ENVIRONMENT

Technological Innovation

ABSTRACT

Reclaiming inorganic industrial wastes is in keeping with the basic principles of waste management. The 4 R's of waste management are reduce (source reduction), reuse, recycle and reclaim (or recover), in that order.

Although reclaiming a residual material can be a complex undertaking, it may lead to lucrative commercial activities, since it involves taking an essentially worthless item and turning it into a product or a value-added material for which there is demand.

The approach devised by the Centre de transfert technologique en écologie industrielle (CTTÉI) and presented in this document consists of a decision-support tool that can help directors and environmental managers make informed decisions and more effectively plan, assess and carry out projects to reclaim a residual material.

WASTE MANAGEMENT

APPROACH FOR RECLAIMING INORGANIC INDUSTRIAL RESIDUAL MATERIALS

Photo: CTTÉI

HIGHLIGHTS

Overall approach

The methodology developed by CTTÉI:

- Guides and accelerates the decision-making process (analysis of environmental and economic benefits);
- Aims to put the residual material back onto a production line or create a new product;
- Aids in identifying suitable technical and scientific resources.

Characterization of industrial wastes

- Chemical composition, concentrations and structure of constituents;
- Physical characteristics (particle-size distribution, % moisture, etc.);
- Environmental suitability (leaching, toxicity, etc.).

Treatability testing

- Capacity of the residual material to undergo treatment;
- Validation at the laboratory scale and pilot scale;
- Commercial feasibility.

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CENTRE DE TRANSFERT TECHNOLOGIQUE EN ÉCOLOGIE INDUSTRIELLE
Centre G.-Édouard-Simard

CENTRE DE RECHERCHE EN ENVIRONNEMENT
UQAM SOREL-TRACY

OBJECTIVES OF PROJECT/ PHASES

The aim of this data sheet is to provide a decision-support tool and reference guide for industrial waste generators, consultants, research facilities and universities that deal with waste management and industrial ecology issues, and, more specifically, to promote the reclamation of such materials. The first 3 R's of waste management (reduction, reuse and recycling) should always be given priority. The reclamation approach that is outlined here comes into play after reduction, reuse and recycling have all been ruled out as potential options for adding value to the residual material of interest.

This document will:

- **Describe the industrial reclamation approach used by CTTÉI, setting out the key steps in informed decision making;**
- **List the reclamation expertise and facilities available in Quebec, at universities, research centres and government research institutes;**
- **Identify the legal issues arising in connection with reclamation-related activities such as transportation, storage, disposal, treatment and reclamation per se, so as to highlight the requirements and limitations associated with this type of undertaking.**

BACKGROUND

Residual materials management is an area that has generated a great deal of interest in recent years.
A number of organizations and private companies are now getting involved in managing and controlling such materials or raising awareness of their reclamation potential. This includes the Quebec Department of the Environment (Ministère de l'Environnement du Québec), Recyc-Québec, Collecte sélective Québec, Environment Canada, Natural Resources Canada, the Quebec network of Centres de formation en entreprise et récupération (waste recovery training centres) and the Ressourceries du Québec network. However, there is no tool available at present to help industries and decision-makers identify avenues for reclaiming residual materials arising in the manufacturing process, except perhaps guidelines for certain non-hazardous inorganic materials (Guide de valorisation des matières résiduelles inorganiques non dangereuses de source industrielle comme matériau de construction, ministère de l'Environnement du Québec, Service des matières résiduelles, June 2002).

Reclaiming industrial wastes (mine tailings, steel manufacturing wastes, quarry wastes, aluminium smelter wastes, chemical industry wastes, commercial and institutional wastes, municipal waste, etc.) is a complex undertaking that involves studying many different facets, such as technical and scientific feasibility, management and treatment costs and financing, environmental protection, regulations, transportation, labour force, work organization, hygiene, health and marketing. It may be difficult for companies and stakeholders concerned with the reclamation of industrial by-products to identify and compile the necessary information. This document will provide a better grasp of the different issues involved in such projects and assist all those interested in locating the necessary expertise. A table listing various research facilities specializing in industrial by-product reclamation is appended.

