and metalloids	
Level 2: Screening the Limited-Potential Site Uses.	Municipalities are investigating what are the potential redevelopment opportunities for this site	• ABC Automotive Service Garage is a *potential* - residential site. - commercial/business site. • ABC Automotive Service Garage is not a *potential* - industrial site - institutional site - assembly site	
Level 3: Classifying Site Based on Basic End uses	Municipalities are investigating what are the barriers if either a potential residential or a commercial development are carried out	Characteristic Combination for Potential Residential Use $\begin{bmatrix} CRA \\ CRA \\ Y \\ CRA \end{bmatrix}$	Characteristic Combination for Potential Commercial Use $\begin{bmatrix} CRA \\ CRA \\ CRA \\ CRA \end{bmatrix}$
Level 3-Advanced: Assessing the Severity of CRA	Level 3 is further refined at Level 3-Advanced	Potential Residential Use $\begin{bmatrix} M-CRA \\ \text{L}-CRA \\ Y \\ \text{L}-CRA \end{bmatrix}$	Potential Commercial Use $\begin{bmatrix} L-CRA \\ \text{H}-CRA \\ L-CRA \\ \text{L}-CRA \end{bmatrix}$

Level 3-Advanced concludes that for the ***residential end use option***:

- The land and infrastructure score is "M". Moderate levels of actions are required to modify the land and make it suitable for proposed residential redevelopment.
- The economics score is "L". Low levels of incentives can make the project economically viable. Without such incentives, the project is not economically viable. In this example, an additional 20% tax incentive could make the residential redevelopment economically viable.
- The health score is "L". Minimal levels of actions (e.g. clean up, paving etc.) are required to bring the health risk below the acceptable standards.
- Of course the social score is "Yes" and in this case, no further advanced evaluation is required beyond Level 3 for the "social" category.

Level 3- Advanced concludes that for the ***commercial end use option***:

- The land score and infrastructure score is "L". Low levels of actions are required to modify the land and make it suitable for proposed residential redevelopment.
- The economics score is "H". A high level of action (e.g. incentives/tax cuts) can make the project economically viable. Without such incentives, the project is not economically viable.
- The health score is "L". Minimal levels of actions (e.g. clean up, paving etc.) are required to bring the health risk below the acceptable standards.
- The social score is "L", so minimal actions are required in social category to conjure community support.

12.2 DEMONSTRATING THE TRADEOFFS

In the above example, the municipalities are left to make a decision of what redevelopment options they should undertake depending on the incentives that are available and the capability of the municipality to undertake actions to modify the land, remediate the site to reduce risk, and gauge community support. Ideally, this classification system could lead the stakeholders to an all-around "win-win" situation. However, there may be practical limitations that necessitate tradeoffs between various parties. As an example, Table 12-2 illustrates the trade-offs posed by different situations in the previous illustration depending on the end use option.

Table 12-2: Presentation of Trade-offs for ABC Automotive Service Garage

Categories	Residential End Use Option (Degree of CRA)	Commercial End Use Option Degree of CRA)
Land and Infrastructure	M	L
Economics	L	H
Health	Y	L
Social	L	L

Realistically, a brownfield redevelopment project involves trade-offs among different stakeholders at the various levels of redevelopment. Planning a successful redevelopment project involves identifying the significance of various courses of actions, and how these might then in turn affect the concerned parties/stakeholders. Identifying and satisfying all the stakeholders is the ideal objective of any redevelopment effort; realistically, there will always be some limitations. For example, a project that receives extensive community support (Community is "Y") may have economics evaluated as "H-CRA" and a decision to go ahead with such a redevelopment scenario may involve a trade-off between the developer's economic benefit and the community needs.

In the example summarized by Table 12-2, it appears that the residential end use option – because it has the lower overall corrective actions required – would seem to be the easier option to pursue. However, this presentation does not yet consider the weighting of each category (e.g., significance assigned to land and infrastructure versus economics), nor does it explicitly isolate the effects on each stakeholder that might be affected. However, it does show how trade-offs could be viewed by the stakeholders. For example, if the municipality of ABC Automotive Service Garage wants to expend *limited* effort in terms of land and infrastructure (e.g., removing the onsite assets, compromising with the ecological features and providing site services), a commercial option could be preferred. It could be that the municipality is not in a position to expend significant effort on land and infrastructure improvements and thus while the "easiest" option to satisfy all involved would seem to be the residential end use, the preferred option given its constraints might be the commercial one. On the other hand, if the municipality prefers to expand significant effort for land and infrastructure and wants to promote a redevelopment option which is supported by the community, the residential option may still be pursued. The classification system is therefore capable of structuring the trade-offs posed by the possible revitalization options. Table 12-2 is not the only or definitive means for presenting the trade-offs, but can be used as a starting point for showing and then later evaluating the preferred course of action.

This classification system demonstrates the trade-offs that the stakeholders have to address in order for a proposed redevelopment to take place. The outcomes can help the regulators to advance policy and decision-making based on clear demonstrations of trade-offs.

13.0 CONCLUSIONS AND RECOMMENDATIONS

13.1 CONCLUSIONS

This methodology classifies brownfields in terms of their site characteristics, potential remedial actions, feasible site uses, and relevant community issues. The output from this classification system enables the user to set priorities, rank alternatives, consider recommended preferred actions, and to either implement or suggest alternate actions based on the policies governing brownfields in a particular jurisdiction. This system has significant potential in terms of integrating a large array of attributes for the multidisciplinary evaluation of brownfields, and could be an excellent and powerful tool to promote successful redevelopment by identifying the barriers, the path forward and the trade-offs.

Several sections of this classification could be considered as stand alone tools for respective stakeholders, and of course, the entire classification system could be used as an entire integrated tool. For example, government based or other monetary incentives could be quantified by evaluating only the economic factors, or risk could be evaluated by investigating the risk ranking. Moreover, the tiered approach could help the user to attain at least a basic evaluation of a brownfield when resources are inadequate to conduct a detailed investigation. However, the user is cautioned that using sections as standalone tools may limit the understanding of the overall context and therefore open the system up to greater misuse (for example, to justify unreasonably a preconceived outcome).

13.2 RECOMMENDATIONS

Addressing the following recommendations would further enhance the classification system:

- The algorithms developed in this research should be compiled in the form of an expert system. This system should be usable by:
    - Expert users such as consultants and municipal officials for guiding or encouraging proponents of brownfields redevelopment.
    - Non-expert users such as the public at large for understanding brownfields issues.

Because of the different values held by different stakeholders, the expert system could take different forms for expert and non-expert users, the proposed expert system may need to be customized. For example, additional data fields may be required or the computational model may need to be modified to work with the existing data (e.g., the risk premium values could differ if different developers plan to purchase the tools and analyze the project). The additional advantage of rendering this classification system into an expert and even a computer based system is to allow for managing and archiving large data sets, particularly in situations (e.g., larger municipalities) where there tends to be more readily available data.

- This research illustrates how the social attributes could be incorporated within the classification framework. However, more research is needed to finally evaluate whether the community attributes for a brownfield redevelopment is "Yes" or a "CRA".
- Although this research was to investigate all of the four categories as separate issues within this framework (e.g. land, economics, health), in reality they are interdependent. More research is recommended to investigate the interrelationship among the four categories and the influence of such interdependency on the proposed methodology.
- This classification system should be used "piece-wise" for the large multiple use sites and the method should be applied for each single use land parcel. However, in such situations the synergistic effects of the end-uses are overlooked by the system. For example, if a site is used for development of a high density residential complex and a commercial store, the commercial development may have the benefits of the new customer base created by the residential use. On the other hand the residential units may be of more value because of the presence of a commercial store in the vicinity, as opposed to a stand alone residential unit in the same location. However, this classification system does not take this into account. More research is recommended in the area of evaluating these synergistic/antagonistic effects of the end-uses for multiple use sites.
- It is also possible to develop custom overlays, such as from the regulations relevant to a specific region, to show how specific regulatory actions or policies may influence

the evaluation of various end uses. It is also possible to extend the classification system to then develop an explicit means of evaluating the trade-offs given the stakeholders' preferences.

REFERENCES

Alker, S; Barrett, P; Clayton, D.; Jones, G.; Joy V. and Roberts, P. (2000). "Delivering Regeneration: A Brownfield Renaissance Reporting the Findings of the National Brownfield Sites Project" ISBN: 0-9539730-0-X. National Brownfield Sites Project. Urban Mines Ltd, UK.

Amekudzi, A.; Fomunung, I.; (2004). "Integrating Brownfields Redevelopment with Transportation Planning." Journal of Urban Planning and Development, vol. 130, no. 4, Dec. 2004, pp. 204-212.

About Remediation (AR) (2005). Available from World Wide Web: <http://www.aboutremediation.com/toolbox/step2_propertyvalue.asp>. Accessed: Aug 2006.

Asante-Duah, D. K. (1996). Management of Contaminated Site Problems. CRC Press, Inc. USA.

Attoh-Okine N. (2001). "Use of Belief Function in Brownfield Infrastructure Redevelopment Decision Making." Journal of Urban Planning and Development, vol. 127 no. 3, pp. 126-143.

Bartsch, C. Deane; R. and Dorfman., B. (2001); Brownfields "State of the States" 11th Annual Edition, Northeast Midwest Institute Press, Washington D.C. USA.

BuildCost (2007). "Building Construction Cost Solutions". Available from World Wide Web <http://www.buildcost-ipmg.com/anoverview.php>. Accessed Jan 2007.

Butler, B., Petts, J.; (2006) "Land Contamination Risk Assessment Tools – An Evaluation of some of the Commonly Used Methods." R&D Technical Report. Geodelft Environmental and Loughborough University.

Bobechko, J. (2005) "Brownfield Progress", Canadian Brownfields Chronicle, August/September 2005, pp. 20-23.

Bush, G. W.(2000). "President Signs Legislation to Clean Environment and Create Jobs." www.epa.gov (March, 2002)

Breggin, L.; Pendergrass, J.; Welks, K.; Rosenbaum, K.; (1999). "A Guidebook to Brownfield Owners." Environmental Law Institue. Washington D.C. USA

Cabernet (2005). Available from World Wide Web: <http://www.cabernet.org.uk/index.asp?c=1124>. Accessed June 2006

CCME (Canadian Council of Ministers of the Environment). (1992) "National Classification System for Contaminated Sites." Report No. CCME EPC-CS39E, March 1992, CCME, Winnipeg, Manitoba, Canada.

Canadian Council of Ministers of the Environment (CCME). (1998). "Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life" Report No. CCME EPC-98E, March 1998, CCME, Winnipeg, Manitoba, Canada.

Canadian Council of Ministers of the Environment (CCME) (2005). "National Classification System for Contaminated Sites-Executive Summary" Available from World Wide Web: http://www.ccme.ca/ourwork/ Accessed Jan 2006.

Canning, G.(2005) Putting it Right with the Direct Comparison Approach. The Canadian Appraiser. ABI/INFORM Global, vol. 49, no. 2, pp. 45-48.

Chay K.Y. and Greenstone,M (2005).Does Air Quality Matter? Evidence from the Housing Market," Journal of Political Economy, University of Chicago Press, vol. 113, no. 2, pp 376-424.

City of Windsor Official Master Plan (2006); "Volume I- The Primary Plan"; Windsor, On, Canada.

