RESEARCH REPORT

Assessing the Full Costs of Water, Liquid Waste, Energy and Solid Waste Infrastructure in the Fraser Valley Regional District

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Assessing the Full Costs of Water, Liquid Waste, Energy and Solid Waste Infrastructure in the Fraser Valley Regional District

Part 1: Accounting Methods, Issues of Concern and Benchmarks of Performance

Submitted to:
Research Division, CMHC
Planning Department, Fraser Valley Regional District
Growth Strategies Office, Ministry of Municipal Affairs

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and
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February 2000

Executive Summary: Assessing the Full Costs of Water, Liquid Waste, Energy and Solid Waste Infrastructure in the Fraser Valley Regional District

Brief:

This project was conducted for CMHC by The Sheltair Group Inc. in order to demonstrate the benefits of using full-cost accounting tools and techniques to evaluate the social, economic, and environmental costs and impacts of urban growth. Using the Fraser Valley Regional District (FVRD) in British Columbia as a case study, a two-part project was conducted. The project resulted in the development of a methodology and an associated software tool for compiling and analysing detailed infrastructure profiles, and then using these profiles to assess the full costs of different growth scenarios. The report is organised in two parts: Part 1 provides background information about the FVRD, and presents a methodology specific to the Regional District. Part 2 describes the development of the software tool, and presents results of our application to the FVRD.

Executive Summary:

In accordance with the BC Growth Strategies Act, the FVRD is currently drafting a Regional Growth Strategy. The Growth Strategy is intended to guide decisions on growth, change and development in the Valley over the next 25 years. It must deal with broad regional growth management issues such as air pollution, water quality, traffic congestion, affordable housing, employment, energy use, parks, and green space. Its purpose is to promote human settlement that is socially, economically and environmentally sustainable.

As part of the development of the FVRD Regional Growth Strategy, Part 1 of this project provides a framework for assessing and evaluating various growth options, with a focus on the impact on sustainability associated with different patterns of land development. Part 1 also provides information on the status of infrastructure in the Valley, including background information on the systems, their current capacity and location.

Part 1 of the project includes the development of a methodology that links the Regional District's goals and objectives for infrastructure and land use issue categories to a set of indicators for measuring and monitoring performance. Specifically, the following issue categories are addressed: Solid Waste, Water and Wastewater, Energy, Land Use and Roads and Infrastructure Costs. Each issue category is described in terms of its current status within the FVRD, the issues of greatest concern, and associated indicators of performance. The selected indicators are measured in terms of current performance, preferred performance, and performance associated with three different urban settlement patterns.

Part 2 of the project provides a software tool for monitoring and evaluating infrastructure costs and performance. Using ACCESS database software and a GIS application, the tool allows planners to compare indicators of performance at various spatial scales. A database is included that provides the essential information for analysing the FVRD infrastructure. Part 2 further refines the indicators of performance used in Part 1, such that they can be used within the tool for any regional planning purposes. Part 2 presents results for the FVRD in terms of water, wastewater and energy infrastructure.

Together, Parts 1 and 2 provide a foundation for a regional Environmental Management System (EMS). In general, an EMS provides a proactive approach for protecting and enhancing environmental quality. Rather than trying to mitigate environmental damage on a project by project basis, an EMS attempts to integrate environmental goals within the existing management structure.

Typically, an EMS includes a comprehensive set of policies and procedures that are intended to minimise negative impacts of resource use, and allow the organization to efficiently and effectively achieve goals for environmental performance. An EMS also makes it easy for an organisation to communicate its environmental performance, both internally and externally, as part of full cost accounting.

The basic elements of EMS include:

i. Goal statements (and a commitment to achieve the goals)
ii. An analysis of the potential environmental impacts related to company operations
iii. Creation of a set of indicators, or evaluation criteria, that can be used to assess performance, and to set measurable targets and triggers
iv. An action plan for meeting targets
v. A monitoring program for ensuring accountability.

Part 1 of this study clearly outlines the FVRD goals related to environmental performance and infrastructure. We used these goals to create a set of key indicators that can be measured over time and used to assess performance.

Part 2 puts in place a system that can be used for monitoring the performance of the FVRD, and ensuring accountability. The software tool provides a mechanism for efficiently collecting data, and calculating the key indicators of performance for the FVRD. As such, it represents an evaluation and monitoring system that can be used to provide planners and others with feedback on how well the FVRD is performing relative to the goals established by the board.

Design Features and Essential Outputs of the Tool

The tool consists of an ACCESS database and an ARCVIEW GIS file. This allows input and output data to be presented spatially, or as part of standard reporting formats. Key features of the database structure are described below.

Enumeration Areas

The database is broken down on a geographical basis, using Enumeration Areas (EAs). The FVRD currently is made up of 354 EAs. Their area varies considerably. The average population for an EA is approximately 1000 people – about as many people as a single census-taker can handle. The EAs represent a suitable building block for the database, since this is the structure for the census data. The areas and boundaries of the EAs are congruent with the municipal jurisdictions - for example, the municipality of Mission is made up of exactly 47 EAs.

Indicators

Since the EA is the lowest level of aggregation within the database, all indicators are reported at the EA level – or for any combination of EAs.

The tool addresses a core set of 29 different indicators, covering water, liquid waste and energy, along with a summary of statistics on the EA. Indicators measure the performance of collections of end uses, as opposed to every end use. For example, energy for lighting, appliances and motors has been summed together. This can be expanded as appropriate, by disaggregating each indicator into more specific terms. The focus of the analysis is on resource use, and the associated emissions and dollar costs. Indicators have been selected that address both resource demand and resource supply.

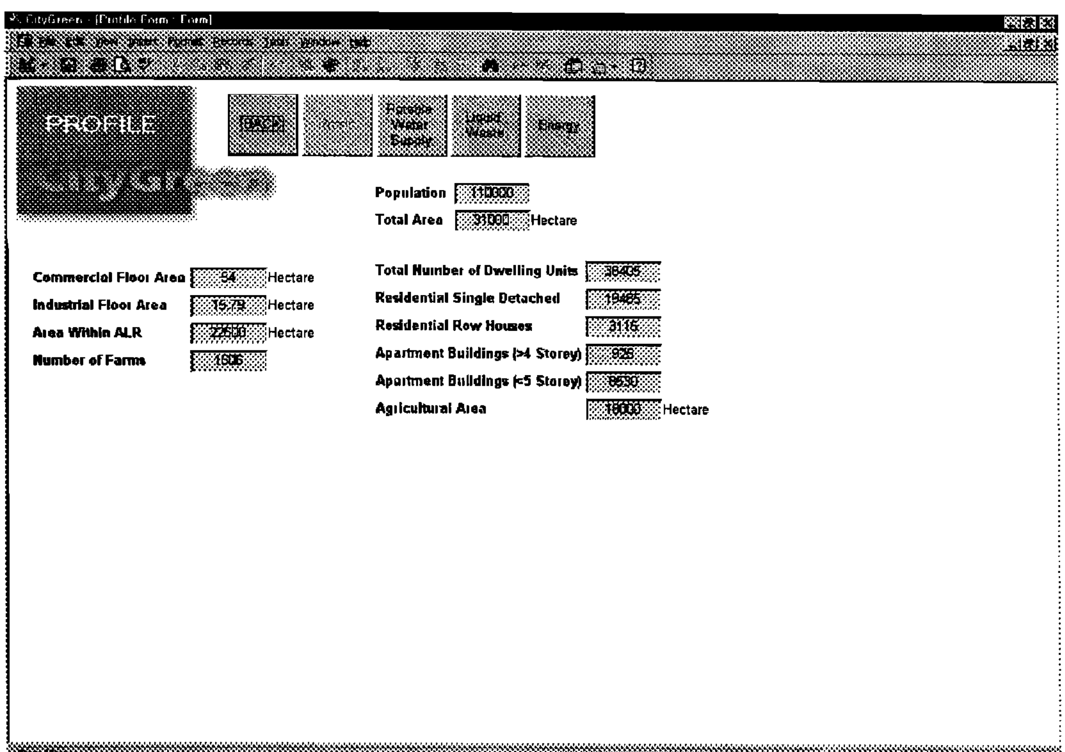
Indicators are calculated from a hybrid approach using bottom-up and top-down methods. Bottom up approaches use statistics on population, housing, agriculture, industry, land area, road and linear infrastructure lengths and widths, and so on. The bottom-up values are then modified as reasonable to ensure that the total resource flows and costs are consistent with any metered or measured resource flows. The database should be capable of increased accuracy, as more empirical data becomes available.

Indicators are calculated for the year in which the most current data is available. Initially no historical data is included. However if the database is regenerated each year, earlier years can be archived and used for year-to-year comparisons and trend analysis.

EA Statistics

The software tool includes an "EA Profile" report, to provide a more complete overview of the basic statistics on the EA. An example of this report is shown in Figure 1.

Figure 1 EA Profile



The sources of information for such an EA profile have been listed in Table 1.

Table 1 Sources of Information for Profiles

Contents of an EA Profile:	Sources of Data
♦ Population for EA	♦ Stats Canada Census
♦ Dwelling numbers and type.	♦ Stats Canada Census
♦ Sq. meters of commercial floor area by use-type	♦ Municipal statistics
♦ Agricultural area in Ha, by type	♦ Ministry of Agriculture, collected from Census of Agriculture
♦ Commercial floor area	♦ Estimated from ratios developed from one city in FVRD, and one rural area, using BCAA data.
♦ Number of Farms per EA	♦ Counted from polygons on the GIS map showing farm classifications and property lines

The report provides important information on the development of the database, the indicators, and the case study on the FVRD. However, the software is best appreciated when viewed as part of a computerised demonstration and presentation.

Résumé : Évaluation du coût global des infrastructures d'énergie, d'approvisionnement en eau et d'élimination des déchets solides et liquides dans le District régional de la vallée du Fraser

Aperçu

L'étude entreprise par The Sheltair Group Inc. pour le compte de la SCHL visait à démontrer les avantages résultant de l'utilisation des outils et des techniques de la comptabilisation du coût complet pour évaluer les répercussions et les coûts sociaux, économiques et environnementaux liés à la croissance urbaine. Cette étude de cas, menée en deux volets, a porté sur le District régional de la vallée du Fraser (DRVF), en Colombie-Britannique. Il en est ressorti une méthode et un logiciel correspondant qui permettent d'analyser et de compiler des profils détaillés d'infrastructures qui peuvent ensuite servir à évaluer l'incidence sur les coûts de différents scénarios de croissance. Le rapport dont il est ici question est organisé en deux parties : la partie 1 fournit des renseignements généraux relatifs au DRVF et présente par la suite une méthode particulière pour ce district régional tandis que la partie 2 décrit la mise au point de l'outil informatisé et donne les résultats de son application au DRVF.

Résumé

Aux termes des exigences du *BC Growth Strategies Act*, le DRVF prépare actuellement sa stratégie régionale de croissance, laquelle guidera les interventions relatives à la croissance, au changement et au développement dans la vallée du Fraser au cours des 25 prochaines années. Celle-ci doit tenir compte de la gestion des enjeux régionaux majeurs suivants : pollution de l'air, qualité de l'eau, bouchons de circulation, abordabilité de l'habitation, emploi, consommation d'énergie, parcs et espaces verts. La stratégie vise à promouvoir les établissements humains qui sont durables du point de vue socio-économique et environnemental.

Partie intégrante de l'élaboration de la stratégie régionale de croissance du DRVF, la partie 1 des travaux propose un cadre de travail qui permet d'évaluer différents scénarios de croissance et de mettre l'accent sur leurs conséquences pour le développement durable en fonction de divers schémas d'aménagement. Elle fournit également des informations sur l'état des infrastructures dans la vallée du Fraser ainsi que des renseignements de base relatifs aux installations, à leur capacité actuelle et à leur emplacement.

Dans la partie 1, on élabore une méthode qui lie les buts et objectifs du District régional relatifs aux infrastructures et aux grands enjeux régionaux à un ensemble d'indicateurs permettant de mesurer et de contrôler la performance. Plus précisément, on se préoccupe des éléments majeurs suivants : les déchets solides, l'eau potable et les eaux usées, l'énergie, l'occupation du sol et le coût des rues et des infrastructures. Chacun de ces éléments est décrit en fonction de son état au sein du DRVF, des enjeux les plus inquiétants et des indicateurs de performance connexes. On évalue les indicateurs choisis en fonction de la performance actuelle et idéale ainsi que celle qui correspond à trois différents scénarios d'aménagement urbain.

La partie 2 de la recherche présente un outil informatisé permettant d'évaluer et de contrôler le coût et la performance des infrastructures. À l'aide du logiciel de base de données ACCESS et d'une application sur Système d'information géographique (SIG), l'outil permet aux urbanistes de

Secteurs de dénombrement

La base de données est répartie géographiquement au moyen de secteurs de dénombrement (SD). Le DRVF est actuellement composé de 354 SD dont la superficie varie considérablement. La population moyenne d'un SD se chiffre à environ 1 000 personnes – ce qui représente à peu près le nombre de personnes qu'un seul recenseur peut gérer. Les SD servent de composants primaires de la base de données, puisqu'ils ont la même structure que les données du recensement. Les superficies et les frontières des SD sont congruents avec ceux des municipalités : par exemple, la municipalité de Mission est composée précisément de 47 SD.

Indicateurs

Puisque les SD constituent le niveau fondamental d'agrégation de la base, tous les indicateurs sont rapportés en fonction d'un SD ou de tout regroupement de SD.

L'outil aborde un ensemble de 29 indicateurs clefs différents, y compris l'eau potable, les déchets liquides, l'énergie, ainsi qu'un résumé statistique du SD. Les indicateurs mesurent la performance de regroupements d'utilisations finales, plutôt que chacune d'elles. Par exemple, l'énergie consommée par les appareils d'éclairage, les électroménagers et les moteurs a été regroupée sous un seul élément. On peut développer les résultats au besoin, en désagrégeant chaque indicateur en éléments spécifiques. L'analyse porte sur la consommation des ressources ainsi que sur leurs émissions et les coûts correspondants. Les indicateurs sélectionnés tiennent compte à la fois de la demande et de l'approvisionnement en ressources.

Le calcul des indicateurs est fondé sur une approche hybride : les méthodes ascendantes et descendantes. Les méthodes ascendantes utilisent les statistiques sur les populations, l'habitation, l'agriculture, le secteur industriel, la superficie des terrains, la longueur et la largeur des routes des infrastructures linéaires, etc. Les valeurs ascendantes sont ensuite modifiées, au besoin, afin de s'assurer que la consommation totale des ressources et leurs coûts correspondent à tout débit mesuré. Au fur et à mesure que des données empiriques deviennent disponibles, la base de données devrait fournir des résultats plus précis.

Les indicateurs sont calculés en fonction de l'année où l'on dispose des données les plus à jour. Au départ, il n'y a aucune donnée historique. Toutefois, si la base est régénérée chaque année, on peut archiver les données des années antérieures et les utiliser pour fins de comparaison et d'analyse des tendances.

Statistiques relatives aux secteurs de dénombrement

Le logiciel interactif produit également un rapport qui établit le profil d'un SD afin de brosser un tableau plus complet de ses statistiques de base. Un exemple de rapport est présenté à la figure 1 ci-dessous.

comparer les indicateurs de performance en fonction de différentes échelles spatiales. Une base de données comprenant toutes les informations permettant l'analyse des infrastructures du DRVF est également incluse. La partie 2 précise davantage les indicateurs de performance décrits dans la partie 1 de façon à ce qu'ils puissent être utilisés dans l'outil informatisé, peu importe le domaine de planification régional. Elle décrit en outre les résultats de la DRVF en fonction des infrastructures d'élimination des eaux usées, d'énergie et d'alimentation en eau.

Ensembles, les parties 1 et 2 constituent le fondement d'un système de gestion environnemental (SGE) pour la région. De façon générale, la mise en oeuvre d'un SGE constitue une approche proactive permettant de protéger et d'améliorer la qualité de l'environnement. Plutôt que de tenter de limiter les conséquences pour l'environnement en s'y prenant projet par projet, on tente, à l'aide d'un SGE, d'intégrer les objectifs environnementaux à même le schéma existant de gestion.

Habituellement, un SGE comprend un ensemble exhaustif de directives et de méthodes visant à réduire au minimum les répercussions négatives de la consommation des ressources, ainsi qu'à permettre à l'entreprise d'atteindre efficacement ses buts en matière de performance environnementale. Tant à l'interne qu'à l'externe, le SGE permet à l'entreprise de communiquer aisément les résultats relatifs à sa performance environnementale comme une partie intégrante d'un système de comptabilisation du coût complet.

Voici les éléments clefs d'un système de gestion environnemental :

i. Un énoncé des objectifs (et l'engagement de les atteindre).
ii. Une analyse des répercussions environnementales possibles liées aux activités de l'entreprise.
iii. La formulation d'un ensemble d'indicateurs ou de critères d'évaluation à utiliser pour évaluer la performance, ainsi que des cibles et des déclencheurs mesurables.
iv. Un plan d'action pour atteindre les cibles fixées.
v. Un système de contrôle pour s'assurer de l'imputabilité.

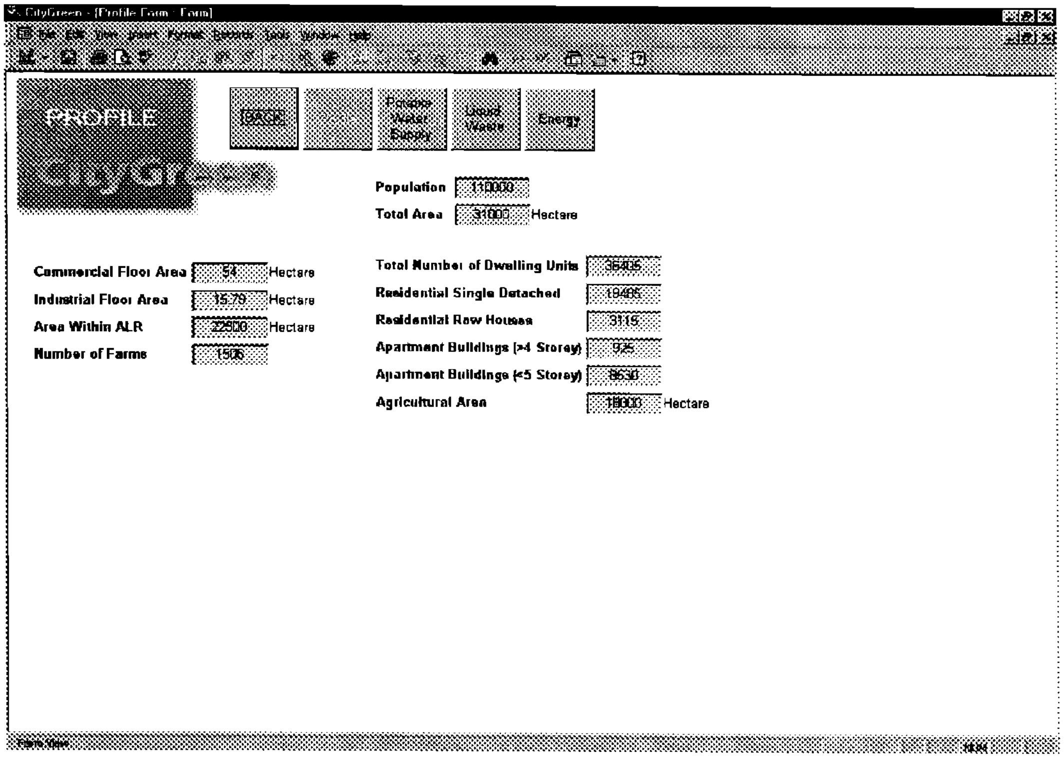
La partie 1 de l'étude délimite clairement les objectifs du DRVF visant les infrastructures et la performance environnementale. Ces objectifs ont été utilisés pour mettre au point des indicateurs clefs pouvant être mesurés dans le temps et servant à évaluer la performance.

On élabore, dans la partie 2, un système qui permet d'évaluer la performance du DRVF, et d'en assurer l'imputabilité. L'outil informatisé fournit un mécanisme servant à recueillir efficacement des données et à calculer les indicateurs de performance clefs du DRVF. Il s'agit donc d'un système d'évaluation et de surveillance qui permet aux urbanistes et autres de prendre connaissance de la performance relative du DRVF par rapport aux objectifs établis par le conseil.

Caractéristiques nominales et données de sortie essentielles de l'outil

L'outil interactif consiste en une base de données ACCESS de Microsoft et d'un fichier ARCVIEW en Système d'information géographique permettant une présentation des résultats spatiale ou autre, selon le format normalisé préétabli. Les caractéristiques importantes de la base de données sont décrites ci-dessous.

Figure 1 : Profil d'un SD



[Translation of terms in screen shot]

Population : **Population**
Total Area : **Superficie totale**
Commercial Floor Area : **Aire de plancher à usage commercial**
Industrial Floor Area : **Aire de plancher à usage industriel**
Area Within ALR : **Superficie à l'intérieur du l'ALR**
Number of Farms : **Nombre de fermes**
Total Number of Dwelling Units : **Nombre total de logements**
Residential Single Detached : **Nombre de maisons individuelles isolées**
Residential Row Houses : **Nombre de maisons en bande**
Apartment Buildings : **Nombre de collectifs d'habitation (> 4 étages)**
Apartment Buildings : **Nombre de collectifs d'habitation (< 5 étages)**
Agricultural Area : **Superficie des terres agricoles**

Les sources d'information permettant de préparer le profil d'un SD sont énumérées dans le tableau 1 ci-dessous.

Tableau 1 : Sources d'information permettant l'établissement des profils

Contenu du profil d'un SD	Sources de données
♦ Population du SD	♦ Recensement, Statistique Canada
♦ Nombre et types de logements	♦ Recensement, Statistique Canada
♦ Aire en m² des usages commerciaux par type	♦ Statistiques municipales
♦ Superficies de terres agricoles en Ha, par catégorie	♦ Ministère de l'Agriculture (Recensement de l'agriculture)
♦ Aires de plancher commerciales	♦ Estimées à partir des rapports existants dans une des villes du DRVF et une zone rurale, à partir de données fournies par la BCAA
♦ Nombre de fermes par SD	♦ Données comptabilisées à partir des polygones de la carte SIG montrant la classification des fermes et les limites de propriété

Le rapport dont il est ici question fournit des renseignements importants sur la conception de la base de données, sur les indicateurs et sur l'étude de cas du District régional de la vallée du Fraser. Toutefois, on appréciera mieux le logiciel lors d'une démonstration informatisée.

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CONTENTS

1. Introduction

1.1 Project Overview

This is the first of a two-part report on infrastructure and energy services in the Fraser Valley Regional District (FVRD).