Photos: CTTÉI, Melri, RECMIX and Suzanne Lachance

METHODOLOGY

Reclaiming an industrial residual material requires an evaluation protocol that addresses all of the aspects covered in this data sheet. The different stages in the fact-finding and decision-making process are illustrated in Figure 1.

Knowledge of the process in which the residual material arises, the associated monitoring efforts, the management methods applied and accurate characterization are key components of an effective reflection approach. After this stage is completed, a preliminary analysis can be made of problems that are likely to be encountered in the course of reclamation. Summarizing the data that have been compiled aids in identifying information gaps. A literature search can be carried out, as needed, and consulting the network of experts listed in the appendix may be essential for success.

Complementary characterization of the material destined for reclamation may be recommended after the data compilation stage. However, before it can be determined whether the potential exists for reclamation, it is important to characterize the solid material. A re-evaluation of the situation may make it necessary to modify the initial hypotheses or even the reclamation options selected at the outset.

This characterization will aid in determining the regulatory status of the residual material. Depending on whether the material is deemed to be hazardous or non-hazardous (within the meaning of the provincial Regulation respecting hazardous materials), various tools are available to support decision making. There are four existing reclamation guides that deal with non-hazardous materials. Table 1 lists the acts and regulations governing activities such as the transportation, storage, disposal, reclamation, management, treatment and recovery of residual materials, all of which may influence the feasibility of a reclamation operation.

Upon completion of this stage, it should be known whether the residual material can be used as is and whether reclamation is a feasible option. What remains to be determined is the treatment process or processes (treatment line) that will allow the material to be reclaimed in whole or in part. The treatment options will be tested in the laboratory. Laboratory testing is done to test the hypotheses and reduce the scientific and technical uncertainty surrounding the targeted results or the methods that will be used during the pilot phase. The results of these tests will provide enough information to decide whether to make adjustments during the project development stage or whether to halt the undertaking. The financial situation of the project is crucial at this stage.

During the pilot phase, concrete data are obtained that can be used to scale up the process for the treatment line.

The last phase consists in transferring the technology to clients who will use it. Knowledge transfer can be achieved through various approaches, such as providing a theoretical and practical course.

