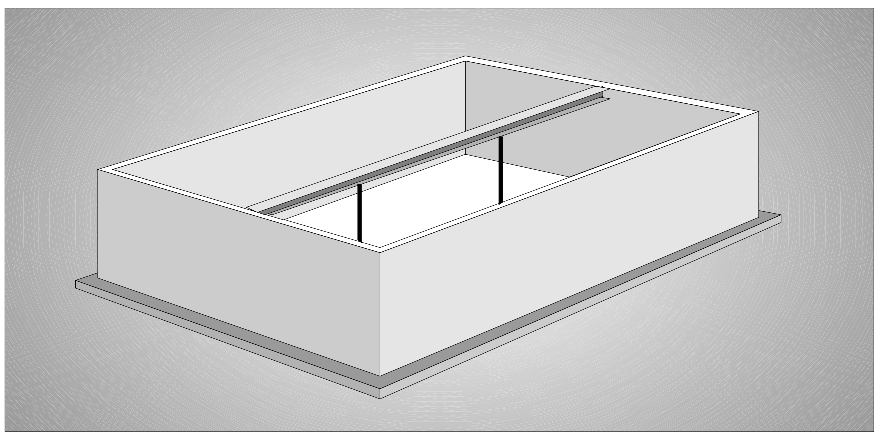
FINAL REPORT

ECONOMIC ASSESSMENT OF BASEMENT SYSTEMS



prepared for
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by
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Acknowledgements

This study would not have been possible without the guidance provided by Mr. Mike Swinton of the Institute for Research in Construction, and the members of the Basement Guidelines Project Steering Committee. Much thanks is also due to the Ontario builders who participated in a confidential survey and who shall regrettably remain anonymous at their own request. Appreciation is also expressed to Natural Resources Canada, Statistics Canada and the various energy sector organizations for the provision of regional energy prices.

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PART 1

ECONOMIC ASSESSMENT METHODOLOGY

Part 1 of this report outlines the tasks undertaken in this study, and describes the methodology employed for each of the associated stages. It also provides a background to the rationale guiding this study, which is later intended to form part of Phase III of the *Performance Guidelines for Basement Envelope Systems and Materials* project.

BACKGROUND

From the early stages of the *Performance Guidelines for Basement Envelope Systems and Materials* project, a key element in the development of the *Guidelines* document has been the assessment of costs and benefits associated with various basement system options identified to be viable for the Canadian house construction market.

In recognition of the importance of an economic assessment of viable basement technology alternatives, a preliminary study was commissioned by IRC/NRCC, entitled *Economic Assessment Issues Relating to Residential Basement System Performance*. This formed part of the final Phase I report *Development of Performance Guidelines for Basement Envelope Systems and Materials*, October 14, 1997. Since that time, the *Guidelines* project has awaited completion of applied research, monitoring and computer simulations from Phase II, parts of which were intended to feed into this study. Having completed Phase II, and recently secured funding for Phase III, IRC/NRCC launched this study in February of 1999.

The primary objectives of this study, as identified by the Steering Committee, are as follows:

1. To comparatively assess conventional basement system alternatives and the marginal cost of improved construction, in the form of packaged systems, from three economic perspectives: the builder; the consumer; and society;
2. To assess the cost effectiveness of various technological developments in materials, components and sub-systems aimed at improving the performance of the basement system;
3. To assess the cost effectiveness of various better construction practices aimed at improving the quality and performance of the basement system;
4. To estimate the current value (incremental sale price, market appeal, etc.) that builders obtain from selecting basement systems with demonstrable future savings in operations, maintenance and repair costs.
5. To address non-monetary differences, such as comfort, year-round buildability and adaptability.

The following section outlines the major tasks related to the realization of these objectives.

OUTLINE OF STUDY

The major tasks involved in the completion of this study are outlined below in Figure 1. There are essentially 7 steps associated with the study, not including review and comment at key stages, and roundtable meetings.

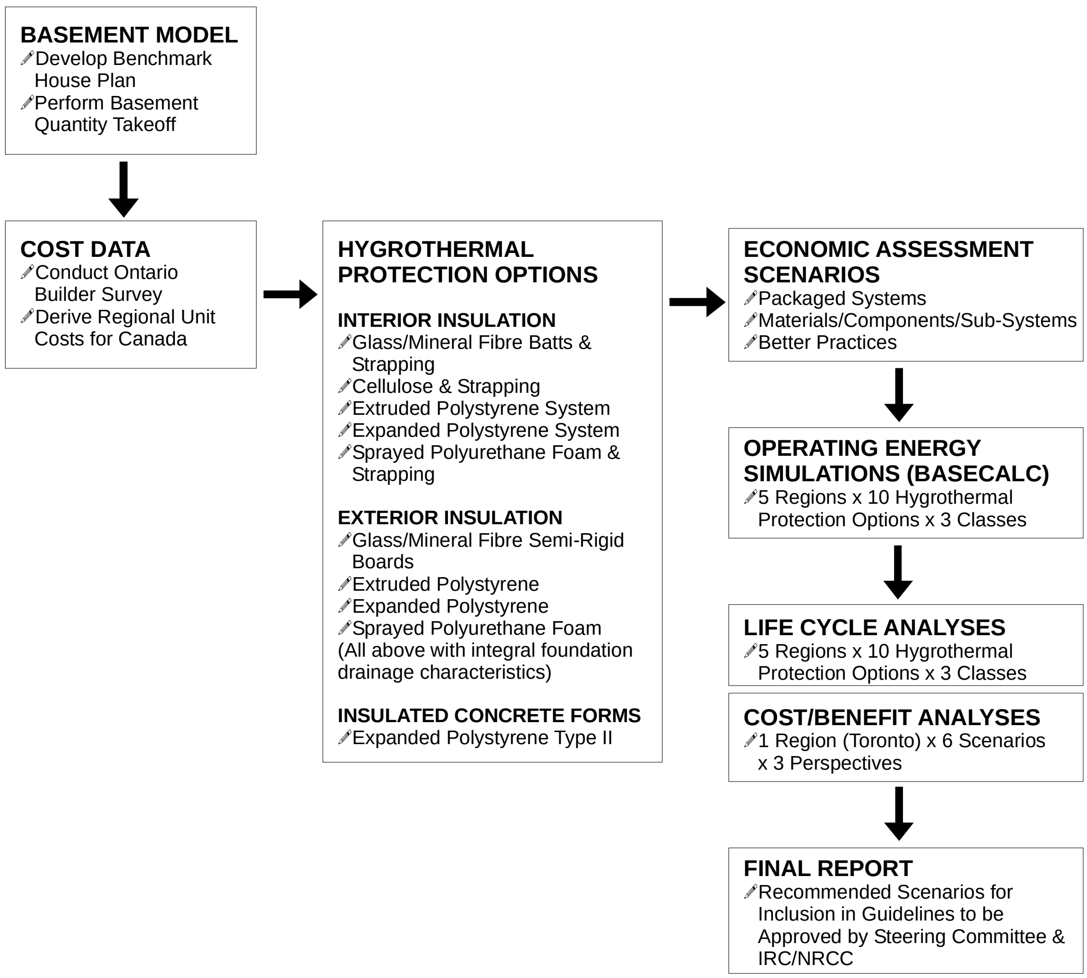

Figure 1. Outline of major tasks associated with the *Economic Assessment of Basement Systems Study*.

Each of these tasks is described in greater detail in the sections which follow. The Appendices to this report document data collected and analyzed. A series of electronic data files have also been provided for future updating, and the investigation of alternative scenarios.

SCOPE, ASSUMPTIONS AND LIMITATIONS

This study is limited to a tightly defined scope and guided by several key assumptions and limitations. The scope of this study is limited to a single, simple model of a residential basement system, which is assessed according to a limited number of scenarios that are later described. The rationale supporting this scope for the study is as follows:

- A comprehensive and exhaustive economic assessment of basement system alternatives is neither affordable nor useful to stakeholders.
- The most common types of basement system alternatives are of greatest interest to the vast majority of stakeholders.
- A case study approach to the alternatives, using real builders and localities, provides a more realistic and credible perspective than a "quantity survey" approach.

It is being assumed that the results of this study are comparatively extensible to most typical basement systems, recognizing they may not necessarily apply to unusual cases. More importantly, this study is intended to reasonably support helpful examples in the *Guidelines* publication, and does not claim absolute accuracy. Users of the publication are cautioned to exercise judgement and local cost data when applying the assessment methodologies presented in the *Guidelines* publication.

This study is also limited in the assessment of factors affecting basement performance. Table 1 indicates the types of factors which are readily quantifiable, as well as those which are either somewhat quantifiable or not practically quantifiable. Ill-defined factors are not addressed in this study.

MONETARY	INTANGIBLE*	ILL-DEFINED**
Construction	Comfort	Molds (Health Impact)
Operating	Compatibility	Adaptability
Maintenance	Buildability	Sustainability
Repair	Marketability	
Warranty Fees		
Insurance Premiums		
Externalities		
Opportunity Costs		
* Factors which may be monetized and/or qualitatively expressed.		
** Factors which are difficult to monetize and/or qualitatively express.		

Table 1. Limitations of quantitative economic assessments of basement system alternatives

Due to the regional variations in basement construction practices across Canada, it has not been possible to address every type of basement system in this study. However, the methodologies which have been developed may be applied by interested parties to yield specialized/localized answers to questions which commonly interest builders, consumers and society.

DESCRIPTION OF STUDY MODELS

A number of models have been developed and/or adopted for use in this study. Some are used to describe the basement system, and others to simulate operating energy performance and perform economic assessments of alternative basement technologies. The approach taken to modelling in this study is consistent with approaches taken to similar studies conducted in the past.[1]

Benchmark House and Basement System Model

The benchmark house plan which was selected for use in this study is depicted in Figure 2. This modest design was selected for its simplicity of basement configuration, recognizing that analyses will not involve the ground and second floor elements of the dwelling.

Figure 2. Plans and elevations of benchmark house.

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[1] Lio, M. and T. Kesik, *Implications of Adopting the National Energy Code for Housing in Ontario*, for Ontario Hydro, Ontario Ministry of Housing, Ontario Ministry of Environment and Energy, the Ontario Natural Gas Association, and CMHC, 1995.

The basement model used for estimating costs and operating energy performance is depicted in Figure 3. Two critical features of the basement configuration are:

1. The average height of the basement walls above grade is set at 1 foot (300 mm) in keeping with conventional practices for typical new homes. This enables a more realistic modelling of the above-grade heat loss.
2. No windows are included in the basement, recognizing that these are usually provided. The difficulty associated with the inclusion of windows is that the cost of the windows must be factored into the total basement system cost, and their orientation impacts solar gains. Window qualities and costs vary significantly, and the cost implications of window wells must also be considered. The windowless model enables more efficient economic and thermal analyses.

PARAMETER	QUANTITY	UNITS
Length	28	ft
Width	24	ft
Height	8	ft
Perimeter	104	ft
Area	672	ft2
Volume	5376	ft3
Fdn. Wall Area	832	ft2
Above-Grade	104	ft2
Below-Grade	728	ft2

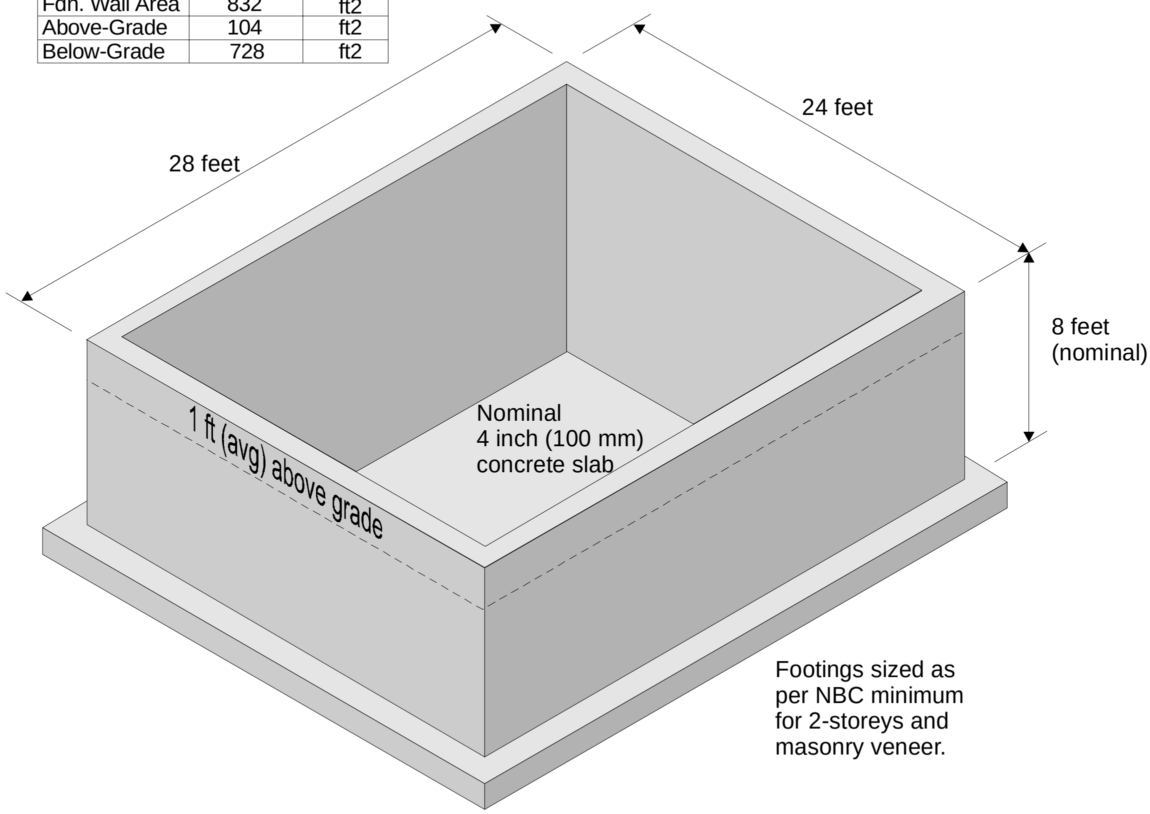

Figure 3. Physical characteristics of benchmark basement model.

During the first two phases of the *Guidelines* project, a basement system classification was developed for use in Phase III. For packaged system scenarios (see Table 4) the requirements associated with each classification are attached to the basic benchmark model of the basement depicted in Figure 3.

CLASS	INTENDED USE	SERVICE CRITERIA	LIMITATIONS/ALLOWANCES
A-1	Separate dwelling unit.	• Satisfies consumer expectations for control of heat, moisture, air and radiation. • Access/egress, fire & sound separation, and fenestration meet all Code requirements. • Separate environmental control system. • Thermal comfort comparable to above-grade storeys of the dwelling.	• Not suitable for flood prone areas, or areas prone to sewer backup. • Basement can be finished with materials that are moisture or water sensitive. • Virtually defect free construction. • Redundancy of critical control measures provided.
A-2	Liveable space (e.g., family room, home office, etc.)	• Satisfies consumer expectations for control of heat, moisture, air and radiation. • Thermal comfort comparable to above-grade storeys of the dwelling.	• Not suitable for flood prone areas, or areas prone to sewer backup. • Basement can be finished with materials that are moisture or water sensitive. • Virtually defect free construction. • Redundancy of critical control measures provided.
A-3	Near-liveable (e.g. unfinished surfaces)	• Satisfies all functions of the basement envelope, except for comfort, and is unfinished (e.g. no flooring nor carpet, paint,etc.)	• Virtually defect free construction. • Redundancy of critical control measures provided.
B	Convertible or adaptable basement.	• Satisfies minimum requirements for control of heat, moisture, air and radiation (e.g. no explicit wall drainage layer) • Thermal comfort can be upgraded to same quality as above-grade storeys of the dwelling. (e.g. Partially insulated wall)	• Not suitable for flood prone areas, or areas prone to sewer backup. • All structural and interior finishing materials (if any) must recover to original specifications after wetting and drying. • Practically free of defects in free-draining soils where adequate site drainage has been provided. • Normal frequency of defects can be expected otherwise.
C	Basement/cellar - convertible or adaptable at significant future premium.	• Unfinished basement with no intentional control of heat, moisture, air and radiation.	• Practically free of defects in free-draining soils where adequate site drainage has been provided. • Normal frequency of defects can be expected otherwise.
D	Basement serving a dwelling in a flood-prone area, or area prone to sewer backup.	• Class A-1, A-2 or A-3, B or C service criteria may apply.	• Interior finishes capable of withstanding periodic wetting, drying, cleaning and disinfecting.
E	Basement acting as a structural foundation only.	• Acceptable factor of safety for structural performance including frost heaving, adhesion freezing and expansive soils.	• Not intended to be inside the building envelope and no finishing intended. • Floor separating basement and indoors is now the building envelope and must address all functions. • Equipment in basement must be rated to operate outdoors or located in a suitably conditioned enclosure.
Note: Minimum requirements for health and safety are assumed for all of the basement classes listed above. In the case of the Class E basement, only the structural safety requirements are addressed.			