Kansan Master Plan. Available from World Wide Web: <http://www.opkansas.org/_Assets/pds/mp/2007/draft_documents/planned_residential_land_use_goals.pdf>. Accessed Dec 2007.

Contaminated Site Information Management Strategy (CSIMS) Report U99/74. (1999). Environment Canterbury. Available from World Wide Web: <http://www.ecan.govt.nz/home>. Accessed: January 2006.

Creswell, J. W. (1994); "Research Design: Qualitative & Quantitative Approaches." Thousand Oaks, CA: Sage Publications.

"Designated Substance – Asbestos on Construction Projects and in Buildings and Repair Operations". (2005).O. Reg. 278/05, s. vol 26 no. 1.

DETR (Department of the Environment, Transport and the Regions) (2000) "Achieving A Better Quality of Life: A Strategy for Sustainable Development in the United Kingdom" , Government Annual Report, London, UK.

ECO (Environmental Commissioner of Ontario), (2005). 2004/2005 Annual Report: Planning Our Landscape, Oct. 2005.

Environment Canada (EC) (2005) "A Method for Ranking Contaminated Marine and Aquatic Sites on Canadian Federal Properties." Report by Contaminated Site Management Working Group (CSMWG). Ottawa, Canada.

Environment Canada (EC) (2007). "Complience Promotion Bulletin "COMPRO #18Federal Storage Tank Registration Regulations". Available online <http://www.on.ec.gc.ca/epb/fpd/cpb/3018-e.html> Accessed Oct 2007.

Environmental Technology Cost-Savings Analysis Project (ETCAP). 1997. Los Almos National Laboratory. Available from World Wide Web: <http://www.lanl.gov/orgs/d/d4/enviro/etcap/browse.html.>. Accessed, December 2007.

EPA (United States Environmental Protection Agency). (1990). "The Revised Hazard Ranking System: Background Information." Office of Solid Waste and Emergency Response. Publication 9320.7-03FS.

EPA (United States Environmental Protection Agency). (2001). "Remediation Technology Cost Compendium". Publication EPA-542-R-01-009.

EPA (Environmental Protection Agency). "Brownfield Site Redevelopment." Viewpoint 2006. Available from World Wide Web: <http://www.epa.ie/downloads/pubs/other/viewpoints/epa_viewpoint_brownfield_site_sept%2006.pdf.> Accessed Dec 2008.

EPA (United States Environmental Protection Agency). (2007). "Brownfield Cleanup and Redevelopment Homepage." Available from World Wide Web: http://www.epa.gov/brownfields/. Accessed, August 2007.

FRTR (Federal Remediation Technology Roundtable). (2006). "Remediation Technologies Screening Matrix and Reference Guide, Version 4.0". Prepared for the US Department of Defence and other Federal Agencies. Available from World Wide Web: <http://www.frtr.gov/matrix2/top_page.html>, accessed November 2007.

Gallant, B.T.; Blickle, F.W. (2005) "The Building Decommissioning Assessment: A New Six-Step Process to Manage Redevelopment of Brownfields with Major Structures" Environmental Practices. vol. 7, no. 2, June 2005. pp. 97-107.

GAO United States General Accounting Office .1995. Report to the Chair, Committee on Small Business, House or Representatives. GAO/RCED-95-172.

Girlon, G., Basigalupo, C., Hull, R. 2004. "Ontarios New Record of Site Condition Evaluation: What Will it Mean to You?" Envision. Available from World Wide Web: http://www.cantoxenvironmental.com. Accessed Dec 2007.

GSG (GSG Consultants) (2005). "Smart Growth for Brownfield Redevelopment." GSG Project No.: E03-24.06. Prepared for City of Chicago, Department of the Environment.

Hazardeous Products Act (1991) "Hazardous Products (Liquid Coating Materials) Regulations". SOR/91-262, s. 1(F).

Health Canada (HC) (2005). "Lead Based Paint". Available from World Wide Web: <http://hc-sc.gc.ca/iyh-vsv/prod/paint-peinture_e.html>. Accessed Oct 2007.

Hybrid Geophysical Technology for the Evaluation of Insidious Contaminated Areas (HYGIA).(2002). The Europian Commission Community Research. Available from World Wide Web: http://www.hygeia-eu.org/media/docs/D.3.1.pdf. Accessed: December 2006.

Investopedia.2007. Available from World Wide Web: <http://www.investopedia.com/>. Accessed May 2007.

Kenneth, S.; Earnest, C. (2006). "Environmental Due Dilligence – A Professional Handbook". Infinity Publishing. PA 19428-2713, USA.

Kinder, C. "Preventing Lead Poisoning in Children".(1993). "Curriculum Units by Fellows of the Yale-New Haven Teachers Institute" Vol. 5 - Environmental Science. Yale New Haven Teachers Institute, USA.

Lange, D. A. ; McNeil, S. (2004) "Brownfield Development: Tools for Stewardship. Journal of Urban Planning and Development, Vol. 130, no. 2, Jun. 2004, pp. 109-116 .
Lexa, F. and Berlin. J; (2005)"Financial Modeling in Medicine: Cash flow, Basic Metrics, the Time Value of Money, Discount Rates, and Internal Rate of Return." Journal of the American College of Radiology vol. 2, no.3, pp. 225-231.

Long, E.R. and D.D. MacDonald. 1997. "Effects Range Low and Median, Threshold and Probable Effects Levels". Use of Sediment Quality Guidelines in the Assessment and Management of Contaminated Sediments". Society of Environmental Toxicology and Chemistry (SETAC), 1997 short course.

Martin, J.C. and Toll, D.G. (2006). "The Development of Knowledge Based System for Preliminary Investigation of Contaminated Lands". Computer and Geo techniques vol. 33, pp. 97-103.

MOE (Ontario Ministry of the Environment). (2004a). "Record of Site Condition: A Guide on the Site Assessment, the Cleanup of Brownfield Sites and the Filing of Records Site Condition"Toronto, Queen' Printer for Ontario, Canada.

Mundy, B. (2001). "Valuing Brownfield." Brownfields- A Comprehensive Guide to Rredeveloping Contaminated Property, 2nd Ed./ Editor Todd. A Davis. Chapter 6. American Bar Association Publishers. Chicago, IL.,USA.

National Building Code of Canada (NBCC) (2005). Associate Committee on the National Building Code, National Research Council of Canada, Ottawa, ON,Canada.

Neill, J.; (2007) "Qualitative versus Quantitative Research: Key Points in a Classic Debate" Available from World Wide Web

<http://wilderdom.com/research/QualitativeVersusQuantitativeResearch.html#Features>. Accessed, Dec. 2006.

New Hampshire Department of Environmental Services (NHES).(2007). "List of Asbestos Containing Materials." Available from World Wide Web <http://www.des.state.nh.us/ARD/doc/asbestos_materials.doc.> Accessed Dec. 2007.

NRTEE (1996). "The Financial Services Sector and Brownfield Redevelopment." Ottawa: National Round Table on the Environment and the Economy, Financial Services Task Force. NRTEE, Ottawa, ON, Canada.

NRTEE (National Round Table on the Environment and the Economy) (1997a). "Removing Barriers: Redeveloping Contaminated Lands for Housing." Ottawa:, Report prepared by Canadian Mortgage and Housing Corporation, Delcan Corporation, Golder Associates ltd., McCarthy- Tetrault. NRTEE, Ottawa, ON, Canada.

NRTEE (1997b). (National Round Table on the Environment and the Economy) "Improving Site Specific Data on the Environmental Condition of Land." Golder Associates ltd., McCarthy- Tetrault. NRTEE, Ottawa, ON, Canada.

NRTEE (National Round Table on the Environment and the Economy) (2003), Cleaning up the Past, Building the Future, NTREE, Ottawa, ON, Canada.

NZ MFE (New Zealand Ministry for the Environment). (1993). National Rapid Hazard Assessment System for Potentially Contaminated Sites (draft). Ministry for the Environment, Wellington, New Zealand.

NZ MFE (New Zealand Ministry for the Environment). (2004). Risk Screening System – Contaminated Land Management Guideline No. 3., ISBN: 0-478018922-2, New Zealand.

OdelionResearch.2007.Available from World Wide Web <http://www.ode llion.com/> Accessed March 2007.

Petts, J.; Cariney, T.; Smith, M.;(1997) "Risk-Based Contaminated Land Investigation and Assessment", John Wiley and Sons, England.

RAI. Regional Analytics Inc. (2002). "A Preliminary Investigation into the Economic Impact of Brownfield Redevelopment Activities in Canada." background document prepared for the NRTEE. NTREE, Ottawa, ON, Canada.

Roberts, P., Joy, V., Alker, S. (1998), "Towards a Brownfield sites Taxonomy: Issues in the Definition and Classification of Problems and Potentials", paper presented at the Remediation of Brownfield Sites for Housing Conference, UK.

Schimitter, B. (1998). “Brownfields at the Grassroots, Impacts” July-August 1998, vol. 1, Economic Development Institute, Georgia, Institute of Technology Press, Atlanta, USA.

Schruder, N. (2007). “Methods for Classifying Human health and Safety Risks of Brownfield Sites.” M.A.Sc. Thesis, University of Toronto., ON, Canada.

Simons, R.; (1998). “Turning Brownfields into Greenbacks”. Urban Land Institute, Washington, USA.

Surface Coating Materials Regulations Hazardous Products Act Registration.SOR/2005-109 April 19, 2005 vol. 139, no. 9 — May 4, 2005.

STC (Specialty Technical Consultants) (2006).” Site Auditing Environmental Assessment of Property”-1225 East Keith Road, North Vancouver, B.C. Canada.

Tam, E; and Byer. P.(2002). “Remediation of Contaminated Lands: a Decision Methodology for Site Owners. Journal of Environmental Management.” vol. 64, pp. 387-400.

Tam, E; and Byer. P. (2004). “Estimating the Liability of Redeveloped Contaminated Lands.” Journal of Urban Planning and Development, vol. 130, no. 4, Dec (2004), pp. 184-194

Thomas, M.R.; (2003) "Brownfield Rredevelopment: Information Issues and the Affected Public." Environmental Practice vol. 5, no. 1, pp. 62-68.

U.S. Conference of Mayors (2000). “Recycling America’s Land: A National Report on Brownfields Redevelopment” .Vol. III. Washington, D.C. USA.

Varner, B. G.; (2005) “Think Twice About the Cost Approach - a Claims Summary” The Canadian Appraiser; vol. 49, no. 3; ABI/INFORM Global, pp. 26-28.

WSDE (Washington State Department of Ecology) (2007). “Terrestrial Ecological Evaluation Process”. Toxic Cleanups Program., Washington, U.S.A., Available from World Wide Web: <http://www.ecy.wa.gov/programs/tcp/policies/terrestrial/TEEHome.htm>. Accessed May 2007.

APPENDIX A
Input Data for Evaluating ABC Automotive Service Garage

ABC Automotive Service Garage is considered to be a representative site in Ontario. It is assumed that the municipality is willing to proceed for a residential or a commercial development at ABC Automotive Service Garage. Following information was available about the site:

Preliminary Information

The site is underutilized and is located at a mixed residential/commercial neighborhood in an urban location. Historical uses may include:

- Painting and auto parts repair and vehicle maintenance.
- Gasoline station.
- The site is underutilized and is located at a mixed residential/commercial neighborhood in an urban location.
- No harm has been suspected to have been caused by the site.
- The site is not likely to have any physical hazard.