Part 1 provides an overview of methods for full cost accounting, and applies a specific method to the FVRD. The method uses a series of key indicators to measure performance in environmental and economic terms. Part 1 also provides information on the status of the infrastructure in the valley, including background information on the systems, their current capacity and location, and issues of concern.

Part 2 provides a tool for monitoring and evaluating the infrastructure costs and performance, as part of an Environmental Management System. The tool uses a database and GIS application to tool to allow planners to compare indicators of performance at varying spatial scales throughout the valley. The indicators of performance are refined and adapted to a standardised tool that can be used in any region. Results are presented for the FVRD.

1.2 Limitations in Scope:

These costing and evaluation methods address technical and economic issues, but not the social costs of growth.

This report represents a contribution to the "technical program" of the Plan Concept of the FVRD's first Regional Growth Strategy. It accompanies a range of other documents dealing with such issues as water quality, environmental degradation, transportation, and liveability. For this reason some of these issues are not dealt with in detail within this Report.

1.3 Objectives of Part 1

The objectives of this Report are to:

- outline the issues of concern for the Regional District in terms of basic infrastructure;
- provide a situational analysis of existing infrastructure;
- create a list of "operational goals" from the list of goals already adopted by the FVRD;
- propose a series of indicators for measuring performance relative to each operational goal; and
- estimate the current performance of the communities within the FVRD, and, where appropriate, set targets for future performance.

This Report uses indicators of performance that combine economic and environmental concerns to analyse the impact of alternative land use patterns. Consequently, an important first step towards 'full' cost accounting of growth options has been made. While in this Report relevant indicators are measured at an aggregated scale for the whole Fraser Valley Regional District, greater disaggregation is presented in Part 2. Also, an analysis of potential strategies for achieving the proposed targets of sustainability will be fulfilled in later phases of this project.

1.4 Background to the FVRD Regional Growth Strategy

In accordance with the BC Growth Strategies Act, the FVRD is currently drafting a Regional Growth Strategy. The Growth Strategy will guide decisions on growth, change, and development in the Valley over for the next 25 years. It must deal with broad regional growth management issues such as air pollution, water quality, traffic congestion, affordable housing, employment, energy use, parks and green space. Its purpose will be to promote human settlement that is socially, economically and environmentally sustainable.

The growth issue for FVRD is multi-faceted. The region must accommodate a rapid population increase while safeguarding community identity and the quality of life. The quality of life for Valley residents could presently be characterised as "country living." This is manifested in the relatively low-density residential development, dominated by single family detached housing on large lots, and the commitment to preserve the agricultural land base within the ALR.

Future growth in the Valley could take a number of different forms, depending upon how the Region chooses to evolve. Specifically, the Regional District needs to address the following growth-related constraints:

- Facilities must be provided for double the current population over the next 20 years;
- The current supply of single family lots is low, and consequently new land reserves must be developed if lots are to be supplied at existing densities;
- The Agricultural Land Commission is opposed to any large-scale removal of ALR lands, which means that urban expansion is possible only by increasing density in current urban areas and/or by expanding to the urban land reserves, which include hillside areas;
- The Regional District intends to pursue "sustainable development", which means ensuring that future development meets the needs of the present without compromising the ability of future generations to meet their own needs;
- The municipalities and districts have only limited financial resources and cannot afford to service too many growth areas at a given time.

The FVRD's Plan Concept was created to assist policy-makers, the development community, and the general public in identifying appropriate growth management strategies for the FVRD. The Plan Concept will provide a long-term vision, and will describe a growth pattern that minimises costs while helping to meet goals for revitalising existing downtown cores, building "complete" communities, and protecting the natural environment. The Plan Concept will consist of a number of complementary components, addressing land use, transportation, environment, employment, infrastructure, housing, and quality of life issues. This Report will contribute primarily to the infrastructure component of the Plan Concept.

2. A Framework for Evaluating the Full Costs of Infrastructure

2.1 Introduction to Full Cost Accounting

Full cost accounting (FCA) is a tool that is becoming increasingly more popular as an important component of urban growth analysis. While different methodologies exist for conducting full cost accounting, the premises that underlie the use of this tool are typically the same.

Full cost accounting represents a method through which the costs of a given action are assessed from a broader perspective than a purely economic one. Thus, rather than translating the impacts of growth only into monetary terms, the impacts are considered from a range of perspectives. These perspectives are typically grouped into the social, environmental and economic spheres. In this manner, full cost accounting provides a method for considering all of the potential impacts of proposed development actions. This not only allows for the inclusion of qualitative impacts into the equation, but also enables the social and environmental costs borne by third parties to be evaluated. Most importantly, it enables complex decisions to be evaluated from a holistic and integrated viewpoint.

2.2 Towards Full Cost Accounting in the FVRD

There are several key components to the method used by the Sheltair Group for the FVRD. First, the methodology relies on the assembly and calculation of detailed information in terms of resource use, demographics, building stock, emissions and wastes, land profile, and so on. Second, computer modelling is performed where appropriate to permit the development of archetypes, or single entities that are representative of a much larger body of that same entity. And third, indicators are used as a method of measuring performance and impacts in key areas. It is this latter component that provides the crucial link between the information assembly and modelling, and full costs accounting.

Indicators provide a mechanism through which performance can be measured in a standardised and technical, albeit not necessarily economic, manner. While one individual indicator measures only a portion of a question or problem, a group of indicators together permit the integration of a range of perspectives into an impact analysis. Thus, a set of data can be used to provide answers to a group of indicators, which, when considered together can give a much broader understanding of the impacts of growth. While the indicators are not necessarily measured in dollar factors, they are measured in a manner that permits comparison, in a manner that allows value to be assigned to non-monetary issues, and in a manner that expands our understanding of the fuller costs of any given decision.

For example, wastewater is an issue often analysed as part of a growth impact analysis. An economically-based analysis would look at the increased dollar costs of the municipal wastewater system associated with an increase in population and/or spatial growth. Through accessing a database of information, the change in dollar costs would be calculated. A full cost accounting approach, however, would assess this issue from a broader perspective. Using a range of indicators such as, for example, increased impermeability of a given area, or increased sedimentation of receiving bodies of water, or erosion associated with storm run-off, the broader impacts of growth could be assessed. Thus, the use of indicators permits the calculation of costs in a holistic and integrated manner, and provides important information for assessing the true impacts of growth.

2.3 Methodology to developing a Full Cost Accounting Framework

In this work we present a framework for assessing and evaluating various growth options with a focus on the impact on sustainability associated with different patterns of land development. The approach we have established is a common sense or framework approach.

The first step in the developing an indicator framework is to identify and list goals and objectives. This is not radically different from what practitioners of traditional cost-benefit analysis may view as identifying all costs and benefits. However, the framework approach allows consideration of both quantitative and qualitative impacts. Restricting assessments of effects to factors that can be stated in specific monetary terms poses a number of problems. Most importantly, it reduces the scope of analysis due to the vast number of factors that defy the price-based paradigm. Such factors include social equity, ecosystem health, aesthetics, and quality of life.

Monetarisation of costs is particularly problematic in cases of high uncertainty -- that is, where it is impossible to identify and quantify all possible outcomes. In these cases, rather than placing a burden of proof on monetised "benefits" exceeding the estimated costs, decision-makers might want to consider the nature of the uncertainty -- and how both action and inaction present different "risks" or possible outcomes to society.

Part of the difficulty in applying a full cost accounting framework for regional growth analysis is coping with the large number of potential impacts. These impacts include economic, social and environmental costs, all of which must be addressed by decision-makers. In the current study only a core set of indicators (or cost categories) have been addressed in the economic and environmental spheres. Appendix One includes a more detailed description of the full range of impact categories that may ultimately need to be addressed when accounting for the full costs of regional growth.

2.4 Operational Goals for a Regional Growth Strategy

In order *to "promote human settlement that is socially, economically and environmentally healthy"*, the Regional Board has identified a number of goals. These goals are intended to guide the content and process of a Regional Growth Strategy for Fraser Valley Regional District.

The FVRD goals are used in this report to create a framework on which to base regional growth planning for infrastructure. The framework begins by identifying all of the FVRD goals related to infrastructure and land use. These goals are then translated into Operational Goals, as illustrated in *Figure 1* below.

FVRD Goals	Issues	Operational Goals
Increase the density and compactness of urban areas in the region and ensure that development takes place where adequate infrastructure and community facilities exist or can be provided in a timely, economic and efficient manner. Reduce and prevent air, land and water pollution. Protect the quality and quantity of ground water and surface water. Encourage environmentally sustainable methods for liquid and solid waste management. Support a healthy environment as fundamental to human health. Plan for energy supply and promote efficient use, conservation and alternative forms of energy. Anticipate the needs of the future population of the region especially with respect to changing demographic characteristics and needs. Emphasize the fundamental role of sound, long-term fiscal planning. Ensure adequate inventories of suitable land and resources for future settlement.	**Solid Waste**	Reduce and manage the generation of municipal solid waste. Reduce and prevent land pollution.
	Water And Wastewater	Maximize efficiency in use of fresh water. Reduce and prevent water pollution. Optimize the use of appropriate water treatment methods.
	Energy	Maximize sustainability and efficiency in use of energy resources. Minimize the need to expand the existing energy infrastructure.
	Land Use	Minimize the amount of public and private property devoted to automobiles. Minimize impact on health of landscape from developing urban land reserves Increase the density and compactness of urban areas. Optimize potential for mixed-use zoning
	Infrastructure costs	Minimize financial costs associated with solid waste management. Minimize financial costs of water supply infrastructure. Minimize financial costs associated with water treatment. Minimize financial costs associated with street networks / accessibility.

Figure 1:Translating FVRD Goals into Operational Goals for Infrastructure Planning

2.5 Indicators for Measuring and Monitoring Performance

The framework used in this report expands upon the operational goals listed in *Figure 1* through identifying indicators for measuring performance of the infrastructure. For example, an indicator for solid waste is the amount of waste produced annually in kilograms per person. One or more indicators have been selected for each Operational Goal.

The role of an indicator is to make complex systems understandable or perceptible to the public and decision-makers. A set of indicators is often required to capture the many issues of concern, and thus present a "fuller" cost account for existing infrastructure, and the proposed growth strategies. Usually the set of indicators encompasses several broad issue categories (e.g. Water). An effective set of indicators helps a community determine, in measurable terms, where it is, where it is going, and how far it is from its desired targets.

Ideally the indicators used for the FVRD would be designed to measure the region's long-term viability, based on the degree to which its economic, environmental, and social systems are efficient and supportive. This would help to manage growth and achieve sustainable development.

Due to the scope and budget of this study, the number of indicators has been limited, and their focus restricted to infrastructure, energy, and land-use issues. Therefore, the indicators in this report are only a partial measure of sustainability, and of the long-range health of the district. They must be used in conjunction with other evaluative tools and reports comprising the FVRD Technical Plan, including transportation, environment and ecology, housing, employment and economy, quality of life, and agriculture.

Selection Criteria for Indicators

- exhibits a clear linkage to an identified goal and issue of concern;
- broadly indicative and responsive;
- synergistic with other goals;
- reflects considerations related to urban form issues;
- measurable by a standard method at reasonable cost;
- is in a form understandable by target audience(s);
- feasible to collect data and analyse data within the decision-making timeframe;
- possible to access appropriate data; and
- commonly used elsewhere.

A number of criteria were used to select optimum indicators (see box). For example, the indicator of *per capita expenditure on sewage treatment* was chosen because:

- there is a direct link to the FVRD's goal to "emphasise the fundamental role of sound, long-term fiscal planning," and indirect links to several other FVRD goals.
- the dollar-figure will depend in part on the length of sewage pipes, and therefore is expected to vary, depending on the assumed urban form. Urban sprawl requires more sewage pipes than compact urban settlement, thus affecting the sewage treatment expenditure.

A full list of Operational Goals and selected indicators is provided in *Figure 2.*

Issues	Operational Goals	Indicators
Solid Waste	Reduce and manage the generation of municipal solid waste. Reduce and prevent land pollution.	♦ Amount of solid waste produced and disposed yearly per capita
Water And Wastewater	Maximize efficiency in use of fresh water. Reduce and prevent water pollution. Optimize the use of appropriate water treatment methods.	♦ Amount of water consumed yearly per capita ♦ Percent of land area that is impermeable
Energy	Maximize sustainability and efficiency in use of energy resources. Minimize the need to expand the existing energy infrastructure.	♦ Electricity and fossil fuel energy used for operation of residential buildings ♦ $CO2$ emissions from energy used for single occupancy vehicles
Land Use	Minimize the amount of public and private property devoted to automobiles. Minimize impact on health of landscape from developing urban land reserves Increase the density and compactness of urban areas. Optimize potential for mixed-use zoning.	♦ Area of land used for streets, roads, and alleys
Infrastructure Costs	Minimize financial costs associated with solid waste management. Minimize financial costs of water supply infrastructure. Minimize financial costs associated with water treatment. Minimize financial costs associated with street networks / accessibility.	♦ Yearly expenditure on municipal solid waste management services per capita ♦ Yearly expenditure on water abstraction, treatment and distribution per capita ♦ Yearly expenditure on sewage treatment per capita ♦ Yearly per capita expenditure of building and maintaining streets, roads, and alleys

Figure 2 A list of Indicators Corresponding to the Operational Goals for FVRD

3. Analytical Methods and Assumptions

3.1 General Approach to Analysing Performance

This Report is organised into five *Issue Categories*:

- Solid Waste,
- Water and Waste Water,
- Energy,
- Land Use and Roads, and
- Infrastructure Costs.

Each *Issue Category* is described in the following fashion:

- Current Status within the FVRD
- Issues of Greatest Concern, and
- Indicators of Performance

The *Indicators of Performance* section within each issue category is organized around five questions:

- Why is this indicator important?
- What is the current performance of the FVRD?
- What is the preferred performance target for the FVRD?

3.2 Benchmarks and Targets for Specific Indicators

The current performance of the FVRD for a specific indicator is in most cases represented by baseline data from the year 1996. To assist in interpretation, the current performance is compared to performances at other times and in other places. Such comparisons are referred to as '*benchmarks*'. The benchmarks used in this report are generally drawn from nearby locations such as the GVRD and CRD, although sometimes benchmarks are included for noteworthy and exemplary communities outside of BC. Estimates for each indicator showing where the FVRD is likely to be in the year 2021 will be addressed in later stages of this project.

In addition to benchmarks, the report presents specific target values for each of the environmental indicators. The target values are intended to represent a recommended level of performance for the FVRD in the year 2021. Targets proposed are not intended to create regulations. Rather, the targets are intended to give some idea of what level of performance the Regional District should attain over the next twenty-five years. As such they should function as a challenge to the many decision-makers that want more information on what constitutes a responsible plan or design. Targets provide a means for co-ordinating the efforts and plans of many stakeholders over the next few years. The targets are considered to be technically and economically achievable, while moving the region towards environmental sustainability.

4. Issue Category: Municipal Solid Waste

4.1 Current Status within the FVRD

Existing practices and sites for solid waste disposal in the FVRD are recorded below. Graphic notation of the current status is provided in the *Map of Existing Infrastructure* in the Appendices.

The District of Mission takes waste to Minnie's Pit landfill for disposal, and recyclables to the Abbottsford Community Services (ACS) processing facility in Abbottsford. Minnie's Pit is expected to reach capacity between 2003 and 2005, with expansion to the site boundaries extending capacity constraints to 2018-2025.

The City of Abbottsford sends waste to the GVRD Matsqui Transfer Station, which is subsequently hauled to the Cache Creek landfill for disposal, and recyclables to the ACS processing facility.

The District of Chilliwack relies on independent haulers to collect residential waste and dispose of it at the Bailey Road landfill; all waste in Chilliwack is privately hauled. Recyclables are dropped of at specific sites and handled by Waste Management Inc. The Bailey Road landfill has a projected date of closure of 2010.

Other areas within the Region follow a range of waste disposal methods, sending waste to the Hope landfill, the Chaumox landfill, the Cultus Lake landfill, and the ones already mentioned with respect to the three largest municipalities. The District of Hope landfill will reach capacity in 2000-2002, with possible extension until 2020. The Chaumox landfill is expected to close in 2013, while the Cultus Lake facility is currently reaching capacity.

4.2 Issues of Greatest Concern

British Columbians are among the highest consumers in the world, resulting in the production of vast quantities of solid waste. (See *State of the Environment Report for British Columbia*, Ministry Of Environment, Lands and Parks, 1993). For the FVRD, this translates into a host of negative societal and environmental impacts, which will only increase dramatically as a result of the expected increase in population over the next two decades.

For example, landfill sites are becoming increasingly difficult to procure, in part due to the "not in my backyard" attitude of communities. People who live adjacent to them must bear the external costs of these facilities.

As well, because of the public health and environmental safeguards required for landfills, they are expensive to build and operate.

For every extra resident in the FVRD, additional quantities of waste will be generated. Construction and demolition waste alone will put enormous pressure on landfills, some of which are already overextended. Impacts from increased production of solid waste include:

- depletion of natural resources through materials being discarded before their functional use is exhausted;
- degradation of large areas of land to the point of being unsuitable for other uses;
- contamination of ground water from land fill leachate;
- increased air emissions from transporting waste to disposal facilities and transfer stations;
- expensive solid waste management infrastructure;
- significant emissions of methane and other greenhouse gases; and
- loss of valuable organic material disposed at landfills.

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To address these issues, the provincial government implemented a solid waste management strategy in 1989 that included a number of reduce, reuse and recycle strategies. As a result, total solid waste produced per capita decreased between 1990 and 1994, from 1125 kg/person/year to 803 kg/person/year. Of the latter amount, 600 kg per person was disposed to landfills and incinerators. British Columbia's goal is to reduce the solid waste disposed to landfills or incinerators to 400 kg/person/year by the year 2000.

To achieve this, the Provincial Government requires all regional districts in British Columbia to complete a Regional Solid Waste Management Plan to address the Province's goal of a 50% reduction in solid waste requiring disposal by the year 2000. Reduce, reuse and recycle are the management strategies to be employed toward reaching this goal. The *Fraser Valley Regional District Regional Solid Waste Management Plan* (August 1996) summarises existing solid waste management practices and facilities in the region, and proposes strategies that can increase the plan area's waste diversion rate to 51.5% by the year 2000.

Although increasing the diversion of waste from landfills is an important aspect of the solid waste issue, recycled waste also requires infrastructure that carries negative financial and environmental impacts. These impacts include increased air emissions from waste collection trucks, and increased use of energy by recycling facilities and transfer stations. Focusing solely on maximising diversion of solid waste from landfills will, therefore, only partially minimise the negative impacts associated with consumption and disposal. Total solid waste produced per capita should be minimised as well.

4.3 Indicators of Performance

With the above issues in mind, and using the Selection Criteria noted in Chapter 3, some of the possible solid waste indicators are listed below. To the extent that these indicators seek to measure a broader range of impacts, they can be considered relevant to a full-cost accounting methodology

Environmental Indicators

- Amount of solid waste produced annually per capita
- Amount of solid waste disposed to landfills annually per capita

Economic Indicator

- Annual expenditure on municipal solid waste services per capita

The remainder of this chapter discusses the performance of the FVRD for the environmental indicators, and proposes targets for improved performance in these areas.

INDICATORS: SOLID WASTE

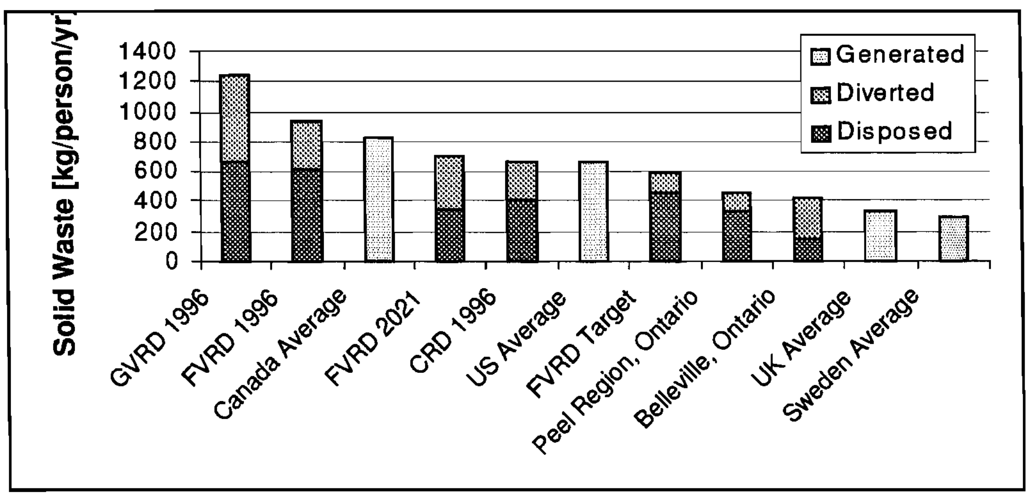
- Amount of solid waste produced annually per capita
- Amount of solid waste disposed to landfills annually per capita

Why are these Indicators Important?

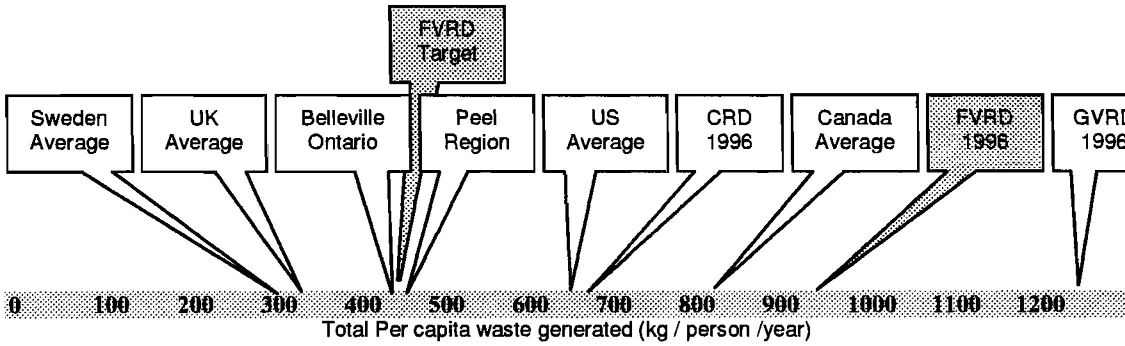
These indicators seek to measure both the quantity of waste being generated, as well as how much of it ends up in the landfills. They are important for several reasons. Most obviously, they measure the population's consumption level, and identify whether it is increasing or decreasing in response to provincial-government initiatives, education, increased public awareness, varying settlement patterns and so on. Second, they will reflect how well the FVRD is progressing toward achieving its goals of supporting a healthy environment, and of encouraging environmentally sustainable methods of liquid and solid waste management.