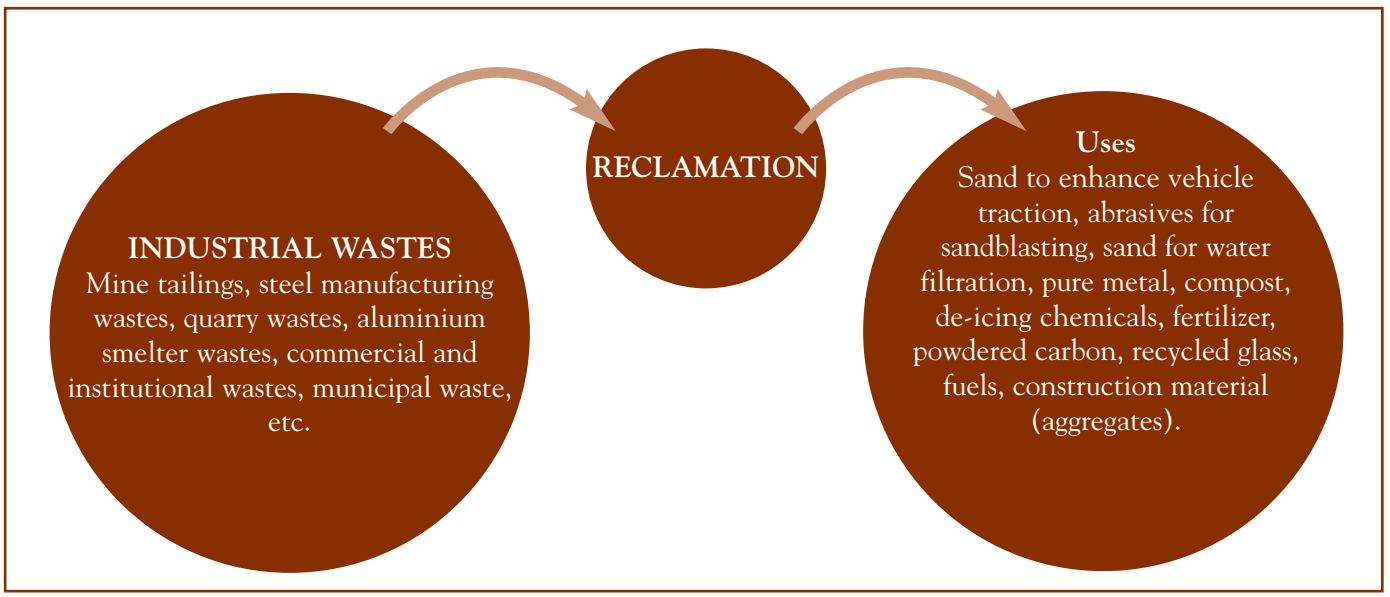
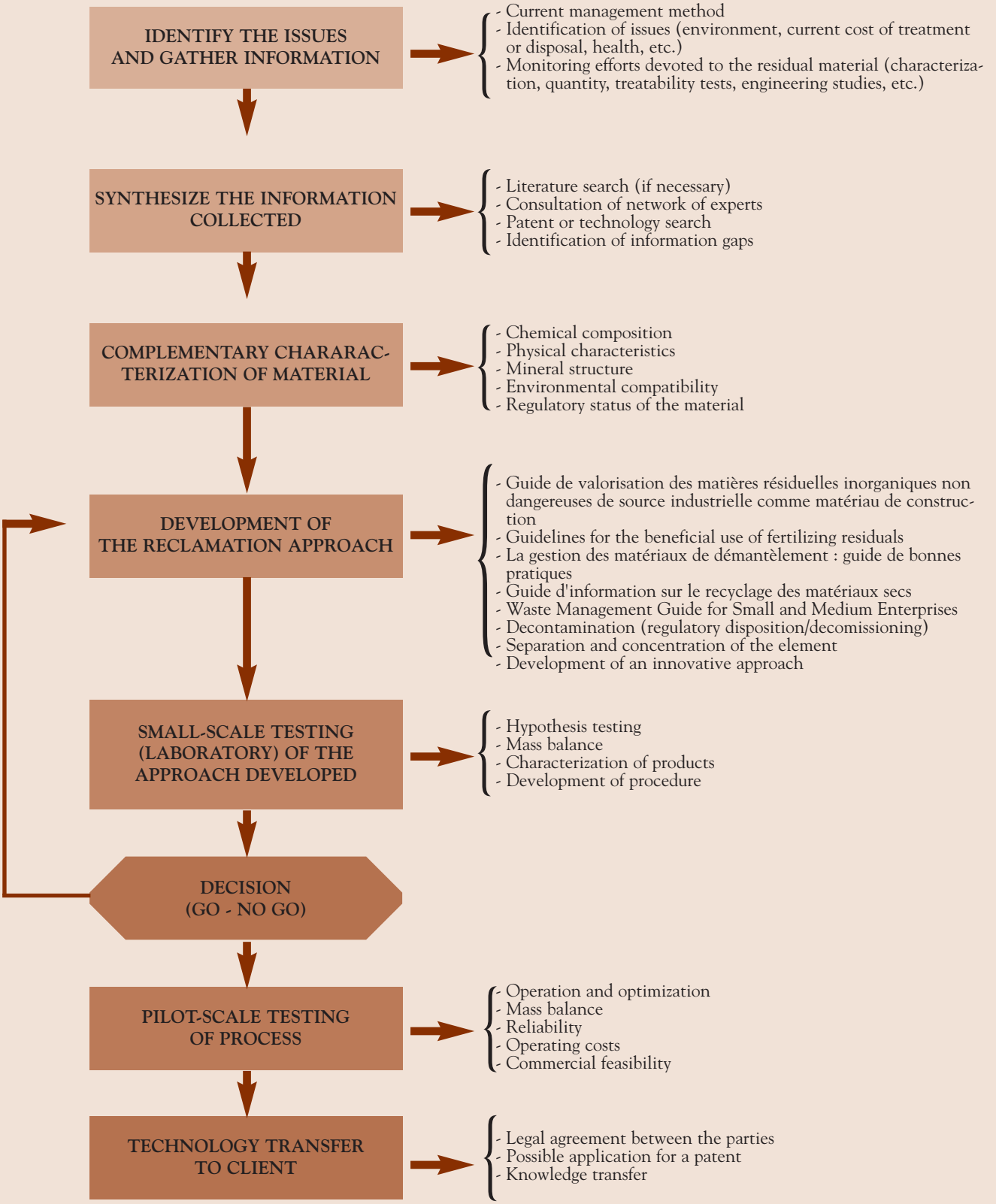


