RESEARCH REPORT

External Research Program

Shared Servicing for Rural Cohousing
A Sustainable Approach to Rural Habitation

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SHARED SERVICING FOR

RURAL COHOUSING

A SUSTAINABLE APPROACH TO

RURAL HABITATION

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ABSTRACT

The need for affordable housing in farming communities has become an important issue in rural planning. With a market for rural properties increasing, restraints on development are creating conditions that allow only a narrow portion of our population to live in rural areas. Gentrification, once confined to city centres, is now prevalent in rural districts throughout Ontario. Increasingly, the social and economic diversity characteristic of farming communities is changing, as the youth are migrating to urban centres to obtain work and affordable housing. When the new development, popular to rural areas, is reviewed in detail, it is clear that these overall development methods are not sustainable from social, economic and environmental perspectives. These condition and other related issues have prompted people in the housing industry to look for viable options to the standard development of rural subdivisions Among these options, Cohousing offers many advantages over standard subdivision-type developments.

Cohousing is an idea that is gaining support in North America It can take on many different forms; from a tight cluster of independent dwellings to a low rise multiple. (usually 25 to 40 living units) Ownership of a cohousing development can be communal and shared facilities such as daycare, and common rooms are an important part of the overall concept. In Cohousing, the emphasis is on the formation of a strong community based on resident participation. As a housing model it offers an interesting alternative to the conventional North American forms of habitation, particularly in a rural context. Some important advantages of this model for rural housing are as follows:

1 Multiple dwellings are less costly to construct on a per unit basis
2 With increased density, spatial and environmental impact can be decreased. Less land is required to be cleared and a desired qualitative control can be exercised in one site design.
3. Social advantages include the ability to house a more diverse group of people because dwellings can be appropriately sized. Amenities, such as daycare and shared services, open rural living to a wide range of people in the housing market.
4 Mechanical requirements such as water systems, sewage treatment, storm water control and heating, that are problematic in rural housing development, can be combined and integrated. This increases efficiency, heightens system performance and potentially reduces negative environmental effects.

New technologies and design parameters can be associated with new housing models. The limitations of existing provincial guidelines for on-site servicing are an immediate barrier to the potential benefits of new technologies which could be used in Cohousing or any small cluster-type developments for rural areas Throughout North America new systems are being developed to deal with the problems associated with on-site servicing for rural residential communities The intention of this report is to study alternative on-site servicing systems for Cohousing type developments and create a model for sustainable rural habitation.

EXECUTIVE SUMMARY

Introduction

This report is a primary study and is written to act as an impetus for the creation of alternative forms of rural housing. Trends in the land development industry of Ontario are currently shifting towards more sustainable approaches to land-use and planning. The problems with existing forms of rural development, can be isolated at the scale of community, into issues relating to the provision of servicing and environmental design. The aim of this project is to focus on these issues and in doing so, demonstrate the feasibility of sustainable alternatives to existing housing methods. The report concentrates on the factors relating to the design, development and servicing of a small rural community.

The following are issues confronting existing housing development in rural districts that are causing reasons for concern.
> Nitrate contamination of ground water is common and is a result, to some degree, of the excessive numbers of septic tile fields in concentrated areas.
> In rural subdivisions, concentrated run-off from increased impervious surfaces is creating a similar problems to those experienced in cities. The receiving streams and lakes however are more notably effected due to their sensitivity
> Land-use practices are allowing low density suburban type development on Class 1 & 2 farm land.
> The increased immigration of urban families to farming areas is causing housing prices to rise in rural communities to levels beyond the market range of the average local family. This is resulting in a form of gentrification, as young rural based families are force to emigrate to nearby urban centres for affordable housing and work.
> The general demand for rural properties may increase as a major portion of our population is ageing. This is expected to significantly increase pressures for future rural development.
> Legislation to control the adverse environmental effects of conventional servicing systems is putting more restrictions on the type of properties that can be developed and the form the development can take

The following parameters have had a great affect on the form and location of development as the land best suited for development is often Class 1 and 2 farmland. In Ontario, the method of servicing conventional rural developments, with water and sewerage is done on an individual basis. Provincial guidelines defining requirements for septic tanks, tile fields and wells have a significant impact on minimal lot sizes. The conditions suitable for a typical development of detached homes requires level, clear land with soils having a good water permeability rate for proper tile field operation. This is also necessary to achieve cost effective grading and road construction.

Objectives

This study focuses on the 4 systems required for the servicing of a group of 30 clustered dwellings. The four essential systems for servicing housing are Sewage Treatment, Water Supply, Storm Water Control and Heating. The first research objective is to provide a complete summary of the viable alternatives available to those suited for this scale of development and capable of working effectively in a northern climate. A holistic approach is taken when analyzing the different systems to ensure the precepts of sustainability are adhered to. In-depth system analysis relating to specific mechanical design issues are not addressed unless such information is considered relevant

A second objective of the report is to provide alternative approaches to development. In order to demonstrate this, a theoretical housing model is created. This hypothetical community, **Hamlet Co-X**, serves the function of providing a basis for system comparison. The hamlet design demonstrates by example, the importance of integrated design in forming sustainable communities and gives an indication of the many possibilities not yet explored in housing.