An eventual Phase I and II ESA revealed the following details:

Information from Phase I and II ESA

- ABC Automotive Service garage is located in a small urban city (under 50,000) in Ontario, in a typical urban setting in an area of mixed residential and commercial land use. The owner has been occupying the 15000 m^2 property since 1971 as an automotive dealership and service garage.
- The historical uses include an automotive dealership and service garage, with major operations including vehicle repair and maintenance and an automotive showroom/ car lot.
- The site is an irregular shaped 15,000 m^2 acre property occupied by three commercial buildings :
    - The southern building has a footprint of 2250 m^2
    - The northern building has a footprint of 140 m^2
    - The eastern building has a footprint of 250 m^2
- Major types of contaminant are metals, metalloids and hydrocarbons.

- Following information are available about groundwater
    - "Appropriate Site Condition Standards for the Site were determined to be the Table 3 Standards for non-potable ground water[1] for industrial/commercial/community property use and medium to fine-textured soils[2] from Part XV.1 of the Environmental Protection Act.
    - Petroleum hydrocarbons ("PHCs") and benzene, toluene, ethylbenzene and xylenes ("BTEX") were not identified above justified criteria in the groundwater samples analyzed from any of the boreholes/ monitoring wells, UST excavation or test pits at the Site, with the exception of PHCs in a borehole located below the northern building.
    - Volatile Organic Compounds ("VOCs"), including BTEX and heavy metals were not identified above the criteria in groundwater samples analyzed from any of the boreholes/monitoring wells at the Site."
- Two steel USTs (one 3785L and one 11356L) were present at the site that were later removed.
- No active or closed waste disposal site was listed within 1 km of the site by the Waste Manage Branch of the MOE.
- No coal tar or waste sites were listed as being present within 1 km of the site by "Inventory of Coal Gasification Plant" by MOE.
- The site and surrounding sites is not registered PCB waste storage site. Light ballasts were tested for PCB and the concentration was below acceptable standards.
- The site is not a registered waste generator based on MOE database
- The site was well maintained and no amounts of debris, uncontrolled chemical storage or waste storage were observed at the site.
- Following descriptions show the status of the designated substances:

---

[1] Since no potable water wells are located at the Site and the surrounding properties are connected to municipal water system.
[2] Determined by grain size distribution plot conducted on soil samples.

- Some of the interiors and exterior walls of the site building contained painted surfaces. The site building was approximately constructed in 1950s and given the date, it is possible that lead based paint might be present. LBP was verified using sampling and the concentration was <0.05 mg/L.
- Based on the date of the construction of site building (i.e. beginning of 1950s, friable ACMs may be present at the site as the use of friable ACMs was not discontinued until early 1980. However, reconnaissance was made only in the readily accessible areas of the existing building and no asbestos was found.
- No other designated substances were identified at the site.

- There were no areas of natural significance or condition in the vicinity of the site, which would cause the site to be classified as potentially sensitive according to the Ministry of Natural Resources (MNR)' Natural heritage club website.
- MNR has been contacted regarding the presence of a 'threatened'/'other' species in the vicinity of the site and no response was received. If the response is received about the sensitivity of the site the status may change.
- According to the site representative the site is connected to municipal water supply. Sanitary wastewater is discharged to municipal sewer system. Stormwater flows to catch basins located across the site and into municipal storm water system. Electrical services are supplied to the site via hydro through aboveground and underground service cables. Pad and pole mounted transformers are present adjacent to the site. The locations nearby have fiber optic cables available.

Following Redevelopment Options are Available for the Municipalities for Redevelopment

Option 1: Residential Redevelopment Option

Developers have expressed interest in purchasing and redeveloping the site to a set of town houses and complete the town houses in three years.

- Developer has an established company with a strong and stable cash flow. The opportunity cost estimated for the developer is 10% and the assessors estimate the acceptable range of risk premium is between 5-10%.
- The upfront cost for property purchase and other legal considerations was $1M
- 20% of the investments come from government grants and 60% of the funding is expected to come from a bank at an interest rate of 8%.
- The proposed end use is 80 residential town houses each having an estimated FMV of 0.2 M each and the project is to be completed in 3 yrs and the site is to be sold at the 4^{th} year.
- The effective tax rate at the region is 40%.
- The redevelopment cost was estimated to be $8.2 M. This was estimated using building costing software.
- Community supports a proposed residential development

Option 2: Commercial Redevelopment Option

The existing owner plans to renovate the existing buildings and use it as a business/ commercial property. Renovating the property would involve the followings:

- Encapsulation of the contaminant using barrier walls to prevent any offsite and vertical migration of the contaminant.
- Renovation of the existing buildings and developing them as follows:
    - Renovating the southern and northern buildings to commercial stores.
    - Demolishing the eastern building.
    - Removing all of the ASTs and USTs.

- 60% of the funding is expected to come from a bank at an interest rate of 8%. Rest is the equity investment. Availability of government grants is unsure at this point.
- The proposed end use is two commercial buildings with estimated total FMV of $2.5M and the renovation project is to be completed in 2 years and the site is to be sold at the third year.
- The effective tax rate at the region is 40%.
- The cost of providing encapsulation was assumed to be $1M and renovation cost was assumed to be another $1M.
- Community is slightly adverse of a commercial development.

APPENDIX B
Chemicals Considered Under Each Contaminant Group Discussed in Level 1
(FRTR, 2005)

1.0 Nonhalogenated Volatile Organic Compounds (VOCs)

1-butanol	Cyclohexanone	Methyl isobutyl ketone
4-Methyl-2-pentanone	Ethanol	n-Butyl alcohol
Acetone	Ethyl acetate	Styrene
Acrolein	Ethyl ether	Tetrahydrofuran
Acrylonitrile	Isobutanol	Vinyl acetate
Aminobenzene	Methanol	
Carbon disulfide	Methyl ethyl ketone (MEK)	

2.0 Halogenated Volatile Organic Compounds

1,1,1,2-Tetrachloroethane	Bromoform	Glycerol trichlorohydrin
1,1,1-Trichloroethane	Bromomethane	Hexachlorobutadiene
1,1,2,2-Tetrachloroethane	Carbon tetrachloride	Hexachlorocyclopentadiene
1,1,2-Trichloroethane	Chlorodibromomethane	Hexachloroethane
1,1-Dichloroethane	Chloroethane	Methylene chloride
1,1-Dichloroethylene	Chloroform	Neoprene
1,2,2-Trifluoroethane (Freon 113)	Chloromethane	Pentachloroethane
1,2-Dichloroethane	Chloropropane	Perchloroethylene
1,2-Dichloropropane	Cis-1,2-dichloroethylene	Propylene dichloride
1,2-Trans-dichloroethylene	Cis-1,3-dichloropropene	Trichlorotrifluoroethane
1,3-cis-dichloro-1-propene	Dibromochloropropane	Monochlorobenzene
1,3-trans-dichloropropene	Dibromomethane	Tetrachloroethylene (Perchloroethylene) (PCE)
1-chloro-2-propene	Dichlorobromomethane	Trichloroethylene (TCE)
2-butylene dichloride	Dichloromethane	Vinyl chloride
Acetylene tetrachloride	Ethylene dibromide	Vinyl trichloride
Bromodichloromethane	Fluorotrichloromethane (Freon 11)	Vinylidene chloride

3.0 Nonhalogenated Semivolatile Organic Compounds (SVOCs).

1,2-benzacenaphthene	Benzidine	Ethyl parathion
1,2-Diphenylhydrazine	Benzo(a)anthracene	Fluorene
1-aminonaphathalene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
2,3-phenylenepyrene	Benzo(b)fluoranthene	Isophorone
2,4,-Dinitrophenol	Benzo(k)fluoranthene	Malathion
2-aminonaphthalene	Benzoic Acid	Methylparathion
2-Methylnaphthalene	Benzyl alcohol	Naphthalene
2-Nitroaniline	Bis(2-ethylhexyl)phthalate	n-Nitrosodimethylamine
2-Nitrophenol	Butyl benzyl phthalate	n-Nitrosodi-n-propylamine
3-Nitroaniline	Chrysene	n-Nitrosodiphenylamine
4,6-Dinitro-2-methylphenol	Dibenzofuran	Parathion
4-Nitroaniline	Diethyl phthalate	Phenanthrene
4-Nitrophenol	Dimethyl phthalate	Phenyl naphthalene
Acenaphthene	Di-n-butyl phthalate	Pyrene
Acenaphthylene	Di-n-octyl phthalate	tetraphene
Allyldioxybenzene methylene ether	Diphenylenemethane	
Anthracene	Ethion	

Pesticides:

Aldrin	4,4′-DDT	Ethyl parathion
BHC-alpha	Dieldrin	Heptachlor
BHC-beta	Endosulfan I	Heptachlor epoxide
BHC-delta	Endosulfan II	Malathion
BHC-gamma	Endosulfan sulfate	Methylparathion
Chlordane	Endrin	Parathion
4,4′-DDD	Endrin aldehyde	Toxaphene
4,4′-DDE	Ethion	

4.0 Fuels.

,2,3,4-Tetramethylbenzene	2-Methylheptane	Benzo(k)fluoranthene
1,2,4,5-Tetramethylbenzene	2-Methylnaphthalene	Chrysene
1,2,4-Trimethyl- 5-ethylbenzene	2-Methylpentane	Cis-2-butene
1,2,4-Trimethylbenzene	2-Methylphenol	Creosols
1,3,5-Trimethylbenzene	3,3,5-Trimethylheptane	Cyclohexane
1-Pentene	3,3-Dimethyl-1-butene	Cyclopentane
2,2,4-Trimethylheptane	3-Ethylpentane	Dibenzo(a,h)anthracene
2,2,4-Trimethylpentane	3-Methyl-1,2-butadiene	Dimethylethylbenzene
2,2-Dimethylheptane	3-Methyl-1-butene	Ethylbenzene
2,2-Dimethylhexane	3-Methyl-1-pentene	Fluoranthene
2,2-Dimethylpentane	3-Methylheptane	Fluorene
2,3,4-Trimethylheptane	3-Methylhexane	Ideno(1,2,3-c,d)pyrene
2,3,4-Trimethylhexane	3-Methylpentane	Isobutane
2,3,4-Trimethylpentane	4-Methylphenol	Isopentane
2,3-Dimethylbutane	Acenaphthene	Methylcyclohexane
2,3-Dimethylpentane	Anthracene	Methylcyclopentane
2,4,4-Trimethylhexane	Benz(a)anthracene	Methylnaphthalene
2,4-Dimethylphenol	Benzene	Methylpropylbenzene
2-Methyl-1,3-butadiene	Benzo(a)pyrene	m-Xylene
2-Methyl-2-butene	Benzo(b)fluoranthene	Naphthalene
2-Methyl-butene	Benzo(g,h,i)perylene	n-Butane

5.0 Metals and Metalloids (inorganics)

- Metals

Alumina	Cobalt	Selenium
Aluminum	Copper	Silver
Antimony	Iron	Sodium
Arsenic*	Lead	Thallium
Barium	Magnesium	Tin
Beryllium	Manganese	Titanium
Bismuth	Mercury	Vanadium
Boron	Metallic cyanides	Zinc
Cadmium	Molybdenum	Zirconium
Calcium	Nickel	
Chromium	Potassium	