FIGURE 1: RECLAMATION APPROACH OF A RESIDUAL MATERIAL AT THE CTTÉI



REGULATORY FRAMEWORK

Residual material*
Any residue resulting from a production, treatment or utilization process and any substance, material or product or, more generally, any object that is discarded or that the holder intends to discard.

Hazardous material*
A material which, by reason of its properties, is a hazard to health or to the environment and which is explosive, gaseous, flammable, poisonous, radioactive, corrosive, oxidizing or leachable.

*Source: Quebec's Environment Quality Act

TABLE 1: ACTS, REGULATIONS AND GOVERNMENT GUIDES DEALING WITH INORGANIC RESIDUAL MATERIALS

Activities	Acts, regulations and Guides	General Description
TRANSPORT	Transportation of Dangerous Goods Act, 1992	Deals with signage, safety requirements, means of containment and emergency response plans.
	Regulation respecting hazardous materials (provincial)	Requirement to entrust the shipment of hazardous materials to a carrier holding a permit.
	Transportation of Dangerous Substances Regulation (provincial)	Covers most aspects of transportation.
STORAGE	Environment Quality Act (section 70.9) (Quebec)	A permit is required to store hazardous materials received from a third party.
	Regulation respecting hazardous materials. (Chapter IV) (provincial)	Deals specifically with the storage of residual hazardous materials.
DISPOSAL	Environment Quality Act (Quebec)	Division VII covers aspects related to the disposal of residual materials (management plan, site operating standards).
	Regulation respecting solid waste (Quebec)	Deals specifically with the management and operation of disposal sites (definitions, recovery, composting, certificate of authorization, financial guarantees).
	Regulation respecting hazardous materials (provincial)	Section 5 defines "hazardous materials disposal site". Chapter V sets out the provisions governing final disposal sites.
RECLAMATION	Environment Quality Act (Quebec)	In section 53.1, the term "reclamation" is defined. Division VII focuses on reclamation of residual materials.
	Regulation respecting hazardous materials (provincial)	Chapter 3 sets out the provisions related to the use of hazardous materials as an energy source.
	Guide de valorisation des matières résiduelles inorganiques non dangereuses de source industrielle comme matériau de construction (provincial)	Based on an exhaustive characterization of residual materials, this guide is designed to promote and facilitate the reclamation of residual materials.
	Guidelines for the beneficial use of fertilizing residuals (FR) (provincial)	Used to determine whether an FR reclamation activity is subject to a certificate of authorization, and sets out the applicable criteria and standards.
MANAGEMENT OF RESIDUE MATERIALS	Environment Quality Act (Quebec)	A register must be kept of hazardous materials. Requirement to submit an annual management plan for hazardous materials.
	Regulation respecting hazardous materials (provincial)	Defines the contents of the annual report.
	Environment Quality Act (section 53.4) (Quebec)	Introduction of the Quebec policy on residual materials management.
	Québec Residual Materials Management Policy	Sets out the government's policy on the management of residual materials.
	La gestion des matériaux de démantèlement : guide de bonnes pratiques (best practices guide) (provincial)	The aim of this guide is to promote appropriate management of these materials so as to minimize associated environmental effects.
TREATMENT	Waste Management Guide for Small and Medium Enterprises (federal and provincial)	Designed to assist managers of SMEs in developing and implementing a customized waste management program.
	Environment Quality Act (Quebec)	A permit or certificate of authorization is required to treat hazardous materials, pursuant to section 70.9(2).
RECOVERY	Regulation respecting solid waste (provincial)	Governs most of the aspects related to the recovery of mixed wastes.