These indicators also demonstrate progress towards other goals, such as the protection of quality and quantity of ground water and surface water; the reduction and prevention of air, land and water pollution; and the assurance of adequate inventories of suitable land and resources for future settlement. Finally, progress in these indicator areas will impact on other indicators, such as the cost of solid waste management services.

What is the current performance of the FVRD in these indicator areas?



The table above provides a graphic depiction of where the FVRD lies in relationship to a range of other communities in terms of waste generation and disposal. The scale graph below indicates the quantity of waste generated only, without identifying diversion rates.



The FVRD Solid Waste Management Plan (1996) indicates that since 1991, approximately 930 kilograms of solid waste were produced per capita each year. As the graphic above indicates, this amount is significantly higher than the average waste produced per capita in the US, UK and Sweden. Some of the amount generated in the FVRD is being diverted from landfills, either through reduction, re-use, recycling or recovery. Diversion rates in 1996, varied from 15% to 45% in the region, with a regional average of 33%. Thus, approximately 620 kilograms/person/year were disposed into landfills.

If the **FVRD** achieves the already targeted diversion rate of 51.5% without reducing the total amount of solid waste produced per capita, it will send 451kg/person to the landfills each year. This amount is higher than the Province's target of reducing the amount of solid waste disposed to landfills or incinerators to 400 kg/person each year by the year 2000. This amount is also significantly higher than averages in many other industrialised countries, and other communities in North America.

The **GVRD** and **CRD** values are derived from the Solid Waste Department and the Engineering Departments respectively. Both these regions employ a number of demand side management policies, including blue box programs and distribution of subsidized back yard composters.

The **Belleville, Ontario** 3Rs program represents the first Canadian community to achieve greater than 50% per capita waste reduction. The City generates a total of 420 kg/person each year, of which only 150 kilograms is disposed. This was achieved primarily by using education to improve capture rates for paper and organics, rather than by targeting other types of waste. (Centre and South Hastings Waste Services Board, Ontario)

In the **Peel Region, Ontario**, 450 kg/person is currently being collected and disposed of each year, of which 333 kg ends up in landfills or incinerators. With input from the public, staff developed a twenty-year blueprint that should result in a 70 percent diversion rate. (*Solid Waste and Recycling Magazine*, December/January 1998) This means that, by 2020, only 135 kg of solid waste per person will be landfilled each year, assuming that the total waste produced stays constant. This model represents a truly integrated waste management system that uses curbside recycling, aggressive organics diversion, energy-from-waste, a user-pay system, and (minimal) landfilling.

Other targets being set for diversion rates are even more ambitious. At the extreme is the **City of Canberra** in Australia that, in conjunction with extensive community participation, has identified a strong desire to achieve a waste free society by 2010.

What is the preferred performance target for the FVRD in this indicator area?

If the FVRD institutes progressive measures and policies similar to those cited in the case studies noted above, a feasible target for the region could be to reduce total per capita production of solid waste to 450 kg/person/year by the year 2021and increase diversion to 135 kg/person/year. Achieving these targets may require collaboration and joint investment by local governments within the FVRD.

5. Issue Category: Water and Wastewater

5.1 Current Status within the FVRD

At present, the water supply for the communities in the FVRD comes from various sources. This includes municipal water systems that draw from ground and surface waters, and individual agricultural or industrial operations that have licenses to draw directly from surface water. These existing sources cannot, however, necessarily be relied upon for the future. For example, according to the *1995/96 Update of Master Plan on the Central Fraser Valley Water Commission* (which serves the Abbottsford and Mission areas), groundwater cannot be counted upon as a major future municipal water supply source.

Mission and Abbotsford are served primarily by a combined system that draws water from Norrish Creek on the Northern side of the Valley, and then stores the water in the Cannell Reservoir. The present Norrish Creek/Cannell Reservoir surface water system can be expanded to serve up to a total of around 300,000 residents. After this point it will likely be more economical to tap into new rivers and lakes in the region to supply anticipated water demands.

The present system in Chilliwack relies on wells in the Vedder Aquifer, which has excellent water quality. Projections prepared by the district suggest that the Vedder Aquifer will have sufficient capacity until 2010, when additional water sources will be required. At the same time, the District of Chilliwack is developing a groundwater protection plan in order to ensure the future health of its water supply.

Discussions with engineers in the three major municipalities in the FVRD revealed that some water conservation initiatives are already in place in the Valley. In Chilliwack, all houses are metered and the municipality educates developers on the benefits of installing low flow toilets and showers, for all new construction. The Municipality also enforces sprinkler restrictions during the summer. In Abbottsford, all houses are metered, there is an education program in the schools on water consumption, and sprinkler use is restricted during summer time. In Mission, sprinkler restrictions are in effect in the summer, but the houses are not metered.

5.2 Issues of Greatest Concern

The issue of water use is environmental, economic, and social in nature. One impact associated with excessive water use is the need for new or upgraded water infrastructure; increasing water demand in the FVRD will require the construction of new facilities, as well as the expansion of existing facilities. Such infrastructure improvements consume energy, land, and other resources, and can impact on the quality of life and health. Another possible impact of increased water use is in the potential for water shortages. As well, the way water is used can impact on water quality, which in turn can add to the costs of supplying water and restoring its quality and the health of those affected. Responsible management of our water resources is, therefore, essential to the economic health of the Region and the ecological health of local watersheds and water bodies.

Another area of critical importance in the FVRD in terms of water is the impact of urbanisation on both the quality and quantity of stormwater and drainage.

Urbanisation can affect water quality in a number of ways, including land clearing, the creation of numerous additional pollution sources, and the direct disposal of solid and liquid wastes. In addition, replacing natural ground cover with roads, buildings, parking lots, and other impermeable surfaces disrupts natural stream hydrology. The flow of surface and groundwater is disrupted, and the potential for erosion, sedimentation and flooding is increased.

Water pollution is generally caused by waste discharges from point sources such as sewage treatment plants, and non-point sources such as urban run-off and storm water overflows. Minimizing the impacts from these sources is dependent on waste treatment and reduction technologies, as well as land use patterns.

Rainfall incident on a site may be collected, infiltrated to the soil, or run off the surface. In most urban areas, runoff is directed to a storm sewer, and then either directly to water bodies, or to sewage treatment plants. In the case that it is directed to a sewage treatment plant, reduction in storm water runoff reduces the pressure on treatment plant capacity. In the case that it is directed to water bodies, reduction in the quantity of storm water runoff reduces the quantity of pollutants being transmitted into the receiving bodies of water.

Of great importance is the impact that such changes to stormwater quality and quantity have on adjacent lands, in particular agricultural lands. An area currently identified by the Agricultural Land Commission as being highly contentious is the conflict caused by the interface of urban growth and agricultural areas. The effects of flooding from urban developments and of runoff from pollutants entering ditch systems used as a water source for farm purposes can be significant.

5.3 Indicators of Performance

With the above issues in mind, and using the Selection Criteria specified in Chapter 3, the indicators chosen for the analysis of water and wastewater are as listed below.

Environmental Indicators:

- Annual per capita amount of water consumed for residential purposes
- Per capita area of land used for streets, roads and alleys

Economic Indicators:

- Annual per capita expenditure on water abstraction, treatment and distribution per capita
- Annual expenditure on sewage treatment

The remainder of this chapter discusses the FVRD's performance relative to the environmental indicators and proposes targets for improved performance. The economic indicators are discussed in Section 8 of this Report.

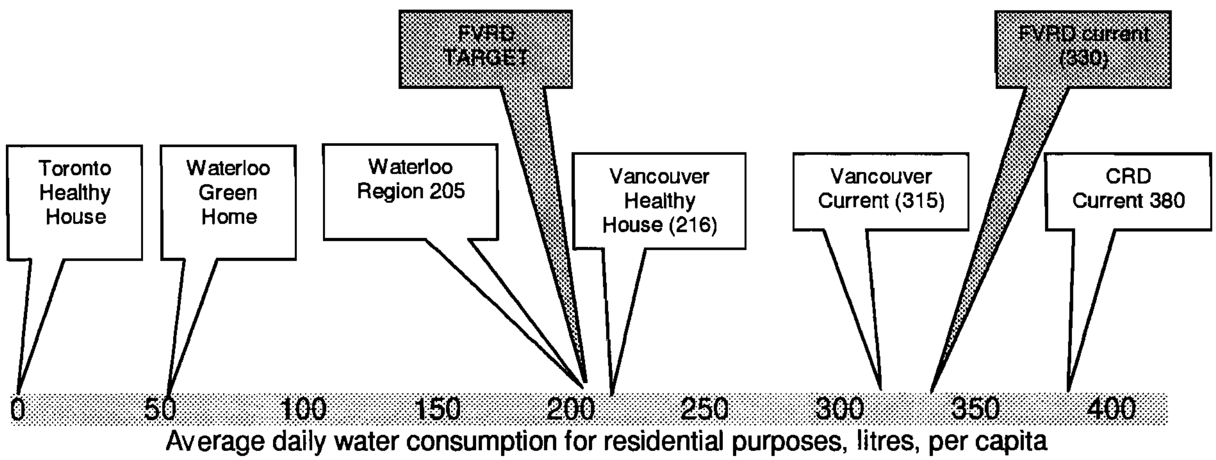
INDICATOR: WATER

- **Annual per capita amount of water consumed for residential purposes**

Why is this Indicator Important?

This indicator seeks to measure how much water each person in the FVRD consumes on average each year for residential purposes. The indicator was selected because it will reflect how well the FVRD is progressing toward achieving a number of its goals, including encouraging environmentally sustainable methods of liquid and solid waste management, and protecting the quality and quantity of ground and surface water. It is also synergetic with other goals, as the amount of water consumed yearly per capita is a factor that must be taken into account in ensuring adequate inventories of suitable land and resources for future settlement, and supporting a healthy environment as fundamental to human health. This indicator will also have an impact on other indicators, such as the yearly per capita expenditure on sewage treatment and water abstraction, treatment and distribution.

What is the current performance of the FVRD in this indicator area?



The Fraser Valley Regional District 1995/96 Update of Master Plan (Dayton & Knight) indicates that, based on metered water, an average of 330 litres of water per person were consumed each day for residential purposes.

The current performance measurement compares favourably to the Capital Region District in which the per capita average of water consumption for residential purposes is 380 l/day. It is, however, higher than the City of Vancouver's average residential water consumption of 315 l/person/day day.

Other benchmarks shown above illustrate how building designs can incorporate innovative water conservation technologies, thus greatly reducing residential water consumption. They include the following:

The Vancouver Healthy House is a CMHC demonstration project in Vancouver, B.C. Based on monitored results and assuming an occupancy of 5 persons, water consumption averaged for the two buildings is about 216 l/person/day.

The **Region of Waterloo** has been in the water efficiency business for over 20 years. As a result of extensive public education, universal metering, and a variety of other progressive initiatives, the Region has achieved an average water consumption of 205 l/person/day for residential purposes—the lowest in Canada. The Region is also about to release a ten-year master plan that sets a target to reduce water consumption by a further 3-4%.

The Waterloo Region Green Home is single family demonstration project with a low environmental impact in Waterloo, Ontario. It uses rainwater collection and water efficient fixtures such as 3 l/flush toilets. Its total water consumption from municipal supply is approximately 51 l/person/day.

The CMHC Toronto Healthy House is a CMHC demonstration project in Toronto, Ontario. The house uses only rainwater as a source and reclaims all greywater and blackwater resulting in no use of municipal potable water.

What is the preferred performance target in this indicator area?

A target of 210 l/person/day is recommended for the FRVD for the year 2021.

INDICATOR: WASTEWATER

♦ **Per capita area of land used for streets, roads and alleys**

Why is this Indicator Important?

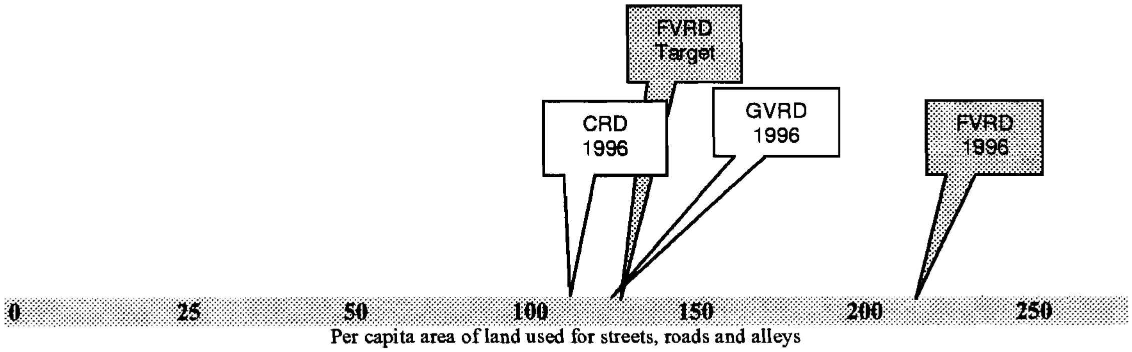
Wastewater includes both storm run-off and sewage. The amount of water treated as sewage is largely determined by the water consumption, and is thus addressed in part by the previous indicator (treated water use per capita per year). Storm water and run-off volumes are much less related to water consumption, and are also a major source of pollution for the Fraser River and its tributaries in the valley.

The imperviousness of a parcel of land is a strong determinant of how much stormwater will run off of the site rather than infiltrating into the soil, and is closely linked to the amount of land that is paved. For example, while rainwater can infiltrate earth and recharge aquifers, if the original terrain is covered by asphalt this rainwater flows away from the site. Because stormwater typically flows along hard-surface materials, it picks up high levels of contaminants and deposits these to the receiving body of water. Consequently, a reduction in the quantity of runoff will reduce contaminant loadings to the Fraser River and the surrounding estuaries and streams. While land-use characteristics of a catchment area are critical in the determination of flow rate and quantity of storm water directed to receiving water bodies, in the absence of other factors imperviousness is considered to increase both the flow rate and amount of runoff.

A further impact of impermeability is in the dramatic changes that development of the land can have on the way water is transported and stored. This disruption of the natural hydrologic cycle causes stormwater runoff to reach streams and rivers more quickly than these water bodies can absorb it. One effect is more frequent flooding events and lower than normal stream base flows. Undisturbed forested lands generally have the highest capacity to absorb water and subsequently the lowest rates of stormwater runoff. In contrast, impervious surfaces have the highest runoff rates. The volume of stormwater that washes off a one-acre parking lot during a storm is about sixteen times greater that that of a comparable sized meadow.

This indicator seeks to measure the area of land that is taken up for vehicular use. It is important as it reflects the quantity of land area that is impermeable. There is also synergy between this indicator and expenditure on other linear infrastructure such as water, sewage, energy, and waste management, as these networks follow the road grid.

What is the current performance of the FVRD in this indicator area?



According to Municipal Statistics (1996), the area of land used for streets, roads, and alleys per capita, (not including highways) is significantly higher in the FVRD (212 m2/capita) than in the GVRD (120 m2/capita) or the CRD (115 m2/capita).

What is the preferred performance target for the FVRD?

The preferred performance target is to achieve the performance of the GVRD, which is 120 m2 per capita.

6. Issue Category: Energy

6.1 Current Status within the FVRD

The principal sources of energy and power in the FVRD are gasoline and diesel for transportation, hydro-electricity from BC Hydro, and natural gas from BC Gas.

Present and future electricity supply in the lower mainland is summarized in the BC Hydro report on "Bringing Electricity to the Livable Region, An electricity Perspective on Growth and Livability in the Lower Mainland". Detailed forecasts and development plans are provided in BC Hydro's 10-Year Electricity System Plan.

About 10% of the electricity consumed in the FVRD is generated in the Lower Mainland. Local power sources currently include the natural gas-fired Burrard Thermal generating plant in Port Moody, and a number of hydro generating stations including Ruskin, Stave Falls and Wahleach. The remainder of the Regional District's electricity needs are satisfied by the 50kvh line via Duffy Lake. Electricity is transformed at a series of substations, including at least one major substation in each municipality and district.

Since 1965, total electricity consumption in the Lower Mainland has quadrupled. The average growth rate in electricity demand for the entire Lower Mainland is projected at 2.2 percent. Based on current trends, however, the annual growth rate in electricity demand for the Fraser Valley Regional District is 3.5 percent.[1] With the expected continuation in population growth in the FVRD, consumption of electricity is expected to continue to increase proportionally.

Despite this expected growth BC Hydro does not foresee any need to add new transmission capacity prior to 2021, unless major new industrial demand occurs in the valley. However many new substations and transmission lines will be required to meet the electricity needs of the growing population. For instance, current investments in increasing the regional supply capacity in the FVRD include a new 69/25 kV switchyard to be in service by 2001 and reinforcement of the 500 kV system to be completed in the second quarter of 1999[2]

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[1] BC Hydro, *Bringing Electricity to the Liveable Region*, 1993

[2] BC Hydro, *10 Year Electricity System Plan*, pp. 5-8, 1998.

6.2 Issues of Greatest Concern

Provision of energy and power requires an infrastructure to generate, deliver, convert, store, and monitor the various energy commodities. This infrastructure is composed of dams, thermal generating plants, pumps, pipelines, power lines, rights-of-way, sub stations, transformers, and so on. Any increase of demand for energy within the valley leads to an expansion of infrastructure, which in turn creates additional costs for energy users and produces a range of negative impacts on the environment.

A general discussion of many cost and environmental issues related to energy use in BC and the lower mainland can be found "A Tool Kit for Community Energy Planning in B.C." a production by the BC Energy Aware Committee. A concise review of issues of concern for the FVRD is provided below.

Energy for Transportation

A major issue for energy use in the FVRD is the quantity of energy resources, and the air pollution, associated with transporting people form their homes to places of work, school, shops and essential services. The trend in the FVRD has been towards less dense land uses along transportation corridors. This has resulted in longer and more frequent trips, an increase in vehicle kilometers traveled (VKT), and an increase in energy consumption and vehicle emissions. Although improvements have been made in fleet efficiency and vehicle emission technology, these reductions have been offset by the growth in the number of vehicle trips and the increase in the average length of these trips.

The Effect of Density on Fuel Consumption[1]

Net Population Density (persons/Ha)	Annual Vehicle Kilometres Travelled	Annual Fuel Consumption (litres)
117	4400	500
32	8300	960
14	11300	1320
6.8	12300	1440
3.8	16300	1940

Both the need to travel and the method of travel from an origin to a destination are influenced significantly by land use patterns and the availability of transportation services. The side box illustrates typical variations in fuel consumption for transportation relative to the net population density of the residential area.

Energy for Buildings

Capital Costs for Infrastructure

Energy supply costs do not appear to represent major concerns for the FVRD to 2021. Although line extensions and sub-stations will be required, these do not represent direct costs for the communities and developers, but are instead averaged across the entire rate base of BC Hydro and BC Gas. However, the cost of expanding the energy distribution system is an important concern for the energy utilities.

Increasingly, utilities are working with municipalities and developers to encourage development that requires less capital investment in energy infrastructure. In comparison to the low-density single family developments that are common throughout the FVRD, moderate density and mixed-use development patterns decrease the cost to the energy utility. Costs drop simply because fewer kilometres of lines are required to service the same customer base. The on-going operating and maintenance costs are also higher since there is more equipment to look after, and because the longer connections mean higher line losses for the utility.

Both BC Hydro and BC Gas are now looking at ways to allocate costs of infrastructure more fairly. Communities within the FVRD needs to determine whether they wish to support this process, by working with utilities to improve the fees and rate structures faced by developers and homeowners. A more equitable allocation of costs should help to encourage a more efficient and sustainable energy system for the regional districts, and lower costs for all ratepayers.

Smog and Greenhouse Gases

Of direct concern to the FVRD are the energy-related air emissions, especially the localised air emissions that cause smog, and greenhouse gas emissions.

Localised air emissions are a concern, particularly nitrogen oxides that cause smog. Smog can impair individual health, reduce visibility, and damage crops and buildings. Transportation is the greatest source of emissions, with buildings and power generation comprising less than 20%.

Greenhouse gas emissions from use of fossil fuels in the valley are increasing both for housing and transportation sectors. Without major efforts to improve efficiency and conserve energy, it will be impossible for the FVRD to meet provincial, national and international targets.

Long-term Reliability and Adaptability of Energy Systems

Both the electrical and natural gas grids throughout the lower mainland are fairly centralised in terms of generation capacity, control systems and distribution corridors. Centralised power generation is inherently more vulnerable to disruptions caused by catastrophic accidents like windstorms, ice, floods, earthquakes, and from problems like sabotage, equipment breakdowns, and resource scarcities. An alternative approach would be a system using a variety of energy sources, and a variety of energy generation technologies.

Despite this centralisation, the energy infrastructure is more reliable and adaptable than most systems in North America. Hydro electricity is a renewable resource that is not likely to become scarce. Hydro generating plants are located throughout the lower mainland. Hydro is supplemented with natural gas fired thermal generation from Burrard Thermal. All of these features enhance the reliability and adaptability of the system.

From the perspective of long-term reliability and adaptability, a more sustainable system would include a greater variety of renewable energy sources, and many small widely distributed energy generation and distribution systems. Historically, the low average cost and widespread availability of energy throughout the FVRD, in combination with BC's monopolistic and highly integrated energy sector, have restricted opportunities for investment in a diverse mix of local energy supply technologies. However, over time the system is likely to diversify further. Both the electricity and natural gas systems are currently in the process of being deregulated to permit other energy suppliers to transfer gas and electricity on the existing distribution lines. There may be opportunities to create regional policies that can enhance the benefits from changes to energy systems. For example it may be worth exploring public private partnerships for new local utilities, district energy zones, combined communication and energy service companies, multi-purpose trenches, revenue generation from right of ways, and so on.

6.3 Indicators of Performance

With the above issues in mind, and by using the Selection Criteria listed in Chapter 3, the following indicators were chosen to measure performance for Energy:

Environmental Indicators

- Per Capita electricity and fossil fuel energy consumed for operation of residential buildings
- CO_2 emissions from single occupancy vehicles

The remainder of this chapter discusses the performance of the FVRD in these terms, and proposes targets for improved performance.