* Although arsenic is not a true metal, it is included here

- Other inorganic contaminants

Asbestos
Fluorine
Cyanide

6.0 Explosives.

TNT (2,4,6-Trinitrotoluene)	Picrates
RDX (Cyclo-1,3,5-trimethylene-2,4,6-trinitramine)	TNB (Trinitrobenzenes)
Tetryl (N-Methyl-N,2,4,6-tetranitrobenzeneamine)	DNB (Dintrobenzenes)
2,4-DNT (2,4-Dinitrotoluene)	Nitroglycerine
2,6-DNT (2,6-Dinitrotoluene)	Nitrocellulose
HMX (1,3,5,7-Tetranitro-1,3,5,7-tetraazocyclooctane)	AP (Ammonium perchlorate)
Nitroaromatics	Nitroglycerine

APPENDIX C
Contaminants Associated with Historical Uses and Disposed Chemicals
(EPA, 2005)

1.0 Typical Contaminants Associated with Past site Uses (EPA-542-B-05-001, 2005)

Past Use	Halogenated VOCs	Non-halogeated VOCs	Halogenated SVOCs	Non-halogeated SVOCs	Fuels	Metals and Metalloids	Explosives
Agricultural	√	√	√	√		√	
Battery recycling and disposal						√	
Chemical and Dye manufacturing	√	√	√	√			
Chlor-alkali manufacturing	√		√			√	
Cosmeics manufacturing	√	√				√	
Drum recycling	√	√	√	√	√	√	
Dry cleaning	√	√					
Gasoline stations		√		√	√	√	
Glass manufacturing						√	
Hospitals	√	√				√	
Incinerators			√			√	√
Landfills/ dumps	√	√	√	√	√	√	
Leather manufacturing					√	√	
Machine shops and metal fabrication	√	√	√			√	
Manufactured gas plants and coal gasification		√		√	√	√	
Marine maintenance	√	√				√	
Metal plating and finishing	√	√	√	√		√	
Metal recycling and automobile salvage			√		√	√	
Munition manufacturing and ordinances						√	√
Mining	√				√	√	
Painting and automobile body repair	√	√			√	√	
Pesticide manufacturing and use	√	√	√	√	√	√	
Petroleum refining and use					√	√	
Pharmaceuticals manufacturing	√	√				√	
Photographic film manufacturing and development	√	√		√		√	
Plastic manufacturing	√	√		√		√	
Printing ink manufacturing	√	√			√	√	
Railroad yards	√	√	√	√	√		
Research and educational instituitions	√	√	√		√		
Semiconductor manufacturing	√	√				√	
Smelter operation						√	
Underground storage tank	√	√			√	√	
Vehicle maintenance	√	√			√	√	
Wood [reservation		√	√	√	√	√	
Wood, pulp and paper manufacturing	√		√				

2.0 Chemicals and the Typical Groups of Contaminants

Chemicals	Halogenated VOCs	Non-halogenated VOCs	Halogenated SVOCs	Non-halogenated SVOCs	Fuels	Metals and Metalloids	Explosives
Acids and bases	√		√			√	
Batteries						√	
Cleaning products	√	√					
Coal tar		√		√	√	√	
Solvents/degreasing agents	√	√	√	√		√	
Petroleum products (diesel fuels, gasoline, motor oil, oil sludge and waste oil)	√	√			√	√	
Dyes, pigments and inks	√	√	√	√	√	√	
Explosives and ordinances						√	√
Fertilizers	√	√	√	√		√	
Hydraulic fluids and lubricants	√	√			√	√	
Insulations	---						
Paints	√	√			√	√	
Plastics	√	√		√		√	
Polymers and epoxy compounds	√	√	√	√			
Pesticides (herbicides and insecticides)	√	√	√	√	√	√	
Refrigerants and coolants	√	√	√			√	
Soaps	√	√			√		
Surfactants	√	√		√	√	√	
Waxes	√	√		√	√	√	

APPENDIX D
Minimum Land Area Required for Various Potential End Uses

1.0 Method for Estimating the Minimum Land Area Required (Used in Table 6.2)

Minimum land area required
= (Minimum # people that may use the facility) * (minimum area per person)/ (Floor Space Index)
(Default values are provided, however the user is strongly urged to select the preferences so that more accurate results could be determined)

2.0 Table for Minimum Land Area Required

	Area per person (m^2)	# of people	Default FSI	Minimum area (m^2)
Assembly Occupancy				
Default value	***0.6***	***50***	***0.8***	***37***
space with fixed seats	0.75			
space with nonfixed seats	0.75			
stages for theatrical performances	0.75			
space with nonfixed seats and tables	0.95			
stadia and grandstands	0.60			
bowling alleys, pool and billiard rooms	9.30			
classrooms	1.85			
school shops and vocational rooms	9.30			
reading or writing rooms or lounges	1.85			
dining, alcoholic beverage and cafeteria space	1.10			
*laboratories in schools	4.60			
exhibition halls other than those classified in Group E	2.80			
Institutional Occupancy				
Default value	***10***	***20***	***0.8***	***250***
detention quarters	11.6			
treatment and sleeping room areas	10			
sleeping room areas	10			
Residential Occupancy				
Default value	***>4.6***	***4***	***0.8***	***23***
*Business and Personal Services Uses**				
Default value	**4.6**	**10**	**0.8**	**57**
personal service shops	4.60			
offices	9.30			
*Commercial Occupancy**				
Default value	***1.1***	***50***	***0.8***	***44***
basements and first storeys	3.70			
second storeys having a principal entrance from a pedestrian thoroughfare or a parking area	3.70			
dining, alcoholic beverage and cafeteria space	1.10			
other storeys	5.60			
basements and first storeys				
Industrial Occupancy				
Default value	***4.6***	***30***	***0.8***	***172***
manufacturing or process rooms	4.60			
storage garages	46.00			
storage spaces (warehouse)	28.00			
Storage hangers	46.00			

* Limiting value for business and commercial uses is considered to be 50 m^2

APPENDIX E
Definitions of Arterial and Collector Roads
(City of Windsor Master Plan, 2006)

1.0 Arterial Road

An **arterial road** is a medium to high-capacity road which is immediately below a highway level of service. Arterials are designed to carry high volumes of both passenger and commercial traffic for intra-city travel at moderate speeds.

- Class I arterial roads contain: four or more divided or undivided travel lanes with right-of-way widths no more than 36 m;
- Class II arterial roads contain: four undivided travel lanes, with rights-of-way widths no more than 30 m;

2.0 Collector Road

A **collector road** is a low or moderate-capacity road which is below a highway or arterial road level of service.

- Class I Collector Roads are the roads that carry moderate volumes of passenger traffic, except in industrial areas where they may carry passenger and commercial traffic, between Local Roads. They usually consist of two undivided travel lanes, and not more than four travel lanes, in a right-of-way up to 24 m
- Class II Collector Roads are the roads that carry passenger traffic in predominately residential areas at low to moderate speeds; Class II Collector Roads usually consist of two undivided travel lanes in rights-of-way of not more than 22 m

APPENDIX F
Screening Limited Potential Site Uses – Commercial, Institutional, Assembly

Table 1.0: Screening the Limited Potential Site Uses – Commercial, Institutional, Assembly

Potential Use	Standard Siting Protocols	Quite Likely	Not Likely
Commercial/ Business*	• The site includes the minimum land area required for the construction of a commercial unit .(default value 50 sq. m).* **15,000 m^2**	☒	☐
	• Direct access to Class I or Class II Arterial roads.*[1] **Access to Class II arterial road AR#1**	☒	☐
	• Full municipal physical services can be provided. **Site connected to municipal water supply** **Storm water is discharged into municipal swear system**	☒	☐
	• Public transportation service can be provided. **Figure 6-3 shows nearby transit routes**	☒	☐
	All protocols are met →This is a potential commercial site		
Institutional	• The site includes the minimum land area required for the construction of a institutional unit. (default value 23 sq. m) **15,000 m^2**		☐
	• Direct access to a Class II Arterial Road or Class I or Class II Collector Road.*[1] **Access to Class II arterial road AR#1**	☒	☐
	• Public transportation service can be provided. **Figure 6-3 shows nearby transit routes**	☒	☐
	• The size of the property provides opportunities for expansion. **No, Figure 6-2 shows that the property is surrounded by several residential and commercial units. Difficult to expand.**	☐	☒
	• Full municipal physical services can be provided. **Site connected to municipal water supply** **Storm water is discharged into municipal swear system**	☒	☐
	• Traffic can be directed away from residential areas. **No. It has access to only one arterial road which goes through residential areas**	☐	☒
	All protocols are NOT met →This is NOT a potential institutional site		
Assembly	• Direct access to Arterial or Collector Roads.*[1] **Access to Class II arterial road AR#1**	☒	☐
	• The site includes the minimum land area required for the construction of an assembly occupancy.(default value 37 sq. m)* **15,000 m^2**	☒	☐
	• Full municipal physical services and emergency services, can be provided as appropriate. **Site is connected to municipal water supply** **Storm water is discharged into municipal swear system**	☒ ☒ ☒	☐ ☐ ☐
	• Public transportation service can be provided. **Figure 6-3 shows nearby transit routes**	☒	☐
	• The use will be compatible with the surrounding area in terms of scale, massing, height, siting, orientation, setbacks and landscaped areas. **No/ Unknown. It is unsure whether the assembly use will be compatible or not. However, this is unlikely that an assembly end use will be compatible as the site has access to only one arterial road and the additional traffic for assembly use may not be compatible with the location.**	☐	☒
	• Adequate off-street parking can be provided. **No. This is a dense, residential and commercial neighborhood. It is unlikely that an assembly site of 15,000 m^2 will have parking arrangements unless other only a part of the site is utilized.**	☐	☒
All protocols are NOT met →This is a NOT potential assembly site			

*The default values of minimum area requirements are calculated using methods provided in Appendix E

*[1] Definitions of different types of roads are provided in Appendix F

APPENDIX G

List of Common Asbestos Containing Materials
(Compiled from **Kenneth and Earnest, 2006)**
and NHDE, 2007)

- Pipe and duct insulation
- Building insulation
- Roofing materials
- Patching and spackling compound
- Pot holder and ironing board pads
- Floor tiles
- Textured paints
- Wall and ceiling panels
- Carpet underlays and mastic
- Artificial fireplaces and materials
- Brake pads and linings
- Hair dryers
- Electric wires
- Furnaces boilers and associated gaskets
- Cements/ window culking Cement Pipes
- Cement Wallboard
- Cement Siding
- Asphalt Floor Tile
- Vinyl Floor Tile
- Vinyl Sheet Flooring
- Flooring Backing
- Construction Mastics (floor tile, carpet, ceiling tile, etc.)
- Acoustical Plaster
- Decorative Plaster
- Textured Paints/Coatings
- Ceiling Tiles and Lay-in Panels
- Spray-Applied Insulation
- Blown-in Insulation
- Fireproofing Materials
- Taping Compounds (thermal)
- Packing Materials (for wall/floor penetrations)
- High Temperature Gaskets
- Laboratory Hoods/Table Tops
- Laboratory Gloves
- Fire Blankets
- Fire Curtains
- Elevator Equipment Panels
- Elevator Brake Shoes
- HVAC Duct Insulation
- Boiler Insulation
- Breaching Insulation
- Ductwork Flexible Fabric Connections
- Cooling Towers
- Pipe Insulation (corrugated air-cell, block, etc.)