Table 2. Classification of basements by intended use.

Moisture, Thermal and Air Leakage Protection Options

The combination of materials and assemblies needed to satisfy the requirements for moisture, thermal and air leakage protection in basements is often guided by the placement of insulation with respect to the foundation walls. Figure 4 delineates conventional basement system alternatives according to insulation placement and type of material.

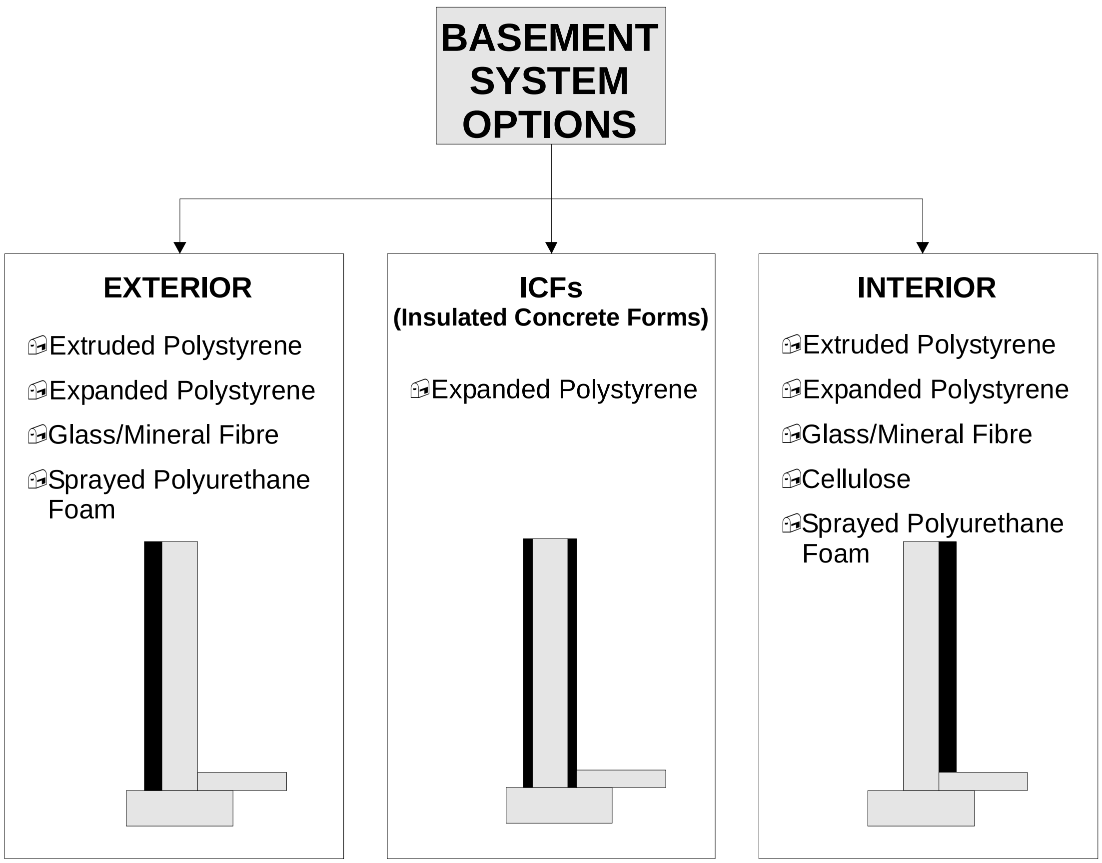

Figure 4. Basement system alternatives considered in the study bases on thermal insulation placement.

These options were applied to actual basement assemblies to arrive at a number of basement system types depicted in Figures 5 to 8, inclusive. It is important to recognize that in each of these instances, only the full-height basement insulation scheme is illustrated. Partial-height insulation schemes, where practical, simply reduce the height of the insulation below grade with no changes to materials or construction. Insulated basement floors are also not shown in these figures, as these are beyond the scope of this study. (Refer to an analysis of insulation options for heated slabs in the *National Energy Code for Houses, 1995*.)

Figure 5 depicts the most common approach to the insulation of new residential basements. The provision of a drainage layer is shown in the instance of full-height basement insulation. It should be recognized that while a foundation drainage layer is not explicitly required in the National Building Code, in some jurisdictions, such as Ontario, it is required for basements insulated to a depth of 3 feet (900 mm) or more below grade. A variety of approved insulation materials are available to fill the cavity between and/or behind the wall strapping.

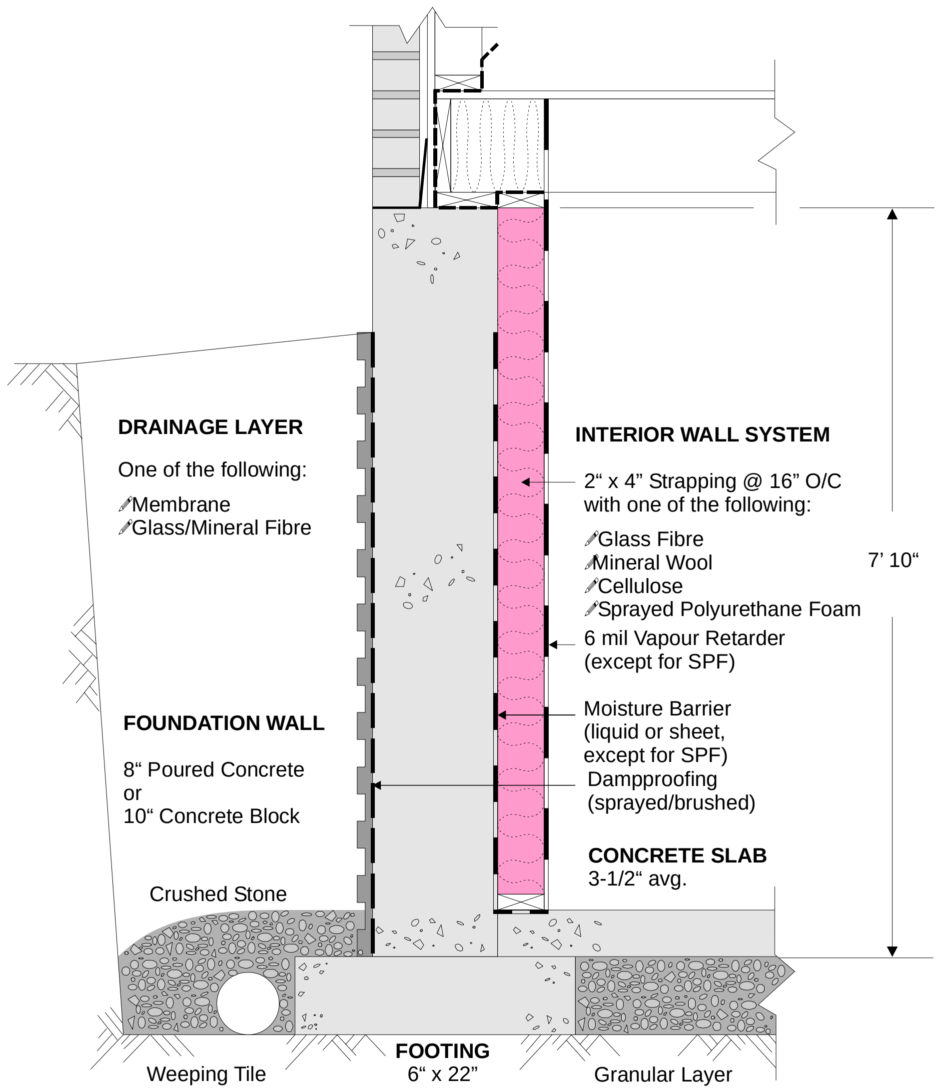

Figure 5. Basement system based on strapping and interior placement of thermal insulation.

Note: For higher levels of thermal insulation, the strapping is assumed to be offset from the interior surface of the foundation wall.

Another approach to the interior placement of thermal insulation is the use of plastic foam insulation panels fastened to the concrete wall, which are then protected against flamespread by gypsum drywall or a similar rated material. Figure 6 depicts the conventional arrangement of the materials within the assembly for this type of basement system, and also indicates a drainage layer, consistent with the system in Figure 5.

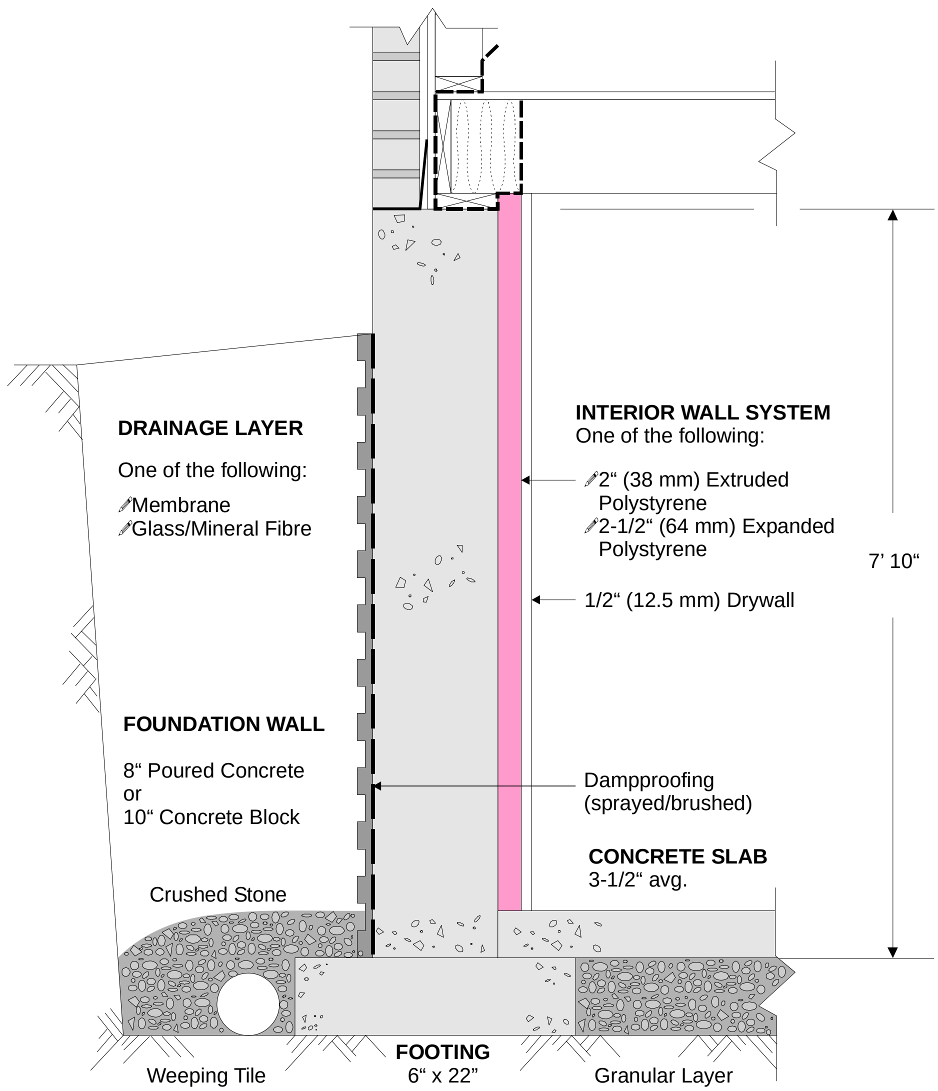

Figure 6. Basement system based on interior placement of plastic thermal insulation.

Figure 7 depicts an exterior insulation placement for the basement system. Exterior insulation schemes tend to involve the use of proprietary insulation systems, and remain confined to expanded and extruded polystyrene boards, rigid glass fibre or mineral wool panels, or sprayed polyurethane foam. Attachment of the board and panel type insulation to the foundation wall involves either the use of mechanical fasteners or a mastic-type adhesive. In the case of extruded polystyrene and sprayed polyurethane foam products, dampproofing of the foundation wall is not required. All systems require a suitable form of exterior protection of the exposed insulation, and when masonry veneers are used for upper floors, special details are required to preserve a marketable appearance of the dwelling.

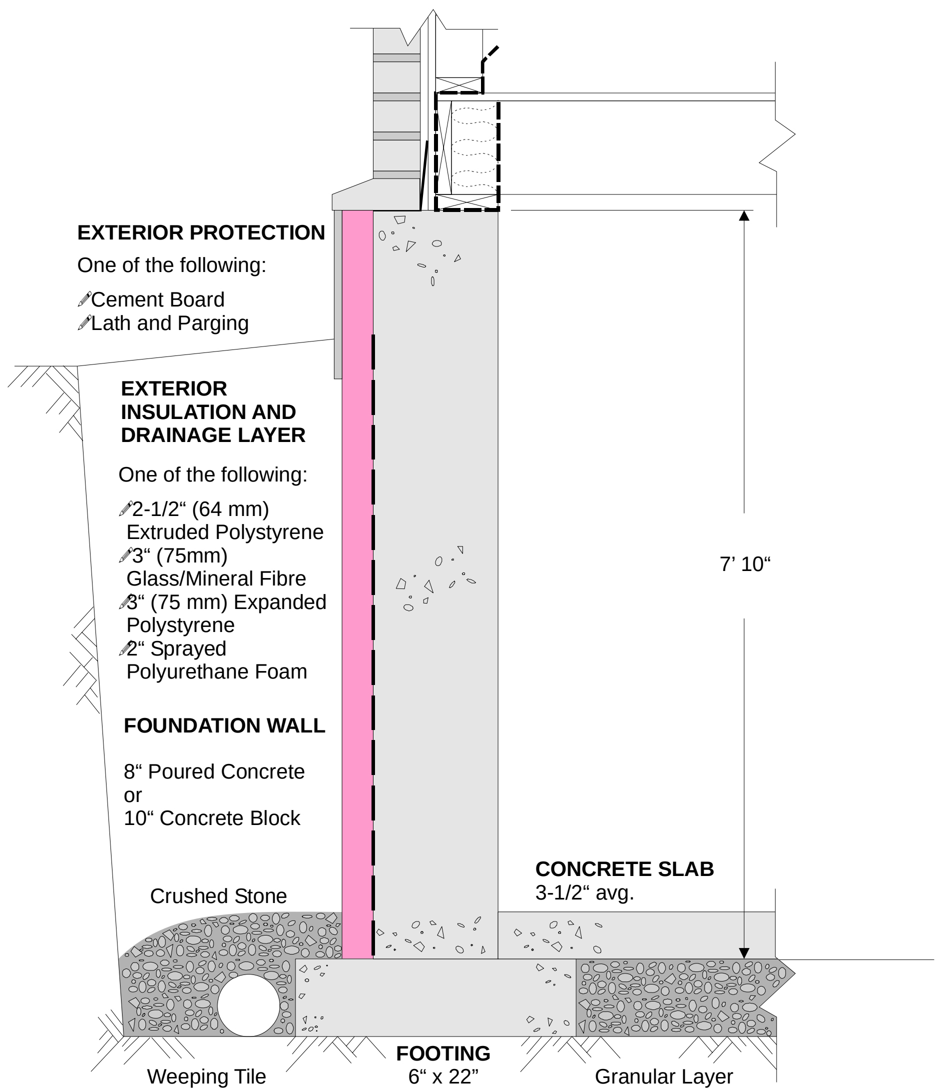

Figure 7. Basement system based on exterior placement of thermal insulation.