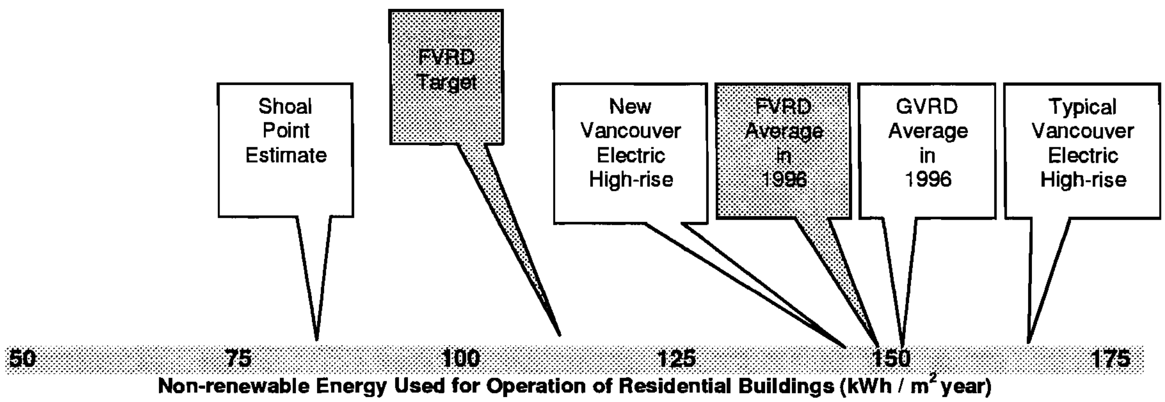
INDICATOR: ENERGY USED FOR HOUSING

- **Annual per capita electricity and fossil fuel energy consumed for operation of residential buildings**

Why is this Indicator Important?

This indicator is important because it will reflect how well the FVRD is progressing toward achieving a number of goals. These include supporting a healthy environment; reducing air, land and water pollution; planning for energy supply and promoting efficient use, conservation and alternative forms of energy; and ensuring adequate inventories of suitable land and resources for future settlement.

What is the current performance of the FVRD for this indicator?



Currently, the average amount of energy used to operate residential buildings in the FVRD is 149 kwh/m2. Although this compares favourably with the **GVRD average**, other benchmarks indicate that a much lower energy consumption value is possible.

Energy consumption figures for a **typical Vancouver high-rise** (167 kWh / m2 year) are based on energy simulations (for secondary energy) of 12-story electrically heated multifamily residential buildings constructed before the implementation of the Vancouver Energy Bylaw.

New Vancouver high-rise energy-consumption figures are based on results of energy simulations (for secondary energy) of typical electric (143 kWh / m2 year) and gas-heated (170 kWh / m2 year) 12-story multifamily residential buildings designed to follow the Vancouver Energy Bylaw

Shoal Point (53 kWh/m2*year) is a 13-story residential complex under development in Victoria, BC. Energy conservation measures include ocean source heat pumps for space heating and hot water heating, high insulation levels, and high efficiency systems. Energy simulations indicate a targeted secondary energy consumption that meets the standards of Canada's C2000 program (i.e. the building energy consumption is at least 45% less than ASHRAE Standard 90.1).

What is the preferred performance target for the FVRD?

An appropriate target for the FVRD energy in housing is 112 kWh/m^{2}, for all attachment styles. This target represents a reduction in percentage terms that is equivalent to improvements that have occurred in new buildings over the past decade, as a result of better designs for building envelopes and more energy efficient appliances

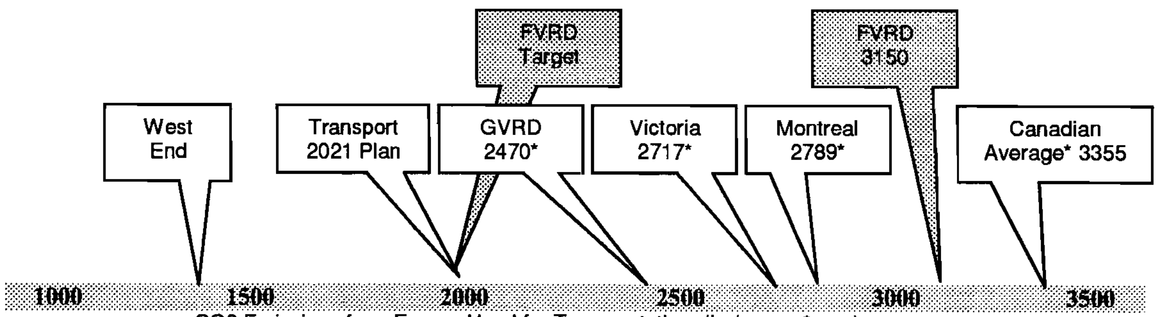
INDICATOR: AIR EMISSIONS FROM TRANSPORTATION
♦ Emissions from single occupancy vehicles

Why is this Indicator Important?

This indicator was selected because it reflects how well the FVRD is progressing toward achieving a number of its goals, including reducing and preventing air, land and water pollution, and supporting a healthy environment as a fundamental component of human health.

About 36% of the Lower Mainland's (GVRD) total CO_2 emissions are the result of energy consumption in the transportation sector. While air pollution levels are expected to decrease over the next few years due to improvements in vehicle emission controls, carbon dioxide emissions from vehicles are not. Unlike other air pollutants, carbon dioxide emissions from vehicles cannot be reduced by improvements in pollution control equipment. They can only be reduced by decreasing hydrocarbon-based energy consumption by using fuels that contain no or less carbon, or by using power from non hydrocarbon-based electrical generation.

What is the current performance of the FVRD for this indicator?



CO2 Emissions from Energy Used for Transportation (kg/person*year)
*Initiatives to Limit Transportation Energy Consumption and Emissions in Canadian Cities, prepared by IBI Group, 1993

Currently in the FVRD approximately 3150 kg per person of CO_2 is emitted from energy used for transportation. This baseline data was calculated by using the data for the GVRD (from *Initiatives to Limit Transportation Energy Consumption and Emissions in Canadian Cities*, prepared by IBI Group, 1993) and then factoring in information on average trip distances (16 kilometres) and an average vehicle occupancy of 1.35. (GVRD's travel surveys (1992)

The Canadian Average (3355) is based on total transportation-related CO_2 emissions per year averaged over the entire Canadian urban population. Data is for year 1990 (Initiatives to Limit Transportation Energy Consumption and Emissions in Canadian Cities, prepared by IBI Group, 1993).

Transport 2021 Plan is based on projections for year 2021. It assumes implementation of Transport 2021 recommendations and a 70% population increase from 1991. (Transport 2021 Report)

What is the preferred performance target for the FVRD?

A challenging target for the FVRD is to adopt the recommendations of Transport 2021, and reduce CO_2 emissions to 2000 kg/person year.

7. Issue Category: Infrastructure Costs

7.1 Current Status within the FVRD

The current status of infrastructure costs in the FVRD is specifically outlined in the Indicators section, which follows.

7.2 Issues of Greatest Concern

The great debate in the field of alternative development standards is cost efficiency. There is a body of research that finds that compact development is neutral or more cost efficient than conventional suburban development. Another body of research argues that compact development is more expensive, by assuming higher ongoing costs and constant densities. Disputes over methodology, comparative factors and findings have been ongoing. Furthermore, an accurate comparison of costs is complicated by the fact that community level costs are usually not passed fully on to the individual consumer.

A recently completed study by CMHC, which takes into account capital, operating, maintenance and replacement costs for a wide range of hard and soft infrastructure over a 75 year life span found that alternative development patterns result in life cycle savings of approximately $11,000 per unit. Most of these cost savings can be attributed to more efficient use of infrastructure resulting from increased densities, mainly because compact development patterns result in fewer linear metres of infrastructure such as water, sewage and regional roads.

In another study, the Cornell Development Group commissioned a comparative study of the engineering costs associated with alternative development standards. The study compared capital, maintenance and replacement costs of the Cornell community, a proposed “new urbanism” development in Markham, Ontario, with two typical examples of post World War II development near the Cornell lands. Capital costs associated with the construction of sewers, utilities, roads, sidewalks, trees, etc. for Cornell were estimated to be reduced by as much as 20% per dwelling unit compared to conventional developments. Maintenance cost, including sewer cleaning, street sweeping, snow plowing, street lighting, grass cutting and garbage collection, were estimated to be reduced by as much as 13% per dwelling unit even with an assumed “high” level of snow clearing service in the lanes. Replacement costs were estimated to be up to 25% less per dwelling unit.

Infrastructure costs depend on several factors. Apart from public education and demand-side management, which can reduce infrastructure costs both on, and off site, there are three major factors affecting the cost of on-site linear infrastructure for new developments: street configuration, engineering and development standards and density and urban form.

7.3 Indicators of Performance

In the context of the issues described above, and by using the Selection Criteria listed in Chapter 3, the following indicators have been selected to evaluate infrastructure costs within the FVRD:

- Annual expenditure on municipal solid waste services per capita
- Annual expenditure on water abstraction, treatment and distribution per capita
- Annual expenditure on sewage treatment per capita

INDICATORS: INFRASTRUCTURE COSTS

- Annual expenditure on municipal solid waste services
- Annual expenditure on water abstraction, treatment and distribution
- Annual expenditure on sewage treatment

Why are these indicators important?

The anticipated increase in population in the FVRD will create new demands on municipal services, resulting in increased expenditures. Such expenditures should be optimised and monitored in order to avoid fiscal constraints that may jeopardise meeting the needs of the community in the future. These indicators are important as they reflect the FVRD goal of emphasising the role of sound, long-term fiscal planning while at the same time maximizing progress towards environmental goals. Furthermore, the costs of municipal infrastructure can also be seen as an indication of the efficiency in the service, which in turn reflects progress being made in social, environmental and economic areas.

What is the current performance of the FVRD in this indicator area?

	Annual Expenditure per capita 1996*			
District	Solid Waste	Water Extract	Water Sewage	Streets and Roads
FVRD	**$24.39**	**$80.87**	**$89.94**	**$103**
GVRD	$35.04	$81.03	$62.58	$102
CRD*	$23.71	$81.93	$69.41	$103

*Municipal Statistics (Ministry of Municipal Affairs 1996)

The values in the table were calculated by summing up the related *Municipal Statistics* values for the cities, districts, and villages in the Fraser Valley Regional District. (1996)

The differences in per capita costs are not only related to the efficiency of the systems employed, but also to such factors as urban form (discussed below) and:

- Age of the system – typically the longer the time period over which service has been available, the lower the unit costs; and
- Geography – typically hillside locations will reduce costs of sewage collection, and slightly increase costs for everything else.

8. Alternative Settlement Patterns

The manner in which population growth is distributed throughout the Regional District can influence the environmental, social, and economic impacts of growth. Consequently each indicator in this report has been used to evaluate the impact of urban form. For this purpose it was necessary to make assumptions about both the rate of population growth, and the options for urban form.

Population growth assumptions have been drawn from the document *FVRD Growth Distribution Scenarios for Working Paper Analysis*[3]. The FVRD estimated a total population of 450,000 as a planning concept target that is expected to be reached within the next 20-25 years. This is an increase of about 227,000 over the 1996 population.

Options for urban form were defined by FVRD planning staff. Three alternative settlement patterns were proposed at a conceptual level, and are referred to as High Density, Medium Density and Low Density. The ratios of housing types and locations for each pattern are described below, and are summarised in *Table 1.* Together these three settlement patterns cover the extremes of what might be possible within the Valley. This approach helps to establish the sensitivity of specific indicators to changes in urban form. In some cases, however, the settlement patterns were not sensitive to particular changes. For example, reducing the generation of solid waste is not so much a factor of where and how population grows, but of by how much the population is increasing.

The sensitivity analysis was accomplished by holding constant all other variables, such as improvement in technologies, change in market forces, and behavioural changes. The impact of urban form on each indicator was then calculated and expressed as a percent change relative to the baseline value for the FVRD (1996).

The three settlement patterns were derived through accommodating the additional population using varying ratios of housing types and densities, and then placing these new buildings into the existing urbanised areas and the urban reserve areas. Each of the settlement patterns is described below:

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[3] *FVRD Growth Distribution Scenarios for Working Paper Analysis, Revision 1,* July 1998, FVRD

Table 1 Details of Alternative Settlement Patterns

Housing Type	Occupancy per unit	Settlement Patterns High Density	Medium Density	Low Density
Single Family	2.70	30%	46.5%	58%
Row Houses	2.25	5%	8%	17%
Low Rises	2.25	46%	35%	25%
High Rises	2.25	19%	10.5%	0

Pattern 1: High Density
This settlement pattern assumes that by the year 2021, the distribution of residential building types within the FVRD will be equivalent to the current spread in the City of Vancouver. Specifically, 30% of the residential buildings will be single-family dwellings, 19% will be high rises, 46% low rises, and 5% row houses. To achieve this ratio, 90% of the population growth must be housed within the existing urban areas of the main communities (Abbottsford, Chilliwack, Mission, Hope, Kent electoral areas). The remaining 10% are housed within the urban reserve areas (currently largely undeveloped) of these communities.

Pattern 2: Medium Density
This settlement pattern assumes that in the year 2021, 50% of the building types and densities will be a 50/50 compromise between what exists now in the valley, and what currently exists in Vancouver. Therefore, 46.5% of the residential buildings will be single-family dwellings, 10.5% will be high rises, 35% low rises, and 8% row houses. To accommodate this type of development, 50% of the new growth will be housed within the existing urban areas, and 50% within the urban reserves.

Pattern 3: Low Density
This settlement pattern assumes that in the year 2021, the FVRD will have the same distribution of building types as it does now. Therefore, 58% of the residential buildings will be single-family dwellings, 25% low rises, and 17% row houses. There will be no high rises. To accommodate this ratio, the settlement pattern is assumed to require only 10% of the growth in the existing urban areas and the remaining 90% within the urban reserve areas.

8.1 Solid Waste

How does the choice of urban form affect the FVRD's performance on solid waste generation?

As the table below indicates, the choice of urban settlement pattern has a small but significant impact on the amount of solid waste produced and disposed of in landfills. If the settlement pattern in the FVRD is as dense in 2021 as the City of Vancouver is today (the high-density settlement pattern), and all other factors are held constant, the total amount of solid waste generated will be 11% less than in 1996. If the density does not change over the next couple of decades, however, there will be no such change in the amount of solid waste generated. In terms of waste disposed of in landfills, there will be an 8% difference between the high and low-density settlement patterns.

This variance is in most part a result of different levels of yard waste. Approximately thirty percent of the residential waste stream in the GVRD is made up of yard waste. Yard waste is the part of the waste stream that is most likely to vary with urban form settlement patterns, although other parts of the waste stream, such as construction and demolition waste, indoor waste, and white goods, such as large appliances, might vary as well.

Effect of Urban Form on Amount of Solid Waste Generated and Disposed

Settlement Pattern	% Change from 1996 Baseline	
	Solid Waste Produced	Solid Waste Disposed
High Density	-11%	-36%
Medium Density	-5%	-31%
Low Density	0	-28%

The effect of urban form on the amount of solid waste generated was calculated by varying the baseline amount by the decrease in garden waste that will occur with the increase in higher density urban form. Row houses were assumed to produce half of the yard waste of single family dwellings, and high rises were assumed to produce no yard waste. The amount of solid waste disposed of in landfills was then calculated by subtracting the target 51.5% of recycled waste from the total waste produced.

8.2 Water and Wastewater

How does the choice of urban form affect the FVRD's performance on water use?

As the table below demonstrates, if all other factors are held constant, the high-density settlement pattern will result in 13% less water consumption that the low-density settlement pattern. It also reveals that any amount of densification will reduce water consumption in the FVRD. The impact of urban settlement patterns on water consumption is primarily related to the fact that people living in single family dwellings will tend to consume more water caring for individual lawns and gardens.

Effect of Urban Form on annual per capita residential water consumption

Settlement Pattern	% change from 1996 baseline
High Density	-13%
Medium Density	-6%
Low Density	0

The percent change from the baseline was calculated by assuming a variation for the amount of water used for outdoor purposes, dependent on the land area per capita associated with the building types assumed in each type of settlement pattern. It was assumed that incremental pumping costs for hillside development would be insignificant, as in GVRD it costs $0.005/m3 for pumping potable water. *(GVRD Financial Statement, 1996)*

How does the choice of urban form affect the FVRD's performance for impermeability?

Urban form has a direct relationship to the area used for road networks, as demonstrated in the table below. The more densely populated a community, the less street frontage will be needed for housing, and the less roads will be needed for access and transport. It is no surprise, then, that the effect of urban form on the area of land used for roadways is very significant, with high-density development requiring less than half the land for roads than the current norm for the Region.

Effect of Urban Form on Area of Land used for Roadways

Settlement	% Change from 1996 Baseline

Pattern	
High Density	-53%
Medium Density	-30%
Low Density	-6%

The area of land used for streets, roads, and alleys for the different settlement patterns was calculated by varying two values for area of road per person. In the high-density settlement pattern it was assumed that every person used 122 square meters of road network —the equivalent value for GVRD in 1996. For the low-density settlement pattern it was assumed that every person used 211 square meters of road network — the equivalent value that was used for the FVRD in 1996. The medium density settlement pattern assumed a 50/50 ratio of the above values.

8.3 Energy

How does choice of urban form affect the FVRD's performance for energy use?

When analysing non-renewable energy on a per capita basis, urban form has a significant impact on the amount of energy used for operation of residential buildings. This is the case because different settlement patterns lead to different types of buildings and different building types offer different amounts of floor area per occupant. A multiple unit dwelling, for example, tends to use space more efficiently, and therefore the energy consumed per person is less than normal for a single-family dwelling. Also the multiple unit dwelling has shared walls, and may require less heat energy per square meter.

The more single-family dwellings there are in a community, the more energy will be consumed on average, for every individual. As the table below indicates, there would be 21% savings in the amount of energy consumed for every individual in the high-density settlement pattern.

The settlement patterns have almost no impact on the amount of energy used for each type of building. In other words, a building located in a dense development will use almost the same as a similar building in a less dense development. (This may not be the case if the building happened to be an advanced design, incorporating special features to maximise solar access and natural ventilation.)

Effect of Urban Form on annual electricity and fossil fuel energy used for operation of residential buildings

	% change	% change

Settlement Pattern	from baseline per square meter	from baseline per capita
High Density	0	-21%
Medium Density	0	-9%
Low Density	0	0

The values for the different settlement patterns were calculated using data on the number of different buildings combined with energy-use intensities of different building types. All electricity in new development is assumed to be non-renewable as it comes from Burrard Thermal. Single-family dwellings and row houses are assumed to be compliant with the National Energy Code for Houses. Low and high-rise apartments are assumed to be compliant with ASHRAE 90.1.

How does the choice of urban form affect the FVRD's performance for air emissions?

The impact of urban settlement patterns on CO_2 emissions is primarily related to the tendency for people travel shorter distances and use vehicles less when living in a denser urban form. Calculations reveal that if all other factors are held constant, the high-density settlement pattern will result in 22% less CO_2 emissions than the low-density settlement pattern. It also reveals that any amount of densification will reduce CO_2 emissions in the FVRD.

Effect of Urban Form on CO_2 emissions from energy used for transportation

Settlement Pattern	% change from baseline
High Density	-22%
Medium Density	-11%
Low Density	0

The values for the different settlement patterns were calculated by modifying the GVRD baseline with projected average travel distance and vehicle occupancy. For the low-density pattern, the GVRD baseline was modified with a projected average travel distance of 16 kilometres and an average vehicle occupancy of 1.35. For the high-density scenario, the baseline was modified by a projected average travel distance of 12.3 kilometres and an average vehicle occupancy of 1.3. The value for the medium density settlement pattern was calculated by averaging the high and low values. These values assume that all other factors such as changes to emissions, fuel efficiency, travel speed, behavioural changes, and demographic changes, remain constant.

8.4 Infrastructure Costs

How does the choice of urban form affect the FVRD's performance in terms of infrastructure costs?

As the table below illustrates, urban settlement patterns have a significant impact on three of the four infrastructure costs.

For solid waste, and water, the sensitivity analysis of the effect of urban form on these indicators reveals that, holding all other factors constant, the highest-density urban settlement pattern will result in 11%-14%% lower costs each year for each person than the lowest density scenario. Furthermore, for solid waste and water extraction, the high-density pattern would result in a decrease of per capita expenditure from the 1996 amount.

This occurs for several reasons. First, a low-density settlement pattern indicates that houses are bigger and more spread apart, while a higher density pattern denotes more compact houses. Experience demonstrates that people living in smaller units and lots produce less solid waste, and consume less water, thus minimizing the demand on the municipal infrastructure. Second, a more compact urban form has less road networks, requiring less driving distance for waste collection, and less length of water distribution and sewage pipes.

> "For conventional suburban developments such as Armadale and Mintleaf, a 50% increase in density from 14 to 21 upha, coul dreduce per unit infrastructure costs by about 25%. A doubling in density, from 14 to 28 upha, could reduce per unit costs by about 35%."
> (from *Changing Values, Changing Communities*, CMHC, 1997, p.36)

If all other factors are held constant, expenditure on water extraction will increase regardless of urban form. Of the three settlement patterns, however, the highest-density settlement pattern will result in the smallest increase in expenditure for waster extraction.

With respect to wastewater, the low-density settlement pattern is the only pattern that will result in an increase in expenditure over time, keeping all other factors constant. It is interesting to note that none of the patterns will result in expenditures as low as in the GVRD and the CRD.

Although urban form has a direct relationship to the area used for road networks (see previous indicator) there does not seem to be an impact on the expenditure for road networks.