- Heating and Electrical Ducts
- Electrical Panel Partitions
- Electrical Cloth
- Electric Wiring Insulation
- Chalkboards
- Roofing Shingles
- Roofing Felt
- Roll Roofing
- Roof Patching Cement
- Base Flashing
- Thermal Paper Products
- Fire Doors
- Caulking/Putties
- Adhesives
- Wallboard
- Joint Compounds
- Vinyl Wall Coverings
- Spackling Compounds

Note: This list does not include every product/material that may contain asbestos. It is intended as a general guide to show which types of materials may contain asbestos.

APPENDIX H

List of Chemicals that Aid in Deciding if the Site is a Low Ecological Impact (LEI) Site

List of Chemicals that Aid in Deciding if the Site is a Low Ecological Impact (LEI) Site

- Chlorinated dioxins or furans.
- PCB mixtures.
- DDT, DDE, DDD.
- Aldrin.
- Chlordane.
- Dieldrin.
- Endosulfan.
- Endrin.
- Heptachlor or Heptachlor epoxide.
- Benzene hexachloride.
- Toxaphene.
- Hexachlorobenzene.
- Pentachlorophenol.
- Pentachlorobenzene.

APPENDIX I
Limiting Concentrations of Hazardous Substances for Ecological Evaluation (WSDE, 2007)

Table 1: Limiting Concentrations of Hazardous Substances

Hazardous Substance	Plants	Soil biota	Wildlife
METALS			
Aluminum (soluble salts)	50		
Antimony	5		
Arsenic III			7
Arsenic V	10	60	132
Barium	500		102
Beryllium	10		
Boron	0.5		
Bromine	10		
Cadmium	4	20	14
Chromium (total)	42	42	67
Cobalt	20		
Copper	100	50	217
Fluorine	200		
Iodine	4		
Lead	50	500	118
Lithium	35		
Manganese	1,100		1,500
Mercury, Inorganic	0.3	0.1	5.5
Mercury, Organic			0.4
Molybdenum	2		7
Nickel	30	200	980
Selenium	1	70	0.3
Silver	2		
Technetium	0.2		
Thallium	1		
Tin	50		
Uranium	5		
Vanadium	2		
Zinc	86	200	360
OTHER CHLORINATED ORGANICS			
1,2,3,4-Tetrachlorobenzene		10	
1, 2,3-Trichlorobenzene		20	
1,2,4-Trichlorobenzene		20	
1,2-Dichloropropane		700	
1,4-Dichlorobenzene		20	
2,3,4,5-Tetrachlorophenol		20	
2,3,5,6-Tetrachloroaniline	20	20	
2,4,5-Trichloroaniline	20	20	
2,4,5-Trichlorophenol	4	9	
2,4,6-Trichlorophenol		10	
2,4-Dichloroaniline		100	

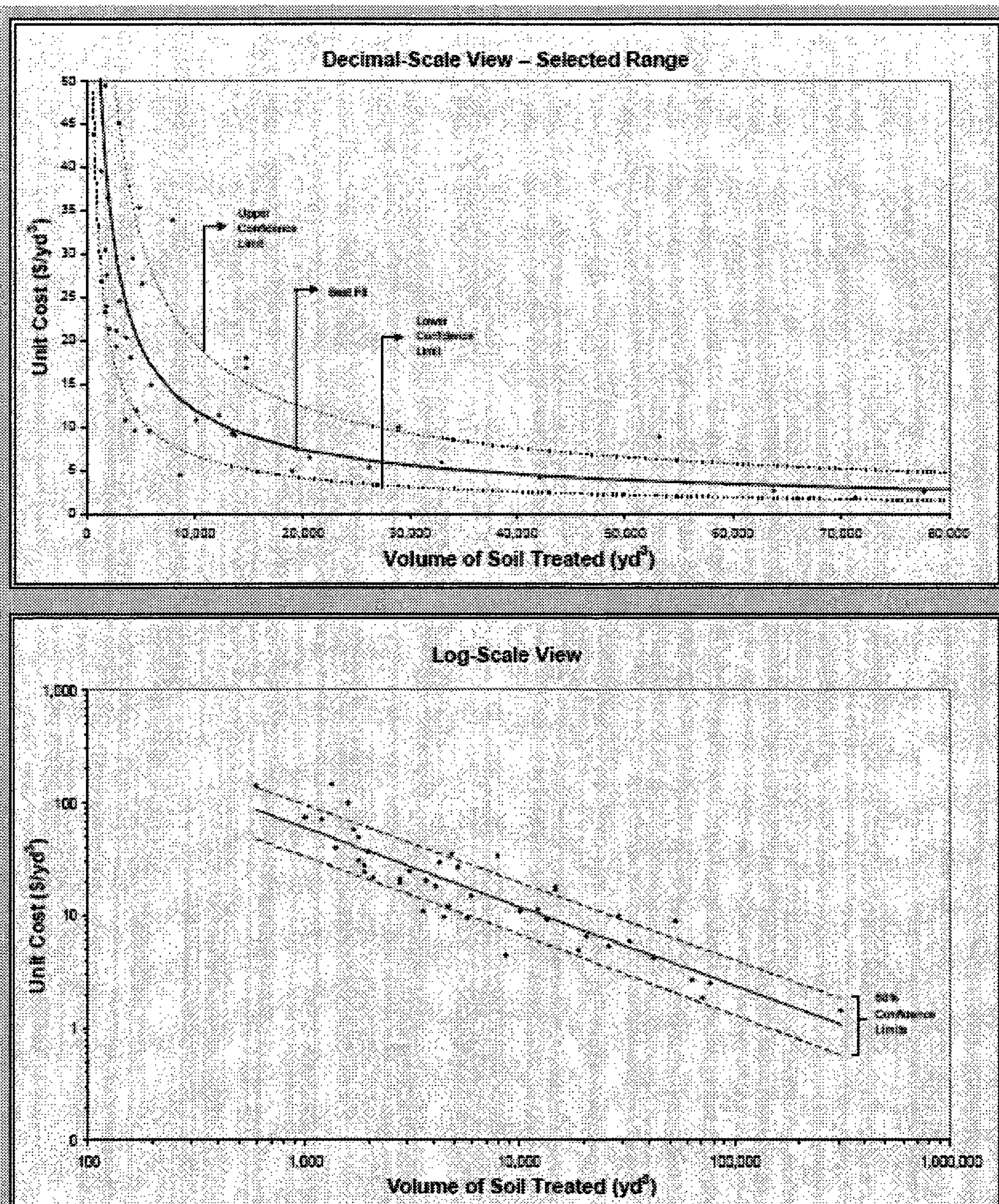
Hazardous Substance	Plants	Soil biota	Wildlife
3,4-Dichloroaniline		20	
3,4-Dichlorophenol	20	20	
3-Chloroaniline	20	30	
3-Chlorophenol	7	10	
Chlorinated dibenzofurans (total)			2E-06
Chloroacetamide		2	
Chlorobenzene		40	
Dioxins			2E-06
Hexachlorocyclopentadiene	10		
PCB mixtures (total)	40		0.65
Pentachloroaniline		100	
Pentachlorobenzene		20	
OTHER NONCHLORINATED ORGANICS			
2,4-Dinitrophenol	20		
4-Nitrophenol		7	
Acenaphthene	20		
Benzo(a)pyrene			12
Biphenyl	60		
Diethylphthalate	100		
Dimethylphthalate		200	
Di-n-butyl phthalate	200		
Fluorene		30	
Furan	600		
Nitrobenzene		40	
N-nitrosodiphenylamine		20	
Phenol	70	30	
Styrene	300		
Toluene	200		
Gasoline Range Organics		100	5,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics		200	6,000 except that the concentration shall not exceed residual saturation at the soil surface.

APPENDIX J

Sample Remediation Cost for Various Techniques from Remediation Technology Cost Compendium (EPA, 2000)

EPA information that is public domain may be used without specific permission (Michael Scott, Director, EPA Communications Product Review, 07 Jan 2008)

Figure 1: AFCEE Bioventing Projects – Unit Cost vs. Volume Treated (with 68-Percent Confidence Interval)



Notes:

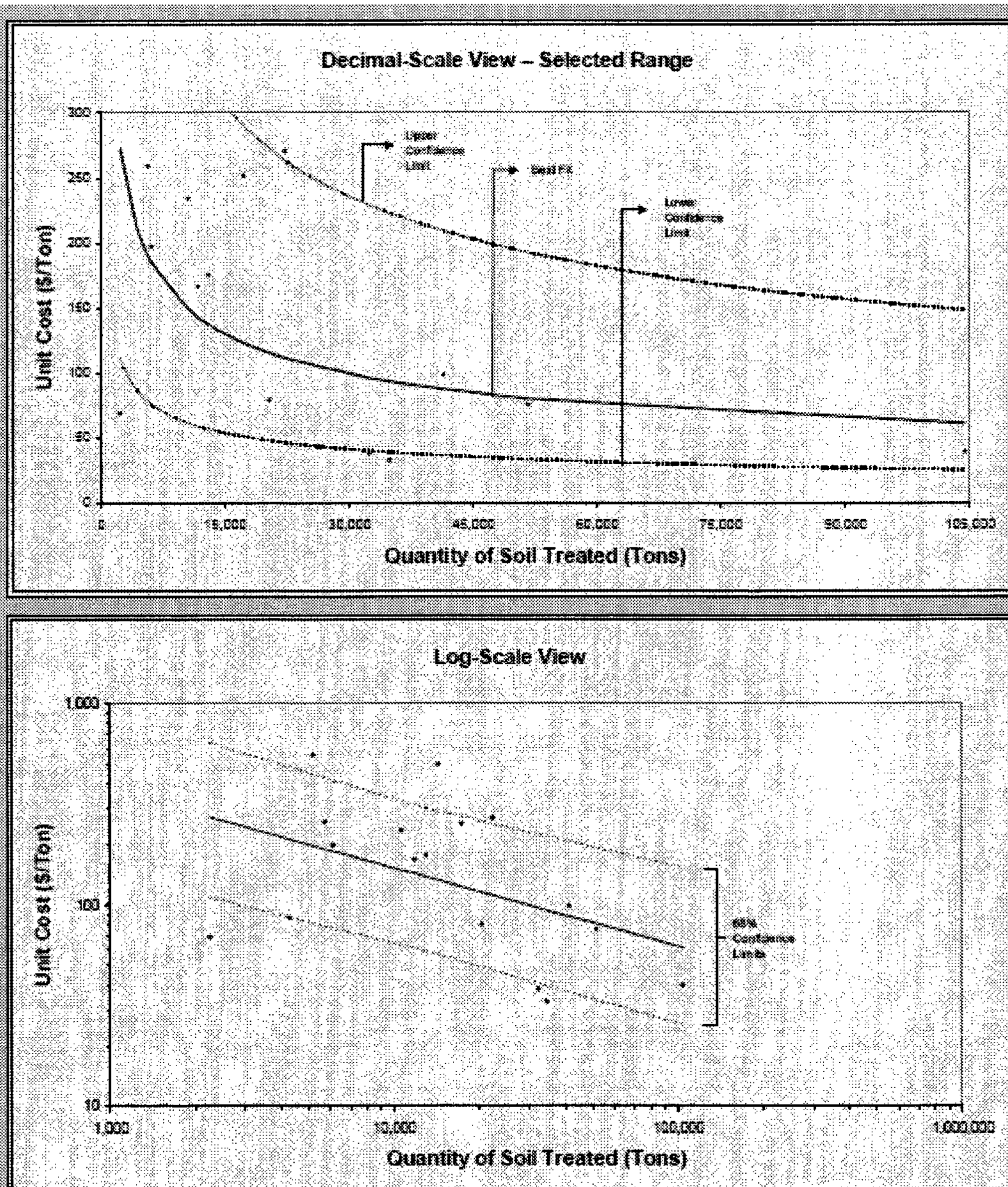
1 The line of best fit (solid line) and 68-percent confidence limits (dashed lines) for individual predicted points for 45 bioventing projects are shown in the plots above. The line of best fit and confidence limits were calculated using linear regression of the natural-log transformed data. The upper plot was prepared by back transformation of the log-transformed data to show the line of best fit and confidence limits in original units. (The upper plot shows projects under which less than 80,000 cubic yards of soil were treated and the unit cost was less than $50 per cubic yard.)