Methodology

The research for this project has been conducted using much of the available information sources from Canada and the United States, and includes the work of public, private and institutional groups Due to the lack of information available for some systems, additional corporations and individuals in advisory roles have played a key part in the assessment of new and existing systems In order to ensure this study's relevance to contemporary housing needs, the four main servicing systems previously identified have been generally reviewed. Specific systems considered feasible have then been compared and evaluated under certain criteria, which are presented as follows:

1. Energy efficiency
   - What are the operating energy requirements?
   - What is the systems energy source?
   - Are alternatives available or feasible?
   - What energy conservation devices can be used?

2 Cost Effectiveness
   - What are the construction costs of the system?
   - What are the operating and maintenance costs?
   - What other cost ramifications are involved or related?
   - If energy conservation systems are used, what is the pay back period?

3. Environmental Sustainability
   - What environmental issues are associated with the system regarding its method of construction, materials used or operating requirements?
   - What are the system's land requirements?
   - Does it require the alteration of existing natural systems?
   - Can the natural environment contribute to it's operation?

4. Design Integration
   - Can the system be integrated or combined with other services?
   - Are any constraints evident that could conflict with other aspects of the project?
   - Can the system be combined or modified to form another amenity?
   - Does it work well with housing or other site related criteria?

It is assumed that the site amenities available to the proposed community adhere to those that are typical for the average rural site in Ontario. These typical conditions are listed as follows

> Electric power available.
> Natural gas not available.
> Receiving water available for surface run-off.
> Aquifer capable of sustaining the water requirements for 30 homes at an assigned need of 30,000 litres/day.

Findings

1.0 Water

1.1 A communal ground water system designed for HAMLET CO-X complete with chlorination system and water tower could be constructed for an estimated 50% of construction costs of 30 individual well systems. In a communal system of this type, total energy consumption and system maintenance is less and has a higher degree of quality control.

2.0 Stormwater

2.1 Effective site and landscape design is the single most important factor in controlling storm water runoff. This is achieved most notably by reducing impervious surfaces were possible and providing effective planting in conjunction with proper site grading.

2.2 A wide variety of stormwater management techniques exist to handle excessive overland flow that appear to be potentially quite effective in allowing for the treatment and ground infiltration of runoff water. These techniques can be integrated into any development provided they are part of a full storm water management strategy and are incorporated at a project's inception.

2.3 Landscape design in conventional forms of housing development is difficult to control because of freehold land ownership. These sprawling forms of housing have substantial amounts of impervious surfaces from driveways and roads with often little land set aside for storm water retention or treatment areas.

3.0 Heating & Energy

3.1 Energy efficiency in housing is achieved most effectively through design and proper construction techniques

3.2 Complex mechanical systems and other energy saving devices must be reviewed thoroughly to access capital costs and operating requirements. For this reason, many specialized systems are not feasible for general applications in the building industry. Often the potential energy savings cannot justify the capital costs involved when applied to single family dwellings

3.3 Given the parameters of this project, the most sustainable system for home heating, is a ground source heat pump. Individual home heat pump systems provide excellent performance but remain quite expensive when compared to other standard heating options.

3 4 The tight clustering of the dwellings in HAMLET CO-X provides an opportunity for a district heating system. Using a ground source heat pump energy source in a district heating system versus individual home systems reduces the total capital installation costs for this project by an estimated 36 %. Using a district heating system, a ground source heat pump can be an effective heating option for higher density housing in a rural context.

4.0 Sewerage

4.1 Small diameter sewer systems offer a good alternative to conventional gravity flow collection systems These systems are proven effective for residential applications both in terms of cost and performance. Of the three types reviewed, each system has different characteristics to suit different situations Collection systems should be selected based on the design of the project, the terrain of a site and the treatment system used.

4 2 The SOLAR AQUATIC SYSTEM and the PEAT FILTER are both good options for the treatment of waste water in a small community. The two systems are similar in cost however differ greatly in operating principles

4 3 The PEAT FILTER offers the highest degree of denitrification using the least amount of energy. The filters must be separated from pedestrian traffic and can only treat septic tank effluent.

4.4 The SOLAR AQUATIC SYSTEM provides the most all encompassing treatment, processing all the waste and removing heavy metals. For land development purposes it is more flexible to implement and has the potential to provide additional social and economic amenities. Although its energy requirements are high it is the option that is most desirable from a sustainable perspective

4.5 It is estimated that a communal sewage system for HAMLET CO-X, using either treatment method, will cost approximately $100,000 less than individual septic/tile field systems serving a development with an equal number of dwellings.

Conclusions

1.0 Existing standards for the planning and the provision of servicing for housing in rural areas do not address the goals of a sustainable approach to land development and are an important factor in restricting the formation of alternative and more diversified communities.

2.0 In order to create communities that are economically and environmentally sustainable, the physical design and the provision of servicing for a housing development must be considered together. This requires an approach to planning and development that is the antithesis to conventional and accepted methods. In a sustainable approach, natural systems, programmatic requirements and servicing must be fully integrated.

3.0 Clustered, higher density housing forms in rural areas, can result in less environmental impact and provide the opportunity for servicing to be shared, which has notable cost and performance advantages.

4.0 For rural applications, a very large number of options exist for both the physical forms a community can take and the types of servicing systems that can be used The research revealed that very few of these options have been explored or tested in Canada.