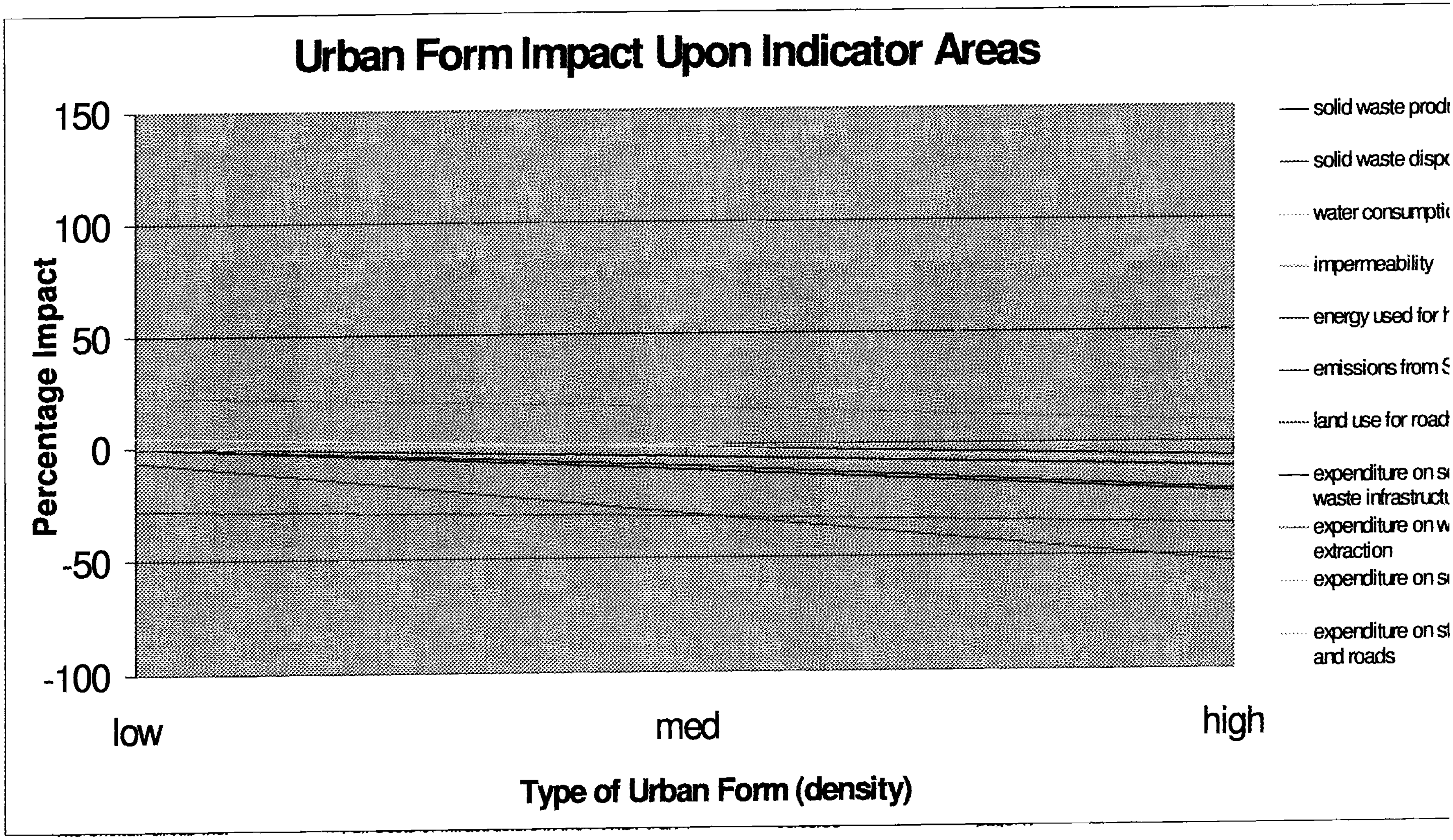
Effect of Urban Form on Expenditure on Municipal Infrastructure, per capita

	% change from baseline			
	Solid Waste	Water Extraction	Sewage	Streets and Roads
High Density	-6%	9%	-9%	-1%
Medium Density	-1%	17%	-1%	0%
Low Density	5%	23%	5%	0%

The effect of urban form on the cost of solid waste management services was calculated by using the 1996 value as a baseline, and factoring in the amount of solid waste produced per capita for each of the urban form patterns (the data calculated in the previous section). An amount of two cents was then added for each $1000 of assessed property value — the expected increase in cost for solid waste management if the Regional Solid Waste Management Plan is implemented. Operating and maintenance costs for garbage trucks, based on driving distance for the three settlement patterns was also calculated. For the lowest density pattern, it will cost $0.18 more per capita, or less than 1% variation from the baseline.

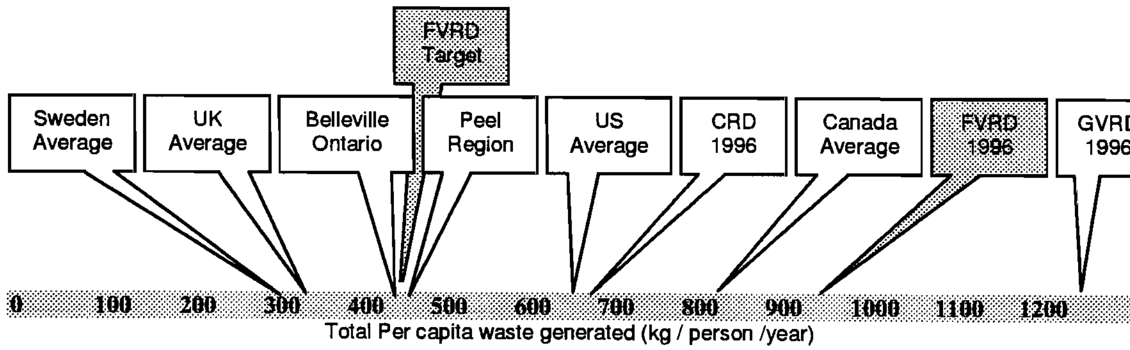
The baseline for the water indicators was obtained from *Municipal Statistics* (1996). The costs were then broken down into expenses that were either factors of consumption or the total number of dwelling units in each settlement pattern. For example, administration, and interest charges varied according to the number of units, and distribution, treatment, debt charges and transfers varied according to the amount of water consumed for each settlement pattern.

The expenditure on road construction and maintenance for the high-density settlement pattern was calculated by assuming that the municipality would spend $102/person each year—the baseline amount for the GVRD. The value for the low-density pattern was calculated by assuming that the municipality would spend $103/person each year—the baseline amount for FVRD. The medium density pattern was calculated by averaging the two.

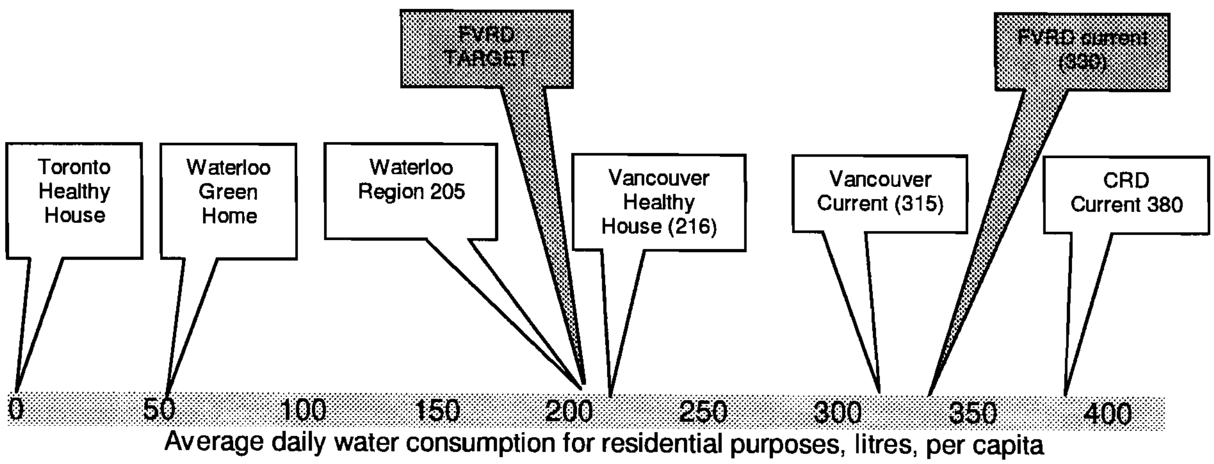

Urban Form Impact Upon Indicator Areas
150
100
50
0
-50
-100
Percentage Impact
low
med
high
Type of Urban Form (density)
solid waste prod
solid waste disp
water consumpti
impermeability
energy used for
emissions from
land use for road
expenditure on s
waste infrastruct
expenditure on w
extraction
expenditure on s
expenditure on s
and roads

9. Summary of Indicators and Targets

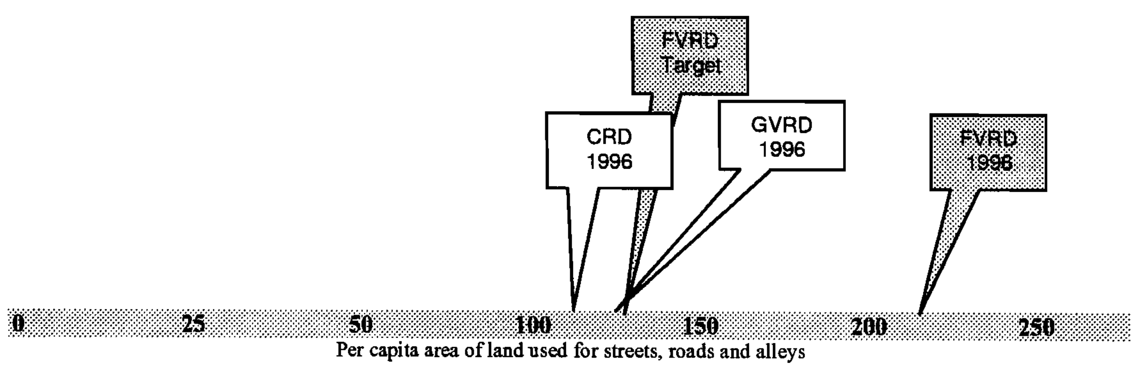
9.1 Indicator Area: Solid Waste



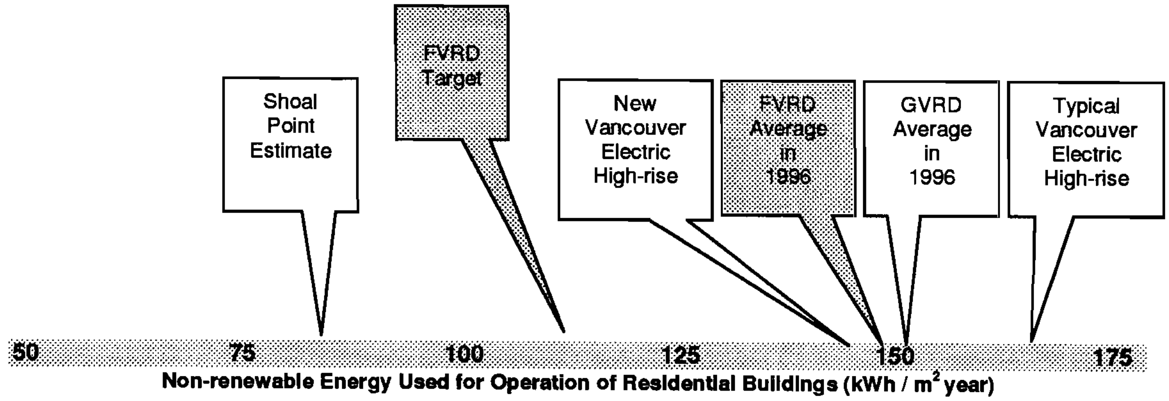
9.2 Indicator Area: Water Consumption



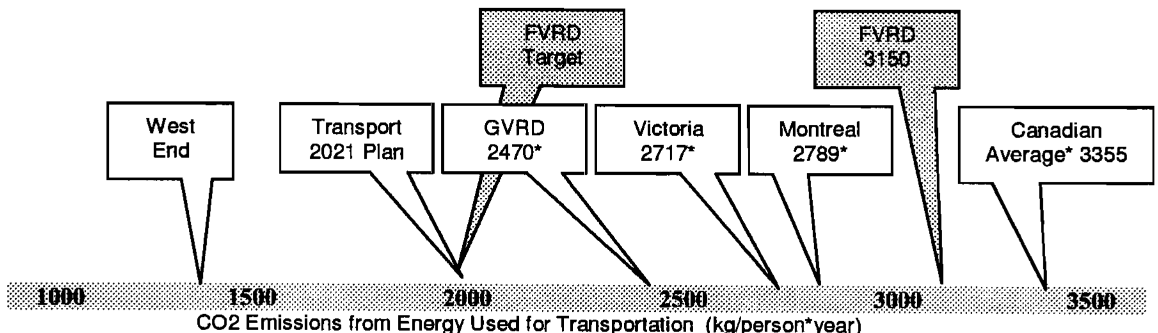
9.3 Indicator Area: Wastewater



9.4 Indicator Area: Energy Consumption



9.5 Indicator Area: Air Emissions



*Initiatives to Limit Transportation Energy Consumption and Emissions in Canadian Cities, prepared by IBI Group, 1993

10. Appendix One: Economic, Social and Environmental Impacts and Full Cost Accounting

10.1 Economic Impacts

Economic Impacts on the Private Sector

Measures of economic impact include employment, income and expenditures. Direct increases in these measures due to new development are straightforward calculations using data from local, regional, provincial and Federal sources.

Indirect increases in these measures are usually estimated through the use of input-output models. This type of analysis is most useful to compare impacts by types of jobs or industrial sectors associated with new development, or to compare different land uses on the same site. This type of economic analysis also predicts conditions at build-out of a proposed project or plan, based on existing conditions.

Indirect economic impacts can also be calculated through the use of econometric models. Such models are time-consuming and expensive to apply. However, they can account for interactions over time between growth and the economic base. For example, if public policies and regulations discourage new development in the urban reserve of the FVRD and encourage development in existing urbanised areas, over time residential and employment locations in the urban core and inner suburbs will become more desirable. As a result, property values, household incomes and employment opportunities there will increase. An econometric model can account for such improvements, and for the redistribution of households and jobs over time. Therefore this technique is most useful to compare economic impacts of compact versus sprawl development.

Economic Impacts on the Public Sector

Fiscal impact analysis compares the costs of public facilities and services needed to serve new development, to the revenues generated by growth. The result of this comparison is net revenues or costs to the FVRD and member municipalities.

Fiscal impact analysis most commonly uses the per capita method, or average costs per new resident and per job. Another technique is the case study method, in which the true marginal or average costs of growth are captured. This is important where the capacity of expensive public facilities such as water or waste facilities is an issue.

In Phase I of the FVRD work a case study fiscal analysis was conducted to show cost savings associated with more compact development due to less need for costly new infrastructure. However, a limitation of that analysis is that in using such a method, revenue projections were based on current market values. Due to lesser desirability of the urban core and inner suburbs as locations for new houses and jobs, lower market values may generate lower revenues for compact development.

As with economic impact analysis, the use of econometric modelling can address this problem with fiscal analysis. That is, if new development in the urban reserves were discouraged, market values in the inner suburbs and the urban core should increase over time. This would result in revenue projections less likely to penalise compact development as compared to a more sprawl development. It is beyond the scope of the current project, however, to perform this level of analysis.

Economic Impact Analysis and Development Patterns

Economic impact analysis is routinely included as parts of the long range planning process at the local, regional and Provincial levels. This type of analysis is a sharper tool with which to compare patterns of land development than is traditional economic analysis.

Outputs of a fiscal impact analysis include costs for infrastructure that is sensitive to distance, such as water and sewer lines and roadways. These capital costs are likely to be lower under compact development patterns. Of course, some of these distance-sensitive capital costs are borne by the private sector. This includes the construction of local roads and connection to existing water and sewer systems. However, the public sector is usually responsible for part or all of construction or expansion of regional facilities, such as wastewater treatment plants, and water and sewer distribution lines. The need to construct or expand centralised facilities is often greater under sprawl than under compact land uses.

Other outputs of a case study, marginal cost fiscal impact analysis include costs for infrastructure that is sensitive to capacity. This includes school buildings and arterial and collector roadways If existing systems have available capacity, these capital costs are also likely to be lower under compact development patterns. If existing systems do not have available capacity, and retrofitting is necessary (such as installing larger water and sewer pipes, or widening existing roads), infrastructure costs under compact development patterns may be significant.

To the extent that operating costs are associated with capital facilities which have existing capacity, they will tend to be lower under compact development than sprawl. However, recent research indicates that a number of other operating costs, such as public safety and traffic control, tend to increase with density.

A third output of fiscal impact analysis is revenues. Large proportions of public revenues are based on the market values of real property. To the extent that assumptions regarding consumer preferences and hence market values of new housing and workplaces are based on a snapshot of existing conditions, revenues may project out as higher under sprawl than under compact development. However, if the fiscal analysis is linked to econometric analysis, the assumptions driving revenues under compact development patterns may become more positive over time.

The final output of fiscal analysis is the net impact, or revenues minus costs. Fiscal analyses with revenue projections based on existing conditions may show that compact development generates lower net revenues, or even higher net costs, than sprawl. Fiscal analyses with revenue projections based on changing conditions over time are less likely to show net benefits to sprawl.

10.2 Social Impacts

The direct social impacts of new development are generally increases in population and employment, which are basic inputs for economic, fiscal, transportation and environmental analysis. Population and employment in turn generate demands for public facilities and services such as schools sewer systems and new energy infrastructure. Once these direct social impacts are quantified, they may become inputs to fiscal impact analysis.

Some indirect social impacts are documented as part of environmental impact analysis. These include the preservation of historic and cultural resources; the availability of open space, parks and recreational facilities; the quality of environmental design; and the availability of affordable housing. These impacts are usually described based on locally available data and surveys. They may be described quantitatively but are difficult to monetise. Social impacts are most often described qualitatively using indicators.

Indirect social impacts not usually documented are issues of equity, or who wins and who loses from changes in land use. A promising, but as yet rare, technique here is to develop a "social accounting matrix." This technique disaggregates the results of input-output economic analysis to households and workers by race, gender, age and income.

A comprehensive analysis of social impacts would compare changes in the level of community well-being, before and after development takes place. This technique is also rarely applied, although some communities in the United States are beginning to document baseline quality of life indicators. Documenting the baseline permits monitoring of change and tracking conditions in the future.

Social Impact Analysis and Development Patterns

Social impact analysis is an emerging field. At the most basic level, its outputs serve as inputs to all other forms of development impact analysis. These outputs include population, school enrolment, and employment. These outputs are also linked to the inputs of fiscal impact analysis, as follows. Given current levels of service, population generates the need for police officers, fire-fighters, and other public staff and facilities; and schoolchildren generate the need for classroom space, teachers, and other school staff and facilities.

Beyond such direct social impacts, a comparison of development patterns might attempt to include measures of quality of life (QOL) through the use of community surveys To date, such qualitative measures are not routinely included in development impact analysis.

10.3 Environmental Impacts

In local environmental assessments, baseline conditions are documented and compared to expected future conditions after build-out of a proposed development. Analysts use available data such as surveys, engineering and scientific studies, and data bases which link environmental impacts to types of land use. Comparison of baseline to future conditions is often done through the use of checklists and matrices. Another common method of comparison is through maps produced using Geographic Information Systems (GIS).

Measurements of impacts include acres of open space, wetlands, and wildlife habitats either lost or preserved; levels of pollutants in the air and water; volumes of storm water runoff; and decibels of noise. The carrying capacity of related manmade systems, such as water, wastewater and solid waste, can also be compared to the projected demands generated by a new development.

Because environmental impacts are expressed in so many different units of measurement, analysts have constructed techniques and models that attempt to weight and scale impacts in the same units of measurement, and even to assign monetary values. Such techniques and models present obstacles for decision-makers in following the steps in reasoning, and in challenging the judgements involved in assigning values to environmental impacts. Evaluating the significance of environmental impacts is best done by an interdisciplinary team of professionals, working with decision-makers.

Environmental Impact Analysis and Development Patterns

In this paper environmental impacts are focused on natural resources such as air, water, soil, species and habitats. Generally, compact development will result in lower consumption of natural resources and fewer negative environmental impacts.

These impacts can be measured in terms of acres of open space, wetlands, and wildlife habitats either lost or preserved. Impacts can also be measured in terms of levels of pollutants in the air and water, volumes of stormwater runoff, and decibels of noise. Finally, impacts can be compared to the carrying capacity of natural and related manmade systems, such as water, wastewater and solid waste.

Baseline and future conditions are expressed in different units of measurement, depending upon the type of impact. In other words, environmental impacts (like social impacts) are measured in apples and oranges. Analysts have attempted to construct techniques and models, which permit the comparison of apples and oranges, and even their valuation in monetary terms. However, the use of such techniques and models "prevent(s) the public and decision makers from following the steps in reasoning and challenging judgements." Or, to continue with the analogy, "it is easier for a decision maker to apply his or her own weights to apples and oranges when they are presented as such, than when they have both been scaled to some organic fruit using panel(s) of experts". For this reason the full costs of infrastructure are expressed using a series of indicators, and no effort is made to aggregate the results into an index or dollar value.

11. Appendix Two: Key Sources of Information

Key sources of information used for this research are summarized by topic below.

Topic	References
General, Background, and Costs	Blais, P., The Economics of Urban Form, Prepared by the GTA Task Force, 1996 Canada Mortgage and Housing Corporation, Changing Values Changing Communities, A Guide to the Development of Healthy Sustainable Communities, 1997 Canada Mortgage and Housing Corporation, The Integrated Community, A Study of Alternative Land Development Standards, 1997 Canada Mortgage and Housing Corporation, Conventional and Alternative Development Patterns, Phase 1 Infrastructure Costs, 1997 Healy, M., Ed., Fraser Basin Ecosystem Study, Westwater Research Centre, Vancouver, 1997 Ministry of Municipal Affairs, Municipal Statistics, 1996, Victoria, BC, 1996 Sheltair Group, Visions Tools and Targets, Environmentally Sustainable Development Guidelines for Southeast False Creek, Vancouver, 1998 The Corporation of the Village of Harrison Hot Springs Official Community Plan, 1995 The City of Chilliwack, Chilliwack Future Plan, 1998. The District of Kent, Official Community Plan The District of Mission Official Community Plan, 1998 The City of Chilliwack Personal Communication City of Abbotsford, Official Community Plan, 1998 The District of Mission, Personal Communication The City of Abbotsford, Personal Communication Township of Langley, Construction Cost Estimating Guide, 1998
Land Use & Roads	BC Ministry of Agriculture, Fisheries and Food, Subdivision Near Agriculture, 1996 Community Matters, Managing Colorado's Future, A guidebook for Integrating Land Use, Transportation and Air Quality Planning, 1997 Condon, P.M. Ed., Urban Landscapes, The Surrey Design Charrette, University of British Columbia, 1996 District of Kent, Official Community Plan, 1994 Environment Canada, State of the Environment British Columbia, 1994.