A relatively novel approach to the construction of basement systems is the use of insulated concrete forming systems (ICFs). These pre-engineered, proprietary systems utilize expanded polystyrene forms to cast-in-place reinforced concrete which satisfies the structural requirements - the forms remain to provide thermal protection. ICFs require exterior protection of the exposed insulation above-grade. Most ICFs incorporate special forms which permit the casting of supports for masonry veneers, however, the thermal bridging associated with these approaches tends to be similar to that depicted in Figure 8 below. A foundation drainage layer is normally provided for these systems. On the interior of ICF system, the insulation (form) must be protected against flamespread by gypsum drywall or a similar rated material.

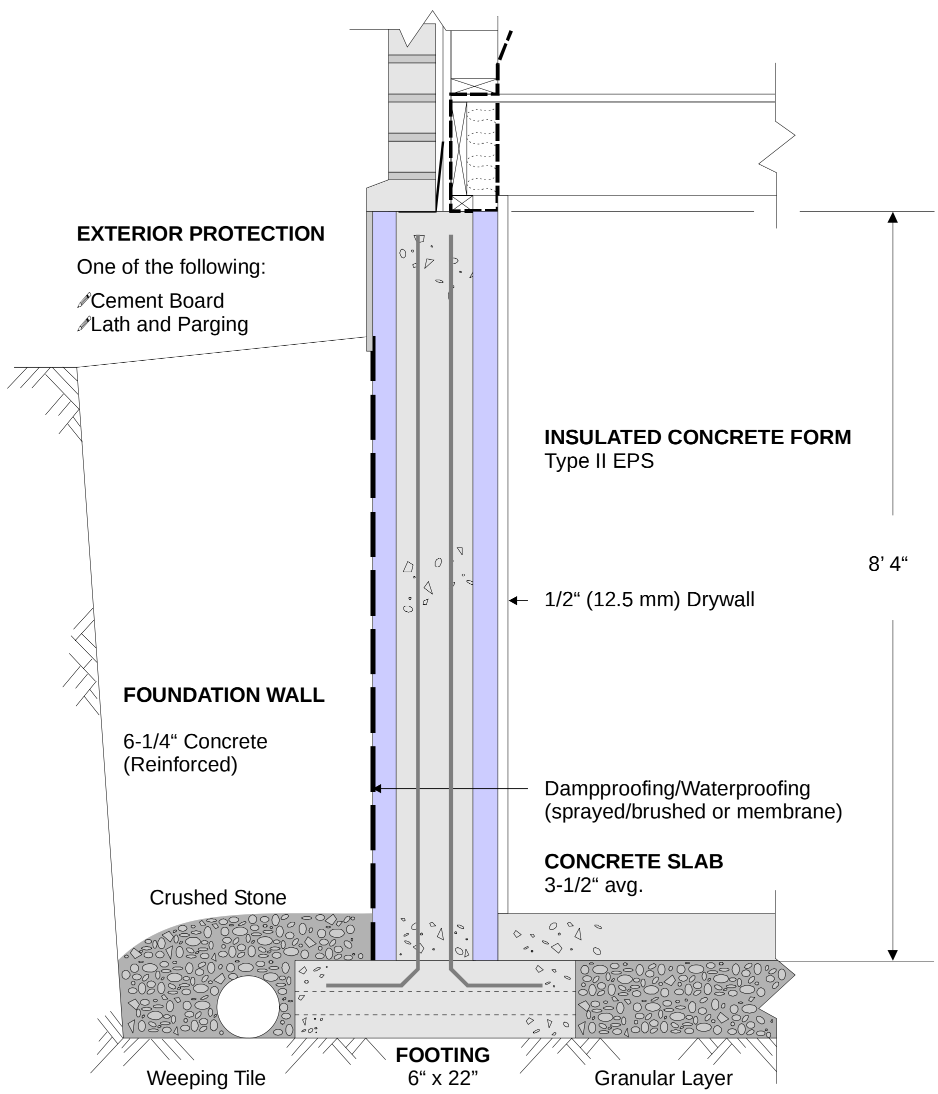

Figure 8. Basement system based on utilization of insulated concrete forms.

ICFs are normally used to construct the below and above-grade walls of residential buildings, and the isolation of the below-grade portion for this study cannot fully assess all of the benefits of a whole house system.

BASECALC

Version 1.0d of BASECALC™ software was used to perform all operating energy simulations. Documentation on the technical features of BASECALC is available from Natural Resources Canada (CANMET) and published literature.[2]

Using the National Research Council of Canada's Mitalas method as a starting point, CANMET has developed a new numerical technique to model basement and slab-on-grade heat losses. BASECALC was created to allow researchers, building-simulation software developers and users, code writers and enforcers, insulation and building-component manufacturers, builders, and others to apply this new heat-loss technique easily and efficiently.

Version 1.0d of the BASECALC performs a series of detailed finite-element calculations to estimate heat losses through residential foundations. The software can be used to assess the energy impact of new insulation placements and products, to develop building- and energy-code requirements, to perform research, and for developing improved foundation heat-loss models for whole-building simulation programs. BASECALC has been applied in a number of code-related projects, including: an analysis of inside/outside "combination" insulation for the National Energy Code for Houses; a comparison of insulation options for the Ontario Building Code; and an analysis of insulation options for heated slabs for the National Energy Code for Houses.

ECONOMIC ASSESSMENT MODELS

The economic assessment models used in this study were derived from the *ASTM Standards on Building Economics*, and selected to reflect the economic perspectives of builders, consumers (owners and tenants) and society.

The various perspectives that are brought to bear on investments in building technology require careful consideration if the results obtained from analyses are to prove useful to stakeholders. For buildings in general, including residential basements, there exist three major perspectives to be considered: builders; consumers (owners and tenants); and society.

Builders and/or developers, are primarily concerned with first costs and how these costs affect their business operations. The carrying costs and opportunity costs associated with higher first costs must result in substantial benefits, both short term (marketability) and long term (reduced callbacks and complaints), if builders are to elect better practices.

Consumers of housing are generally more interested in affordability. Affordability relates the cost of securing adequate housing at a cost which does not place an unreasonable financial burden on a household. It involves the downpayment and monthly expenditures on principal, interest, taxes and energy (PITE). Insurance premiums may also prove significant depending on the risk of damages associated with a potential dwelling (e.g., flooding, etc.). Generally, consumers are averse to improvements in housing which negatively impact affordability, unless these arise in response to matters of health and safety.

[2] I. Beausoleil-Morrison, *BASECALC™:A Software Tool for Modelling Residential-Foundation Heat Losses*, Proc. Third Canadian Conference on Computing in Civil and Building Engineering, Concordia University, Montréal Canada (1996) 117-126.

I. Beausoleil-Morrison, G.P. Mitalas, and H. Chin, *Estimating Three-Dimensional Below-Grade Heat Losses from Houses Using Two-Dimensional Calculations*, Proc. Thermal Performance of the Exterior Envelopes of Buildings VI, ASHRAE, Clearwater Beach USA, (1995) 95-99.

. Beausoleil-Morrison, G.P. Mitalas, and C. McLarnon, *BASECALC: New Software for Modelling Basement and Slab-on-Grade Heat Losses*, Proc. Building Simulation ‘95, International Building Performance Simulation Association, Madison, USA, (1995) 698-700.

The societal perspective on investments in building technology is generally long term, taken over the useful life of the dwelling. The primary concern is the viability of the housing over its life cycle and how to maximize this benefit across all of society. The construction of new housing commits society to supply many forms of energy and services, on demand, for the useful life of the building (50 years, plus). Where housing development exceeds the capacity of existing infrastructure, an escalation in the cost of energy and municipal servicing normally results. The societal commitment to servicing new housing and dealing with all forms of effluents (storm water, sewage, products of combustion, etc.) must be partly attributed to basements. Economic repercussions, environmental impacts and quality of life are some of the issues which take on a societal importance with respect to building technology, including basements.

Table 3 summarizes the criteria associated with the selection of appropriate study periods and economic measures used in the assessment of basement systems, based on the economic perspective of key stakeholders.

Perspective	Investment or Improvement	Study Period	Economic Measure
Builder	Technology exceeding minimum health and safety requirements	Commencement of construction to time of sale (< 1 year, typically)	Internal Rate of Return (IRR)
Consumer	Discretionary, depreciable and non-depreciable improvements	Expected period for benefits to exceed costs (5 to 10 years)	Simple Payback (SPB) or IRR
	Non-discretionary, depreciable investments	Useful service life of investment	Life Cycle Cost (LCC) using Uniform Present Worth (UPW)
	Non-discretionary, non-depreciable investments	Duration of tenure or mortgage (25 to 40 years)	Life Cycle Cost (LCC) using Uniform Present Worth (UPW)
Societal	All investments	Service life of system, including components, equipment, fixtures and finishes (50 to 100 years)	Life Cycle Cost (LCC) using Modified Uniform Present Worth (MUPW)
The term *discretionary improvements* refer to any measures which exceed minimum requirements for health and safety, whereas *non-discretionary investments* refer to any available measures needed to comply with minimum requirements for health and safety. From a consumer perspective, a *depreciable* item is one with a service life which is less than the duration of tenure or mortgage, whereas a *non-depreciable* item does not significantly depreciate during this period.			

Table 3. Study periods and measures for economic assessment of basement technology.

The mathematical formulae for the calculations of costs and benefits associated with each of the economic measures listed in Table 3 are summarized on the following page. These conform to normative practices within the building industry.[3]

[3] ASTM E 1185-93, *Standard Guide for Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems*, ASTM Standards on Economics, Third Edition, 1994.

Internal Rate of Return (IRR)

$$PVNB = \sum_{t=0}^{N} \frac{(B_t - \bar{C}_t)}{(1 + i^*)^t} = 0$$

where:

PVNB = present value of net benefits (or, if applied to a cost reducing investment, present value of net savings).

N = number of discounting periods in the study period.

B_t = dollar value of benefits in period *t* for the alternative evaluated less the counterpart benefits in period *t* for the mutually exclusive alternative against which it is compared.

$\bar{C}_t$ = dollar costs, excluding investment costs, in period *t* for the alternative evaluated less the counterpart costs in period *t* for the mutually exclusive alternative against which it is compared.

i^* = interest rate for which PVNB = 0, that is, the IRR measure expressed as a decimal.

Simple Payback

$$SPB = C_o / (B - \tilde{C})$$

where:

SPB = period of time, expressed in years, over which investments are recovered to the breakeven point.

C_o = dollar value of initial investment costs, as of the base time.

B = dollar value of annual benefits (or savings).

$\tilde{C}$ = dollar value of annual costs.

Life Cycle Cost

Modified Uniform Present Worth

$$P = A_o \cdot \left(\frac{1 + e}{i - e}\right) \cdot \left[1 - \left(\frac{1 + e}{1 + i}\right)^N\right]$$

Uniform Present Worth

$$P = A \cdot \left(\frac{(1 + i)^N - 1}{i\,(1 + i)^N}\right)$$

where:

P = present sum of money.

A = end-of-period payment (or receipt) in a uniform series of payments (or receipts) over N periods at I interest or discount rate.

A_o = initial value of a periodic payment (receipt) evaluated at the beginning of the study period.

N = number of interest or discount periods.

i = interest or discount rate.

e = price escalation rate per period.

Given the above noted economic measures and techniques, a number of assessment scenarios were developed. These are further discusses in the section which follows.

ECONOMIC ASSESSMENT SCENARIOS

Several types of economic assessments have been performed for inclusion within the *Guidelines* publication. These do not include the case studies of failures or statistics gathered by Robert Marshall[4], however this data has been used in the assessment of consulting engineering cost effectiveness vis-à-vis structural failures. There are three types of economic assessments which have been performed:

1. Packaged system assessments which deal with the basement-as-a-system;
2. Material/component/subsystem assessments which deal with technological improvements to aspects of the basement; and
3. Better practice assessments, which focus on the cost effectiveness of exceeding minimum standards or applying higher levels of quality control.

Packaged System Assessments

A series of upgrades to basement systems are estimated for several types of generic basement packages corresponding to the classification system defined in Table 2.

	ECONOMIC PERSPECTIVE /MEASURE		
SCENARIO	**BUILDER**	**CONSUMER**	**SOCIETAL**
1. Class C (cellar) to Class B (conventional)	IRR	SPB	LCC
2. Class B (conventional) to Class A-3 (near-liveable)	IRR	SPB	LCC
3. Class B (conventional) to Class A-2 (liveable space)	IRR	SPB	LCC
4. Class B (conventional) to Class A-1 (dwelling unit)	IRR	SPB & AIRR	LCC
IRR - Internal Rate of Return; SPB - Simple Payback; LCC - Life Cycle Cost (MUPW)			

Table 4. Packaged system economic assessment scenarios.

Material/Component/Sub-System Assessments

In response to various technical developments presented to the *Guidelines* project Steering Committee, economic assessments of were suggested for items such as high performance concrete, Covercrete, and engineered foundation drainage systems. Due to factors such as the lack of documented data, only the last item was assessed as indicated in Table 5.

	ECONOMIC PERSPECTIVE /MEASURE		
SCENARIO	**BUILDER**	**CONSUMER**	**SOCIETAL**
5. Engineered Foundation Drainage Systems	IRR	SPB	LCC
IRR - Internal Rate of Return; SPB - Simple Payback; LCC - Life Cycle Cost (UPW)			

Table 5. Material/component/subsystem economic assessment scenarios.

[4] *Survey to Characterize the Causes of 1994 and 1995 Foundation Failures in New Residential Construction*, Report No. 39604.00, July 1997.

Better Practice Assessments

In recognition of the pivotal role of workmanship in the long-term performance of basement systems, a number of better practices were also identified during the first two phases of the *Guidelines* project. It was only possible to consider the practice of employing consulting engineering to avoid structural foundation failures, as depicted in Table 6.

	ECONOMIC PERSPECTIVE /MEASURE		
SCENARIO	BUILDER	CONSUMER	SOCIETAL
6. Consulting Engineering (structural failures)	IRR	SPB	LCC
IRR - Internal Rate of Return; SPB - Simple Payback; LCC - Life Cycle Cost (UPW)			

Table 6. Better practices economic assessment scenarios.

Required Data Collection

In order to perform the analyses associated with these scenarios, the following data were collected and interpreted:

- ❑ Capital costs of basement systems and improvements.
- ❑ Builder carrying costs/profit margins.
- ❑ Energy prices and forecasts.

Computer Simulations and Analyses

A large number of computer simulations were also performed using BASECALC™ to determine the energy performance of the various basement systems in the following 5 geographic locations:

- ❑ Vancouver, BC
- ❑ Winnipeg MN
- ❑ Toronto ON
- ❑ Ottawa ON / Hull PQ
- ❑ Halifax NS

It is important to note that collected data listed previously also correspond to these locations.

SOURCES OF INFORMATION

To perform the assessment of the various economic scenarios, a number of sources of information were referenced.

Material Cost Survey

A limited survey was performed in the Toronto area to obtain prices for the various materials comprising the basement systems considered in this study. For some materials (e.g., sprayed-in-place insulation) quotes for material and labour were obtained from qualified contractors since this reflects normal practice. For validation purposes, the material was then summarized into unit costs which could easily be applied to check against prices reported by builders.

Builder Survey

To obtain realistic costs and builder perspectives on basement construction, a survey was administered to a cross-section of 8 builders in Ontario. The demographics of the survey sample is representative of Ontario climate and geography, and also the range of economic conditions within communities. Builders who demonstrated efficient cost accounting systems were given preference to improve the accuracy of the data. Cost data from the Canadian Centre for Housing Technology have also been contributed to this study. Explanatory notes detailing the builder surveys may be found in Appendix B.