5.0 The final analysis of the options available for the servicing of rural housing was carried out using a specific community model, HAMLET CO-X, which was intentionally designed to maximize efficiency of systems and to minimize environmental impact Conclusions can be drawn about the suitability of specific systems to a general situation however, an alternative community form in a different context will provide varied design constraints and possibly different systemic requirements

RÉSUMÉ

Introduction

Faisant état d'une étude de base, ce rapport a pour but de donner le coup d'envoi à la création d'autres formes de logement rural. Dans le secteur ontarien de l'aménagement des sols, tant la planification que l'utilisation du sol se font de plus en plus dans un contexte écologique. Au niveau de la collectivité, les problèmes des différentes formules courantes d'aménagement rural proviennent soit de la viabilisation ou de la conception environnementale. Cette recherche se concentrera donc sur ces questions en tentant de démontrer la faisabilité d'options écologiques différentes des méthodes traditionnelles de construction d'habitations. Le rapport traite surtout des facteurs touchant la conception, l'aménagement et la viabilisation d'une petite collectivité rurale.

Les aménagements résidentiels existants en milieu rural sont actuellement confrontés aux préoccupations suivantes :

- La nappe d'eau souterraine est couramment contaminée par le nitrate, en raison, dans une certaine mesure, du nombre excessif de fosses septiques dans des secteurs concentrés.
- En milieu rural, la concentration des eaux de ruissellement due à l'accroissement des surfaces imperméables cause des problèmes semblables à ceux que connaissent les villes. Les cours d'eau et les lacs récepteurs sont toutefois davantage touchés en raison de leur sensibilité.
- Les pratiques d'utilisation des sols permettent d'aménager à faible densité, en banlieue, les terres agricoles de catégories 1 et 2.
- L'accroissement de l'immigration des familles urbaines vers les régions rurales fait augmenter le prix des maisons au-delà de la portée de la famille moyenne. Il s'ensuit donc une sorte d'embourgeoisement, les jeunes familles rurales se voyant forcées d'émigrer vers les centres urbains voisins pour y rechercher du travail et un logement abordable.
- Le vieillissement d'une proportion importante de la population peut provoquer un accroissement de la demande générale à l'égard des propriétés rurales. L'avenir devrait donc se traduire par une augmentation significative de la demande pour des aménagements ruraux.
- La législation visant à enrayer les effets néfastes qu'exercent sur l'environnement les méthodes classiques de viabilisation restreint davantage le type de propriétés et la forme d'aménagement.

Les paramètres, dont il est question ci-après, ont exercé une grande influence tant sur la forme que sur l'endroit des aménagements, étant donné que les terrains se prêtant le mieux à l'aménagement sont souvent les terres agricoles de catégorie 1 et 2. En Ontario, la prestation de services d'alimentation en eau et d'évacuation des eaux usées dans les aménagements ruraux traditionnels est assurée cas par cas. Les directives provinciales définissant les exigences en matière de fosses septiques, de champs d'épandage et de puits ont des répercussions considérables sur les dimensions minimales des terrains. L'aménagement de maisons individuelles types requiert des terrains de niveau et dégagés, dont le sol se caractérise

par une bonne perméabilité à l'eau de façon à assurer le fonctionnement satisfaisant du champ d'épandage. La même situation est nécessaire pour garantir l'efficience du nivellement des terrains et de la construction de voies de circulation.

Objectifs

Cette étude se concentre sur les quatre services que suppose la viabilisation de 30 maisons construites en grappe. Les quatre services essentiels s'entendent du traitement des eaux usées, de l'alimentation en eau potable, de la régulation des eaux de ruissellement et du chauffage. Le premier objectif de cette recherche consiste à fournir un résumé complet des options possibles convenant à des aménagements de cette envergure et susceptibles de fonctionner efficacement dans un climat nordique. Afin de s'assurer du respect des principes du développement durable, les différents réseaux sont soumis à une analyse holistique. Les questions précises de conception mécanique ne sont pas analysées en profondeur à moins d'être considérées comme pertinentes.

Le deuxième objectif du rapport est de présenter des approches différentes en matière d'aménagement. Pour en faire la démonstration, un modèle d'habitation théorique est créé. Cette collectivité hypothétique, **HAMLET CO-X**, sert de base pour comparer les réseaux. Par exemple, le modèle illustre l'importance de la conception intégrée pour aménager des collectivités écologiques et les nombreuses possibilités non encore explorées dans le domaine de l'habitation.

Méthodologie

La recherche a fait appel à une grande partie des sources d'information disponibles au Canada et aux États-Unis, de même qu'aux travaux d'organismes publics, privés et d'établissements. Vu le manque d'information au sujet de certains réseaux, d'autres sociétés et particuliers retenus à titre de conseillers ont joué un rôle clé dans l'évaluation de réseaux nouveaux et existants. Pour s'assurer de la pertinence de l'étude par rapport aux besoins actuels en matière d'habitation, les quatre principaux réseaux de services furent soumis à une revue générale. Des réseaux spécifiques, jugés faisables, furent alors comparés et évalués en fonction des critères suivants :

1. Efficacité énergétique
   - Quels sont les besoins énergétiques nécessaires à leur fonctionnement?
   - Quelle en est la source d'énergie?
   - Existe-t-il des solutions de rechange disponibles ou faisables?
   - Quels dispositifs d'économie d'énergie peuvent être utilisés?