Topic	References
	Environment Canada, State of the Environment for the Lower Fraser River Basin, 1992. Quadra Planning Consultants, Environmental and Ecological Working Paper, Vols. I & II, 1998-11-20 The District of Mission, Cedar Valley Comprehensive Development Plan, 1996 The City of Chilliwack, Downtown Revitalisation Plan, 1996 The City of Chilliwack, City Centre Plan, 1997
Water & Wastewater	BC Ministry of Environment Parks and Land, BC Water Quality Status Report, 1996 Dayton & Knight, Fraser Valley Regional District, 1995/96 Update of Master Plan, Vancouver, 1996 Dayton & Knight, Abbotsford Mission Study Area Liquid Waste Management Plan, Vancouver, August, 1998 Fisheries and Oceans Canada, Fraser River Basin Strategic Water Quality Plan, Vancouver, 1998. Ministries of Health, Lands and Parks, Fisheries and Forestry, Fraser Valley Groundwater Monitoring Program: Final Report, 1995 Ministry of Agriculture, Fisheries and Food, Census of Agriculture. 1996
Solid Waste	Fraser Valley Regional District Regional Solid Waste Management Plan, August 1996
Energy	BC Hydro, Bringing Electricity to the Livable Region: An Electricity Perspective on Growth and Livability in the Lower Mainland, 1994. BC Hydro, High and Low Rise Apartment Audit and Simulation Study, 1994 ASHRAE, Energy Efficient Design of New Buildings, ASHRAE 90.1, 1990 Sheltair Group, Residential Action Opportunity Cost Curves for the National Climate Change Secretariat Buildings Table. 1999. Ministry of Agriculture, Fisheries and Food, Census of Agriculture. 1996

12. Appendix Three: Background Assumptions for Indicators

Indicator	Background Assumptions and Notes
Population	Current and projected populations obtained from Urban Eco Consultants documents. To obtain information on the relative number of each dwelling type (SFD/duplex/row/low rise and highrise) for the 3 scenarios, the densification scenarios assume a residential building mix found in the city of Vancouver, and the sprawl scenario uses a building mix in the FVRD in 1996. This methodology was requested by the FVRD. Note that Urban Eco developed population projections for each TAZ (traffic area zone) in the FVRD. Initially, this information was used to generate the housing mix by using population density in each TAZ to estimate housing type (ie/ a density of 160 people per capita implies high rise buildings).
Amount of solid waste produced annually per capita	Baseline from FVRD Regional Solid Waste Management Plan (SWMP). Differences occur mainly due to generation of yard waste in single family dwellings versus no yard waste from apartments.
Amount of solid waste disposed to landfills annually per capita	Landfilled waste is based on targets from the SWMP. Note that some municipalities do not pick up yard waste. Yard waste in these areas must be composted. Therefore the indicator may overestimate solid waste to landfills.
Cost of garbage collection service	Baseline obtained from Municipal Statistics. Projected costs are obtained from using per capita costs and multiplying by the population. This value is further modified by adding the cost of implementing the SWMP (which is obtained from the SWMP documentation). The cost of implementing the SWMP is based on the assessed value of buildings. The number of single family dwellings versus apartments for the three scenarios was used, along with average assessed value of different building types to develop the estimate. The cost is dependent on the relative mix of single family dwellings versus apartments. This mix is not adequately modeled. Presumably there will be additional cost to collect garbage if development is spread out, but the current analysis cannot capture this. The cost of waste management will likely be more highly dependent on the availability of landfill sites. This is probably the reason the cost of waste management in the GVRD is substantially higher than in the CRD or FVRD. Note that a couple of the landfills in the FVRD have about 10 years left in them. Note also that Chilliwack does not have municipal collection.
Annual expenditure per capita on municipal solid waste services	This is the indicator above divided by population.
Annual per capita amount of water consumed for residential purposes.	The baseline data comes from the Dayton and Knight Report on water consumption (FVRD 1995/6 Update of Master Plan). Information therein is broken down into indoor and outdoor use. Differences between the scenarios are due to different outdoor water consumptions. It is assumed that there will be no change in technology over the next 20 years.

Annual expenditure per capita on water extraction, treatment and distribution.	Baseline obtained from Municipal Statistics. Costs are broken down into categories such as administration, distribution, debt charge and transfers. These items are dependent on • total volume of water • number of customers • spatial distribution (defined by density) To develop the projections for the 3 scenarios, the line items are multiplied by the appropriate factor to come up with a cost. In order to derive a per capita value, the indicator is divided by the population.
Annual per capita expenditure on sewage treatment	Baseline obtained from Municipal Statistics. Cost are broken down into categories such as administration, distribution, debt charge and transfers. These items are dependent on • total volume of water • number of customers • spatial distribution (defined by density) To develop the projections for the 3 scenarios, the line items are multiplied by the appropriate factor to come up with a cost. In order to derive a per capita value, the indicator is divided by the population.
Quantity of area which is impermeable, excluding unorganized areas (of roads)	Baseline obtained from Municipal Statistics. Projections use an area of road per person for the GVRD and FVRD for the dense and sprawl scenarios respectively. The medium density case is the average of the two extremes.
Quantity of area which is impermeable, excluding unorganized areas (due to residential buildings & parking areas)	Uses the housing mix combined with estimates of permeable versus impermeable area for single family dwellings, apartments and commercial areas. The housing mix used the GVRD housing mix for the dense scenario and existing FVRD for the sprawl scenario. The estimates for permeable versus impermeable areas are based on judgement for average dwelling archetypes. Commercial buildings are not included in this indicator.
Annual per capita expenditure on building and maintaining roadways.	Baseline obtained from Municipal Statistics. The dense scenario uses the same per capita cost for roads as is found in the GVRD. The sprawl scenario uses FVRD numbers. Note that the indicator changes by $1 per person. Although there are fewer roads in the dense scenario than in the sprawl scenario, the roads are used more frequently and will require more maintenance. Therefore the costs are about the same for all scenarios.
Per capita area of land used for streets, roads and alleys	Based on an area of road per person. Uses the GVRD for the densification scenario and the FVRD in 1996 for the sprawl scenario
Annual per capita electricity and fossil fuel energy consumed for operation of residential buildings.	Uses data on the number of different buildings combined with energy use intensities of different building types. Note that all electricity in new development is assumed to be non-renewable as it comes from Burrard Thermal. SFD and row houses are assumed to be compliant with NECH. Low and high-rise apartments are assumed to be compliant with ASHRAE 90.1

Assessing the Full Costs of Water, Liquid Waste, Energy and Solid Waste Infrastructure in the Fraser Valley Regional District

Part 2: Development of a Monitoring Tool, FVRD Case Study

Submitted to:
Research Division, CMHC
Planning Department, Fraser Valley Regional District
Growth Strategies Office, Ministry of Municipal Affairs

Prepared by:
The Sheltair Group Inc.
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The International Centre for Sustainable Cities (Sustainable Cities Foundation)

February 2000

Contents

Introduction

1. Project Overview

This is the second of a two-part report on infrastructure and energy services in the Fraser Valley Regional District (FVRD).

Part 1 provided an overview of methods for full cost accounting, and applies a specific method to the FVRD. The method adopted for the FVRD uses a series of key indicators to measure performance in environmental and economic terms. Part 1 also provided information on the status of the infrastructure in the valley, including background information on the systems, their current capacity and location, and issues of concern.

Part 2 provides a tool for monitoring and evaluating infrastructure costs and performance. The tool is intended to function as a foundation for a regional Environmental Management System. The tool uses database software and a GIS application to allow planners to compare indicators of performance at varying spatial scales. A database is completed that includes the essential information for analysing the FVRD infrastructure. The indicators of performance used in Part 1 are further refined, so that they can be used with the tool for any regional planning purposes. Results are presented for the FVRD water, wastewater and energy infrastructure.

2. Limited Scope of the Tool

An in-depth analysis of data availability for the FVRD lead to revisions in the functionality and scope of the software tool and database structures. Originally it had been proposed to expand Sheltair Group's integrated accounting and forecasting software in order to create a tool suitable for full cost accounting of infrastructure options for FVRD growth management. However in the process of working on the database, an alternative approach evolved which better suits the needs of the FVRD, and the resources of this project.

Firstly, it was difficult to obtain the detailed data required to complete a case study. We tried to resolve this issue by focusing only on only one or two communities within the FVRD, but it proved difficult to agree on specific locations. Eventually an alternative approach was adopted, which involved creating a tool for profiling performance within the entire FVRD, but with limited capabilities. The tool uses a set of core indicators. Default data is used to complete the initial database.

Secondly, we attempted to adapt the design of the software to better reflect planning priorities for the FVRD. The planning tool is now designed to become a foundation for an Environmental Management System for FVRD infrastructure. At this stage, the software will focus only on profiling and comparing performance. At a future date the database may be used to assist in forecasting costs and resource use for specific development scenarios.

The bulk of the effort has been focused on the database structure and mapping of data. This provides a good foundation for future software planning applications. The same database structure is expected to be suitable for use in other regions of BC and Canada. The tool has been designed with Web-based applications in mind.

The tool addresses resource use and costs for three types of infrastructure only: energy, water and liquid waste. Solid waste was dropped from the scope of our work. Feedback from planners at the local municipalities indicated a general lack of interest regarding solid waste performance at this time. Part of the reason for this lack of interest is that responsibility for management of solid waste varies greatly, and is often not germane to planners. Many portions of the waste stream within the FVRD have been privatised, and are excluded from the landfills. This makes it difficult to define the scope of information needs for solid waste planning, to identify indicators of common interest, and to obtain the data.

3. An Environmental Management System for FVRD

In order to define better the software functions, it is useful to elaborate on how regional governments can use an Environmental Management System (EMS).

In general, an EMS is a proactive approach to protecting and enhancing environmental quality. Rather than trying to mitigate environmental damage on a project by project, or product by product basis, an EMS attempts to integrate environmental goals within the existing management structure. An EMS may include ambitious objectives for improving environmental performance, similar to corporate objectives for increasing profit and enhancing customer service.

EMS is now widely used by industries around the world, largely due to the adoption of national and international standards, such as the ISO 14001. Many national government departments are also adopting EMS. Typically, an EMS includes a comprehensive set of policies and procedures that are intended to minimise negative impacts of resource use, and allow the firm or government to efficiently and effectively achieve goals for environmental performance. EMS also makes it easy for an organisation to communicate its environmental performance, both internally and externally, as part of full cost accounting.

An EMS may need to include many elements to ensure success, including staff training, audits, and standard reporting formats. However the basic elements of EMS are simple, and include:

i. Goal statements (and a commitment to achieve the goals)
ii. An analysis of the potential environmental impacts related to company operations
iii. Creation of a set of indicators, or evaluation criteria, that can be used to assess performance, and to set measurable targets and triggers.
iv. An action plan for meeting targets.
v. A monitoring program for ensuring accountability.

When reviewing this list it was apparent that the FVRD already had in place much of what is required to implement an EMS for infrastructure planning. Part 1 of this study clearly outlines the FVRD goals related to environmental performance and infrastructure. We used these goals to create a set of key indicators that can be measured over time and used to assess performance. Part 1 also proposed some targets that might be appropriate for the FVRD.

The next step, therefore, is to put in place a system that can be used for monitoring the performance of the FVRD, and ensuring accountability. This system must be capable of efficiently collecting data, and calculating the key indicators of performance for the FVRD. It should also be capable of producing comparisons relative to past performance, or specific targets, or sub-regions and other locations.

It is just such an evaluation and monitoring system that is the focus of design for the tool we are now developing. It is basically a database and reporting program that can be accessed via the Web, and used to provide planners and others with feedback on how well the FVRD is performing, relative to the goals established by the board.

Design Features and Essential Outputs

The tool consists of an ACCESS database and an ARCVIEW GIS file. This allows input and output data to be presented spatially, or as part of standard reporting formats. Key features of the database structure are described below.

4. Enumeration Areas

The database is broken down on a geographical basis, using Enumeration Areas (EAs). The FVRD currently is made up of 354 EAs. Their area varies considerably. The average population for an EA is approximately 1000 people – about as many people as a single census-taker can handle. The EAs represent a suitable building block for the database, since this is the structure for the census data. The areas and boundaries of the EAs are congruent with the municipal jurisdictions, - for example, the municipality of Mission is made up of exactly 47 EAs.

Originally it was proposed to use traffic zones for the database, since many other planning exercises use these areas for analysis. However the TAZs were rejected, since their boundaries tend change a lot over time. Moreover the traffic area zones proved too large for refined analysis.

5. Indicators

Since the EA will be the lowest level of aggregation within the database, all indicators can be reported at the EA level – or for any combination of EAs.

The software currently addresses a core set of 29 different indicators, covering water, liquid waste and energy, along with a summary of statistics on the EA.

Initially the tool is designed to provide broad and shallow reporting on overall performance. Indicators measure the performance of collections of end uses, as opposed to every end use. For example, energy for lighting, appliances and motors has been summed together. This can be expanded as appropriate, by disaggregating each indicator into more specific terms. The focus of the analysis is on resource use, and the associated emissions and dollar costs. Indicators have been selected that address both resource demand and resource supply.

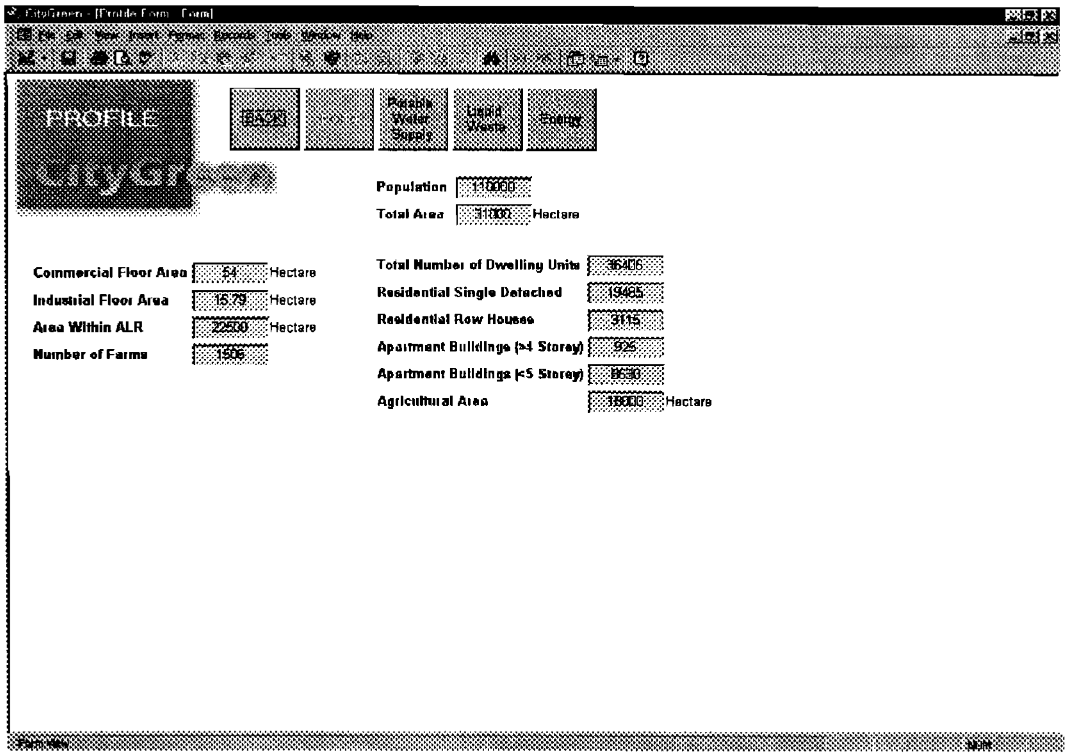
Indicators are calculated from a hybrid approach using bottom-up and top-down methods. Bottom up approaches use statistics on population, housing, agriculture, industry, land area, road and linear infrastructure lengths and widths, and so on. We then alter the bottom-up values as reasonable, to ensure that the total resource flows and costs are consistent with any metered or measured resource flows. The database should be capable of increased accuracy, as more empirical data becomes available.

Indicators are calculated for the year in which we have most current data. Initially no historical data is included. However if the database is regenerated each year, earlier years can be archived and used for year to year comparisons and trend analysis.

6. EA Statistics

The software tool includes an "EA Profile" report, to provide a more complete overview of the basic statistics on the EA. An example of this report is shown in Figure 1.

Figure 1 EA Profile within software tool



The sources of information for such an EA profile have been listed in Table 1.

Table 1 Sources of Information for Profiles

Contents of an EA Profile:	Sources of Data
♦ Population for EA	♦ Stats Canada Census
♦ Dwelling numbers and type.	♦ Stats Canada Census
♦ Sq. meters of commercial floor area by use-type	♦ Municipal statistics
♦ Agricultural area in Ha, by type	♦ Ministry of Agriculture, collected from Census of Agriculture
♦ Commercial floor area	♦ Estimated from ratios developed from

	one city in FVRD, and one rural area, using BCAA data.
♦ Number of Farms per EA	♦ Counted from polygons on the GIS map showing farm classifications and property lines

7. Water Indicators

The set of core indicators used for potable water infrastructure are shown as seen in the software application, in Figure 2. The software is scalable, and allows the user to burrow down into more detailed levels of information as is appropriate. The (MORE) button to the right of each indicator provide options for disaggregation according to the subcategories and variables identified in the data collection work. Future options exist to allow for presentation of the data on graphs. An effort was made to include specific graphics in the current software tool, and examples were created for demonstration purposes. However the budget did not permit completion of the graphics features and at present the only graphical presentation of indicator results is the mapping of data on GIS, (discussed later in this report).

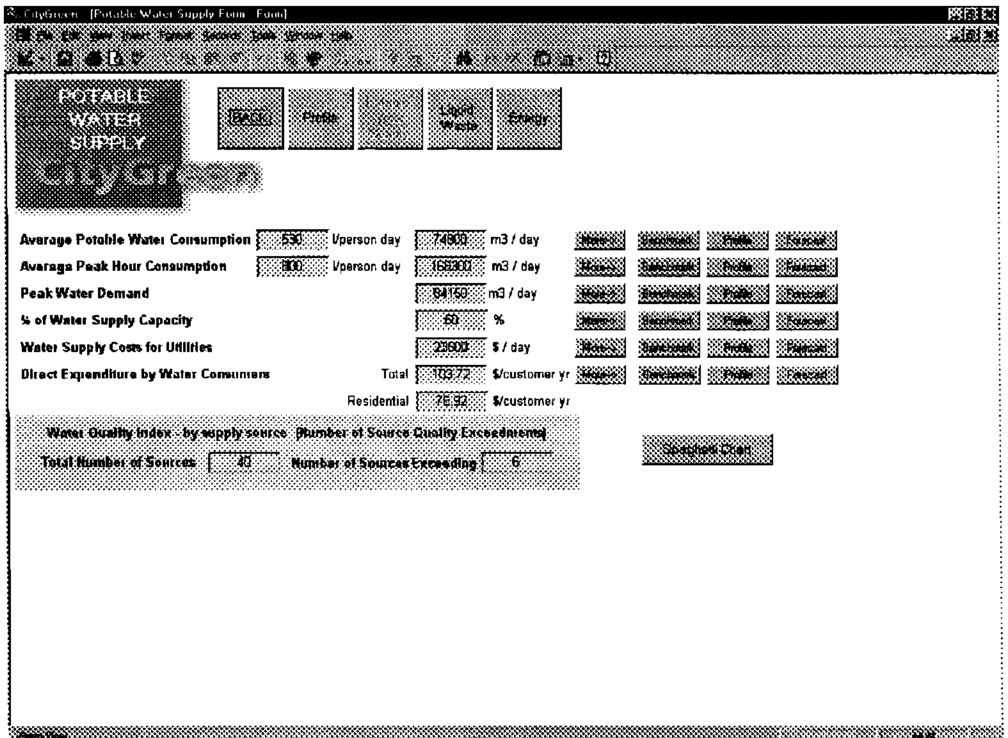


Figure 2 Example Screen Output for Water Indicators

8. Liquid Waste Indicators

The set of core indicators used for liquid waste infrastructure are shown as seen in the software application, in Figure 3.

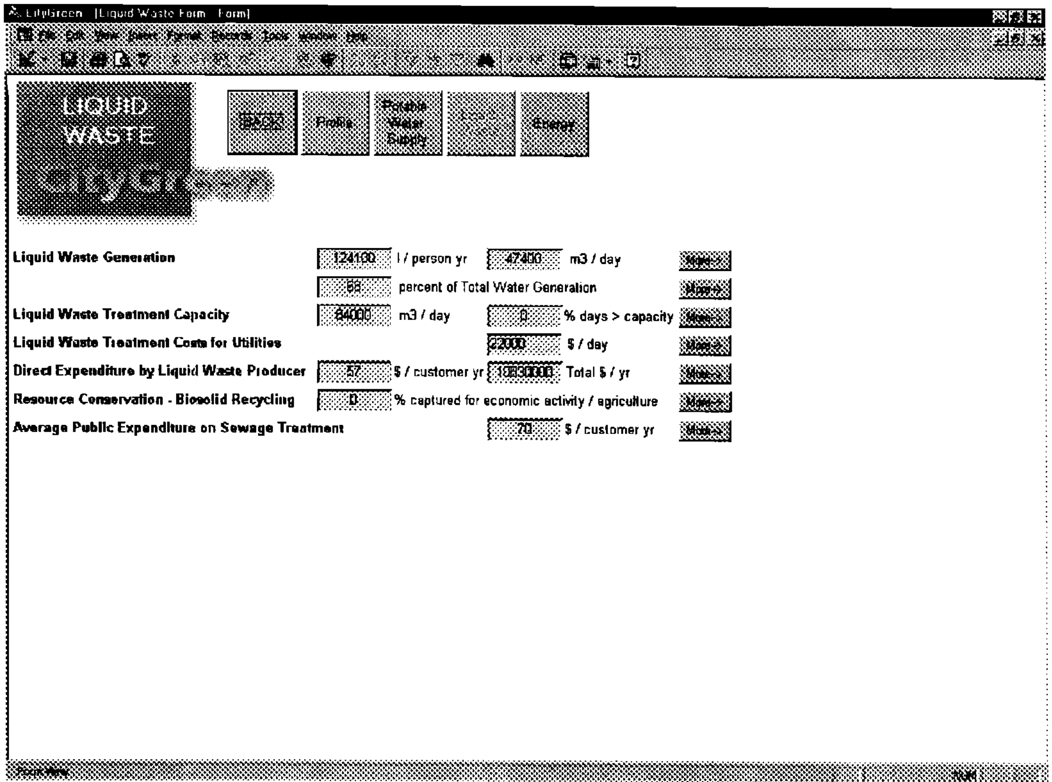


Figure 3 Example of Liquid Waste Indicators

9. Energy Indicators

The set of core indicators analysed for energy infrastructure is presented in the software tool, and includes Average Day Energy Consumption, Direct Expenditures by Rate Payers and Energy Related Greenhouse Gas Emissions. These are summarised by Sector as well as by Fuel Type.

10. Mapping

The GIS application can be used first for three functions:

1. selecting specific EAs for indicator analysis, by pointing at the EAs or circling specific portions of the region that contain a number of EAs;
2. viewing the elements of specific infrastructure (roads, plants, corridors), and
3. mapping the results of indicator analysis

The land use information, and indicator results can be viewed on a map for the entire FVRD, or zoom options can be used for detailed analysis.