Energy Pricing

Energy pricing used in the assessment of life cycle operating costs, and energy pricing forecasts were obtained through Natural Resources Canada, Statistics Canada and fuel energy associations. Regional costs and forecasts were utilized where applicable.

Construction Cost Data

Costs derived for Ontario basement construction in Ontario were adjusted for other parts of Canada using data published in *Residential Costs* by the R.S. Means Co. This source of information has been used in a number of similar studies and has proven acceptable to stakeholders and reviewers.

A valuable source of information was the large number of helpful individuals who volunteered their knowledge and expertise toward this study. This diverse group provided a range of perspectives on the subject of the study, and the major contributors are listed in the acknowledgements. In addition to individuals, several product manufacturers and trade associations contributed information which would otherwise be practically unattainable.

More detailed technical information on the methodology and sources of information associated with each task of the study is presented, as deemed appropriate, in subsequent parts of this report.

COMMENTARY

In developing the model basement for this study, and preparing underlying assumptions for the economic assessments performed later in this study, readers should be aware of the following issues:

1. In selecting a small basement model with a minimal above-grade exposure, the benefits associated with thermal upgrades are conservatively estimated. Hence, if a thermal upgrade is cost effective in a small basement, it is generally more cost effective in a larger basement. The development of a small basement study model was deliberate in order to avoid possible criticisms associated with the use of a large, highly exposed basement, which would tend to skew results in favour of higher levels of thermal insulation and energy efficiency.

2. The base case scenario in the packaged system assessments is the Class C basement - an uninsulated basement with no explicit drainage layer. This base case violates the minimum standard, a Class B basement, which is enforced in many regions of Canada. However, because there are regions of Canada which permit the construction of Class C basements, this was deemed the effective minimum standard.

3. Many of the scenarios are based on information gathered through builder surveys. The sample size for the survey was limited by time and economic constraints, hence it cannot be considered statistically significant. In defence of this limitation, the scenarios are derived from actual builder perspectives from a group of builders with decades of experience operating reputable and financially viable enterprises. Readers should expect that many other perspectives may also be considered equally valid, but unfortunately remain beyond the scope of this study.

Further and more specific commentary regarding these issues may be found in the parts of this report which follow.

PART 2

CONSTRUCTION COST DATA

In order to later perform the economic assessments associated with this study, cost data for the various basement systems and materials outlined in Part 1 of this report were gathered. The tasks associated with this part of the report are as follows:

1. Conduct a survey of building material suppliers to derive unit costs for the various materials corresponding to the basement systems considered in this study;
2. Conduct a survey of builders selected from across Ontario to obtain the costs of basement systems currently constructed within the respective market areas;
3. To apply the averaged cost data from Tasks 1 and 2 above, in order to estimate the cost of the structural basement foundation less any moisture and thermal protection;
4. To further apply the cost data from Tasks 1 and 2 to estimate the cost of various thermal and moisture protection options currently available to Canadian home builders; and
5. To survey the builders to determine the cost of basement finishing above and beyond the cost of the structural foundation and moisture and thermal protection options considered in Tasks 3 and 4.

These costs have been assembled into a structured spreadsheet which enables the consideration of various classes and sizes of basement system (see Appendix A).

MATERIALS SURVEY

In March 1999, a survey of material costs was performed in the greater Toronto area. A list of the various materials used in residential basement construction was prepared and several large building material suppliers were contacted for prices. Where more than one manufacturer supplied a particular material product, costs for each manufacturer's product were obtained and then averaged. Builder discounts, as quoted by the suppliers, were applied to the list prices followed by a provincial tax surcharge. GST was not applied to these prices as this tax component is later rolled into the cost of the basement system paid by the consumer.

In the case of cast-in-place concrete, prices were supplied by the Ready Mix Concrete Association of Canada, and reflected Ontario averages. It is important to note that due to various local market conditions, the volume of concrete purchased (small versus large builder), and the cost of transportation, prices in a given Ontario market area may differ significantly from the provincial averages reported in this study.

The summary of the building materials survey is found in Table 7, and corresponds to Sheet 3 of the electronic spreadsheet.

Survey of Basement Material Costs

This summary of building material costs is based on a survey conducted in Toronto during March 1999. While specific products and suppliers were surveyed, these are reported below generically without reference to the manufacturers.

COST OF CONCRETE AND CONCRETE BLOCK

Concrete	**m3**	**per ft2 ***	**NOTE:**
15 MPa	$90.00	$1.70	Additional charges are
20 MPa	$97.00	$1.83	presented for information
Additional Charges			only, and were not factored
Air Entrainment	$3.00		in to costs derived later in
Calcium Chloride 2%	$3.50		this study.
Superplasticizer	$7.00		
Winter Heat	$8.00		
Concrete Block	**each**	**per ft2**	
8"	$1.52	$1.70	
10"	$1.93	$2.18	
12"	$2.25	$2.53	

* Based on 8" thick concrete wall.

COST OF THERMAL/MOISTURE PROTECTION

Insulation Option	**Price**	**Area ft2**	**Cost/ft2**	**R-Value**
1 - Exterior extruded polystyrene - 2-1/2"	$20.80	16	$1.30	12
2 - Exterior glass/mineral fibre - 1"	$9.08	24	$0.38	3.3
3 - Exterior expanded polystyrene - 3"	$11.36	16	$0.71	11.25
4 - Ext. sprayed polyurethane foam - 2"	$1.50	1	$1.50	12
5 - Interior glass/mineral fibre - 3-1/2"	$16.28	74	$0.22	12
6 - Interior cellulose - 3-1/2"	$0.26	1	$0.26	12
7 - Interior ext. polystyrene - 2"	$17.25	16	$1.08	10
8 - Interior exp. polystyrene - 2-1/2"	$9.46	16	$0.59	9.4
9 - Int. sprayed polyurethane foam - 2"	$1.50	1	$1.50	12
10 - Insulated concrete forms	$22.75	5	$4.27	22

MOISTURE PROTECTION & MISCELLANEOUS MATERIALS

Material	**Area (ft2)**	**Price**	**Cost/ft2**
Vapour Barrier	500	$20.10	$0.04
Glass/Mineral Drainage Board	24	$9.08	$0.38
Plastic Drainage Membrane	393.6	$154.00	$0.47
Strapping (2x4@16)	320	$123.66	$0.48
Drywall (1/2")	32	$5.89	$0.18
Lath and Parging (incl. masonry cove and flashing)			$5.30*

* The unit cost of exterior lath and parging, assuming brick veneer, is derived from the average cost for a 2 foot high application of parging. For smaller basement, like the one used in his study, the unit cost may actually be higher since the cost of the cove and flashing predominate.

Table 7. Survey of basement material costs.

BUILDER SURVEY

A mail survey of selected builders was conducted during the Winter of 1999 (see Appendix B). Builders were selected on the basis of a proven track record (i.e., more than 10 years experience), a good warranty program record, and acceptable cost accounting practices. These criteria were established in order to obtain reliable cost data which reflected proper basement construction practices by profitable building businesses.

Following receipt of the mail survey, follow-up telephone interviews were conducted to clarify information and to obtain further insights on basement system selection and construction.

Table 8 shown below indicates additional information gathered from the follow-up telephone surveys. It summarizes the average unit labour costs for the installation of various materials and assemblies.

Miscellaneous Unit Labour Costs		
The following costs were reported for various work based on a unit measure ($/ft2).		
Material or Assembly Installation		
Studs, Insulation, Poly	$0.46	**NOTE:**
Exterior Insulation/Drainage Layers	$0.53	Costs are for labour only.
Foam Insulation, Strapping, Drywall	$0.64	Builder supplies all materials and provides
Drywall (untaped)	$0.20	electrical power, access, etc.

Table 8. Summary of builder survey costs for miscellaneous labour.

On the following page, Table 9 summarizes the results of the basement system costs reported by the builders which responded to the survey.

Survey of Builder Costs							
	Builder #1	**Builder #2**	**Builder #3**	**Builder #4**	**Builder #5**	**Builder #6**	**AVG.**
Basement Class	A-3	A-3	A-3	A-3	A-3	A-2	
Basement Floor Area	1733	2050	1128.5	2016	2100	840	
Basement Perimeter	178	150	135	180	230	131.6	
Excavation	$1,000.00	$800.00	$940.00	$925.00	$1,000.00	$929.00	
Volume Excavated	396	380	293	448	467	286	
Unit Cost ($/yd3)	$2.53	$2.11	$3.21	$2.06	$2.14	$3.25	***$2.55***
Footings (Formed & Poured)	$0.00	$1,450.00	$0.00	$1,608.00	$1,621.00	$1,114.00	
Length	1	208	1	180	230	131.6	
Unit Cost ($/ft)	$0.00	$6.97	$0.00	$8.93	$7.05	$8.47	***$7.85***
Foundation Walls	$11,800.00	$4,350.00	$4,730.00	$5,958.00	$6,486.00	$4,200.00	
Area	1394	999	1057	1409	1801	930	
Unit Cost ($/ft2)	$8.47	$4.36	$4.47	$4.23	$3.60	$4.51	***$4.23***
Dampproofing	$0.00	$100.00	$0.00	$121.50	$400.00	$100.00	
Area	1	1	1	1	1	1	
Unit Cost (lump sum)	$0.00	$100.00	$0.00	$121.50	$400.00	$100.00	***$180.38***
Weeping Tile/Crushed Stone	$0.00	$600.00	$360.00	$728.00	$0.00	$500.00	
Length	1	150	135	180	230	132	
Unit Cost ($/ft)	$0.00	$4.00	$2.67	$4.04	$0.00	$3.80	***$3.63***
Basement Floor Slab/Gravel	$2,000.00	$1,650.00	$1,000.00	$1,353.00	$3,706.00	$900.00	
Area	1448	2050	1128.5	2016	2100	840	
Unit Cost ($/ft2)	$1.38	$1.80	$1.89	$1.67	$1.76	$1.07	***$1.60***
Drainage Layer	$0.00	$1,200.00	$790.00	$365.00	$1,280.00	$700.00	
Area	1448	750	810	720	1380	789.6	
Unit Cost ($/ft2)	$0.00	$1.60	$0.98	$0.51	$0.93	$0.89	***$0.98***
Basement Insulation	$630.00	$1,100.00	$600.00	$663.00	$600.00	$700.00	
Area	712	1200	1080	1440	1840	1052.8	
Unit Cost ($/ft2)	$0.88	$0.92	$0.56	$0.46	$0.33	$0.66	***$0.63***
Interior Finishes	$0.00	$0.00	$0.00	$0.00	$0.00	$800.00	
Area	1	1	1	1	1	1052.8	
Unit Cost ($/ft2)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.76	***$0.76***
Backfilling	$500.00	$500.00	$200.00	$1,382.00	$800.00	$820.00	
Length	178	150	135	180	230	131.6	
Unit Cost ($/ft)	$2.81	$3.33	$1.48	$7.68	$3.48	$6.23	***$4.17***
Windows and Doors		$750.00	$372.00	$200.00	$600.00	$450.00	
Area	1	30	6	4	20	26.3	
Unit Cost	$0.00	$25.00	$62.00	$50.00	$30.00	$17.11	***$30.69***
Basement Plumbing	$800.00	$600.00	$360.00	$360.00	$350.00	$1,500.00	***$661.67***
Basement Electrical	$250.00	$300.00	$430.00	$430.00	$200.00	$1,500.00	***$518.33***
Miscellaneous Costs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Basement System Cost	**$17,489**	**$13,802**	**$10,075**	**$14,516**	**$17,554**	**$14,639**	***$14,679***
Basement Unit Cost ($/ft2)	**$10.09**	**$6.73**	**$8.93**	**$7.20**	**$8.36**	**$17.43**	***$9.79***
Class A-3 Average Unit Cost							***$8.26***

Table 9. Summary of builder survey costs for basement systems.

Summary of Builder Profiles

BUILDER #1
A custom home builder from the Greater Metropolitan Toronto Area. This builder typically constructs a fully insulated, poured concrete basement without drywall finish. The foundation walls package includes footings, foundation walls, dampproofing and drainage layer. Nearly all of the basement system construction is subcontracted.

BUILDER #2
A builder from Northern Ontario who builds a variety of home types to cater to various market segments. Basement systems are typically constructed from block, insulated full height but without drywall finish. Granular backfill is used for a drainage layer. Most of the basement system construction is subcontracted.

BUILDER #3
A builder from Southwestern Ontario who builds mostly for a move-up homebuyer market. Basement systems are usually poured concrete, insulated full-height but without drywall. A dimpled, plastic membrane is used as a drainage layer. Most of the basement system construction is subcontracted.

BUILDER #4
A custom builder from outside the Greater Metropolitan Toronto Area. This builder typically constructs a fully insulated, poured concrete basement without drywall finish. A glass fibre insulation board is used as a drainage layer. Nearly all of the basement system construction is carried out by the builder's own forces.

BUILDER #5
A custom builder from Eastern Ontario who builds many home types to suit various market segments. Basement systems typically consist of a poured concrete foundation, insulated full-height but without drywall finish. Both a glass fibre insulation board and granular backfill are used for the drainage layer. Nearly all of the basement system construction is subcontracted.

BUILDER #6
A builder from outside the Greater Metropolitan Toronto Area who builds a variety of home types to cater to various market segments. This builder typically constructs a fully insulated, poured concrete basement which is almost completely finished. A glass fibre insulation board is used as a drainage layer. Nearly all of the basement system construction is subcontracted.

SYNOPSIS
In reviewing and comparing the cost data reported by builders, the interesting points to observe are:

1. Prices vary depending on the economic conditions within a locality. Areas with growing economies tend to have higher labour costs, which translate into higher basement system costs.
2. Core costs for items such as excavation, backfilling, sewer and water hook-ups tend to remain constant no matter the size of the basement, small or average.
3. Costs associated with a completely or almost completely finished basement tend to push the costs much higher, approximately doubling the cost per square foot for an average basement system.
4. Basement systems represent a significant cost component of the entire house.

COST OF STRUCTURAL FOUNDATION

To obtain the cost of structural foundations, two methods were followed:

1. The first method employed was intended for cast-in-place concrete or concrete block foundations. The average costs obtained from builder survey were applied to the study model basement (refer to Figure 3).
2. The second method targeted basements constructed using insulated concrete forming systems, and was based on a separate survey of foundation contractors conducted after the builder survey. It should be noted that due to the high activity levels in the Ontario residential construction industry, considerable time and effort was required to obtain reasonable estimates of unit costs.

Table 10 summarized the unit and model basement costs for the structural foundation.

Breakdown of Structural Foundation Costs

The cost of cast-in-place concrete and concrete block foundations are calculated below. Model basement parameters are applied to unit costs derived from the material and builder surveys. Based on the limited number of builders and markets surveyed, the difference in cost between these two structural foundation systems was found to be negligible.

Cast-In-Place Concrete or Concrete Block

Item	**Exc.**	**Footings**	**Walls**	**Damp.**	**Weepers**	**Slab**	**Backfill**	
Unit Cost	$2.55	$7.85	$4.23	$180.38	$3.63	$1.60	$4.17	
Unit	cu.yd.	lin. foot	ft2	lump sum	lin. ft.	ft2	lin. ft	**TOTAL**
Model Basement Cost	$516	$817	$3,523	$180	$377	$1,073	$434	***$6,920***

Insulated Concrete Form System

Item	**Exc.**	**Footings**	**Walls***	**Damp.**	**Weepers**	**Slab**	**Backfill**	
Unit Cost	$2.55	$7.85	$8.16	N/A	$3.63	$1.60	$4.17	
Unit	cu.yd.	lin. foot	ft2	N/A	lin. ft.	ft2	lin. ft	**TOTAL**
Model Basement Cost	$516	$817	$6,785	N/A	$377	$1,073	$434	***$10,001***

* Walls include cost of ICFs, concrete and reinforcing steel.