2. Efficience
   - Quels sont les coûts de construction du réseau?
   - Quels en sont les coûts d'exploitation et d'entretien?
   - Quels autres facteurs peuvent influer sur le coût directement ou indirectement?
   - Si des dispositifs d'économie d'énergie sont utilisés, quel en

est leur délai de récupération?

3. Protection de l'environnement
   - Quelles sont les questions environnementales dont on doit tenir compte dans la méthode de construction, le choix des matériaux et les besoins de fonctionnement du réseau?
   - Le réseau occupera quelle superficie de terrain?
   - Faudra-t-il modifier des réseaux naturels existants?
   - L'environnement naturel peut-il être mis à contribution dans le fonctionnement du réseau?

4. Conception intégrée
   - Le réseau peut-il s'intégrer à d'autres services ou encore s'y combiner?
   - Existe-t-il des contraintes évidentes susceptibles d'entrer en conflit avec d'autres aspects du projet?
   - Peut-on combiner le réseau à un autre ou le modifier de telle sorte à offrir une autre commodité?
   - Le réseau est-il bien adapté à l'habitation ou aux autres critères du site?

On présume que les commodités offertes à la collectivité proposée cadreront bien avec les services typiquement offerts en milieu rural moyen en Ontario, soit:

> l'électricité, mais pas le gaz naturel
> un plan d'eau récepteur des eaux de ruissellement
> une nappe aquifère pouvant subvenir aux besoins en eau de 30 maisons à raison de 30 000 litres par jour.

Résultats de l'enquête

1.0 Eau potable

1.1 Le coût de construction d'un réseau communautaire d'alimentation en eau conçu pour HAMLET CO-X, comprenant un poste de chloration et un réservoir surélevé s'élèverait à environ la moitié de celui de 30 puits individuels. Un réseau communautaire de ce type consomme moins d'énergie, requiert moins d'entretien et se traduit par un meilleur contrôle de la qualité.

2.0 Eaux pluviales

2.1 Il est primordial de bien concevoir le site et l'aménagement paysager pour contrôler les eaux de ruissellement. Réduire les surfaces imperméables dans la mesure du possible, recourir judicieusement aux plantations et au nivellement approprié du sol constituent les meilleurs moyens d'y arriver.

2.2 Il existe une grande variété de techniques de gestion des eaux pluviales servant à contrôler le ruissellement excessif qui pourrait s'avérer d'une grande efficacité dans leur traitement et leur absorption par le sol. Ces techniques peuvent être intégrées à tout aménagement à condition de faire partie de toute stratégie de gestion des eaux de ruissellement et d'y être incorporées, dès le point de départ.

2.3 La propriété foncière libre complique le contrôle de la conception de l'aménagement paysager dans les aménagements résidentiels conventionnels. Ces aménagements tentaculaires, avec leurs allées et leurs chemins formant une quantité importante de surfaces imperméables et comptent souvent peu de terrains réservés à la rétention et au traitement des eaux de ruissellement.

3.0 Chauffage et énergie

3.1 L'adoption de techniques de construction tout indiquées lors de la conception favorise davantage l'efficacité énergétique des habitations.

3.2 Les systèmes mécaniques complexes et les dispositifs d'économie d'énergie doivent être revus à fond pour en déterminer les frais d'immobilisation et les besoins de fonctionnement. C'est pourquoi de nombreux réseaux spécialisés se révèlent alors inutilisables à des fins générales au sein de l'industrie de la construction. Souvent, les économies d'énergie réalisables dans des maisons individuelles ne justifient pas les frais d'immobilisation en jeu.

3.3 Étant donné les paramètres de ce projet, le système de chauffage domestique le plus écologique fait appel à la pompe géothermique. Les pompes à chaleur individuelles assurent une excellente performance, mais leur coût demeure assez élevé par rapport aux autres systèmes de chauffage courants.

3.4 L'aménagement en grappe des maisons du HAMLET CO-X se prête bien à l'installation d'un système de chauffage communautaire. Le coût total en immobilisations d'une pompe géothermique communautaire sera de 36 % inférieur à celui de pompes à chaleur individuelles. Si un système de chauffage communautaire est utilisé, une pompe géothermique constitue une option de chauffage efficace pour un aménagement d'habitations rurales à haute densité.

4.0 Réseaux d'eaux usées

4.1 Des réseaux d'eaux usées de petit diamètre remplaceraient avantageusement les réseaux collecteurs d'eaux usées à écoulement par gravité. Les réseaux de petit diamètre se sont révélés efficaces en milieu résidentiel tant par leur coût que par leur performance. Parmi les trois types revus, chacun comportait des caractéristiques différentes adaptées à différentes situations. Le choix des réseaux collecteurs d'eau usées se fait en fonction de la conception du projet, de la composition du sol et du système de traitement utilisé.

4.2 Les réseaux SOLAR AQUATIC, et PEAT FILTER sont tous deux des options valables pour le traitement des eaux usées des petites collectivités. Les coûts des deux réseaux s'équivalent, mais leurs principes de fonctionnement diffèrent considérablement.

4.3 Le réseau PEAT FILTER offre la dénitrification la plus élevée tout en consommant moins d'énergie. Les filtres, qui ne peuvent traiter que les effluents de fosses septiques, doivent être installés dans un endroit inaccessible aux piétons.