The land use data available for GIS presentation has been combined into a single layered GIS file. An example of the GIS output with land use layers is shown in Figure 4. **Below the** lists the themes and attributes available for examination on the map. The Map of Abbottsford, in Figure 4, shows the indicator results for potable water consumption presented spatially.

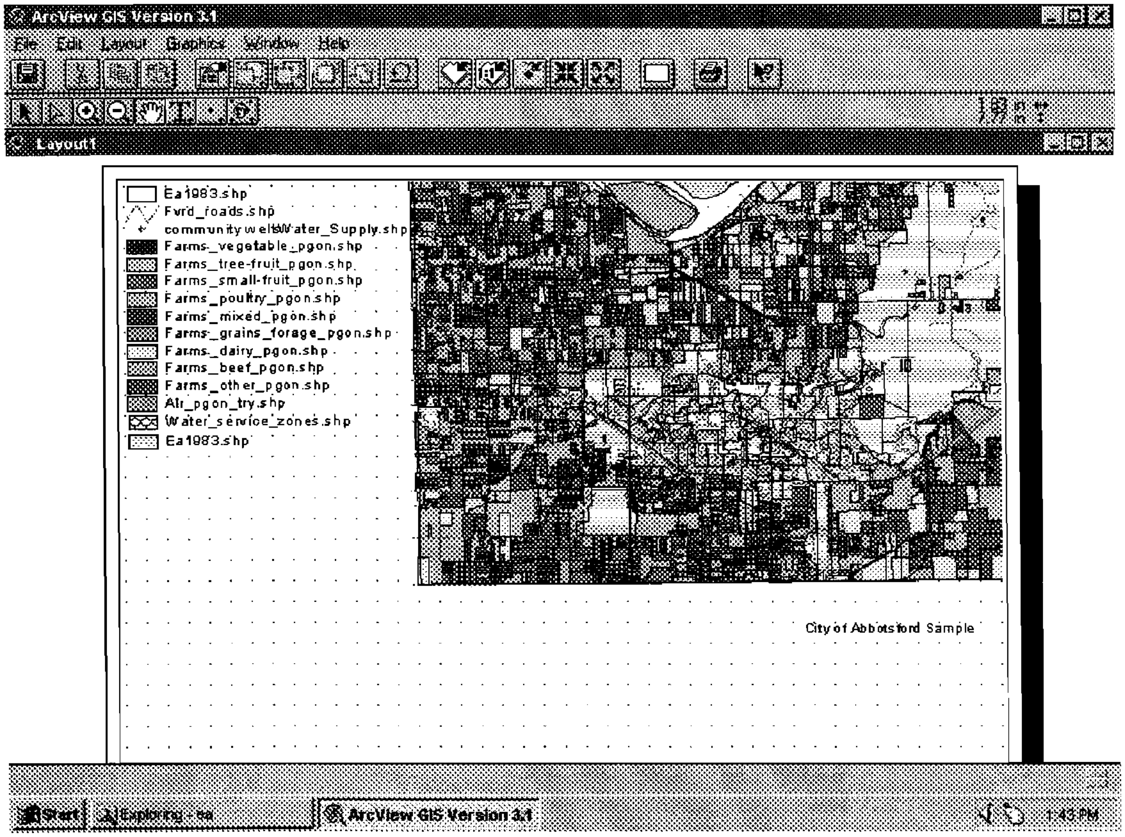


Figure 4 Example of Some of the GIS Layers for FVRD

Table 2 GIS Layers and Data

Theme or layer within GIS for FVRD	Attributes associated with themes
1. EA boundaries	♦ Population, area, dwelling numbers and types
2. Roads on a GIS map	♦ Location and name
3. ALR boundary on a GIS map	♦ Boundary location and total area
4. Agricultural land use	♦ Farm types, locations and areas
5. Community well locations	♦ Location and flow rates
6. Water supply locations	♦ Location, flow rate and capacity
7. Gas pipe right of ways	♦ Location
8. Hydro power lines	♦ Location with substations
9. Water service area polygons	♦ Area, primary water sources
10. Water courses and bodies	♦ Location
11. Municipal boundaries	♦ Location, area, population, length of roads and pipes

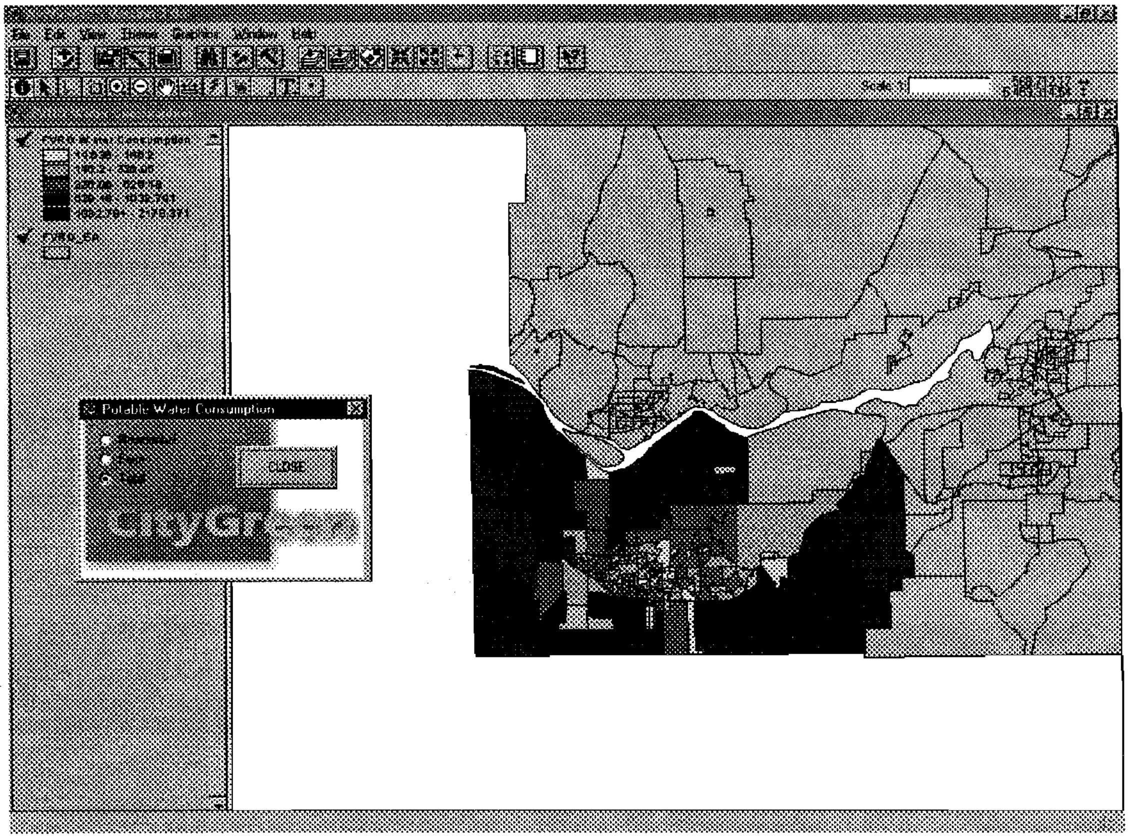


Figure 5 Example Mapping of Indicator Results: Water Consumption in Abbotsford

11. Options for Web-based Access

It is proposed to design the tool so that it can be easily accessed on the Web, should the FVRD planning department deem this to be a worthwhile feature. This means that the database querying function will permit users to specify the type of report, and the specific EAs of interest, and any comparison data (where relevant). This information would then be sent back to the Web site, and processed by the tool. The results would be returned to the email address provided.

Data Collection

The data collection strategy has been designed after analysing each of the required outputs for the tool. Each indicator has been sub-categorised into key variables that represent essential data inputs for the tool.

The sub-categorisation allows for the indicators to be further analysed, at varying levels of detail. For example, the *Peak Water Supply Capacity* will be recorded on a system basis, as well as an EA basis. Any EA that is serviced by two (or more) water systems would therefore have two indicators for *Peak Water Supply Capacity*. Another example is the *Peak Water Demand*, which will be sub-categorised by sector. Thus each EA could have a series of indicator outputs, one each of residential, commercial, agricultural and industrial water demand.

For all of the subcategories of data, it is necessary to identify the best available source of current data for use in the database. This exercise has now been completed, and has guided our data collection efforts. At the end of this Report, a table is provided that identifies the categories of indicators, the issue of concern, the specific indicator, the sub-categories of data required, and, finally, the best available source for the data.

Identifying the best available data, and the degree of specificity for the data, is one of the most difficult elements of the tool design.

12. Limitations with data availability

Data collection for the mapping and profiling has proved problematic for two reasons. First, monetary costs associated with the purchasing of large, highly specific data sets proved prohibitive. Second, much of the specific data do not exist, or they exist in a format not transferable into a GIS system. Table 3 lists some of the difficulties encountered during the extensive investigations undertaken into various data sets of possible value to this project.

Table 3 Difficulties in Obtaining Data

Category of Data	Difficulties Encountered
Residential, Commercial and Industrial Building Stock	▪ detailed data from assessment authorities or others is cost-prohibitive ▪ most data is residential only and lacks building age and floor area statistics
Roadways	▪ data does not specify road classifications (major, secondary, local, etc.) ▪ available data has limited physical attributes (road widths, surface types, right-of-way widths)
Land uses	▪ data is limited to agricultural land use ▪ data from OCPs is limited in terms of actual land use versus proposed zoning ▪ some available data from OCPs is in a non-digital format
Industry activity	▪ existing industrial activity location and statistics are not readily available in digital format for individual municipalities
Water Supply	▪ private well locations are unavailable for the region in an easily transferred format

Manipulation

Incoming data sets require some from of manipulation and editing in order to be useful under a single application. This is done on an ongoing basis until the data set is sufficiently complete to be of value to the program. The following list summarises the various data formats and the required manipulation.

- **CAD** – "layers' of information need to be converted from CAD to GIS and then from polylines to polygons
- **GIS** – Text data needs to be converted from spreadsheet format and manipulated into the GIS format
- ***Compustreets***^{TM} – Road right-of-way information does not exist from this source and road classification data from this source is an added expenditure. Land use information from this source is non-existent for the FVRD. No manipulation is required.
- ***CityView*** ^{TM} – The FVRD uses this format, which *is* transferable into GIS format.

- **BC Assessment Authority** – this source of information is comprehensive and available in digital format (tabularized)
- **Statistics Canada** – EA information is in spreadsheet format and requires transfer, joining and editing in the GIS program.
- **Spreadsheets** – text and numerical information received in this format is used to generate default values for various calculations, including the length of piped infrastructure and resource demands.
- **Selected communities within FVRD** – Several communities do not have CAD or GIS capabilities, therefore they do not have data in digital formats. Any existing information needs to be inputted manually or digitised.

Appendix 1. Variables Identified for the Core Set of Indicators

The following pages specify the data sets required to generate indicators for the categories: Potable Water, Liquid Waste and Energy.

POTABLE WATER INDICATORS:

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
Potable Water Consump-tion	♦ m3 per day* ♦ Litres per person-day* ♦ As a % of Total Water Consumed in EA **consumption averaged over the whole year*	**1. By Source:** **Surface**: ♦ Reservoirs ♦ Springs ♦ Lakes ♦ Ponds ♦ Streams ♦ Estuaries ♦ Wetlands & Swamps **Ground** ♦ Public Well ♦ Private Well ♦ Artificially Re-charged Groundwater **Atmospheric** ♦ Precipitation on Impervious surfaces ♦ Directly condensed **Recycled Waters** ♦ Community Waste Water ♦ Industrial ♦ Mining **Brackish and Saline** ♦ Brackish ♦ SeaWater **2. By End Use:** **Residential** ♦ Drinking ♦ Hygiene ♦ Irrigation **Commercial** ♦ Drinking ♦ Hygiene ♦ Irrigation **Industrial** ♦ Special quality ♦ Processes **Agricultural** ♦ Livestock ♦ Irrigation **3. By Time of Year** ♦ January ♦ August	1. Consumption from each public water source (for use in calibration) ♦ Utilities directly, or recent reports 2. Total Consumption for calibration purposes ♦ Local water utility information will be geo-coded to disaggregate by EA ♦ Consumption from private sources will not be considered for calibration 3. Total Consumption from private sources (e.g. wells). ♦ For private wells we have only the capacity and no data on consumption. 4. Water breakdown for residential and commercial spaces by type and end use ♦ default values from the literature will be used until we have more specific and accurate data ♦ Residential uses will be broken down by person for drinking and Hygiene, and by dwelling type for irrigation. 5. Agricultural consumption by Ha and type ♦ Agricultural consumption by type from default ratios supplied by Ministry of Agriculture 6. Industrial activity by Land Area ♦ From each municipal planning department

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
Peak Water Availability	♦ m3 per day	**1. By Source:** **Surface**: ♦ Reservoirs ♦ Springs ♦ Lakes ♦ Ponds ♦ Streams ♦ Estuaries ♦ Wetlands & Swamps **Ground** ♦ Public Well ♦ Private Well ♦ Artificially Re-charged Groundwater **Atmospheric** ♦ Precipitation on Impervious surfaces ♦ Directly condensed **Recycled Waters** ♦ Community Waste Water ♦ Industrial ♦ Mining **Brackish and Saline** ♦ Brackish Sea Water **2. By Winter and Summer Month:** ♦ January, ♦ August	1. Monthly maximum draws from each source based upon sustainable watershed management plans ♦ From MOE
Peak Water Demand	♦ m3 per hour	**1.By System** **2. By Month**	1. Look up table for each type of user with a daily (hour by hour) demand profile ♦ from the utility or from literature 2. Actual peaks by month (for calibration purposes) ♦ from each utility system
Peak Water Supply Capacity	m3 per hour	**1. By System** **2. By Time Period** ♦ Current Status ♦ planned capacity in 5 years	1. Capacities ♦ From utility (Hypertext link to explain nature of this constraint)
Water supply costs for	$ per m3 water	**1. By System** **2. By Account:**	1. Annual Accounts for water system ♦ From the municipality statements, or from the Ministry of Municipal Affairs "Municipal

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
utilities		♦ Adminstration ♦ Treatment ♦ Distribution ♦ Billing & Collection ♦ Other water supply ♦ Debt charges ♦ Transfers to funds ♦ Transfers to other governments ♦ Surplus	Statistics"
Direct expenditure by water consumers	♦ Total cost in $/yr ♦ Residential $ per person*yr	1. **By System** 2. **By Sector**: ♦ Residential ♦ Commercial ♦ Agricultural ♦ Industrial	1. Price schedule for each system and type of consumer ♦ from utilities 2. Number of connections by type, and average annual consumption by type of dwelling or floor area ♦ from utilities
Water Quality	Water Quality Index	1. **By year** 2. **By source** 3. **By system** (prorated from mix of sources)	1. WQI for each water source used in region ♦ from MOE ♦ local health authority

LIQUID WASTE INDICATORS

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
Liquid Waste Generation	♦ m3 per day on average* ♦ Litres per person-day* ♦ As a % of Total Water Generated in EA ♦ m3 per day at peak flows **generation averaged over the whole year*	**2. By Treatment system:** ♦ Public: ♦ Private **2. By End Use:** ♦ Residential ♦ Commercial ♦ Industrial ♦ Livestock ♦ Irrigation **4. By Level of Treatment** ♦ None ♦ Primary ♦ Secondary ♦ Advanced Secondary ♦ Tertiary	7. Consumption from each public water source (for use in calibration) ♦ Utilities directly, or recent reports 8. Total Consumption for calibration purposes ♦ Local water utility information will be geo-coded to disaggregate by EA ♦ Consumption from private sources will not be considered for calibration 9. Total Consumption from private sources (e.g. wells). ♦ For private wells we have only the capacity and no data on consumption. 10. Water breakdown for residential and commercial spaces by type and end use ♦ default values from the literature will be used until we have more specific and accurate data ♦ Residential uses will be broken down by person for drinking and Hygiene, and by dwelling type for irrigation. 11. Agricultural consumption by Ha and type ♦ Agricultural consumption by type from default ratios supplied by Ministry of Agriculture 12. Industrial activity by Land Area ♦ From each municipal planning department
Liquid Waste Treatment Capacity	♦ m3 per 24 hour day ♦ % of days when capacity is exceeded	**1. By System:**	2. System capacities and exceedences ♦ From engineers at treatment plants
Liquid waste treatment costs for utilities	$ per m3	**3. By System** **4. By Account:** ♦ Administration ♦ Treatment/Disposal ♦ Collection ♦ Other ♦ Debt charges ♦ Transfers to funds ♦ Transfers to other governments ♦ Surplus.	2. Annual Accounts for water system ♦ From the municipality or from the Ministry of Municipal Affairs

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
Direct expenditure by liquid waste producers	♦ Total cost in $/yr ♦ Residential $ per person*yr	3. **By System** 4. **By Sector**: ♦ Residential ♦ Commercial ♦ Agricultural ♦ Industrial	3. Price schedule for each system and type of consumer ♦ from utilities 4. Number of connections by type, and average annual generation by type of dwelling or floor area ♦ from utilities or municipalities
Resource Conservati on	% of biosolids captured for agriculture or other economic activity	4. **By system (prorated)**	2. Percentage of each treatment system bio-solids directed into agriculture or other useful purposes ♦ from Ministry of Agriculture, and from each treatment facility

ENERGY RELATED INDICATORS:

Issue or Category	Core Performance Indicators (*by EA*)	Subcategories for Disaggregation (*these Subtotals can be reported separately*)	Data Required (*in addition to EA Profile data*) ♦ and best data Source for project
Energy Consumption	▪ kWh per day ▪ kWh per person per day for residential ▪ energy consumption per farm type per year	**1. By Fuel Type** ♦ Gas ♦ Electricity from Grid ♦ Other electricity ♦ Methane ♦ Oil ♦ Bio-mass ♦ LPG ♦ Diesel ♦ Wind **2. By End Use:** **Residential Dwellings by type and end use** ♦ Space Heating ♦ Water Heating ♦ Lighting & Appliances **Commercial square meter by Type** ♦ Lighting ♦ Heating ♦ Motors ♦ Cooking/Washing **Industrial square meters by type** ♦ Process ♦ Space Heating **Agricultural Ha by type** ♦ Lighting ♦ Space Heating ♦ Equipment	1. Energy consumption in kWh on a per unit basis for farm type, per residential dwelling type, and per commercial and industrial use type ▪ Look-up tables created by Sheltair Group from modelling archetypal buildings with FVRD climate files 2. Number of farms by type ▪ FVRD data collected from Min. of Agriculture 3. Industrial activity types by area ♦ From Municipal estimates ♦ From BC Hydro, BC Gas
Direct Expeditur-es for Energy by consumers	♦ $ per year ♦ $ per year per person residential ♦ $ per kWh	**3. 1By Fuel Type** ♦ Gas ♦ Electricity from Grid ♦ Other electricity ♦ Methane ♦ Oil ♦ Bio-mass ♦ LPG ♦ Diesel ♦ Wind **4. By End Use:** **Residential Dwellings by**	3. Price schedule for energy by supplier and fuel type ♦ From energy utilities and energy suppliers

Issue or Category	Core Performance Indicators *(by EA)*	Subcategories for Disaggregation *(these Subtotals can be reported separately)*	Data Required *(in addition to EA Profile data)* ♦ and best data Source for project
		type and end use ♦ Space Heating ♦ Water Heating ♦ Lighting & Appliances **Commercial square meter by Type** ♦ Lighting ♦ Heating ♦ Motors ♦ Cooking/Washing **Industrial square meters by type** ♦ Process ♦ Space Heating **Agricultural Ha by type** ♦ Lighting ♦ Space Heating ♦ Equipment	
Peak Energy Demand	♦ KW electricity ♦ GJ natural gas	**1.By Sector** ♦ Residential ♦ Commercial ♦ Industrial ♦ Agricultural	3. Look up table for each type of user with a daily (hour by hour) demand profile ♦ from the utility or from literature 4. Statistical method for adding demand by sector and population size ♦ from the utility or from literature 5. Actual peaks by month (for calibration purposes) ♦ from each utility system
Energy Related Air Emissions	Annual Greenhouse Gase Emissions in tonnes of CO2 equiv.	**.By Sector** ♦ Residential ♦ Commercial ♦ Industrial 5. Agricultural **6. By Person** ♦ Residential energy only	3. Conversion for each local energy source ♦ From the literature 4. WQI for each water source used in region ♦ from MOE

Appendix 2: Descriptions and Calculation Protocols for Each Core Indicator

The following pages provide a standardised and detailed description of each core indicator, along with an explanation of the how the indicator is to be calculated under ideal conditions, and how the indicator has been calculated for the FVRD case study.

1. Average Potable Water Consumption & Average Per Capita Water Consumption

Category: Potable Water

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
StatsCan Census	1996	4 years
Census of Agriculture	1996	5 years
StatsCan Industry Data (input-output analysis)	1998	annual
Municipal Water Utilities.	1998	annual

Description: Average daily water consumption is calculated from total water consumption by individuals or organisations within an area, over a one-year period.

Units:
- m^3 / year
- litres / person / day

Significance: It is important to track the consumption of water to 1)-predict future consumption and 2)-establish targets for conservation and policy initiatives.

Method of Calculation:
Residential: The population of each EA is multiplied by the average daily water consumption per person. This latter value *(Average Per Capita Water Consumption)* is also included in the *Summary Report* and is calculated from empirical metering data provided by local water utilities.

Commercial: Water consumption is calculated by multiplying the number of employees per commercial-type by their associated water consumption rates. This generates total water consumption. It assumes that each commercial-type has an associated water consumption rate, on a per employee basis. This method allows for disaggregation by commercial-type.

Industry: Water consumption by industry is calculated by multiplying each industry's gross output in dollars per year by a water consumption multiplier supplied by Statistics Canada, National Accounts and Environmental Division. Gross output can be calculated by multiplying the number of employees per industry by a nationally averaged level of employee generated gross output per industry type.

Agriculture: Water consumption by agricultural land use type is available from the local water utility. Typical consumption volumes (per acre of land) are used to assume consumption levels by land use type and summed for the entire sector.

Levels of Disaggregation:
Residential:
Summarised by: Dwelling Type
Season
End Use

Commercial:
Summarised by: Sector

Industrial
Summarised by: Sector

Agriculture:
Summarised by: Land Use Type

Interim Approach for the FVRD Demonstration: Where empirical data is unavailable, end use profiles are developed using metered data from an area within the FVRD. The City of Abbotsford water consumption data is used to develop the end use profiles for each municipality in the FVRD, 1998 average water consumption was found to be 0.3589 cubic meters per capita per day. This was calculated from historical consumption quantities for Abbotsford. Using a breakdown via the FVRD Water Master Plan report, seasonal residential end use was calculated[1]

Other sectors' water consumption was generated using a sector-by-sector breakdown, the proportions of which are provided by examining the water meter data from Abbotsford.