NOTE: Dampproofing and foundation drainage (weepers) are normally considered part of the basic basement structural package, recognizing that these are actually part of the thermal and moisture protection measures.

Table 10. Breakdown of structural foundations costs for study model basement.

The higher cost for the ICF basement reflects the provision of thermal insulation as an integral part of this type of basement system.

COST OF MOISTURE AND THERMAL PROTECTION

The cost of thermal and moisture protection was estimated for the 10 insulation options considered in this study. All of the cases listed in Table 11 below represent full-height basement insulation. The total cost for moisture and thermal protection for each option is based on the study model basement parameters found in Figure 3.

Cost of Moisture and Thermal Protection

Full-Height Basement Insulation

	Insulation Option	Insulation	V.B. & Strapping	Drywall	Drainage Layer	Parging	TOTAL
1	Exterior extruded polystyrene	$1,523	N/A	N/A	Integral	$551	**$2,074**
2	Exterior glass/mineral fibre*	$1,385	N/A	N/A	Integral	$551	**$1,936**
3	Exterior expanded polystyrene	$1,031	N/A	N/A	Integral	$551	**$1,583**
4	Ext. sprayed polyurethane foam	$1,248	N/A	N/A	Integral	$551	**$1,799**
5	Interior glass/mineral fibre	$566	$436	N/A	$353	N/A	**$1,355**
6	Interior cellulose	$599	$436	N/A	$353	N/A	**$1,389**
7	Interior ext. polystyrene (XPS)	$1,429	N/A	$320	$353	N/A	**$2,102**
8	Interior exp. polystyrene (EPS)	$1,025	N/A	$320	$353	N/A	**$1,697**
9	Int. sprayed polyurethane foam	$1,248	$403	$320	$353	N/A	**$2,324**
10	Insulated concrete forms**	Included	N/A	$320	$353	$551	**$1,224**

* Assumes 3 inch thickness of application.
** For ICFs, in lieu of a drainage layer, an exterior moisture protection membrane on the below-grade, exterior foundation wall is commonly recommended, at a comparable cost to the drainage layer.

IMPORTANT NOTE: The applicable measures indicated above are based on the requirements of the Ontario Building Code, and reflects the practices of the Ontario builders which were surveyed. Requirements in other regions of Canada may differ.

Table 11. Derived costs of thermal and moisture protection options for study model basement.

COST OF BASEMENT FINISHING

Having derived the costs of the structural foundation system, and the moisture and thermal protection options, the builders were surveyed to determine the cost of basement finishing options. The rounded results are listed in Table 12 below.

Cost of Basement Finishing Options		
This table contains data on the cost of finishing a basement for two intended uses: 1 - as a fully separate dwelling unit, and 2 - as a livable space within a dwelling. These uses correspond to Class A-1 and Class A-2, respectively, as defined in Table 2.		
ASSUMPTIONS & LIMITATIONS 1. These cost were derived through a builder survey, where builders assumed a full height insulated basement as a starting point for the incremental price. 2. Costs may vary significantly depending on site and market conditions.		
	$/ft2	
Class A-1 Upgrade	$25.00	
Class A-2 Upgrade	$15.00	
NOTE: The Class A-1 upgrade accounts for fire separation, access/egress, and provision of a kitchen, bathroom and separate heating system.		

Table 12. Estimated costs of basement finishing options for study model basement.

It is important to note that the variability in the prices provided by the builders was relatively high. The finishing of basements was found to be extremely market sensitive, and while some builders reported that it was an item which was only offered at a significant price premium, others reported that it was used as a loss leader during periods of low market activity to induce sales. All builders indicated that the pricing of basement finishing was dependent on time of year and the stage of subdivision development. For these reasons, the reported pricing was rounded acknowledging that the rounding error was less significant than the variance in prices reported across Ontario.

With this stage of the study complete, it was possible to continue with a derivation of costs for the various assessment scenarios outlined in Part 1 of this study.

PART 3

COSTS OF ASSESSMENT SCENARIOS

Various assessment scenarios were developed at the preliminary stages of this study, as noted in Tables 4, 5 and 6 of Part 1 of this report. The most significant effort in this study involved the costing of packaged system scenarios described in Table 4. This stage of the study required that 10 thermal/moisture protection options be assessed within 5 basement classes (A-1, A-2, A-3, B, C), as per Table 2 of this report. Class D and E basements were not considered in this study as they do not represent a significant proportion of total annual basement construction.

COST OF SELECTED BASEMENT CLASSES

Table 13 summarizes the cost of 5 selected basement classes in Toronto, Ontario, according to the 10 thermal/moisture protection options depicted in Figures 5, 6, 7 and 8 in Part 1 of this report.

Compared Cost of Selected Basement Classes - Ontario

Builder costs for each basement class and thermal/moisture protection option are derived from the previous data. In the case of the Class A-1 basement, it was assumed that half of the basement was converted into a separate dwelling unit. For Class A-2 basements, one-third of the basement was finished.

	Thermal/Moisture Protection Option									
Basement Class	***Ext XPS 1***	***Ext Fibre 2***	***Ext EPS 3***	***Ext SPF 4***	***Int. Fibre 5***	***Int. Cell. 6***	***Int. XPS 7***	***Int EPS 8***	***Int. SPF 9***	***ICFs 10***
A-1	$17,393	$17,256	$16,902	$17,119	$16,675	$16,708	$17,422	$17,017	$17,643	$19,625
A-2	$12,353	$12,216	$11,862	$12,079	$11,635	$11,668	$12,382	$11,977	$12,603	$14,585
A-3	$8,993	$8,856	$8,502	$8,719	$8,275	$8,308	$9,022	$8,617	$9,243	$11,225
B	N/A	N/A	N/A	N/A	$7,244	$7,261	$7,618	$7,415	N/A	N/A
C	N/A	N/A	N/A	N/A	$6,920	$6,920	$6,920	$6,920	N/A	N/A
Special*					$7,156					

N/A signifies that this class of basement system is not normally constructed with this type of insulation option.

NOTES:
(1) Class C basements are normally not permitted in Ontario.
(2) All Class C basements are without thermal/moisture protection and identical for each option.
(3) Due to applicable Code requirements, ICF basements are minimum A-3 class.
* Special case based on 4 feet wide insulation blanket with integral poly wrapped around basement interior.

LEGEND:

1. Ext XPS	Exterior extruded polystyrene insulation
2. Ext Fibre	Exterior glass/mineral fibre semi-rigid draining insulation and dampproofing
3. Ext EPS	Exterior expanded polystyrene insulation and dampproofing
4. Ext SPF	Exterior sprayed polyurethane foam
5. Int. Fibre	Interior glass/mineral fibre batt insulation, strapping, vapour barrier, dampproofing, drainage layer
6. Int. Cell.	Interior cellulose insulation, strapping, vapour barrier, dampproofing and drainage layer
7. Int. XPS	Interior extruded polystyrene insulation, strapping, drywall, dampproofing and drainage layer
8. Int EPS	Interior expanded polystyrene insulation, strapping, drywall, dampproofing and drainage layer
9. Int. SPF	Interior sprayed polyurethane foam, strapping, drywall, dampproofing and drainage layer
10. ICFs	Insulated concrete forms, exterior moisture protection, interior drywall

Table 13. Cost of selected basement classes for study model basement - Ontario.

REGIONAL ENERGY AND CONSTRUCTION COSTS

In order to assess the costs associated with the space heating of the various model basement configurations, it was necessary to establish regional residential energy prices for each of the primary sources. Houses may be heated by natural gas, oil, propane, electricity or wood, however, only the first four energy sources were considered. Variations in the price, energy content and conversion efficiency of wood fuels, and a lack of reliable data, excluded this fuel from the study.

Construction costs also vary from region to region and it was necessary to translate prices obtained in one location to the other locations considered in this study. A methodology consistent with that used in developing the National Energy Code for Houses was employed. Residential construction cost location factors were applied to the costs determined from the Ontario builder survey.

Table 14 lists the regional energy and construction costs used in the economic assessments performed later in this study. Energy prices were obtained from Natural Resources Canada, Statistics Canada and several fuel energy associations. Construction cost location factors were obtained from *Residential Cost Data 1999*, published by R.S. Means Company Inc. A complete listing of the factors may be found on Sheet 18 of the electronic spreadsheet.

Retail Energy Prices and Residential Construction Cost Location Factors

	ENERGY PRICE ($/GJ)					LOCATION FACTOR
LOCATION	**Gas**	**Oil**	**Propane**	**Electricity**		
Toronto	6.98	9.76	16.42	25.64		1.14
Ottawa	6.98	9.76	16.42	20.44		1.11
Halifax	N/A	9.47	18.34	26.11		0.98
Edmonton	4.64	7.97	13.09	20.86		1.01
Victoria*	6.98	10.56	16.83	17.00		1.07

* BC average price for natural gas cited in this study.

Table 14. 1999 energy prices and construction cost location factors

BASEMENT OPERATING COSTS - TORONTO

In order to obtain the annual space heating energy demand, and annual operating energy costs for each basement class and thermal/moisture protection option, simulations using the study model basement parameters were performed using BASECALC™ software. The results for Toronto are presented in Table 15. Further simulations in the 4 other Canadian markets selected in this study were performed after review and approval of the draft report methodology by the Basement Guidelines Project Steering Committee.

TORONTO - Basement System Operating Costs

Annual energy demand was estimated for each basement option using BASECALC software.

The annual cost of operation was calculated using the energy prices listed below.

Space Heating	
Energy	**$/GJ**
Gas (80%)	**8.73**
Oil (80%)	**12.20**
Prop. (80%)	**20.53**
Elec. (100%)	**25.64**

The costs of various types of space heating energy are based on 1999 data, and reflect the space heating system efficiency as noted in parentheses.

ANNUAL ENERGY DEMAND (GJ) AND OPERATING COSTS - TORONTO

Classes A-1, A-2, A-3 Basement Systems										
	Thermal/Moisture Protection Option									
	Ext XPS 1	***Ext Fibre 2***	***Ext EPS 3***	***Ext SPF 4***	***Int. Fibre 5***	***Int. Cell. 6***	***Int. XPS 7***	***Int. EPS 8***	***Int. SPF 9***	***ICFs 10***
Demand (GJ)	**12.4**	**13.1**	**12.6**	**12.6**	**9.8**	**9.8**	**10.6**	**10.8**	**9.8**	**7.7**
Gas (80%)	$108	$114	$110	$110	$86	$86	$92	$94	$86	$67
Oil (80%)	$151	$160	$154	$154	$120	$120	$129	$132	$120	$94
Prop. (80%)	$255	$269	$259	$259	$201	$201	$218	$222	$201	$158
Elec. (100%)	$318	$336	$323	$323	$251	$251	$272	$277	$251	$197
Class B Basement Systems										
	Thermal/Moisture Protection Option									
	Ext XPS 1	***Ext Fibre 2***	***Ext EPS 3***	***Ext SPF 4***	***Int. Fibre 5***	***Int. Cell. 6***	***Int. XPS 7***	***Int. EPS 8***	***Int. SPF 9***	***ICFs 10***
Demand (GJ)	N/A	N/A	N/A	N/A	**13.5**	**13.5**	**13.9**	**14.1**	N/A	N/A
Gas (80%)	N/A	N/A	N/A	N/A	$118	$118	$121	$123	N/A	N/A
Oil (80%)	N/A	N/A	N/A	N/A	$165	$165	$170	$172	N/A	N/A
Prop. (80%)	N/A	N/A	N/A	N/A	$277	$277	$285	$289	N/A	N/A
Elec. (100%)	N/A	N/A	N/A	N/A	$346	$346	$356	$362	N/A	N/A
Class C Basement Systems										
	Thermal/Moisture Protection Option									
	Ext XPS 1	***Ext Fibre 2***	***Ext EPS 3***	***Ext SPF 4***	***Int. Fibre 5***	***Int. Cell. 6***	***Int. XPS 7***	***Int. EPS 8***	***Int. SPF 9***	***ICFs 10***
Demand (GJ)	N/A	N/A	N/A	N/A	**28.6**	**28.6**	**28.6**	**28.6**	N/A	N/A
Gas (80%)	N/A	N/A	N/A	N/A	$250	$250	$250	$250	N/A	N/A
Oil (80%)	N/A	N/A	N/A	N/A	$349	$349	$349	$349	N/A	N/A
Prop. (80%)	N/A	N/A	N/A	N/A	$587	$587	$587	$587	N/A	N/A
Elec. (100%)	N/A	N/A	N/A	N/A	$733	$733	$733	$733	N/A	N/A

NOTE: The Class C basement system is actually the base case basement system without thermal/moisture protection.
N/A signifies that the class of basement cannot normally be upgraded to this thermal/moisture protection option.

Table 15. Annual energy demand and operating costs for selected basement classes - Toronto.

It should be noted that all of the Class A basement systems are equivalent with respect to thermal and moisture protection features (full height insulation and drainage layer, integral or separate). The Class B basement systems are partially insulated to 2 feet (600 mm) below grade, and the Class C basement is completely uninsulated, serving as a cellar.

LIFE CYCLE ANALYSIS - TORONTO

Having established the capital and operating costs of the various basement classes and thermal/moisture protection options, this part of the study proceeded with a life cycle analysis of each resulting combination. The rationale and methodology employed in this process is consistent with that forming the basis for the 1995 National Energy Code for Houses.

Applicable taxes and profit, and the construction cost location factor were also applied to the builder costs of the various basement systems to arrive at consumer (new home buyer) costs for the basement systems in each locality. The life cycle parameters, taxes and profit, and location factor used in the life cycle analyses are noted below.

Life Cycle Parameters		**Taxes and Profit**
Interest	**4%**	**12%**
Escalation	**1%**	
Period (years)	**30**	
TORONTO - Construction Cost Location Factor		**1.036**

The life cycle costs for the Class A-1 basement systems are presented in Table 16 below. The range of basement system consumer costs range from $19,355 to $22,779, representing a 17.7% relative difference. Life cycle costs are based on 4 space heating energy sources most commonly purchased in Canada, along with their respective conversion efficiencies. The life cycle costs range from $21,037 to $26,664. This $5,627 difference indicates the significance of basement system and space heating energy choices among consumers (new home buyers).

Class A-1 Basement Systems	Thermal/Moisture Protection Option									
	Ext XPS	*Ext Fibre*	*Ext EPS*	*Ext SPF*	*Int. Fibre*	*Int. Cell.*	*Int. XPS*	*Int. EPS*	*Int. SPF*	*ICFs*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Demand (GJ)	12.4	13.1	12.6	12.6	9.8	9.8	10.6	10.8	9.8	7.7
System Cost	$20,189	$20,029	$19,619	$19,870	$19,355	$19,394	$20,222	$19,752	$20,479	$22,779
Life Cycle Cost										
Gas (80%)	$22,318	$22,278	$21,782	$22,033	$21,037	$21,076	$22,042	$21,606	$22,161	$24,101
Oil (80%)	$23,166	$23,174	$22,644	$22,895	$21,707	$21,746	$22,767	$22,345	$22,832	$24,628
Prop. (80%)	$25,197	$25,320	$24,707	$24,959	$23,313	$23,351	$24,503	$24,114	$24,437	$25,889
Elec. (100%)	$26,445	$26,638	$25,976	$26,227	$24,299	$24,338	$25,570	$25,201	$25,423	$26,664

Table 16. Life cycle costs for Class A-1 basement systems - Toronto.

It is important to note in the above, and all subsequent, life cycle assessments that the cost of the heating and ventilation systems was not considered. Due to the numerous methods of delivering heating and ventilation to the basement, it was not possible to specify and price each of the conceivable options.