4.4 Le réseau SOLAR AQUATIC, plus complet, traite tous les déchets sans exception, enlevant même les métaux lourds. Il s'implante plus facilement et peut fournir d'autres avantages économiques et sociaux. Bien que les besoins énergétiques de ce réseau soient élevés, c'est l'option à retenir dans une optique de développement durable.

4.5 Quelle que soit la méthode de traitement utilisée, nous estimons qu'un réseau communautaire d'eaux usées coûterait environ 100 000 $ de moins que des fosses septiques individuelles pour desservir un nombre identique de logements à HAMLET CO-X.

Conclusions

1.0 Les normes de planification en vigueur et la viabilisation d'habitations en milieu rural ne répondent pas aux objectifs d'un aménagement écologique et restreignent de façon importante la création d'autres formes de collectivités plus diversifiées.

2.0 Pour créer des collectivités écologiques tant du point de vue économique que du point de vue environnemental, il faut aborder simultanément tant la conception physique que la viabilisation d'un aménagement résidentiel. L'approche de la conception et de l'aménagement doit alors être l'antithèse des méthodes conventionnelles reconnues. L'approche écologique requiert une intégration complète des réseaux naturels et des services publics.

3.0 En région rurale, un aménagement d'habitations en grappe et de haute densité pourra avoir moins d'impact sur l'environnement et se prêter à un partage des services; une telle situation comporte donc des avantages importants à deux niveaux : le coût et la performance.

4.0 En milieu rural, un très grand nombre d'options existent quant à l'aspect physique que peut prendre la collectivité et quant aux types de viabilisation qui peuvent y être implantés. La recherche démontre, cependant, que très peu de ces options ont été explorées, ou encore, éprouvées au Canada.

5.0 Bien que l'analyse finale des options de viabilisation des habitations en milieu rural soit faite à partir du modèle spécifique de la collectivité HAMLET CO-X, volontairement conçu pour maximiser l'efficacité des réseaux et minimiser les effets sur l'environnement, cela n'empêche pas de tirer des conclusions sur la convenance de certains réseaux dans une situation générale. Cependant, tout changement apporté à l'aspect physique de la collectivité ou à son contexte produira, d'une part, des contraintes différentes sur la conception et, d'autre part, d'autres exigences au niveau des services publics.

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FOREWORD

Urban planning, in general terms, has become a discipline for designating the use of physical space It attempts to guide or control the way in which human beings interact within that space By controlling the spatial allocation of land-use and preparing courses of action which facilitate the implementation of plans and development strategies, the planning function seeks to achieve a more desirable future state in the physical and social environment. The Ontario Professional Planning Institute states, "it must include the planning of the orderly disposition of land, resources, facilities and services with a view of securing physical, economic and social efficiency, a sound environment, health and well-being."

Planning, while under the auspices of upper levels of government, has always been regarded primarily as a municipal function and as such has been guided by municipal interests growth, expanding the assessment base, road and transit needs and servicing. Mass implementation of policies based on planning design concepts such as the Garden City, the Garden suburb and the Neighbourhood Unit have accommodated the demand for literally millions of detached ground-oriented dwelling units. What has resulted is a pattern of growth which has led to unbroken expanses of detached, single family houses, costly in terms of land and municipal services. Prevailing land-use regulations have been identified as encouraging and perpetuating environmentally damaging development patterns. Zoning ordinances, which designate the uses of land, have acted to restrict the housing options and forms which hold the ability to reduce residential impacts on the natural environment and enhance affordability. This has been particularly true in the urban fringe or rural areas where land-use standards related to the provision of storm and sanitary sewers, water supply and utilities, often encourage dispersed developments of low densities. Such excessive demands on land for rural residential development has resulted in the loss of prime agricultural land and a situation whereby the infrastructure required is resource and energy intensive. Consequently, housing options have been restricted for many who are unable to afford the "gold plated" land development standards required of some municipalities and the large, detached homes which result.

Spurred by international concern for environmental consciousness, a new approach is becoming popular which recognizes the need to secure a sustainable relationship between people and resources Within the area of land-use planning, it became evident that prevailing patterns of development have contributed significantly to the ongoing pressure being placed on the natural environment. An ecosystem based approach which recognizes this problem has been incorporated into the planning function through the implementation of planning tools such as environmental impact assessment process

Concern over the negative impact of land-use decisions on the natural environment and the ability of the planning system to protect that environment was one of the primary reasons leading to the formation of the Commission on Planning and Development Reform in Ontario. Appointed in June of 1991 by then Minister of Municipal Affairs, the Commission was given a broad mandate to recommend changes to the Planning Act and related policy which would, among other objectives, focus more closely on protecting the natural environment

In its final recommendations, the Commission has been thorough in achieving its goals with respect to placing the environment at the top of the planning agenda. In doing so, it has reinforced emerging values which demand that further growth cannot be sustained at the expense of the natural environment By further addressing the issues of lost agricultural land and infrastructure development, the Commission has put forth policies which encourage intensification of serviced, built up areas and severely restricts the development in unserviced rural areas. This was proposed so that communities would be planned to minimize the consumption of land

The logic of this approach is undeniable and will undoubtably yield a number of social and environmental benefits. However, changes in the area of land-use development standards, while incorporating sustainable principles must be sensitive to changing societal demands and trends. Given the demographics of our aging population, it is expected that the demand for rural housing, will become even more pronounced. Furthermore, as electronic communications become more powerful, this trend towards dispersion can be expected to continue. In light of these trends, is it realistic to implement a freeze on development on rural land?