2 All reported costs were adjusted for site locations, as described in the text.

3 The coefficient of determination (r^2) for the linear fit to the data is 80 percent.

4 Appendix B presents the methodology and other statistical information related to the plots above.

Figure 2: Thermal Desorption Projects – Unit Cost vs. Quantity of Soil Treated (with 68-Percent Confidence Interval)



Notes:

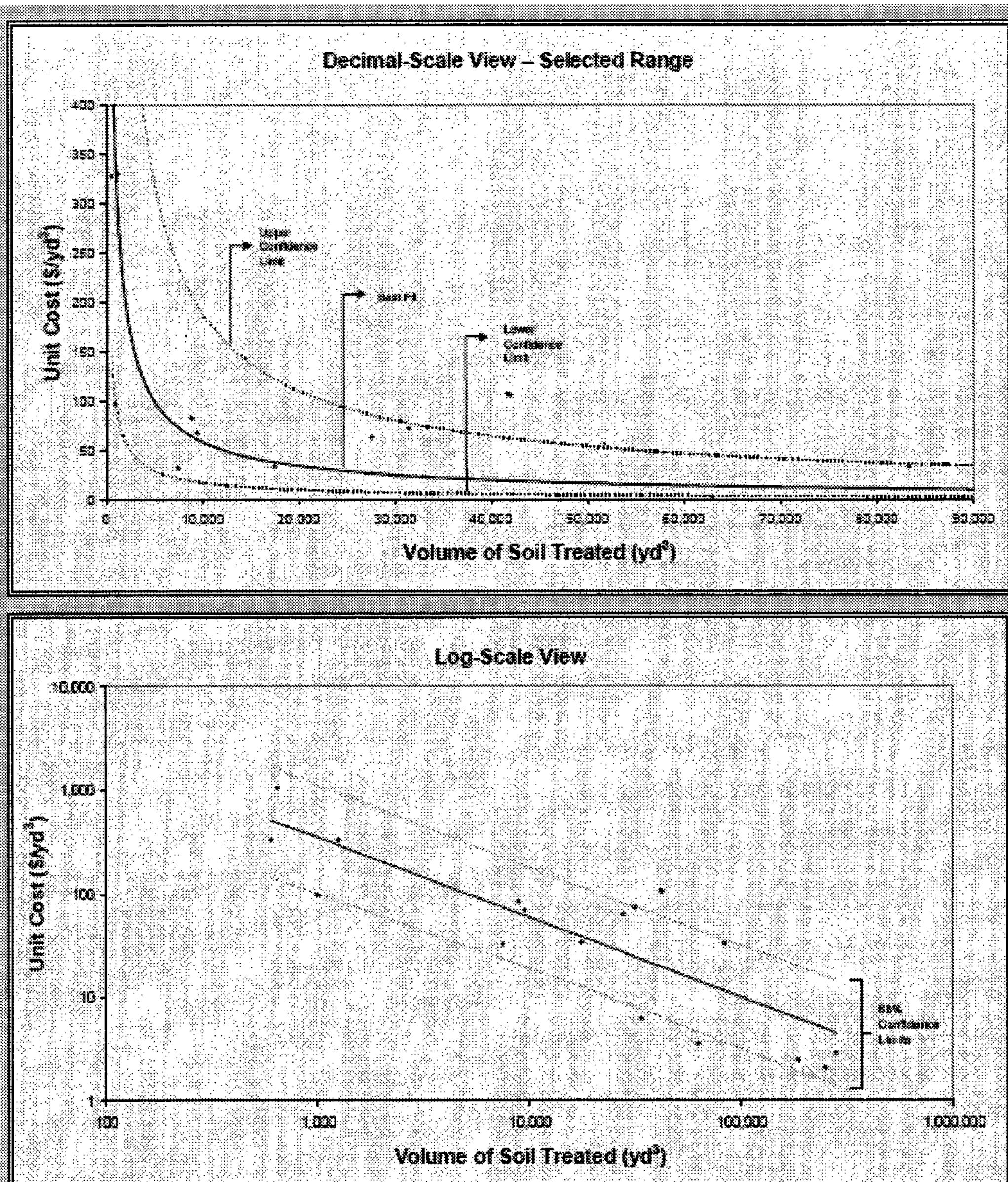
[1] The line of best fit (solid line) and 68-percent confidence limits (dashed lines) for individual predicted points for 17 thermal desorption projects are shown in the plots above. The line of best fit and confidence limits were calculated using linear regression of the natural-log transformed data. The upper plot was prepared by back transformation of the log-transformed data to show the line of best fit and confidence limits in original units. (The upper plot shows projects under which less than 105,000 tons of soil were treated and the unit cost was less than $300 per ton.)

[2] All reported costs were adjusted for location and time, as described in the text.

[3] The coefficient of determination (r^2) for the linear fit to the data is 21 percent.

[4] Appendix B presents the methodology and other statistical information related to above plots.

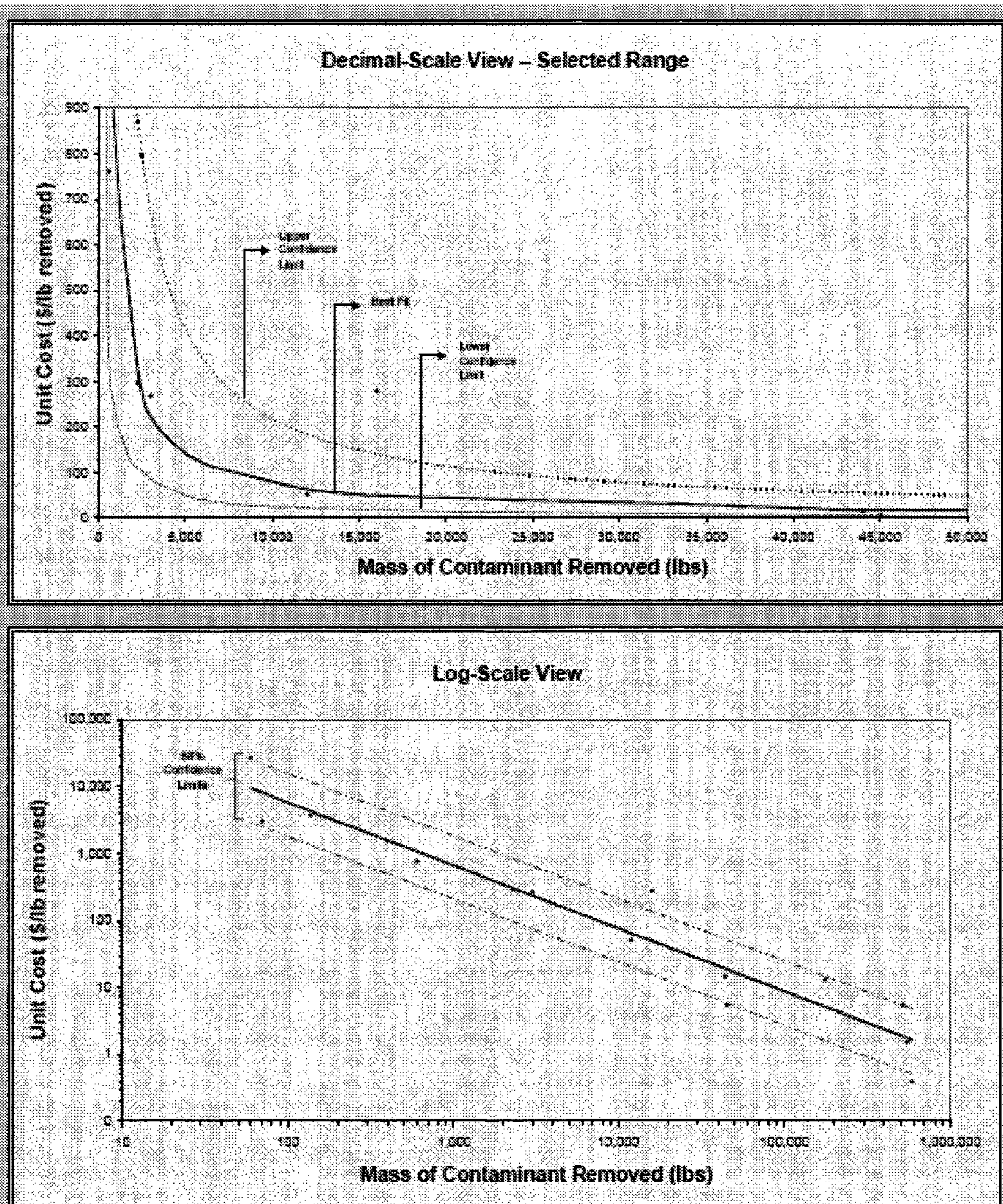
Figure 3: Soil Vapor Extraction Projects – Unit Cost vs. Volume of Soil Treated (with 68 Percent-Confidence Interval)



Notes:

1. The line of best fit (solid line) and 68-percent confidence limits (dashed lines) for individual predicted points for 18 soil vapor extraction projects are shown in the plots above. The line of best fit and confidence limits were calculated using linear regression of the natural-log transformed data. The upper plot was prepared by back transformation of the log-transformed data to show the line of best fit and confidence limits in original units. (The upper plot shows projects under which less than 90,000 cubic yards of soil were treated or unit costs were less than $400 per cubic yard of soil treated).
2. All reported costs were adjusted for location and years during which costs were incurred, as described in the text.
3. The coefficient of determination (r^2) for the linear fit to the data is 69 percent.
4. Appendix B presents the methodology and other statistical information related to the above plots.

Figure 4: Soil Vapor Extraction Projects – Unit Cost vs. Mass of Contaminant Removed (with 68 Percent-Confidence Interval)



Notes:

[1] The line of best fit (solid line) and 68-percent confidence limits (dashed lines) for individual predicted points for 14 soil vapor extraction projects are shown in the plots above. The line of best fit and confidence limits were calculated using linear regression of the natural-log transformed data. The upper plot was prepared by back transformation of the log-transformed data to show the line of best fit and confidence limits in original units. (The upper plot shows projects under which less than 50,000 pounds of contaminant was removed or unit costs were less than $900 per pound of contaminant removed).

[2] All reported costs were adjusted for location and years during which costs were incurred, as described in the text.

[3] The coefficient of determination (r^2) for the linear fit to the data is 92 percent.

[4] Appendix B presents the methodology and other statistical information related to the above plots.