An interesting relationship worth noting, however, is that when electric resistance heating is used to heat the basement space, this alternative is on average $3,634 more expensive than natural gas over the 30 year study period, $2,898 more expensive than oil, and $1,099 more expensive than propane. The use of separately controlled electric baseboard heaters in the basement is a popular choice in finished basements due to separate controls and low first costs, but when less expensive energy sources are available, this approach may not prove to be the most cost effective to consumers. It is also revealing that as the thermal efficiency of the basement system increases, the difference in life cycle costs among fuel types significantly diminishes. These relationships hold for all Class A basements.

Life cycle costs for the Class A-2 basement systems are presented in Table 17. The range of basement system costs to consumers range from $13,505 to $16,929. The life cycle costs range from $15,187 to $20,814. On a comparative basis, the highest priced Class A-2 basement system is 25.4% greater than the lowest priced Class A-2 basement system. The absolute difference between the minimum and maximum life cycle costs for Class A-2 basements remains the same for all Class A basement systems, however the relative difference between Class A-2 options represents a 37.1% premium with respect to the minimum cost system.

Class A-2 Basement Systems										
	Thermal/Moisture Protection Option									
	Ext XPS	***Ext Fibre***	***Ext EPS***	***Ext SPF***	***Int. Fibre***	***Int. Cell.***	***Int. XPS***	***Int. EPS***	***Int. SPF***	***ICFs***
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Demand (GJ)	12.4	13.1	12.6	12.6	9.8	9.8	10.6	10.8	9.8	7.7
System Cost	$14,339	$14,179	$13,769	$14,020	$13,505	$13,544	$14,372	$13,902	$14,629	$16,929
Life Cycle Cost										
Gas (80%)	$16,468	$16,428	$15,932	$16,183	$15,187	$15,226	$16,192	$15,756	$16,311	$18,251
Oil (80%)	$17,316	$17,324	$16,794	$17,045	$15,857	$15,896	$16,917	$16,495	$16,981	$18,778
Prop. (80%)	$19,347	$19,469	$18,857	$19,109	$17,463	$17,501	$18,653	$18,264	$18,587	$20,039
Elec. (100%)	$20,595	$20,788	$20,126	$20,377	$18,449	$18,488	$19,720	$19,351	$19,573	$20,814

Table 17. Life cycle costs for Class A-2 basement systems - Toronto.

Life cycle costs for the Class A-3 basement systems are presented in Table 18. The range of basement system costs to consumers range from $9,605 to $13,029. The life cycle costs range from $11,287 to $16,914. As a relative comparison, the highest basement system capital cost is 35.6% greater than the lowest priced basement system. The absolute difference between the minimum and maximum life cycle costs for Class A-3 basements remains the same for all Class A basement systems, however the relative difference represents a 49.9% premium with respect to the minimum cost system.

Class A-3 Basement Systems										
	Thermal/Moisture Protection Option									
	Ext XPS	***Ext Fibre***	***Ext EPS***	***Ext SPF***	***Int. Fibre***	***Int. Cell.***	***Int. XPS***	***Int. EPS***	***Int. SPF***	***ICFs***
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Demand (GJ)	12.4	13.1	12.6	12.6	9.8	9.8	10.6	10.8	9.8	7.7
System Cost	$10,439	$10,279	$9,869	$10,120	$9,605	$9,644	$10,472	$10,002	$10,729	$13,029
Life Cycle Cost										
Gas (80%)	$12,568	$12,528	$12,032	$12,283	$11,287	$11,326	$12,292	$11,856	$12,411	$14,351
Oil (80%)	$13,416	$13,424	$12,893	$13,145	$11,957	$11,996	$13,017	$12,594	$13,081	$14,878
Prop. (80%)	$15,447	$15,569	$14,957	$15,209	$13,563	$13,601	$14,753	$14,364	$14,687	$16,139
Elec. (100%)	$16,695	$16,888	$16,225	$16,477	$14,549	$14,588	$15,820	$15,450	$15,673	$16,914

Table 18. Life cycle costs for Class A-3 basement systems - Toronto.

Life cycle costs for the Class B basement systems are presented in Table 19. The range of basement system costs to consumers range from $8,408 to $8,842. The life cycle costs range from $10,726 to $15,720, and represent a $4,994 difference. On a comparative basis, the highest priced Class B basement system is 5.2% greater than the lowest priced basement system. The relative difference between the minimum and maximum life cycle costs for Class B basements represents a 46.6% premium with respect to the minimum cost system. The analysis indicates that the Class B basement system becomes less cost effective over its life cycle as space heating energy costs increase. It should be noted in the table below that N/A signifies that the Class B basement system (i.e., insulation to 2 feet below grade), cannot normally be upgraded to a higher basement class using this thermal/moisture protection option

Class B Basement Systems	Thermal/Moisture Protection Option									
	Ext XPS	*Ext Fibre*	*Ext EPS*	*Ext SPF*	*Int. Fibre*	*Int. Cell.*	*Int. XPS*	*Int. EPS*	*Int. SPF*	*ICFs*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Demand (GJ)	N/A	N/A	N/A	N/A	13.5	13.5	13.9	14.1	N/A	N/A
System Cost	N/A	N/A	N/A	N/A	$8,408	$8,428	$8,842	$8,607	N/A	N/A
Life Cycle Cost										
Gas (80%)	N/A	N/A	N/A	N/A	$10,726	$10,745	$11,228	$11,028	N/A	N/A
Oil (80%)	N/A	N/A	N/A	N/A	$11,649	$11,668	$12,179	$11,992	N/A	N/A
Prop. (80%)	N/A	N/A	N/A	N/A	$13,860	$13,880	$14,455	$14,301	N/A	N/A
Elec. (100%)	N/A	N/A	N/A	N/A	$15,219	$15,238	$15,854	$15,720	N/A	N/A

Table 19. Life cycle costs for Class B basement systems - Toronto.

Life cycle costs for the Class C basement systems are presented in Table 20. The cost of each basement system is identical, $8,032, as this configuration represents the base case scenario - an uninsulated, cellar-type basement. Similarly, the life cycle costs are also identical across options, and range from $12,942 to $22,460, representing a $9,518 difference. The relative difference between the minimum and maximum life cycle costs for Class C basements represents a 73.5% premium with respect to the minimum cost system, all of which is accounted for by differences in energy prices. The analysis indicates that the Class C basement system becomes significantly less cost effective over its life cycle as space heating energy costs increase. It should be noted that N/A signifies that the Class C basement cannot normally be upgraded to a higher basement class using this thermal/moisture protection option.

Class C Basement Systems	Thermal/Moisture Protection Option									
	Ext XPS	*Ext Fibre*	*Ext EPS*	*Ext SPF*	*Int. Fibre*	*Int. Cell.*	*Int. XPS*	*Int. EPS*	*Int. SPF*	*ICFs*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Demand (GJ)	N/A	N/A	N/A	N/A	28.6	28.6	28.6	28.6	N/A	N/A
System Cost	N/A	N/A	N/A	N/A	$8,032	$8,032	$8,032	$8,032	N/A	N/A
Life Cycle Cost										
Gas (80%)	N/A	N/A	N/A	N/A	$12,942	$12,942	$12,942	$12,942	N/A	N/A
Oil (80%)	N/A	N/A	N/A	N/A	$14,897	$14,897	$14,897	$14,897	N/A	N/A
Prop. (80%)	N/A	N/A	N/A	N/A	$19,582	$19,582	$19,582	$19,582	N/A	N/A
Elec. (100%)	N/A	N/A	N/A	N/A	$22,460	$22,460	$22,460	$22,460	N/A	N/A

Table 20. Life cycle costs for Class C basement systems - Toronto.

This report now presents a brief summary of the annual operating and life cycle cost analyses performed for Ottawa, Halifax, Edmonton and Victoria.

OTTAWA - OPERATING AND LIFE CYCLE COSTS

Annual operating costs for Ottawa are slightly higher than those estimated for Toronto due to a colder climate, with exception to electrically heated basements where the lower cost of electricity in Ottawa offsets climatic differences.

Based on the Ottawa construction cost location factor, basements are less expensive to construct than in Toronto (the highest cost basements in the study) and the narrower spread in prices between the lowest and highest priced energy sources render the differences in life cycle costs within and between basement options less significant. However, Class A basement systems still provide cost effective value within this market across all energy sources. The results for the annual operating and life cycle costs of basements in Ottawa are found on Sheet 14 of the electronic spreadsheet file (refer to Appendix A).

HALIFAX - OPERATING AND LIFE CYCLE COSTS

Due to the unavailability of natural gas in Halifax, the lowest price fuel (oil) is significantly more expensive than lowest priced fuel (natural gas) in all of the other study locations. When this factor is coupled to the Halifax climate, basement operating costs are relatively high compared to other parts of Canada.

Halifax was estimated to have the lowest basement capital costs, but among the highest life cycle costs, signifying that Class A basements (full-height insulation) represent a highly cost effective alternative to Class B and C basement systems. Annual operating and life cycle costs for basement systems located in Halifax are presented within Sheet 15 of the electronic spreadsheet file (see Appendix A).

EDMONTON - OPERATING AND LIFE CYCLE COSTS

Edmonton represents the coldest climate location in the study, but the lowest energy prices. To put this relationship into a simple perspective, Edmonton is similar to Toronto in terms of the cost effectiveness of full-height basement insulation. For Edmonton, annual operating and life cycle costs for basement systems may be found in Sheet 16 of the electronic spreadsheet file (see Appendix A).

VICTORIA - OPERATING AND LIFE CYCLE COSTS

Victoria climatic conditions cause the least annual basement space heating energy demand among the 5 locations studied. As a result, the cost of heating basements is generally the lowest estimated in this study.

The range of energy prices is narrower than most locations in Canada, and the construction costs are nearly average. Given these circumstances, Class A basements are less cost effective from a thermal efficiency perspective, compared to the other locations considered in this study. However, given the cost of serviced land in lower British Columbia the inclusion of liveable space within the basement may prove more affordable, especially as evidenced in the raised foundation construction traditionally favoured in this region. Sheet 17 of the electronic spreadsheet file contains the annual operating and life cycle costs for basement systems located in Victoria (see Appendix A).

OTHER ASSESSMENT SCENARIO COST DATA

A number of assessment scenarios suggested for study by the Basement Guidelines Project Steering Committee were not successfully assessed. The issues relating to these are further discussed below for the benefit of future studies or projects.

High Performance Concrete and Covercrete

Cost and in-situ performance data for the high performance concrete and Covercrete materials have proven difficult to resolve. In the case of high performance concrete, the cost for this mix design may be obtained, however, the performance of the material has not been clearly demonstrated as in the case for exterior draining insulation materials. The key question which arises is: if high performance concrete is used, can the dampproofing and drainage layer be omitted while providing comparable performance? In the case of Covercrete, the main problem lies with obtaining reliable pricing of this material, in particular the cost of forming and placing. Until these issues are resolved, Scenarios #5 and #6 remain difficult to assess.

Concrete Forming/Crack Control/Curing and

Site Grading and Drainage

Based on telephone interviews with builders, all of them reported that these were no cost items from their perspective. Some remarked that if these items were not provided to their satisfaction, they would simply switch sub-contractors. Builders recognize that the implicit cost effectiveness of better practices which may be achieved at no additional cost.

Thermal Bridging Reduction

The analysis of thermal bridging reduction using BASECALC™ indicates that better insulation placement practices provide relatively minimal benefit so long as the major thermal bridge between the footing and foundation wall is not resolved. While it may be acknowledged that proper insulation selection and placement can reduce the likelihood of mold growth due to condensation, and the cost of these measures may be derived, the benefits remain difficult to quantify.

This report now turns to the discussion of the currently feasible sub-set of economic assessment scenarios which were performed.

PART 4

ECONOMIC ASSESSMENT OF SELECTED BASEMENT SYSTEMS, MATERIALS AND PRACTICES

This stage of the study required that the data gathered in Part 2 and the costs derived in Part 3 be integrated into 6 economic assessment scenarios. Each scenario would feature 3 economic perspectives: 1) builder; 2) consumer; and 3) societal. These scenarios and the associated assessments and measures are listed in Tables 4, 5 and 6 in Part 1 of this report.

The packaged system assessments (see Sheet 11 of the spreadsheet) are somewhat regionally sensitive because the construction costs, severity of climate, and regional energy prices can impact the cost effectiveness of thermal insulation. However in this study, a detailed discussion is only presented for the Toronto area recognizing its significant contribution to new housing starts in Canada. The electronic spreadsheet file has been included with this study to enable future users to explore regional economic assessment themes. Annual energy costs, and life cycle costs for all 5 locations are complete, and the data may be applied to numerous conceivable scenarios as time and resources permit. It is important to note that given the recent volatility in fossil fuel prices in Canada, the data and assumptions used in this study may have to be periodically re-examined.

In the case of the material/component/sub-system assessments (see Sheet 12 of the spreadsheet), the variation in associated costs and benefits is not significant across the 5 regions, hence only a representative assessment is required for each scenario of this type. The same reasoning applies to the better practice assessments (see Sheet 13 of the spreadsheet) which are not regionally sensitive, although they may be regionally specific due to site conditions and/or local building practices.

The purpose of these assessments is their eventual inclusion in the *Guidelines* publication in an appropriate format. The format used in this study is relatively terse and technical, and may not be suitable to the target audience(s). This issue is further discussed in Part 5 of this report, along with the recommendations for the *Guidelines* publication.

PACKAGED SYSTEM ASSESSMENTS

The packaged system assessments comprise Scenarios #1 through #4, inclusive. The intent of this series of assessments is to determine the cost effectiveness of upgrading to various basement classes from two minimum levels corresponding to various regions of Canada. The first minimum level is the Class C basement which is effectively an uninsulated cellar. The second minimum level is the Class B basement, which is the minimum standard in provinces such as Ontario.

Basic assumptions used in all assessment scenarios considered in this study are as follows:

Cost of Construction Financing (per annum)	8%
Taxes	7%
Profit	5%

Scenario # 1 - Class C (cellar) to Class B (conventional)

The results of the assessments for Scenario #1 are presented in Table 21. It should be noted that only the tangible costs and benefits are presented in Table 21, and the non-tangible benefits are further discussed within this part of the report.

From the builder perspective, the carrying cost associated with construction financing, whether through the builder's own funds or a financial institution, represents a cost to be minimized. In this first packaged system scenario, the sensitivity of time to sale is examined. It is assumed that by offering a Class B basement instead of a Class C basement, a house being built on speculation may sell as much as one month earlier. The additional investment in the cost of the basement upgrade is compared to the reduction in interest charges on a construction loan. It has been assumed that the basement is being upgraded at the tail end of the construction process when the construction financing has reached a level of $60,000. The analysis indicates that the return on this investment is 21% under these circumstances. If the builder can find a better return on this investment, then the Class B basement upgrade is not cost effective.

Turning to the consumer perspective, a simple payback calculation indicates that for a dwelling heated with natural gas, the payback period for the additional investment in the Class B basement upgrade is 2.8 years. This information, if made available to the prospective homebuyer could bolster the marketability of the builder's home featuring this upgrade. The basement would also be warmer and less susceptible to condensation in the above grade portions of the walls during winter.

From a societal perspective, the long term cost effectiveness of the Class B basement upgrade is preferable to the life cycle cost associated with the uninsulated basement. The Class B basement not only has a life cycle cost which is $2,216 lower than the Class C basement, but also contributes to lower greenhouse gas emissions.

Scenario # 1 - Class C (cellar) to Class B (conventional)

Builder Perspective

A builder may construct a Class C (cellar) basement, but wants to determine if it is more cost effective to upgrade its quality to a Class B (conventional) system.

Builder Cost of Class C Basement	$6,920
Builder Cost of Class B Basement	$7,250
Difference	$330

Several factors may be considered by the builder:

1) Can the $330 difference provide a better rate of return in an alternative investment?

2) Does a Class B basement make the home more marketable (i.e., sell faster)?

3) Does the Class B basement perform better than the Class C basement?