The report which follows considers this dilemma and examines alternative approaches to rural housing development which are based on ecologically sound principles. More specifically, it considers issues relating to the provision of servicing and environmental design and in doing so, demonstrates that appropriate methods for developing land currently exist which ensure that a balance can be achieved whereby growth in rural, unserviced areas can continue without creating negative environmental impacts. Systems which are outlined in this study are based upon what is thought to be environmentally benign technology and affords planning policy the opportunity to take the lead with respect to rural development issues, determining their application and maintaining control over efficient and orderly growth.

It is a concern that a mass implementation of this technology for small communities will lead to uncontrolled sprawl, however, this fear could be addressed by a proactive planning approach. Rather than reacting to private initiative in an ad hoc manner, Regional and Official Plans could actively define where and when alternative servicing is appropriate. Criteria could be established which would consider the capacity of the environment to absorb development and seek to ensure that the introductions of alternative systems is appropriate from a comprehensive regional planning and service perspective

Historically, it appears that land-use planning has been directed to goals of short-term efficiency and as such, have led to environmental and social problems. Land-use planning cannot be the panacea to all our environmental ills but it is a tool of considerable value. Methods proposed in this paper should be considered as part of an overall approach to sustainable development. Incorporating alternative servicing and design techniques should become part of a comprehensive plan towards identifying and addressing conservation and environmental protection issues. The planning function should act to foster innovations examined in this study so that new developments, rather than undermining the environmental and social systems on which we depend, can contribute to the overall goal of sustainable development.

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1.0 GENERAL

1.1 Introduction

This report is a primary study It is written to act as an impetus for the creation of alternative forms of rural housing Trends in the land development industry of Ontario are currently shifting towards more sustainable approaches to land-use and planning The housing sector, which is a major proponent of this industry, is also experiencing notable signs of change Legislation aimed at environmental protection is having a restrictive effect on rural land development generally, while obsolete methods of planning and design are proving to be ineffective in dealing with the current problems associated with development methods Support is growing for the implementation of alternative solutions to these, and other related socio-economic issues

The problems with existing forms of rural development, however broad reaching in effect, can be isolated at the scale of community, into issues relating to the provision of servicing and environmental design. The aim of this project is to focus on these issues and in doing so, demonstrate the feasibility of sustainable alternatives to existing methods of housing. The report concentrates on the factors relating to the design, development and servicing of a small rural community The model community is be based on a hypothetical Cohousing program. In combining ideas about sustainability, development methods and alternative community design, the report is intended to be holistic in its approach The four basic systems required to service housing in Ontario will be reviewed in detail along with related planning issues, in order to produce a more comprehensive view of the factors involved in creating sustainable communities.

1.2 Sustainability and Rural Housing

Although the meaning of the word sustainability as it relates to planning is difficult to synopsize, a good definition of sustainable urban development may read as follows·

"Sustainable urban development might be defined as a process of change in the built environment which fosters economic development while conserving resources and promoting the health of the individual, the community and the ecosystem (recognizing that in terms of sustainability . the urban environment cannot be separated from the region of which it is part)" [1]

[1]Richardson,Nigel , as cited in D,Amour David , 1991

Unfortunately, our present day urban [2] areas are far from representing the word sustainable, if this definition holds true. The issues confronting housing today are complex and require a re-evaluation of accepted building practices.

> Land-use requirements for residential subdivisions are excessive. In present North American development, residential and road uses account for 50% and 20% respectively of an average city's total land area

> The standard infrastructure required for housing is resource and energy intensive A single family detached house requires at least four times more linear infrastructure per unit than a duplex

> The pollution of receiving waters by urban run-off is severe. A 1977 study of Washington D.C. concluded that the concentration of suspended solids from urban run-off was 104 times greater than the effluent from the secondary sewage treatment plants and lead concentrations 1,025 times higher. [3]

Similarly, the issues confronting urban development in rural districts are equally problematic:

> Nitrate contamination of ground water is common and is a result, to some degree, of the excessive numbers of septic tile fields in concentrated areas. [4]

> In subdivisions, concentrated run-off from increased impervious surfaces is creating a similar problem to those experienced in cities. The receiving streams and lakes however are more notably effected due to their sensitivity. [5]

> Wasteful land-use practices are allowing low density suburban type development on Class 1 & 2 farm land

> The increased immigration of urban families to farming areas is causing housing prices to rise in rural communities to levels beyond the market range of the average local family. This is resulting in a form of gentrification, as young rural based families are force to emigrate to nearby urban centers for affordable housing and work [6]

> The general demand for rural properties is expected to increase as a major portion of our population is ageing. This is expected to increase pressures for future rural development significantly. [7]

> Legislation to control the adverse environmental effects of conventional servicing systems is putting more restrictions on the type of properties that can be developed and the form development can take.

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[2] The word urban does not relate solely to cities. A densely settled Hamlet in a rural context is an urban form.