POTENTIAL AND LIMITATIONS

Potential

- Substitution for raw materials;
- Optimal use of non-renewable materials;
- Value added to resources;
- Reduction of environmental impacts;
- Possible start-up of a company specializing in waste treatment and reclamation;
- Savings for the waste generator;
- Energy savings;
- Reduction in greenhouse gas emissions.

Limitations

Most residual materials or wastes have some valuable constituents, but these constituents are often contaminated with undesirable elements, constraining their use. The feasibility of reclamation depends on how difficult it is to separate out the valuable constituents.

Reclamation of an industrial residual material can be envisaged where:

- A financial advantage exists in relation to the current management situation;
- There are problems associated with current management of the material;
- The reclamation technology is available and affordable;
- The product derived from the reclamation process complies with the applicable regulations;
- There is an economically viable market for the product.

INFORMATION

This data sheet has been prepared through a literature search and is based on the expertise and research work of the Centre de transfert technologique en écologie industrielle (CTTÉI) and the Centre de recherche en environnement UQAM/Sorel-Tracy. The project was funded entirely by Environment Canada.

For more information, please contact:

Centre de transfert technologique en écologie industrielle
Centre J.-É.-Simard
Hélène Gignac, M.Sc.,
Executive Director
Tel.: (450) 742-6651
ext. 5301
E-mail:
helene.gignac@cegep-sorel-tracy.qc.ca
Web site : www.cttei.qc.ca

Environment Canada Innovation, Monitoring and Industrial Sectors
Jean-René Michaud, Eng., M.Sc.A.
Tel.: (514) 283-9207
E-mail:
jean-rene.michaud@ec.gc.ca

ENVIRONMENT
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Technological Innovation Data Sheets, produced by Environment Canada, are intended for all firms, industries, organizations and individuals interested in new environmental technologies. Their purpose is to disseminate the results of technology development and demonstration projects carried out in the following sectors: wastewater, atmospheric emissions, contaminated soil, waste management, hazardous waste, agri-environment and innovative tools and processes. Data sheets can be obtained from:

Environment Canada
Innovation, Monitoring and Industrial Sectors
105 rue McGill, 4th Floor
Montreal, Quebec H2Y 2E7
Tel.: 1 800 463-4311

Publications are available on the Environment Canada Web site in the "Publications" section:
http://www.qc.ec.gc.ca/dpe

Production:
Julie Leduc

Writing Team:
Martin Girard
Jacques Giguère
Patrick Desjardins

Reviewers:
Jean-René Michaud
France Guay
Suzanne Brunelle

Graphic Design:
Lacroix O'Connor Lacroix

Printing:
Les imprimeries IntraMédia

Cat. No.: En153-113/59-2005E
ISSN: 1712-0209
ISBN: 0-662-39930-7

March 2005

Cette fiche est également disponible en français sous le titre : Approche de valorisation des matières résiduelles inorganiques industrielles.