The answer to these questions will depend on the nature of the builder (e.g., small custom versus large tract) and the types of basement systems offered in the local housing market.
Assume a builder carries $60,000 construction financing per year for every home under construction.
The monthly carrying charges must be weighed against the time the house remains on the market.
Assuming the house with the Class B basement sells 1 month earlier than the house with the Class C basement:

Cost of basement upgrade	-$330
Savings in construction financing	400
Internal Rate of Return	21%

Consumer Perspective

A consumer who is considering the upgrade wants to know what the payback will be on the added cost to the house. Assuming 12% mark-up for taxes and profit, the

Class B basement system upgrade costs =	$369.60
Annual energy savings =	$132.00
Payback period on upgrade =	2.8 years

Societal Perspective

From a societal perspective, a housing agency wishes to determine if over the long term it is better to require a Class C or a Class B basement system.

Life Cycle Cost of Class C Basement	$12,942.00
Life Cycle Cost of Class B Basement	$10,726.00
Net Present Value of Class B Basement Benefits	$2,216

Over the 30 year study period, the consumer living in the house with the Class B basement would have $2,216 more disposable income than a person with a Class C basement.

Table 21. Scenario #1 - Class C to Class B basement system upgrade - Toronto.

Scenario # 2 - Class B (conventional) to Class A-3 (near liveable)

The results of the assessments for Scenario #2 are presented in Table 22. Again, three economic perspectives are considered in the assessments.

As in Scenario #1, the carrying cost associated with construction financing, whether through the builder's own funds or a financial institution, represents a cost to be minimized. In this second packaged system scenario, the sensitivity of the annual number of projected house sales is examined. It is assumed that by offering a Class A-3 basement instead of a Class B basement, the builder may sell 25 units a year instead of 24. The reduced cost of callbacks due to the provision of a drainage layer is also a consideration. The additional investment in the cost of the basement upgrade takes place at the end of the construction process prior to closing, hence it is assumed that one month's interest on the cost of the basement is added to the difference in cost between the Class B and Class A-3 basement systems. The avoided cost due to callbacks for water leakage has been assumed to average $200 per house over 24 units constructed with Class B basements. The analysis indicates that the return on this investment is 21% for a single house, 41% over the 25 homes, and 59% when the avoided costs of water leakage callbacks are considered. If the builder can find a better return on this investment, then the Class A-3 basement upgrade is not cost effective. It should be noted that even when the builder sells only 24 homes with Class A-3 basements, the rate of return remains at 41% due to the consumer subsidy of avoided water leakage callbacks. In effect, the purchaser is paying for an upgrade which saves the builder money during the normal warranty period.

From the consumer perspective, a simple payback calculation indicates that for a dwelling heated with natural gas, the payback period for the additional investment in the Class A-3 basement over a Class B basement is 7.2 years. This assumes that the homeowner can recover 80% of the upgrade value (present worth) at the time of resale. (As noted earlier in this study, the use of a small basement which is deep in the ground tends to conservatively estimate the cost effectiveness of thermal insulation upgrades. Also, the payback measure is misleading because the cost of moisture protection, which has no direct thermal contribution, is being factored into the payback analysis). A near liveable basement represents a cost effective alternative to an above-grade addition, and is sufficiently comfortable to permit its use as a play and/or hobby area. Based on current mortgage rates, the upgrade translates into less than a $10 higher monthly payment. It is interesting to note that based on the survey of builders conducted within this study, virtually all of their basements were insulated full-height in response to market demand.

From a societal perspective, the long term cost effectiveness of the Class A-3 basement upgrade is dependent on the cost of energy and the resale value adjustment. For houses heated with natural gas, the Class A-3 basement represents a $326 lower cost over its Class B counterpart. In electrically heated houses, it is $1,619 less costly. The Class A-3 basement is the lowest contributor of greenhouse gas emissions among the three basement classes, as are all of the Class A basements.

Scenario # 2 - Class B (conventional) to Class A-3 (near liveable)

Builder Perspective

A builder may construct a Class B (conventional) basement, but wants to determine if it is more cost effective to upgrade its quality to a Class A-3 (near-liveable) system.

Builder Cost of Class B Basement	$7,250
Builder Cost of Class A-3 Basement	$8,275
Difference	$1,025

Several factors may be considered by the builder:
1) Can the $1025 difference provide a better rate of return in an alternative investment?
2) Does a Class A-3 basement make the home more marketable (i.e., sell faster)?
3) Does the Class A-3 basement perform better than the Class B basement?
The answer to these questions will depend on the nature of the builder (e.g., small custom versus large tract) and the types of basement systems offered in the local housing market.

Assume the builder carries construction financing for every home under construction. The monthly carrying charges must be weighed against the time the house remains on the market, and the number of potential sales. Later, the cost of defects must also be considered during the warranty period.

Assumed annual sales for homes with Class A-3 basements =			25
Assumed annual sales for homes with Class B basements =			24
Assumed sale price of home with Class B basement =			$80,000.00
Assumed profit for home with Class B basement =			$5,000.00
Assumed sale price of home with Class A-3 basement =			$81,250.00
Assumed profit for home with Class A-3 basement =			$5,225.00
Avoided cost of water leakage defects per house =			$200.00
	Each	Total	Defects
Cost of basement upgrade + financing	-$1,031.83	-$25,795.83	-$25,795.83
Revenue (cost + profit)	$1,250.00	$36,250.00	$41,050.00
Internal Rate of Return	21%	41%	59%

Consumer Perspective

A consumer who is considering the upgrade wants to know what the payback will be on the added cost to the house. Assuming 12% mark-up for taxes and profit, the

Class A-3 basement system upgrade costs =	$1,148.00
Upgrade resale value	$918.40
Annual energy savings =	$32.00
Payback period on upgrade =	7.2 years

Societal Perspective

From a societal perspective, a housing agency wishes to determine if over the long term if it is better to require a Class A-3 or a Class B basement system?

	Gas (80%)	Elec (100%)
Life Cycle Cost of Class B Basement	$10,165.00	$14,882.00
Life Cycle Cost of Class A-3 Basement	$10,757.00	$14,181.00
Upgrade Resale Value Adjustment	$918.40	$918.40
Net Present Value of Class A-3 Basement Benefits	$326	$1,619

Over the 30 year study period, the consumer living in the house with the Class A-3 basement and natural gas heating, would have $326 more disposable income than a person with a Class B basement.

Over the 30 year study period, the consumer living in the house with the Class A-3 basement and electric heating, would have $1,619 more disposable income than a person with a Class B basement.

Table 22. Scenario #2 - Class B to Class A-3 basement system upgrade - Toronto.

Scenario # 3 - Class B (conventional) to Class A-2 (liveable)

Economic assessments associated with Scenario #3 are presented in Table 23. Scenario #3 examines a case where a conventional basement is being compared to a basement which is insulated full-height and one third of the floor area is completely finished and liveable (e.g., extra bedroom, den, recreation room, etc.).

Similar to the previous scenario, the sensitivity of the number of prospective sales is being assessed against the carrying costs of the additional investment and the reduction in water leakage callbacks. However, the difference in cost is significantly greater than the previous scenario due to the cost of basement finishing.

For each housing unit sold, the builder stands to earn a rate of return of 13% on the $4,414.23 additional investment (cost of upgrade + cost of financing). This is substantially greater than the rate of return for the house with the Class B basement ($5,000/$80,000 = 6.25%). The reason for this is that the upgrade and financing costs for the upgrade are not incurred until the end of the construction process. As well, builders reported that upgrades may usually be priced at higher margins without jeopardizing the competitiveness of the base model price in the new home market. Therefore, fully finished basements tend to be sold at a premium and carried at less cost than all of the construction performed prior to the finishing of the basement. It was also noted during telephone interviews that when construction activities are extremely high, and the availability of sub-contractors to complete construction to meet closing dates is low, then extras such as finished basements are discouraged with excessive premiums in order to avoid additional workload. Benefits to the builder due to increased sales potential and reduction in defects are similar to those in the previous scenario.

Looking at the consumer perspective, and erroneously factoring in the entire cost of the finished basement, the payback period due to energy savings for this upgrade is about 31 years (the actual payback on the additional thermal insulation associated with going from Class B to any Class A basement is in the order of 5 to 10 years). Another way to view this investment in a finished basement, however, is to examine its comparative value to a living space of comparable utility. For example, based on current mortgage rates, the monthly payment premium for the finished basement is under $50. If the household contains a college or university student seeking more private accommodation, then it is unlikely a residence or shared accommodation could be purchased for less than the monthly mortgage premium. This relationship may be extended to include liveable spaces such as home offices.

From a societal perspective, taking capital and operating energy costs along with resale value into consideration, the Class A-2 basement is only slightly less cost effective than the Class B basement when heated with natural gas. When electricity is used for space heating, the Class A-2 basement is more cost effective than the Class B basement. When all fuel types are considered, and the higher resale price of a home with a finished basement is taken into account, the liveable basement represents no significant additional cost to society. To determine the true cost effectiveness of liveable basements, additional factors such as infrastructure savings due to intensification and lower greenhouse gas emissions due to decreased demand on personal transportation would have to be carefully considered.

Scenario # 3 - Class B (conventional) to Class A-2 (liveable)

Builder Perspective

A builder may construct a Class B (conventional) basement, but wants to determine
if it is more cost effective to upgrade its quality to a Class A-2 (near-liveable) system.

Builder Cost of Class B Basement	$7,250
Builder Cost of Class A-2 Basement	$11,635
Difference	$4,385

Several factors may be considered by the builder:
1) Can the $4385 difference provide a better rate of return in an alternative investment?
2) Does a Class A-2 basement make the home more marketable (i.e., sell faster)?
3) Does the Class A-2 basement perform better than the Class B basement?
The answer to these questions will depend on the nature of the builder (e.g., small custom versus large tract) and the types of basement systems offered in the local housing market.

Assume the builder carries construction financing for every home under construction.
The monthly carrying charges must be weighed against the time
the house remains on the market, and the number of potential sales.
Later, the cost of defects must also be considered during the warranty period.

Assumed annual sales for homes with Class A-2 basements =	25
Assumed annual sales for homes with Class B basements =	24
Assumed sale price of home with Class B basement =	$80,000.00
Assumed profit for home with Class B basement =	$5,000.00
Assumed sale price of home with Class A-2 basement =	$85,000.00
Assumed profit for home with Class A-2 basement =	$5,615.00
Avoided cost of water leakage defects per house =	$200.00

	Each	Total	Defects
Cost of basement upgrade + financing	-$4,414.23	-$110,355.83	-$110,355.83
Revenue (cost + profit)	$5,000.00	$130,000.00	$134,800.00
Internal Rate of Return	13%	18%	22%

Consumer Perspective

A consumer who is considering the upgrade wants to know what the payback will be
on the added cost to the house. Assuming 12% mark-up for taxes and profit, the

Class A-3 basement system upgrade costs =	$4,911.20
Upgrade resale value	$3928.96
Annual energy savings =	$28.00
Payback period on upgrade =	30.7 years

Societal Perspective

From a societal perspective, a housing agency wishes to determine if over the long term
if it is better to require a Class A-2 or a Class B basement system?

	Gas (80%)	Elec (100%)
Life Cycle Cost of Class B Basement	$10,165.00	$14,882.00
Life Cycle Cost of Class A-2 Basement	$14,520.00	$17,944.00
Upgrade Resale Value Adjustment	$3,928.96	$3,928.96
Net Present Value of Class A-2 Basement Benefits	-$426	$867

Over the 30 year study period, the consumer living in the house with the Class A-2 basement and natural gas heating, would have $426 less disposable income than a person with a Class B basement.
Over the 30 year study period, the consumer living in the house with the Class A-2 basement and electric heating, would have $867 more disposable income than a person with a Class B basement.

Table 23. Scenario #3 - Class B to Class A-2 basement system upgrade - Toronto.

Scenario # 4 - Class B (conventional) to Class A-1 (dwelling unit)

Economic assessments associated with Scenario #4 are presented in Table 24. Scenario #4 examines the case where a conventional basement is being compared to a basement which is insulated full-height and a completely separate dwelling unit.

Similar to the previous two scenarios, the sensitivity of the number of prospective sales is being assessed against the carrying costs of the additional investment and the reduction in water leakage callbacks. However, the difference in cost is significantly greater than the previous scenario due to the cost of constructing a separate dwelling unit in the basement.

For each housing unit sold, the builder stands to earn a rate of return of 5% on the $9,487.83 additional investment (cost of upgrade + cost of financing). This is less than the rate of return for the house with the Class B basement ($5,000/$80,000 = 6.25%). The reason for this is that the upgrade and financing costs for the upgrade are incurred throughout the construction process, and in this example, the builder does not wish to cross a given price threshold ($90,000). The increased number of projected sales was kept the same as in previous examples to examine the desirability of a builder offering this upgrade package to prospective buyers. It is observed that the rate of return after considering reductions in defects is only 10%, compared to 22% in the case of Class A-2 basements, and 59% for Class A-3 basement upgrades. In all cases the rate of return is higher than the 6.25% realized for the houses with Class B basements, however, this assumes that the upgrade generates 1 additional sale per year. If the normally projected number of homes was constructed (24), then the return on investment would drop to 5% without factoring for avoided defects, and rise to 8% after factoring for avoided defects. This relationship indicates that drainage layers provide significant benefits to builders which increase in relative importance as the cost of basement upgrades increase.

From the consumer perspective, the simple payback period due to energy savings for this upgrade is about 66 years (as mentioned earlier, the actual payback on the additional thermal insulation associated with going from Class B to any Class A basement is in the order of 5 to 10 years). Clearly, consumers do not upgrade their basements only to save energy. However, similar to the previous example, it is possible to examine the comparative value to a living space of comparable utility, and possibly income potential. Based on current mortgage rates, the monthly payment premium for the Class A-1 basement is $100. If the household was to rent the basement dwelling unit, the return on investment would likely be strongly positive, and render the housing more affordable.

From a societal perspective, taking capital and operating energy costs along with resale value into consideration, the Class A-1 basement is the least cost effective of all basement classes. However, when a net monthly rental income of $400 is assumed for the basement dwelling unit, the life cycle cost becomes a life cycle saving (income) of $74,279. Separate basement dwelling units make housing more affordable because the homeowner can leverage the cost of the basement upgrade against rental income. To determine the true cost effectiveness of separate dwelling units in basements, income potential, tax implications and the additional factors mentioned for Class A-2 basements would have to be fully considered.

Scenario # 4 - Class B (conventional) to Class A-1 (dwelling unit)

Builder Perspective

A builder may construct a Class B (conventional) basement, but wants to determine if it is more cost effective to upgrade its quality to a Class A-1 (dwelling unit) system.

Builder Cost of Class B Basement	$7,250
Builder Cost of Class A-1 Basement	$16,675
Difference	$9,425

Several factors may be considered by the builder:
1) Can the $9425 difference provide a better rate of return in an alternative investment?
2) Does a Class A-1 basement make the home more marketable (i.e., sell faster)?
3) Does the Class A-1 basement perform better than the Class B basement?
The answer to these questions will depend on the nature of the builder (e.g., small custom versus large tract) and the types of basement systems offered in the local housing market.

Assume the builder carries construction financing for every home under construction. The monthly carrying charges must be weighed against the time the house remains on the market, and the number of potential sales. Later, the cost of defects must also be considered during the warranty period.

Assumed annual sales for homes with Class A-2 basements =	25
Assumed annual sales for homes with Class B basements =	24
Assumed sale price of home with Class B basement =	$80,000.00
Assumed profit for home with Class B basement =	$5,000.00
Assumed sale price of home with Class A-1 basement =	$90,000.00
Assumed profit for home with Class A-1 basement =	$5,575.00
Avoided cost of water leakage defects per house =	$200.00

	Each	Total	Defects
Cost of basement upgrade + financing	-$9,487.83	-$237,195.83	-$237,195.83
Revenue (cost + profit)	$10,000.00	$255,000.00	$259,800.00
Internal Rate of Return	5%	8%	10%

Consumer Perspective

A consumer who is considering the upgrade wants to know what the payback will be on the added cost to the house. Assuming 12% mark-up for taxes and profit, the

Class A-1 basement system upgrade costs =	$10,556.00
Resale value adjustment	$8,444.80
Annual energy savings (gas - 80%) =	$32.00
Payback period on upgrade =	66.0 years

Societal Perspective

From a societal perspective, a housing agency wishes to determine if over the long term if it is better to require a Class A-1 or a Class B basement system?