[3] D'Amour, David 1991

[4] Whilhelm, Sheryl 1992.

[5] Zsolt, John., 1993. Refer to Appendix C.

[6] Burke, Christel., Zsolt, John., 1989

[7] Dychtwald, Ken 1989

1.3 Sustainable Community Design and Cohousing

1.31 Criteria for Sustainable Communities

Alternative systems for housing and land-use should be utilized to address the complex issues surrounding present forms of community development In order to uphold the precepts of sustainability, the guidelines for future development should be based on criteria that supports these goals

<u>Diversity</u>

> Economic Diversity: to provide for the potential integration of small industry, work at home arrangements , small scale farming, retail and other services.
> Social Diversity: to ensure housing is adaptable and designed to accommodate a variety of family types and individuals by providing for a range and a mix of housing units.
> Natural Diversity: to uphold the guidelines set for Environmental Controls.

<u>Environmental Controls</u>

> The preservation and creation of wildlife habitat through effective site design and land-use.
> The clustering of buildings to reduce environmental impact and land used.
> The use of alternative technologies for servicing to eliminate the adverse environmental problems associated with existing methods
> Combining the elements of site and climate to achieve an integrated design.

<u>Energy Efficiency</u>

> The application of passive solar design principals in site and building design.
> The use of energy efficient technology and building techniques.
> Clustering of buildings to conserve costs, materials and heating requirements.
> The integration and sharing of servicing systems for increased efficiency and better system performance.

1.32 Cohousing

Cohousing [8] is an idea that was initiated in Denmark and grew as a result of dissatisfaction with conventional popular forms of housing and community. As a program or social structure for community development, it was selected as a model for this research because of its compatibility with the general intentions of the project. Cohousing is primarily different from other forms of community in the sense that it is an **intentional** community, created and perpetuated by its members As a housing model, it can take a wide variety of physical forms however, it is most often a cluster of dwellings (20-40) combined with a variety of other multipurpose spaces such as daycare and common facilities. By definition, Cohousing is a good social model for housing which is compatible with the concept of sustainable urban development.

1.4 Shared Servicing

In Ontario, within conventional rural developments, the method of servicing dwellings with water and sewerage is done on an individual basis. Provincial guidelines defining requirements for septic tanks, tile fields and wells have a significant impact on minimal lot sizes. The conditions suitable for a typical development of detached homes requires level, clear land with soils having a good water permeability rate for proper tile field operation. This is also necessary to achieve cost effective grading and road construction. These parameters have had a great affect on the form and location of development as the land best suited for development is often class 1 and 2 farmland [9]

In providing shared sewerage for example, alternative systems become more feasible. This also permits the location and physical form of the development to be more flexible. Aside from being more cost-effective on a per unit basis, communal waste treatment systems can be more sophisticated, capable of producing an effluent of high quality These systems are also more efficient, requiring less area to operate on a per unit basis.

[8] Cohousing n., adj. 1. co-developed, co-managed group of houses with extensive common facilities that supplement the private houses, designed with the participation of the residents to facilitate a sense of community over time. Durrett, Charles 1993

[9] Zsolt, John. 1993

2.0 RESEARCH

2.1 Research Methods

The primary goal of this research is to investigate and assess the options available for the provision of shared servicing for a cohousing community development of **30 dwellings**. The research for this project has been conducted using all available information sources in Canada the United States, which include the work of public, private and institutional groups. Due to the insufficient information available for some systems, additional corporations and individuals in advisory roles have played a key part in the assessment of new and existing systems

2.2 System Selection

In evaluating the large number of options available for servicing of housing, particular criteria for the selection of applicable systems has been used. To avoid redundancy, only the systems that meet with the following criteria have been addressed in the report:
> The systems should be relatively feasible for use in terms of cost, maintenance and construction requirements. For example, certain conventional sewage treatment systems have not been discussed due to their excessive construction costs and complex operational requirements
> The systems must be environmentally sustainable For example, sewage treatment systems that are not potentially capable of nitrate reduction to acceptable levels for subsurface discharge have been excluded
> The systems must fall into the general parameters of the project as defined in section 2.3

2.3 Project Parameters

It is assumed that the site amenities available to the proposed community adhere to those that are typical for the average rural site in Ontario. These typical conditions are listed as follows:
> Electric power available
> Natural gas not available.[10]
> No existing secondary road systems, land severance etc
> Receiving water available for surface run-off.
> Aquifer capable of sustaining the water requirements for 30 homes at an assigned need of 30,000 litres/day.

[10] Unlike the situation in certain western provinces, most rural district in Ontario do not have the availability of Natural Gas for heating purposes.

2.4 Research Design

Aside from the projects primary purpose, to investigate the servicing options available for rural housing, a theoretical housing model was created. This hypothetical community termed, **Hamlet Co-X**, serves the function of providing a basis for system comparison The project demonstrates, by example, the importance of integrated design in forming sustainable communities.