Figure 5: Bioventing Projects – Unit Cost vs. Volume Treated (with 95- and 68-Percent Confidence Intervals)

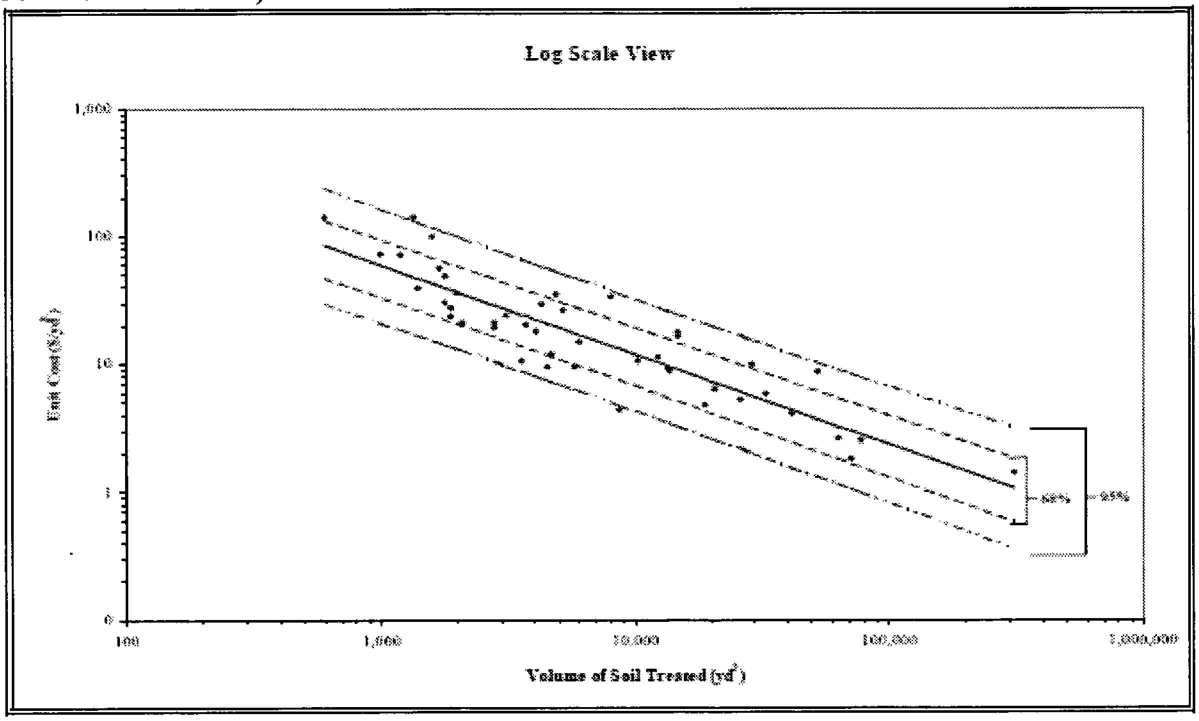
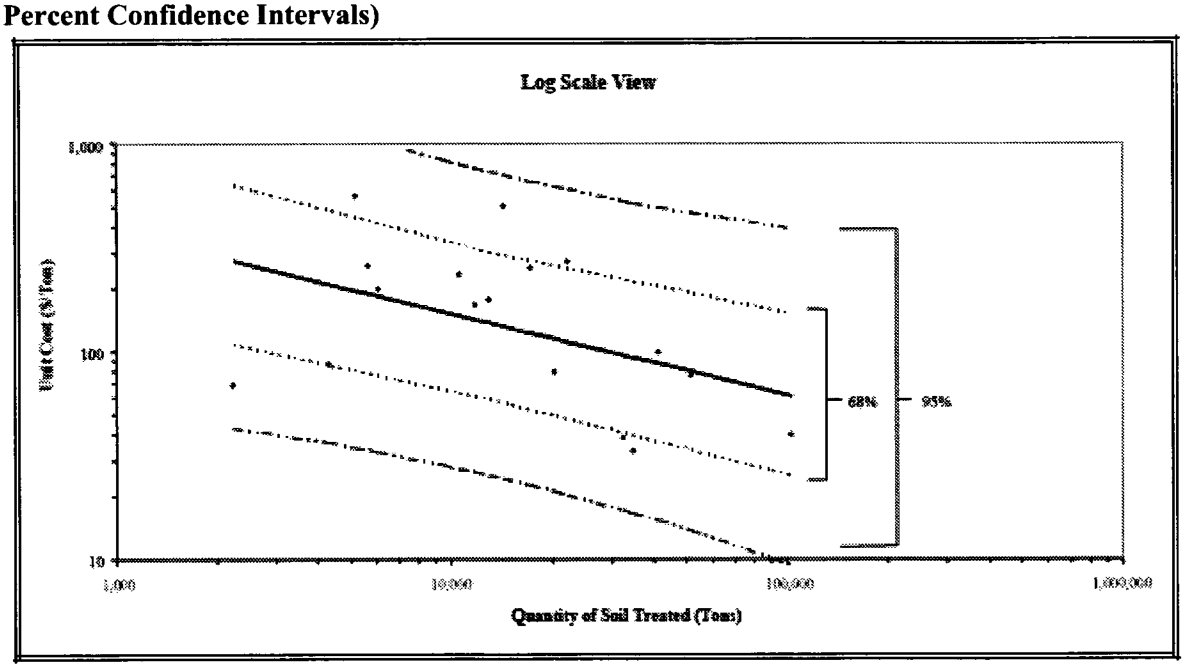


Figure 6: Thermal Desorption Projects – Unit Cost vs. Volume Treated (with 95- and 68-Percent Confidence Intervals)



APPENDIX K
Flow Diagrams for Contamination Health and Safety Risk Pathway (Schruder, 2007)

Written consent for including this material was received from Nik Schruder, MASc student, University of Toronto, on 08Jan2008 and can be provided upon request

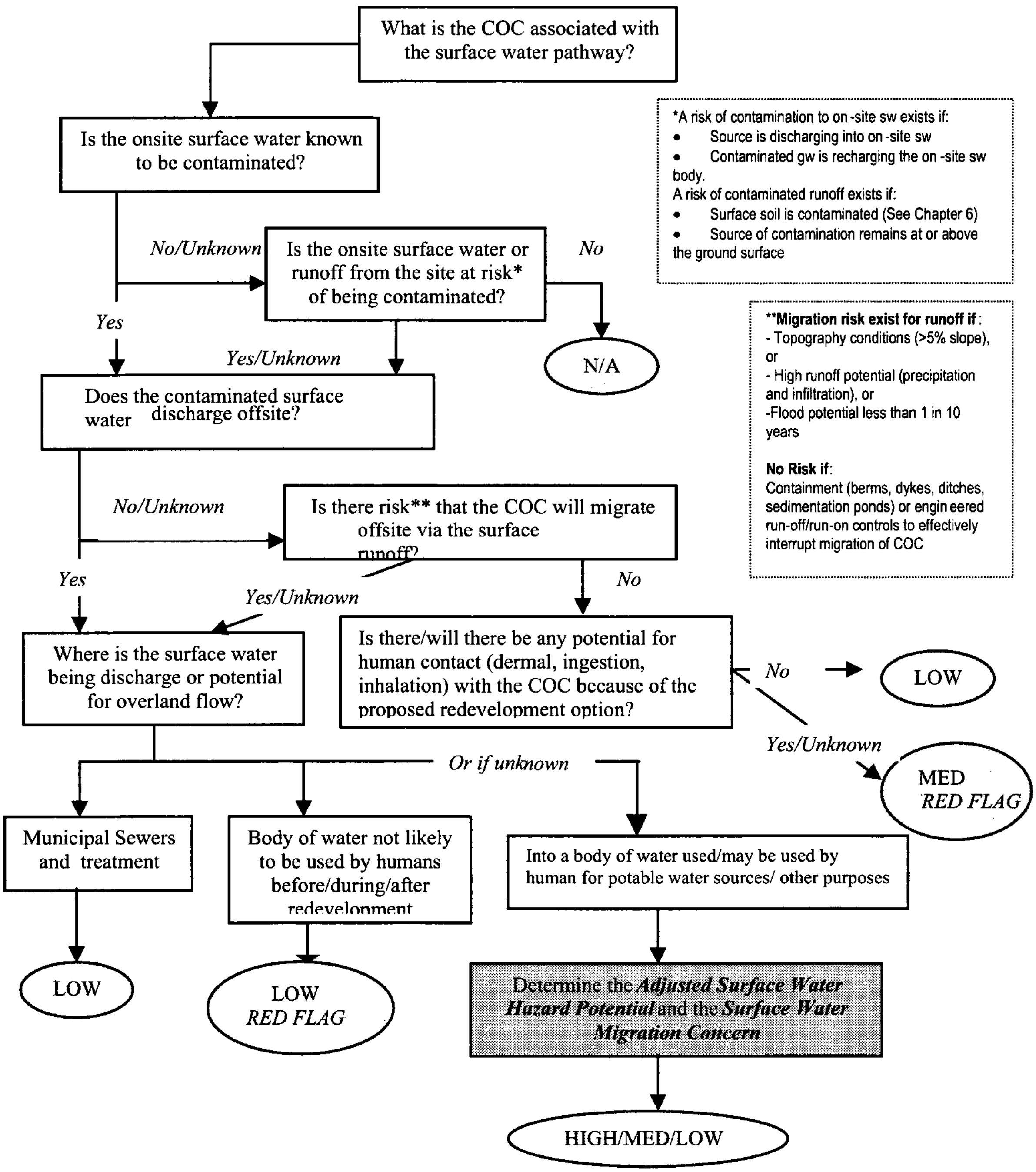


Figure -1: Summary of the Surface-water Pathway.