	Gas (80%)	Elec (100%)
Life Cycle Cost of Class B Basement	$10,165.00	$14,882.00
Life Cycle Cost of Class A-1 Basement	$20,165.00	$23,590.00
Upgrade Resale Value Adjustment	$8,444.80	$8,444.80
Net Present Value of Class A-1 Basement Benefits	-$1,555	-$263

Assuming no rental savings or avoided costs for the basement dwelling unit:

Over the 30 year study period, the consumer living in the house with the Class A-1 basement and natural gas heating, would have $1,555 less disposable income than a person with a Class B basement.

Over the 30 year study period, the consumer living in the house with the Class A-1 basement and electric heating, would have $263 less disposable income than a person with a Class B basement.

Table 24. Scenario #4 - Class B to Class A-1 basement system upgrade - Toronto.

MATERIAL, COMPONENT AND SUB-SYSTEM ASSESSMENTS

Based on the earlier discussion of issues in the last section of Part 3, it was only possible to consider Scenario #5 under the Material, Component and Sub-System Assessments. The results are presented in Table 25.

Scenario #5 - Engineered Foundation Drainage Systems

During interviews with builders, it was reported that engineered foundation drainage systems are required by some municipalities, such as Mississauga, Ontario, to deal with silty soils that tend to plug conventional foundation drainage systems. It was further reported that in the case of Mississauga, the building department retained an engineering firm to prepare specifications which formed part of a building by-law governing problem soil areas. The systems typically consist of smooth-walled plastic drainage piping with a minimum 2% grade, and geotextile fabric laid over the piping to filter out fine particles. Builders participating in the survey were asked to price such a system, however, only 2 builders were able to obtain prices from their sub-contractors for this item. For the study model basement, the averaged cost of an engineered foundation drainage system was $875, representing a $498 premium over the estimated cost of a conventional system.

From the builder perspective, the cost of callbacks during the warranty period and the potential loss of reputation are critical concerns. In this scenario, it has been assumed 1 in 10 conventional foundation drainage systems become plugged and require complete replacement within the warranty period. It costs the builder $501.32 to install and finance the engineered foundation drainage system, and is sold to the consumer at a 4% profit. Assuming that all 30 houses require the upgraded system, the builder still only nets a 4% profit. However, when the avoided cost of defects is factored in, the return on investment is 44%. Clearly, the engineered foundation drainage systems, where required, are cost effective for the builder. Sensitivity analysis indicates that when only 1 in 30 foundation drainage systems fail, the return on investment for the engineered system is 18%. Further, if loss of reputation due to failed weeping tile systems and basement water damage reduces home sales by 10% per year, then the return on investment in the engineered system rises to 104% without consideration of defects, and to 117% when defects are taken into account. It should be noted that interactivity has been built into the electronic spreadsheet to examine these sensitivities.

From the consumer perspective, assuming the failed weeping tile system is replaced by the builder during the warranty period, the deductible portion of the home insurance claim is still normally borne by the consumer. The Insurance Bureau of Canada reported that the most common deductible amount is $500 per occurrence. The consumer must attempt to decide whether the investment in the engineered foundation drainage system is cost effective, bearing in mind the 10% risk of failure, and also the risk of incurring the full cost of the foundation drainage system replacement following expiration of the warranty period. The payback is practically instantaneous if the house has a failed system, but much longer if the 10% risk is taken into account. Given these economic probabilities, it is obvious why some municipalities mandate this better practice rather than permitting the consumer or builder to elect the upgrade.

From a societal perspective, when the entire population of basements in this area are considered over a 30 year study period, the life cycle cost of the engineered foundation drainage system yields a positive result ($526.04) hence it is cost effective, and based on the underlying assumptions, supports mandatory requirements in areas with adverse soil conditions.

Scenario #5 - Engineered Foundation Drainage Systems

Builder Perspective

A builder is constructing homes in an area with fine silty soils. Based on local experience, it is found that about one-tenth of the foundation drainage systems (weeping tile) become plugged with silt and require replacement within the warranty period. The builder is considering the use of an engineered foundation drainage system.

Builder Cost of Conventional Foundation Drainage System	$377
Builder Cost of Engineered Foundation Drainage System	$875
Difference	$498
Cost of replacing defective foundation drainage system	$2,000

Several factors may be considered by the builder:
1) Does the cost of the upgraded drainage system offset the cost of repairing defective systems?
2) How do the drainage system defects affect reputation, and hence sales?

Assumed annual sales for homes =	30
Assumed annual sales of homes due to loss of reputation =	30
Number of drainage systems requiring replacement =	3
Assumed sale price of home with conventional system =	$80,000.00
Assumed profit for home with conventional system =	$5,000.00
Assumed sale price of home with engineered system =	$80,525.00
Assumed profit for home with Class A-3 basement =	$5,025.00
Avoided cost of drainage system defects per house =	$200.00

	Each	Total	Defects
Cost of system upgrade + financing	-$501.32	-$15,039.60	-$15,039.60
Additional Revenue (cost + profit)	$523.00	$15,690.00	$21,690.00
Internal Rate of Return	4%	4%	44%

Consumer Perspective

A prospective new home buyer is comparing between alternative foundation drainage systems offered by competing builders. Which one is more cost effective?

Cost of drainage system upgrade =	$557.76
Cost of deductible for water damage insurance claim =	$500.00
Payback period (assuming annual risk of water damage) =	1.12
Payback period (assuming 10% annual risk of water damage) =	11.16

Societal Perspective

From a societal perspective, a municipality wishes to determine whether or not to pass a by-law governing foundation drainage systems for localities within its jurisdiction which possess adverse soil conditions. A life cycle analysis is performed using the following parameters:

Interest	4%
Escalation	1%
Period	30

Frequency of drainage system failures =	10%
Frequency of drainage system failures after warranty period =	50%
Initial cost of drainage system upgrade =	-$557.76
Average annual avoided cost of water damage claims =	$50.00
Average avoided cost of drainage system replacement =	$100
Life cycle cost of improved foundation drainage system =	$526.04

Table 25. Scenario #5 - engineered foundation drainage systems.

BETTER PRACTICE ASSESSMENTS

Based on the earlier discussion of issues in the last section of Part 3, it was only possible to consider Scenario #6 under the Better Practice Assessments.

Scenario #6 - Consulting Engineering (structural failures)

In this scenario, data from *Survey to Characterize the Causes of 1994 and 1995 Foundation Failures in New Residential Construction*, Report No. 39604.00, July 1997, was used to assess the cost effectiveness of consulting engineering services with respect to problem soil and groundwater conditions. The results are presented in Table 26.

From a builder perspective, major structural failures average $11,776 to repair within the warranty period. The estimated cost of avoidance has been reported as $6,000 on average. When the builder encounters an unusual or problematic soil condition, three options are available: 1) to proceed with normal construction practices; 2) follow an engineered method of construction witnessed locally; or 3) retain an engineer to advise on, and possibly design a suitable foundation structure.

In the first case, it is assumed the builder is inclined to construct an overdesigned foundation. Given a typical cost of $300 for a site visit and cursory investigation by an experienced engineer, the return on investment in the engineering services is 1900% if the engineered foundation system is not required. In the second case, it is assumed the builder is ambivalent and seeks professional advice. If the engineered foundation is warranted, the return on investment is 96% assuming a major structural failure is avoided. In all cases, it is cost effective for the builder to retain engineering services when unusual or problematic soil conditions are encountered.

An economic assessment from a consumer perspective is difficult to model given the intrinsic value of human health and safety, and other variables such as warranty protection and quality of property insurance. It is likely the vast majority of consumers are severely adverse to a major structural failure in their dwelling, and most would elect to pay a reasonable price to avoid this situation rather than deal with fallout from such an event.

Societally, it is difficult to gauge the cost effectiveness of investments aimed at reducing the annual reported cost of $2 million for residential foundation structural failures.

Scenario #6 - Consulting Engineering (structural failures)

A recent survey of foundation failures in new residential construction (see NRC Report No. 39604.00) determined the following:

Cost per failure 1994 =	$10,849
Cost per failure 1995 =	$12,703
Average cost per failure =	$11,776
Estimated cost of avoidance =	$6,000

Key to the avoidance of structural failures was having an engineering assessment of the site conditions and foundation design performed.

Builder Perspective

A builder is planning to construct a house on a site with unusual soil conditions.
He wants to decide whether to proceed with normal construction practice,
or to follow an engineered method of construction used by another local builder,
or to retain an engineer for advice and possibly design services.
There are two considerations in this case:
1) Is the retaining of the engineer cost effective?; and
2) Is constructing the basement foundation according to the engineered design cost effective?

Estimated cost of engineering field review =	-$300
Estimated cost premium of engineered foundation =	$6,000
Rate of return on engineering assuming premium not required =	1900%
Estimated cost premium of engineered foundation =	-$6,000
Estimated cost of structural failure avoidance =	$11,776
Rate of return on engineered foundation =	96%

Consumer Perspective

The economic analysis from the consumer perspective is complex due to various assumptions regarding warranty protection and the quality of house insurance which the homeowner has purchased. Obviously, assuming the house is repaired and the cost of interim lodging, etc. is covered by the insurance, it is likely most homeowners would have elected to pay the higher price for the new home than suffer the disruptions associated with a major structural failure.

Societal Perspective

Based on the findings of the above noted study, a balanced preventative approach to structural failures in the form of builder and building official training is needed to reduce the average annual cost of $2,000,000 for structural failures in Canada.

Table 26. Scenario #6 - consulting engineering (structural failures).

SYNOPSIS

Based on the findings, several key relationships emerge from the assessments performed in this study.

1. From a builder perspective, it may be more profitable to construct Class A basements because the provision of an explicit drainage layer reduces the cost of callbacks and helps maintain an established reputation, and presumably sales. When avoided cost savings are combined with the additional profit generated by basement upgrading, Class A basements provide a significantly higher rate of return than Class C and Class B basement systems. However, to consistently achieve a higher rate of return, structural integrity and moisture/thermal protection measures must be systematically addressed to achieve levels of performance which are acceptable to consumers and society.

2. From the consumer perspective, upgrades to basements represent high marginal benefits because relatively small incremental premiums provide additional liveable space more cost effectively than other forms of building enlargements. In addition to realizing reasonable payback periods on thermal insulation upgrades, consumers enjoy improved thermal comfort while contributing positively to environmental conservation. However, to fully realize these benefits, the basement system must be stable, durable and free from moisture problems over its useful life.

3. From a societal perspective, structurally sound, moisture protected and thermally efficient basements represent significant life cycle benefits, a more efficient use of energy, land and infrastructure, and can increase the utility and/or affordability of housing. This relationship is premised on acceptable performance over the life cycle of the basement system.

4. Based on these observations, the need for and importance of research, development and technology transfer aimed at optimizing the cost and performance of residential basement systems and materials remains significant.

This study and the accompanying electronic spreadsheet file have been structured to enable ongoing cost/benefit assessments which consider changing construction, energy and financing costs associated with residential basements. The synopsis presented herein may have different outcomes when information specific to particular markets or individual builders is input to the assessment models. It may also be appropriate to consider future trends in the escalation rates of energy prices, an example of which was recently experienced at the gasoline pumps. Irrespective of the perspectives, assumptions and limitations, an accessible and transparent process for assessing the costs and benefits of basement technologies remains an essential component in selecting and constructing well performing, economically viable residential basements.

PART 5

RECOMMENDATIONS FOR *GUIDELINES* PUBLICATION

This final part of the study deals with its practical integration within the upcoming *Guidelines* publication. The most important recommendations have been compiled and presented first, followed by a discussion of the key messages to be conveyed within the economic assessment portion of the *Guidelines* publication.

1. For many readers, the complexities and details of economic assessments are difficult to comprehend, especially the concept of life cycle cost analysis. A simple means of explaining these concepts should be developed at the front end of the economic assessments presented in the *Guidelines* publication.

2. The spreadsheet format used to represent the assessments in this report is relatively terse and technical, and should be softened to better convey the message.

3. Comparative examples between regions of Canada should be included to illustrate the relationship between severity of climate and energy prices.

4. Specific references to materials or products should be avoided. Instead, thermal and moisture protection measures should be generically referenced (.e.g., drainage layer/membrane, full-height basement insulation, etc.).

5. Where possible, results of economic assessment should be presented graphically (e.g., pie charts, bar charts, etc.) and reinforced by translating these into monthly costs which may be compared with competing household expenditures.

6. A means of reconciling intangible benefits with capital investments must be clearly presented to enable informed decision making by all users of the *Guidelines* publication.

Incorporating these recommendations is important, however, in the process of preparing this report it was recognized that significant emphasis is needed to ensure that key messages which emerged during the *Guidelines* project are conveyed to readers of the publication. These are presented on the following page with the understanding that further suggestions are welcome from any interested parties.

KEY MESSAGES

1. The importance of foundation drainage and moisture management to proper basement system performance cannot be overestimated. It is not advisable to trade-off costs associated with moisture protection measures when specifying and constructing basements.

2. When constructing basements in unusual or adverse soil conditions, the reported costs of structural failures in basements clearly demonstrate it is cost effective to seek expert advice.

3. With few exceptions, there are no significant economic or physical performance differences between approved basement materials and products, provided they are appropriately selected, correctly specified and properly constructed (according to the process presented in the *Guidelines* publication).

4. Economic factors associated with basements are important, but consumers and society increasingly value health, comfort and utility. There exist numerous basement system options available to cost effectively achieve all objectives.

5. It is in everyone's economic interest to build well performing basements.

SUMMARY OF BASECALC™ ANALYSIS

Electronic data files containing simulations performed using BaseCalc™ accompany this study. The convention for assigning filenames is described in the chart depicted below.

BASEMENT CLASS PREFIX

- **A** - Full-height
- **B** - 2 ft below grade
- **C** - Uninsulated

BASEMENT SYSTEM OPTION

- **base** - base case basement system
- **exeps** - exterior expanded polystyrene
- **exfib** - exterior glass fibre or or mineral wool
- **exspx** - exterior extruded polystyrene or sprayed polyurethane foam
- **icf** - insulated concrete form
- **ineps** - interior expanded polystyrene
- **instd** - interior glass fibre, mineral wool, cellulose or sprayed polyurethane foam
- **inxps** - interior extruded polystyrene

CITY SUFFIX

- **TO** - Toronto
- **OT** - Ottawa
- **HA** - Halifax
- **ED** - Edmonton
- **VI** - Victoria

Example: **AexepsTO** Full-height,
exterior expanded polystyrene,
Toronto

Results from the simulations have been summarized in the table shown below. The annual space heating energy demand due to basement transmission losses is expressed in gigaJoules (GJ).

	Toronto	Ottawa	Halifax	Edmonton	Victoria
BaseCalc™ File	**TO**	**OT**	**HA**	**ED**	**VI**
Class **A**					
exeps	12.6	14.9	14.3	18.3	10.2
exfib	13.1	15.4	14.7	19.0	10.5
exspx	12.4	14.6	14.1	18.1	10.0
icf	7.7	9.3	9.1	11.6	6.5
ineps	10.8	12.8	12.1	15.8	8.8
instd	9.8	11.7	11.3	14.5	8.1
inxps	10.6	12.5	12.1	15.4	8.7
Class **B**					
ineps	14.1	17.7	16.0	20.3	11.4
instd	13.5	16.0	15.4	19.5	11.0
inxps	13.0	16.5	15.8	20.1	11.4
Class **C**					
base	28.6	33.3	31.3	39.7	22.2

Appendix A

Electronic Spreadsheet Files

Appendix B

Builder Survey

APPENDIX C

SUMMARY OF BASECALC™ ANALYSIS