Canada

Appendix: Summary of areas of expertise in Quebec

Name	Areas of Expertise	Facilities/Equipment	Examples of Projects/Application
Centre of Chemical Process Studies of Quebec (CEPROCQ) www.ceprocq.com	. Surface treatment technologies . Bioindustrial technologies . Environmental technologies . Training in industrial automation	. Process simulation laboratory . Chemistry laboratory (bench scale and analytical chemistry) . Health and safety room for manipulating products	. Optimization of production, catalysis, reagents . Effluent and odour treatment
Centre intégré de fonderie et de métallurgie (CIFM) www.cifm.qc.ca	. Development and optimization of metallic materials . Development and optimization of metallurgical processes	. Furnaces for thermal treatment of steel and aluminium . Carburizing, nitriding, annealing, hardening and tempering furnaces	. Recycling of scrap aluminium . Carburizing treatment to produce non-toxic salts
Centre de transfert technologique en écologie industrielle (CTTÉI) www.cttei.qc.ca	. Refinement of value-added products through the reclamation of industrial wastes . Characterization of residual materials . Support to ensure regulatory compliance	. Chemistry and health and safety laboratory . Soil, sediment, liquid and gas sampling equipment . Equipment for carrying out leaching tests using EPA Method 1311 TCLP	. Production of calcium acetate and magnesium acetate from steelmill slag. . Evaluation of technical performance, environmental and industrial hygiene characteristics of an abrasive (Sorelmix) used for sandblasting
Centre de technologie minérale et de plasturgie inc. (CTMP) www.ctmp.ca	. Purification of mineral substances . Crushing, grinding and screening . Recycling of mine tailings	. Grinder . Crusher . Pulverizer . Screener	. Ore processing . Asbestos fibre treatment
Centre national en électrochimie et en technologies environnementales (CNETE) www.cnete.qc.ca	. Zero effluent concept . Reclamation of organic compounds through fermentation	. Ozone generator . Solid-liquid separator . Membranes . Settling tanks/filters.	. Conversion of shrimp waste into a value-added product . Effluent treatment . Electrochemistry
Centre de recherche en environnement UQÀM–Sorel-Tracy (CREUST) www.cttei.qc.ca	. Characterization of fine and ultrafine residues	. Capillary porosity, specific surface area and chemisorption . Thermo-gravimetric analysis and differential thermal analysis . Zeta potential and electrokinetic amplitude . Gas ultrapycnometer for solids and powders . Particle size analyzer (Matec APS-100)	. Production of pigment-based paint from carbon steel dust . Treatment of contaminated sediments . Bioavailability of metals
Department of Chemical Engineering Université de Sherbrooke www.usherbrooke.ca/gchimique/personnel/profs/soucy	. Industrial application of plasma technologies	. Arc torches . Arc furnace, plasma arc furnace, oxyfuel furnace, oxygas furnace . Induction heating . Comprehensive analytical laboratory	. Reclamation or destruction of solid, liquid and gaseous wastes . Synthesis of ultrafine ceramic powders

Name	Areas of Expertise	Facilities/Equipment	Examples of Projects/Application
NSERC- Polytechnique-UQAT Environment and Mine Wastes Management Industrial Chair www.enviro-geremi.polymtl.ca	. Development of geo-environmental tools and techniques . Characterization of mine tailings and environmental impacts	. Leach columns . Triaxial cells for permeability testing and cells for oxygen diffusion and consumption testing . Tempe cells . Sedimentation and consolidation of treatment sludge and tailings . Mercury-pump porosimeter and scanning electron microscope	. Integrated management of wastes while the mine is in operation . Remediation of storage sites that generate acid leacheate after a mine is closed
NSERC Industrial Chair in Site Remediation and Management www.polymtl.ca	. Site conservation and rehabilitation . Fundamental knowledge of biotechnology applied to site remediation	. *In situ* and *ex situ* biofilters . Permeable reactive walls	. Development of simple and inexpensive biotechnology solutions for treating and containing organic pollutants and heavy metals in soils, contaminated residues and groundwater
INRS–Eau, Terre et Environnement www.inrs-ete.uquebec.ca	. Reclamation of organic materials, treatment of mine wastes . Statistical and numerical analysis methods, modelling, remote sensing and geomatics techniques applied to flows	. Atomic absorption spectrophotometer (flame and graphite furnace) . Inductively coupled plasma emission spectrophotometer (ICP) . UV-visible spectrophotometer . Scintillation counter . Gamma counter . Particle counter . Microscopes and image processing room Liquid, gas and ion-exchange chromatography . Organic and inorganic carbon analyser . NCS analyzer . Technicon-type autoanalyzers . Clean room	. Reclamation of municipal sludges . Decontamination, stabilization
INRS-Énergie www.inrs-ener.uquebec.ca	. Expertise in energy and in laser–material interactions	. Laser units	. Generation of extremely hot plasma
McGill Metals Processing Centre (MMPC) www.mmpc.mcgill.ca	. Optimization of metal processing	. Electric resistance furnace . Direct heat furnace . Metal quality analyzers . Characterization equipment	. Control of steel rolling . Monitoring of metal quality