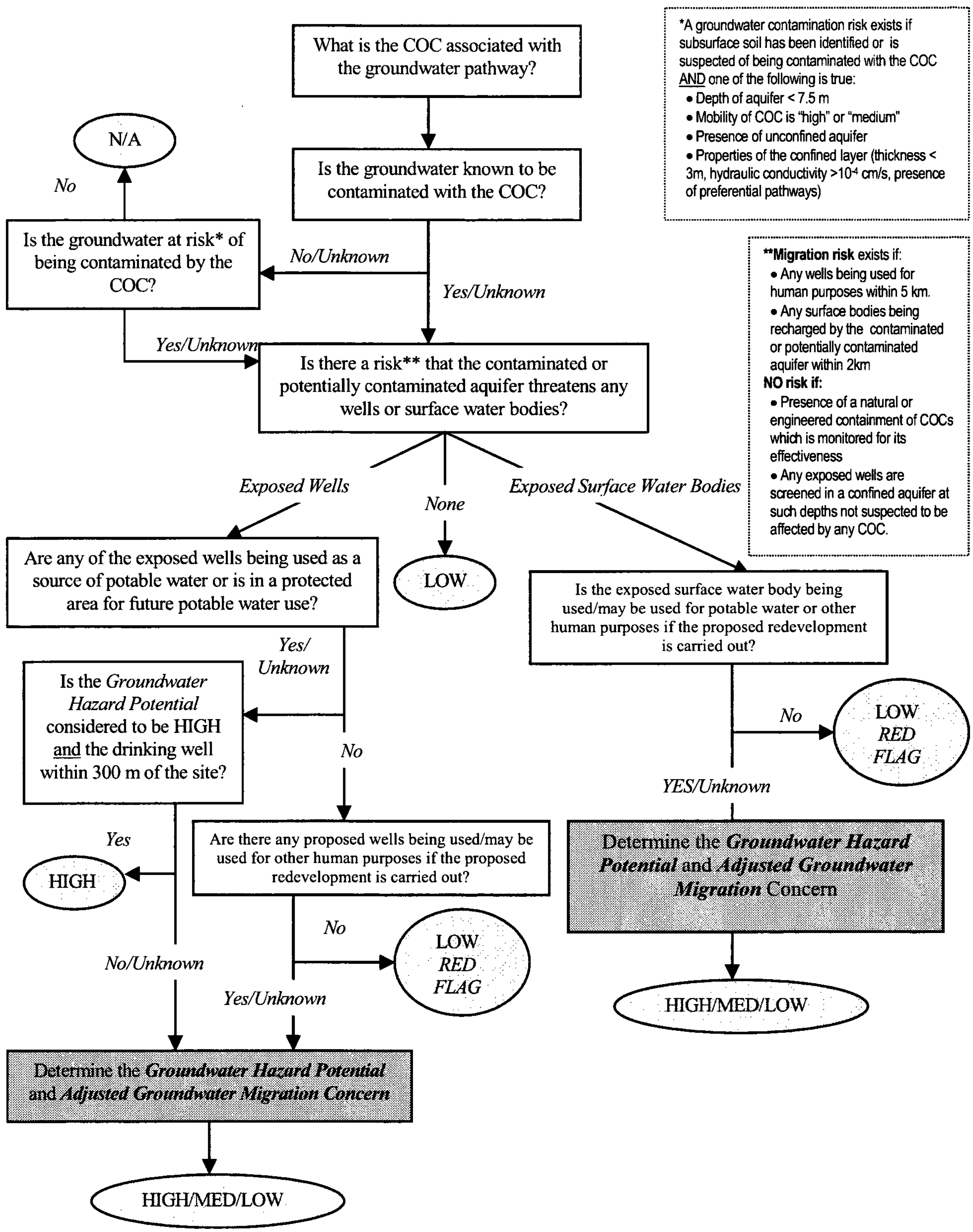


Figure -2: Summary of the Ground-water Pathway.

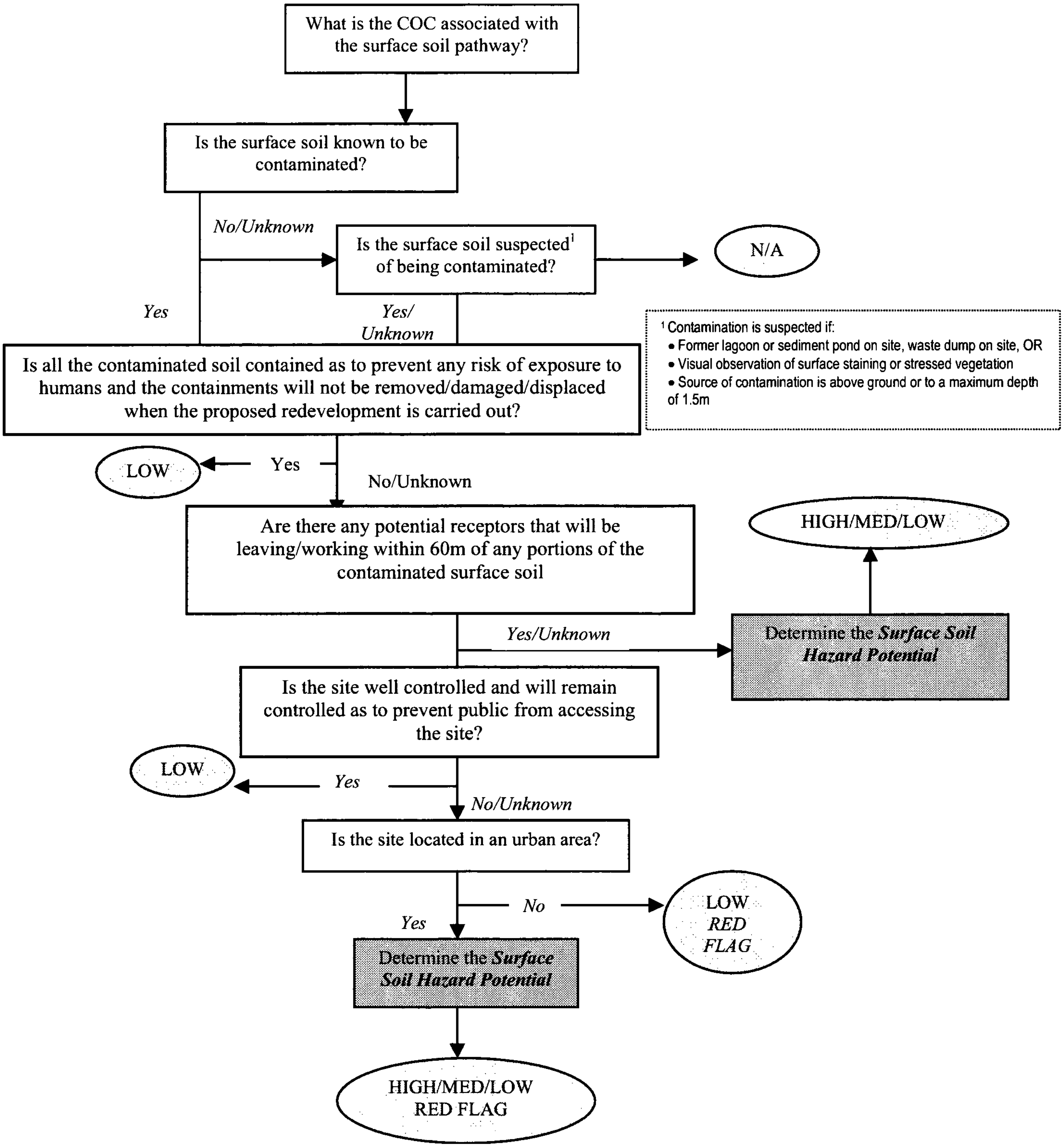


Figure -3: Summary of the Surface soil Pathway.

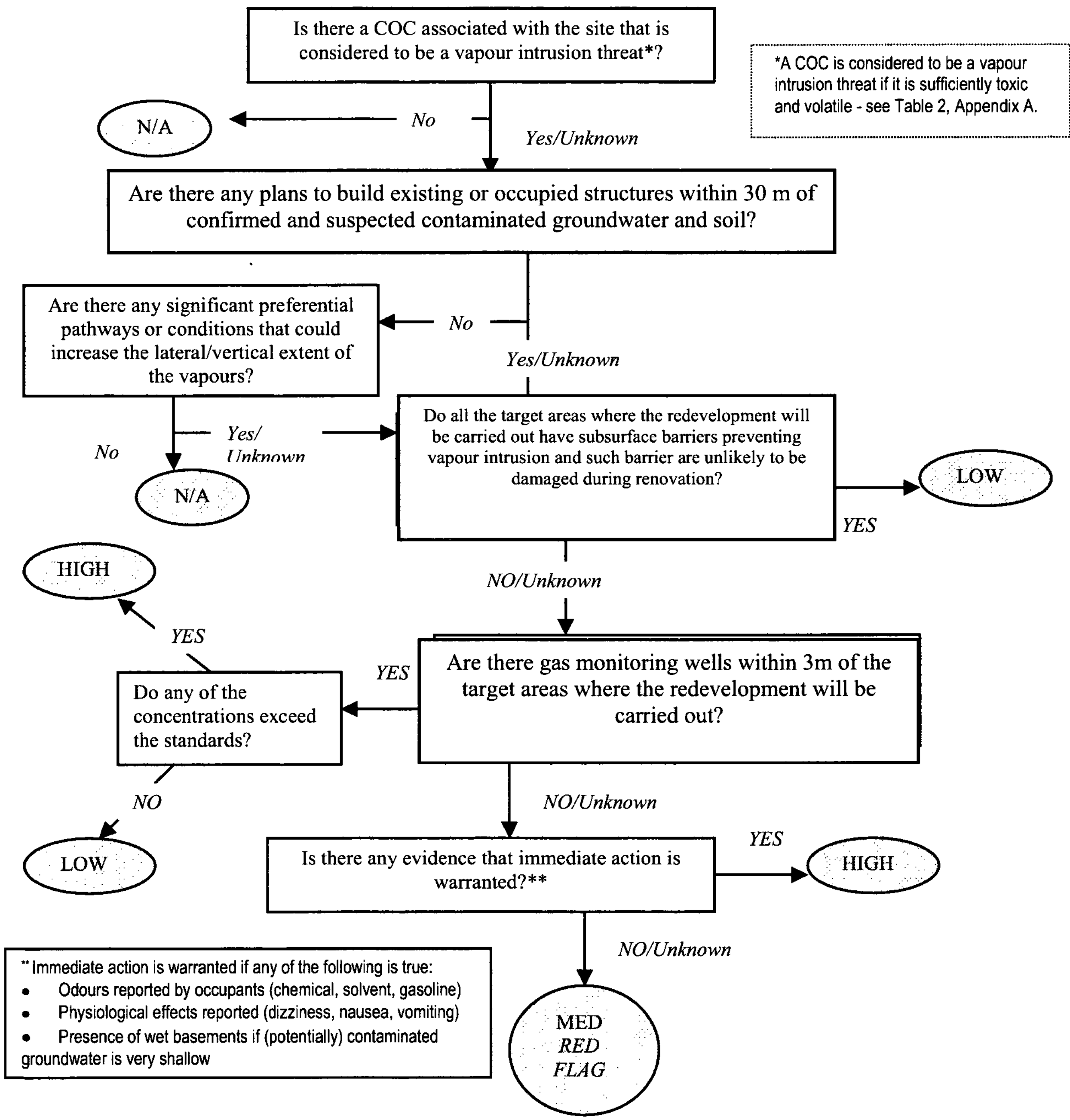


Figure -4: Summary of the Vapour -intrusion Pathway.

VITA AUCTORIS

Name: Shovini Dasgupta
Place of Birth: Calcutta, West Bengal, India
Date of Birth: October 19, 1979

Education:

- Degree of Doctor of Philosophy
  Environmental Engineering
  University of Windsor
  Windsor, Ontario, Canada

- Degree of Master of Applied Science (2004)
  Environmental Engineering
  University of Windsor
  Windsor, Ontario, Canada

- Degree of Bachelor of Engineering (2001)
  Civil Engineering
  Bengal Engineering and Science University, Shibpore
  Calcutta, West Bengal, India

Work/Experience:

- Research and Graduate Assistant
  Department of Civil and Environmental Engineering
  University of Windsor
  Windsor, Ontario, Canada
  2002-2008

Awards:

- Ontario Graduate Scholarship (OGS) - 2005, 2006
- International Graduate Students Tuition Scholarship by University of Windsor, 2005 (Could not accept because of OGS)
- AWMA (Air and Waste Management Association) – Ontario Section Graduate Scholarship, 2005
- International Graduate Students Tuition Scholarship by University of Windsor, 2004
- University of Windsor Travel Grants Award, 2004
- Visa Differential Fee Waiver, 2002, 2003
- Debesh Kamal Scholarship (All India Scholarship Awarded to Five Students every year), 2002
- Merit Certificate in Science Talent and Aptitude Search Test (by All India Science Teachers' Association); 1993, 1994