Agriculture: Agricultural land use areas are allocated to each EA in the Fraser Valley Regional District. The total area of each land use type is multiplied by a water consumption rate for that specific land use, eg. 63 M^3/acre for Beef Farms. These rates are calculated by using the City of Abbotsford as a sample data set and are equal to the sum of all water consumption by land use type, divided by the total area for each agricultural land use type.

[1] Update of the Master Plan, Dayton & Knight, 1997

2. Water Supply Expenditures by Utility

Category: Potable Water

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Municipal Statistics	1997	annual
StatsCan Census	1996	4 years
MoELP Annual Water Use Report	1997	annual
Water Master Plans	various	N/A

Description: Water supply expenditures are the total amount of money spent for the provision of water supply services. These expenditures typically include Bond Redemption and Interest Payments as well as Operating and Maintenance costs.

Units:
- $\$/M^3$
- $/year

Significance:
Water supply expenditures incurred by utilities are useful to track for the purpose of comparing expenditures over time and adjusting fee schedules for customers. Also, they facilitate the comparisons to other utilities located in different municipalities. For comparing expenditures and costs from different systems, this type of indicator will be invaluable for examining alternative solutions to water treatment and distribution mechanisms.

Method of Calculation:
General: Per unit amounts of public expenditures on supply services are calculated from Municipal Financial Statistics and total supplied water figures. Expenditures include Treatment and Service of Supply, Transmission Distribution and Pumping, Customer Billing and Collection as well as Debt Charges including interest payments. Total annual expenditures are divided by the total annual supplied water amount to determine a per unit dollar value for each water service area in the FVRD. This value is used to generate total public expenditure on water services for a given geographic area (below).

All Sectors: Water supply expenditures are calculated by multiplying the per unit amount of public expenditures on supply services ($\$/M^3$) by total water consumption values to equal annual expenditure within the given geographic area ($/year).

Levels of Disaggregation:
Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial:
Summarised by: Sector

Agriculture:
Summarised by: Sector

Interim Approach for the FVRD Demonstration
Where precise expenditure data was unavailable (electoral areas), a 'per cubic meter' cost for water services was estimated by the Water Superintendent.

3. Fee and Rate Payments by Water Utility Customers

Category: Potable Water

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Municipal Utility Bylaws	1998	N/A
StatsCan Census	1996	4 years
Utility Authority	1999	varies

Description: Fee and rate payments by water utility customers are the sum of payments made by water utility users to the water utility authority.

Units:

- $ / year

Significance: This calculation gives an indication of the level of expenditures within specific geographic areas and is useful for calculating present and future revenues from the sale of water and water services.

Method of Calculation:

Residential: Total annual water consumption (M^3) for a selected geographic area is multiplied by the water utility rates, as specified by associated municipal bylaws. Annual water consumption is calculated from total average day demand *(previous section).*

Commercial: Total annual water consumption (M^3) for a selected geographic area is multiplied by the commercial water utility rates as specified by the associated utility authority. Annual water consumption is calculated from total average day demand *(previous section).*

Industry: Total annual water consumption (M^3) for a selected geographic area is multiplied by the industrial water utility rates as specified by the associated utility authority. Annual water consumption is calculated from total average day demand *(previous section).*

Agriculture: In general, this sector uses the same-metered rates as the commercial and industrial sector users. Annual water consumption is calculated from total average day demand *(previous section).*

Levels of Disaggregation:

Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial
Summarised by: Sector

Agriculture:
Summarised by: Sector

Interim Approach for the FVRD Demonstration:
FVRD fees and flat rate schedules are available from each individual water utility authority. Each authority provides the necessary fee schedule bylaws outlining the charges levied for water services. Due to the complex nature of fee schedules, with incremental charges based on consumption volumes, it is necessary to average the rates or use a flat rate fee. For residential, the flat rate fee per connection was used (assuming 3 persons per connection). For all other sectors, an average was taken between the highest and lowest per unit rate for each municipality. Agriculture, Commercial and Industrial use the same rate schedule.

4. Peak Day Demand & Peak Day Demand as a Percentage of System Capacity

Category: Potable Water Supply

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Municipal Water Utilities.	1998	annual
StatsCan Census	1996	4 years

Description: Peak day demand usually occurs in the warm summer months and is attributed to increased outdoor usage. Lawn irrigation is commonly associated with these increased demands. The peak day demand can vary from 1.5 to 5 times the average day demand. This variability depends upon factors such as metered rates, water pressure, landscaping requirements and climate as well as the physical aspects of the water system.

Peak day demand as a percentage of system capacity refers to the proportion of total water supply resources that are being used during periods of peak demand. System capacity refers to the threshold point at which the system will no longer be able to supply an additional unit of water. It can be determined by the water source, the extraction mechanisms, the treatment facility, pipe diameter and other infrastructure elements.

Units:

- percentage

Significance: Examining peak demand allows for the analysis of infrastructure in terms of system capacities. System capacities are often intended to meet present and future demand based upon the peak demand factor as a minimum threshold. Considering ways to lower peak demand is an appropriate method for lowering a system's built capacity and thereby avoiding the unnecessary costs overcompensation.

Peak demand as a percentage of supply capacity is an indication of how close the current situation is to reaching capacity limitations.

Method of Calculation:
Residential: Time series water meter data, daily over one-year periods, will reveal the peak day demand for various residential categories.

Commercial: Depending on the type of activity, peak demand will vary. It can be calculated using water meter data over time.

Industry: Depending on the type of activity, peak demand will vary. It can be calculated using water meter data over time.

Agriculture: Depending on the type of activity, peak demand will vary. It can be calculated using water meter data over time.

Levels of Disaggregation:
Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial:
Summarised by: Sector

Agriculture:
Summarised by: Sector

Interim Approach for the FVRD Demonstration:
For the purposes of projecting water peak demands, and in the absence of empirical data, a peaking factor of 2.25 times average day demand is considered appropriate for system design. However, an observed figure is in the order of 1.8 to 2.12. 1.95 times the average daily consumption was used to generate peak day demand for the FVRD. For the residential sector, a peaking factor was given for several communities3. For communities where data was unavailable, an average of available data was used. 'System Capacity' refers to a measure of the existing capacity of the water service system. For all water service areas, a capacity number was provided from reports or verbal confirmation with Municipal staff. Capacity numbers represent the public water system only, due to the problematic nature of determining capacities for private wells, aquifers and groundwater.

[2] Water Supply Study, Stanley Engineering, 1993.
[3] Update of the Water Master Plan, Dayton & Knight, 1997

5. Number of Quality Exceedences

Category: Potable Water Supply

Geographic Scope: Municipality
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Ministry of Health and Welfare	1998	varies
Fraser Valley Groundwater Monitoring Program	1996	n/a

Description: The number of water quality exceedences refers to the results of water quality testing for the presence of inorganic and organic substances in excess of acceptable standards. Such standards are recommended by the Guidelines for Canadian Drinking Water Quality (GCDWQ), the World Health Organization and the U.S. Environmental Protection Agency. For the purposes of this application, the Canadian standards are considered appropriate.

Units:

- number of exceedences

Significance: The importance of water quality relates to issues surrounding groundwater and surface water contamination and the threat to individual health. Testing for contamination that occurs within these sources becomes particularly important when considering that the majority of private and community well withdrawals are untreated for contaminants. Quality monitoring is a significant indicator in regions exhibiting intense agricultural and/or industrial land use.

Method of Calculation:
Standard laboratory testing methodologies are employed to determine the quantity of a given substance within a sample. The Ministry of Health monitors these results. The presence of a substance over and above a certain pre-determined level (GCDWQ) is presented as the number of water sources exhibiting exceedences out of the total number of possible water sources within a given geographic region.

Levels of Disaggregation:
N/A

Interim Approach for the FVRD Demonstration:
Sampling of public wells was conducted as part of the Fraser Valley Groundwater Monitoring Program: Final Report, 1996. The results of this process are presented as the number of incidences of quality exceedences. Information regarding aquifer vulnerability and classification are also taken from this document. Vulnerability ratings are based upon contamination vulnerability studies conducted for individual aquifers.

Also: Testing is done at specific locations. The presence of contaminants within a water supply source may not necessarily be detected if it is not within the vicinity of a testing location. Therefore, the results of regional quality testing should not be considered comprehensive of an entire area or aquifer in the absence of a private well testing program4.

4 p.88, Fraser Valley Groundwater Monitoring Program, MoH, MoELP, MoAFF, 1995.

6. Average Day Wastewater Generation

Category: Liquid Waste

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
StatsCan Census	1996	4 years
StatsCan Industry Data (input-output analysis)	1998	annual
Utility Authority	1998	Annual.

Description: Average day wastewater generation is the amount of wastewater generated by the sum of all individuals and/or organisations within an area, over a typical 24-hour period.

Units:
- m^3/day

Significance:
This calculation is significant for gauging the overall quantity of wastewater being produced by a community during typical conditions. It is useful for monitoring wastewater generation trends over time.

Method of Calculation:
Residential: Residential wastewater generation is calculated by multiplying the residential population by a typical wastewater generation value that has been calculated from empirical data supplied by the local utility authority or municipality (equal to *Average Per Capita Wastewater Generation*). This amount is equal to the sum off all household water consumption minus outdoor usage.

Agriculture: The amount of liquid waste generated from agricultural activities will vary greatly, depending on the type of activity. For the purposes of this application it is assumed that all liquid waste is recycled into agricultural processes, as fertiliser, and therefore it is not a factor in terms of water treatment infrastructure.

Industrial & Commercial: For these two sectors, liquid waste generation is essentially equal to the amount of water consumption. The same method of calculation relevant to *Water Consumption* is applicable for the liquid waste indicator. A default factor that considers the amount of process water that is not returned as wastewater (steam, beverage product, cement, etc.) is built into this calculation. Statistics Canada provides this value, by industry type.

Levels of Disaggregation:
Residential:
Summarised by: Sector

Commercial & industrial:
Summarised by: Sector

Agriculture: N/A

Interim Approach for the FVRD Demonstration:
Empirical data for Abbotsford was used to generate typical per capita volumes of water consumption. This figure was used in conjunction with water consumption breakdown by end use activity. The breakdown was taken from available literature[5]. Residential per capita wastewater generation is assumed to be equal to winter per capita indoor consumption. Industrial and Commercial wastewater generation is assumed to be equal to 15% of total wastewater generation[6]. This number was adjusted downward (to consider consumed process water) by a factor of 20%. This factor is based on national average consumption rates for industry and commercial activity. Only those activities occurring in the FVRD were considered.

Agricultural: Liquid animal waste may be important in areas where fecal coliform has been found in the groundwater and streams. In such areas, liquid animal waste can be calculated by assuming an average amount of generated waste per animal type.

Average Day Stormwater is defined as the amount of wastewater entering a treatment facility that is generated from precipitation run-off and infiltration. This value is calculated by referring to Utility Authority records that differentiate between average dry and average wet weather flows entering treatment facilities. It is typically calculated on a per capita basis. For the FVRD, 0.095 cubic meters per capita is considered appropriate[7] and represents infiltration only (since stormwater is not treated at any facility in the FVRD).

[5] Update to the Master Plan, Dayton & Knight, 1997
[6] p.5-3, Abbotsford Mission Study Area Liquid Water Management Plan: Stage One Report, Dayton & Knight, 1998.
[7] p.5-6, ibid.

7. Peak Day Generation as a Percentage of System Capacity

Category: Liquid Waste

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
StatsCan Census	1996	4 years
StatsCan Industry Data (input-output analysis)	1998	annual
Utility Authority	1998	Annual.

Description: The peak day generation for liquid waste management purposes will vary depending upon the intensity of water use and the type of water use connected to a given liquid waste treatment facility. In general, one can summarise peak day generation from records provided by individual plants.

Units:
- m^3/day

Significance: Similar to *Peak Water Demand*, this value is significant for calculating trends in water generation, key to the provision of adequate services. Peak volumes indicate the minimum level of servicing infrastructure necessary to ensure an adequate waste management system. Based on past trends, future liquid waste generation amounts can be calculated that assist in the planning of future upgrades to treatment systems.

Method of Calculation:

Residential: The residential sector liquid waste volumes are calculated by assuming indoor water consumption is equal to residential liquid waste generation. Peak day generation is calculated by using a peaking factor. The peaking factor is calculated by dividing the average daily residential flow (per capita) by the maximum-recorded daily flow, over a period of time.

Levels of Disaggregation
Residential:
Summarised by: Sector

Industrial and commercial: Sector

Interim Approach for the FVRD Demonstration:
In the FVRD, Peak Day Generation is calculated using the assumption that stormwater is not diverted into liquid waste treatment plants. The peaking factor (1.4) is based upon recorded (1994-96) maximum daily flows to the J.A.M.E.S. facility in Abbotsford in comparison to average daily flows. Residential flows are assumed to comprise 87.5% of total flow volumes[8].

8 Abbotsford Mission Study Area Liquid Water Management Plan: Stage One Report, Dayton & Knight, 1998.

8. Direct Expenditures by Liquid Waste Treatment Utility

Category: Liquid Waste

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Municipal Statistics	1997	annual
Wastewater Treatment Facility Reports	1998	annual
StatsCan Census	1996	4 years

Description: Wastewater treatment expenditures are the total amount of money spent for the provision of wastewater treatment services. These expenditures typically include Bond Redemption and Interest Payments as well as Operating and Maintenance costs.

Units:
- $\$/m^3$
- $/year

Significance: The significance of considering expenditures for the services of wastewater treatment is important when calculating service fee charges to customers. Also, for the purposes of upgrading treatment facilities and installing new systems, expenditure values can assist in making comparisons between different types of systems.

Method of Calculation: Per unit amounts of public expenditures on wastewater treatment services are calculated from Municipal Financial Statistics and wastewater treatment figures. Expenditures include; collection system and lift station expenditures, transmission and disposal costs as well as debt charges and interest payments. The total volume of wastewater treatment experienced at each individual wastewater treatment facility is divided into the above treatment expenditures.

Levels of Disaggregation:

Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial
Summarised by: Sector

Interim Approach for the FVRD Demonstration: Individual sector calculations are based upon information pertaining to each wastewater treatment facility. Past annual (1998) volumes are considered to be typical yearly volumes for the treatment facilities within the FVRD.

Treatment Facility	Monthly Flow 1998 (cu. meters)
The J.A.M.E.S. Pollution Control Centre	1311898
City of Chilliwack Water Pollution Control Center	480000
District of Hope Pollution Control Centre	66000
Kent Waste Water Treatment Plant	31300
Village of Harrison Hot Springs	9200

9. Fee and Rate Payments by Utility Customers

Category: Liquid Waste

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Municipal Bylaws		
Statistics Canada Census	1996	4 years
StatsCan Industry Data (input-output analysis)	1998	annual

Description: Fee and rate payments by utility customers within each service area consist of the total private expenditures by individuals or organisations for the use of wastewater disposal services. These charges include bi-monthly or semi-annual charges for disposal services.

Units:

- $/year

Significance: The tracking of expenditures by customers is important for projecting revenue streams.

Method of Calculation:
Residential: Service fees are applied to each individual sewer service area. Total wastewater volumes are calculated based upon average day water generation, on a per capita basis. Total volumes are multiplied by corresponding fees and rate schedules, according to municipal bylaws.

Commercial: Calculations are dependent upon the type of commercial activity. Each type of activity has an estimated value for wastewater generation, based on a per employee basis.

Industry: Calculations are dependent upon the type of industrial activity. Each type of activity has an estimated value for wastewater generation, based on a per employee basis. Wastewater generation estimates per industry type are available from Statistics Canada. These estimates take into account the amounts of process water recycled back into the production process.

Levels of Disaggregation:
Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial
Summarised by: Sector

Interim Approach for the FVRD Demonstration:
Industrial and Commercial sewer fees are based upon 50% of their equivalent water charges, as is the case for Abbotsford East and West. This assumption is made in lieu of calculations based on 'per connection' rates, due to 1) a lack of information regarding the number and types of sewer connections at the municipal level and 2) a lack of information regarding the type and extent of industry in the FVRD.

Most agricultural processes have some form of liquid waste reclamation, therefore the agricultural sector's liquid waste generation is primarily residential in nature.

10. Average Day Energy Consumption

Category: Energy

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
Statistics Canada (11-528E)	1993	n/a
Statistics Canada Census	1996	4 years
BC Hydro	1998	n/a
Farm Energy Use Survey	1997	n/a
Census of Agriculture	1996	5 years

Description:
Average day energy consumption is the typical amount of energy consumed in a 24 hr period. Energy use represents the consumption of fuel, typical fuels for BC are electricity, natural gas and oil.

Units:
- kWh/day
- kWh/person/day

Significance: Energy consumption is a significant factor for considering overall resource management for any community. It provides both a baseline to gauge future growth options as well as identifying opportunities for improvements in efficiency.

Method of Calculation:
Residential: Residential energy consumption is calculated by using defaults based upon dwelling types. Each dwelling type (single family, semi-detached, rowhouse, apartment) has specific energy requirements. Census data provides the number of each dwelling type within an enumeration area.

Commercial: Commercial energy requirements are based upon physical specifications for each commercial activity. Default energy consumption quantities are used to calculate total energy consumption.

Industry: Each industry type has specific energy requirements, based upon the type of production activity. One method for calculating energy consumption is to examine the quantity of output that has resulted from the production process for a given time period. This value can be in dollars of output. Default values are then used to calculate the relative amounts of energy required to produce the corresponding levels of output.

Agriculture: Energy consumption is based upon average consumption values per type of farming activity. Default values for oil and natural gas are converted into kWh from total consumed volume figures, using a conversion factor of 38.524 MJ per litre. Electrical consumption, per farm type, is provided by BC Hydro.

Levels of Disaggregation:
Residential:
Summarised by: Fuel Type

Commercial:
Summarised by: Fuel Type

Industrial
Summarised by: Activity Type
Fuel Type

Transportation: Sector
Fuel Type

Agriculture:
Summarised by: Fuel Type

Interim Approach for the FVRD Demonstration:
Residential energy consumption is calculated using typical energy consumption rates for BC, by housing type. An update to the "Star Database" was used for these values[9].

Dwelling Type	Energy Use (GJ/year)
Single Family	145
Semi-Detached	145
Rowhouse	71.8
Apartment	49.6
Mobile Unit	114

note 1 GJ = 277.8 kWh

A typical fuel consumption breakdown by housing type was then applied to each total by dwelling type. This breakdown is typical for the BC housing sector[10].

Agricultural energy use was calculated from the Farm Energy Use Survey by Statistics Canada, 1997. Typical fuel consumption volumes, by farm type, were converted to units of energy and divided by the gross number of acres per farm type, to derive default values. Consumption figures were adjusted to reflect farming operations only, since residential totals include farm residences.

[9] Residential Action Opportunity Cost Curves for National Climate Change Secretariat Building Table, The Sheltair Group, 1999.
[10] ibid.

Commercial sector consumption is generated from typical commercial building averages for BC. These figures are based upon occupied floorspace within each municipality.

Industrial Sector totals and averages are generated from empirical data supplied by BC Hydro for the year 1998, for the entire FVRD. Statistics Canada ratios for fuel consumption, by industry type, were used to calculate fuel consumption for each industry in the FVRD. Commercial transport is calculated from this method.

Personal transportation energy is based upon 60 GJ/person, using the BC average.

11. Direct Expenditures by Rate Payers

Category: Energy

Geographic Scope: Min: Enumeration Area (EA)
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
BC Gas Rate Schedules	1999	varies
BC Hydro Rate Schedules	1999	varies
Statistics Canada Census	1996	4 years
StatsCan Industry Data (input-output analysis)	1998	annual
Census of Agriculture	1996	5 years

Description: Direct expenditures by ratepayers are those payments made to the Utilities for the provision of energy supply services as well as direct expenditures on fuels, such as oil.

Units:
- $/year

Significance: Direct expenditures are an indication of the degree to which individuals, businesses and organisations are financially connected to the consumption of energy. As such, it may provide insight into the most appropriate areas to direct efficiency and conservation-related efforts.

Method of Calculation:
All Sectors: Expenditures on energy are calculated by multiplying energy consumption per fuel type (as calculated above) by their respective costs per unit. Utility companies supply these values.

Levels of Disaggregation:

Residential:
Summarised by: Fuel Type

Commercial:
Summarised by: Activity Type, Fuel Type

Industrial
Summarised by: Activity Type, Fuel Type

Agriculture:
Summarised by: Fuel Type

Interim Approach for the FVRD Demonstration:
Residential rates are calculated using typical rates at the BC Provincial level[11].

Commercial and Industrial rates are assumed to be the provincial average. These values are multiplied by existing and occupied commercial and retail floorspace totals for each municipal area.

11 Residential Action Opportunity Cost Curves for National Climate Change Secretariat Building Table, The Sheltair Group, 1999.

12. Energy Related Greenhouse Gas Emissions

Category: Energy

Geographic Scope: Min: Municipality
Max: Regional District (FVRD)

Data Sources:

Source	Current	Update Period
generated from previous section	1998	n/a

Description: Measurement of greenhouse gas emissions are the amount of gases released into the atmosphere that are responsible for what many believe to be an overall global warming effect. Energy related gases are those resulting from the conversion of energy and its associated consumption of fuel.

Units:

- tonnes CO^2/year

Significance: Scientists around the world agree that greenhouse gases from human related activities are contributing to an overall warming of the earth's climate. Carbon dioxide is the largest greenhouse gas contributor. The main source of carbon dioxide is from the burning of fossil fuels.

Method of Calculation:
All Sectors: Emissions are calculated based upon the amount of fuel consumption within a given sector during a specified time period. Emissions of greenhouse gases are the result, for the most part, of the consumption of fossil fuels. Such consumption will generate specific amounts of greenhouse gases, depending on the fuel type. Default values of greenhouse gas emissions per fuel type are used for this estimation. Emissions are typically measured in tonnes of carbon dioxide ($CO2$).

Levels of Disaggregation:
Residential:
Summarised by: Sector

Commercial:
Summarised by: Sector

Industrial
Summarised by: Sector

Transportation
Summarised by: Sector

Interim Approach for the FVRD Demonstration:
Greenhouse gas emissions are calculated using default emission values. These values are based upon typical emissions rates derived from the consumption of specific fuel types. For the FVRD the following values were used.

Fuel Source	GHG Emission (tonnes CO2 / GJ)
Natural Gas	0.04991
Electricity	0.1505
Gasoline	.06890
Oil	0.07533