Name	Areas of Expertise	Facilities/Equipment	Examples of Projects/Application
Centre de recherche industrielle du Québec (CRIQ) www.criq.qc.ca	. Expertise in biotechnology applications for the environment (water, air, soil)	. Preparatory HPLC . Chemical reactors . CO2 extractor . Tournaire extractor-evaporator . Vacuum reactor Extractor-pulverizer . Thermokinetic mixer	. Treatment of soils contaminated with heavy metals and phenols . Process control . Automation
CANMET Energy Techology Centre <www.cedrl.mets.nrcan.gc.ca>	. Reduction in greenhouse gas emissions . More sustainable use of energy . Enhancement of companies' ability to innovate	. Multi-purpose laboratories and facilities that can be used for various energy configurations	. Enhancement of the energy efficiency of processes and buildings
COREM, mineral research consortium www.corem.qc.ca	. Pre-competitive research in processing and transformation of mineral substances	. Grinder . Shredder . Static mixers . Drum filter and belt filter press . Fluidized bed with a magnetic field . Screen/reactor . Membrane with electric field . Electrolyzer . Settling tank . Solid-liquid separator . Incinerator . Disc filter	. Addition of coke in the iron pellet production process . Management of primary and secondary energy sources in iron pellet baking furnaces
Biotechnology Research Institute (BRI) www.bri.nrc.ca	. Development of bioprocesses . Biological treatment of soils, groundwater, sediments, air and contaminated industrial effluents	. Bioreactors of various sizes . Analytical equipment . Fractionation equipment	. Decontamination processes . Biotechnology application to separate and treat contaminants
Industrial Materials Institute (IMI) www.imi.nrc.ca	. R&D work focussing on materials, their composition/formulation, forming and related process control	. Formulation and forming equipment for metals and polymers	. Design related to the formulation and forming of metals
Laboratoire des technologies de l' énergie (LTE) www.hydroquebec.com	. Developing and promoting effective and innovative applications for electricity	. Static mixers . Membrane with electric field . Evaporator . Induction heating . Plasma arc furnace.	. Treatment of organic sludges by plasma-assisted oxidation, with ash recovery

Name	Areas of Expertise	Facilities/Equipment	Examples of Projects/Application
Observatoire de l' environnement et du développement durable in Sherbrooke (Theme 5: waste management) www.usherbrooke.ca/observatoire/recherche/axes.html	More than 20 professor/researchers with their high-calibre teams. . Reduction and reuse . Recycling of residual materials . Reclamation of industrial wastes and by-products	. All the leading-edge equipment needed for chemical and physical characterization, as well as micro - and nanostructural characterization of materials . Several research laboratories on campus	. Reclamation of industrial by-products (cement and concrete) Reclamation of deinking residues . Reclamation of organic polymers . Reclamation of red clays . Reclamation of urban wastes and biomass
Chaire de valorisation du verre dans les matériaux a.tagnit@usherbrooke.ca	. Reclamation of industrial by-products in cement and concrete . Physico-chemistry of cementitious systems . Development of new cementitious systems	. All the leading-edge equipment needed for chemical and physical characterization, as well as micro - and nanostructural characterization of materials . A very advanced cement and concrete laboratory	. Reclamation of glass contained in with concrete