3.0 WATER

3.1 General

Municipal water use accounts for 11 % of the water used in Canada Within this sector, residential usage accounts for 45%, with 25% of the country's population being served by private wells. [11] As water is an essential element in the servicing of housing, its usage defines the scale and type of systems required for sewerage

Typically, rural housing relies on ground water for its potable water supply. This involves either a bored or drilled well ranging in depth from 30 to 400 feet. Approximately 70 % of individual wells are drilled For communal systems, drilled wells are used exclusively because they provide the most available water A standard individual system requires a well, a pump and a pressure tank The complete system for a single family dwelling with a 100 ft drilled well is estimated to cost on average $ 6000.00. From the well, water is pumped into a tank with an air chamber and the air is compressed to provide the required pressure for the distribution throughout the dwelling The system has electrical requirements, as the pumps can shut on and off up to 25 times daily depending on the water usage. The electrical costs to operate the pump are approximately $1 00 daily based on Ontario rates [12]

The provision of a communal system for water supply is common in rural communities that are as few as 75 inhabitants. These are most prevalent in older communities, usually part of the general servicing provided along with sewerage and storm water. They often exist in towns were the density is relatively high. Water mains typically follow the patterns of sewer and storm piping In new systems and are installed at the same time. In smaller communities, shared water systems are common and quite feasible when compared to the standard option of individual wells.

Shared communal systems are more cost effective to construct and operate if the developments density is high enough to warrant it. [13] Communal systems can also help to facilitate conservation through water demand management programs. [14]

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[11] Environment Canada.,1992

[12] Information regarding individual well systems provided courtesy of Northern Well Drilling Limited.

[13] If based on low housing densities and adverse site conditions are present, a communal systems may not be a more cost effective altemative, particularly in the precambrian shield regions of Ontario.

[14] Some large communities that rely entirely on ground water for their supply have experienced notable water shortages. This has lead certain areas such as The Regional Municipality of Waterloo to develop a water efficiency program which involves an education awareness program and the distribution of packages to modify individual dwellings for lower water usage.

3.2 Communal Systems

3.21 Ground Water Supply

Community systems that rely on ground water supply are the most desirable for small community uses In most districts in Ontario ground water is potable. However, an aquifers ability to sustain the required loading of a communal system will vary from site to site In Ontario, different regulations apply to communal ground water systems for purification that are not required for individual systems These involve chlorination or ozone treatment for disinfection Other treatment systems may also be required, as ground water can be tainted through man made and natural sources Some of the contaminates that can be found in ground water include Hydrogen Sulphide, Iron, Manganese, Calcium, Faecal Bacteria and Nitrate. Excessive levels of these compounds are required to be removed which will vary in terms of cost and operational requirements In areas with high levels of nitrates in the ground water, denitrification systems for example, are feasible for larger systems that for the individual home are not

Communal water systems, in principal, are not very different from individual systems. Water pressure is provided by pumps or by an elevated water tower for a gravity feed Construction of a water tower has several advantages. It uses less energy to operate (pumps are smaller and operate less frequently) and electricity can be utilized at off-peak periods (night-time) to operate the pumps that fill the reservoir Furthermore, a tower guarantees the availability of water for fire-fighting purposes, as a back-up system is not required.

Disadvantages of a communal ground water system include·
> System requires monitoring on a regular basis.
> Communal wells are deeper, must be drilled and require a greater diameter bore, 6" - 20".
> Ground source is not appropriate for all sites. The aquifer must be able to provide needed flows
> System may require additional purification devices depending on the water quality.

3.22 Surface Water Supply

In Ontario an abundance of lakes and rivers make surface water a viable alternative to ground water supply. However, unless ground water is not available, it is not normally considered. Most surface supplies are not potable and require treatment. These treatment facilities require an additional element not present in ground water systems, filtration. Filtration systems are expensive to construct and operate, often requiring full-time personnel to monitor the system. Furthermore, the construction costs associated with the water intake can be compatible to well-drilling depending on the site conditions [15] Unless ground water is not present, it is generally not a viable option for a small community.

3.3 Conservation

Water conservation lowers water supply costs, protects a valuable resource and decreases the costs of sewerage. By reducing flows through conservation, smaller treatment facilities are required and the amount of treated effluent discharged back into the environment is decreased. A communal system offers an additional advantage in the sense that water conservation becomes an issue confronting the whole community and can be dealt with on a community scale. Simple water conservation devices such as low-flush toilets, more efficient appliances and low-flow shower heads can reduce flows substantially. [16] Water reuse is another conserving method. For example, grey water can be used for plant watering or to flush toilets. In terms of water conservation and reuse, the possibilities appear to be endless [17]

[15] The residential community of Lagoon City on Lake Simcoe required an 12" intake pipe to be constructed for its water system The pipe had to extend over 2500 ft.(762 m) out into the lake to obtain a reasonable depth for the intake This was done in 1969 at a cost of over $100,000.00. Information courtesy Inducon Development Corporation.

[16] In a study by the Regional Municipality of Waterloo, the use of low flush toilets alone accounted for a 30 % decrease in water usage for 50 homes The Regional Municipality of Waterloo , 1993

[17] Excellent manuals published by the US Environmental Protection Agency on this and related subjects are available.

4.0 STORM WATER

4.1 General

The control of storm water run-off in rural areas is not considered an integral part of servicing unless the housing is clustered in a subdivision form. In a low density situation, the site and its surroundings are capable of absorbing the rainfall. When however, density is increased so are the concentrations of impervious surfaces such as roads, roofs and driveways. The run-off produced by a conventionally designed subdivision can be quite significant The receiving body of water is usually a lake or small stream and several subdivisions feeding into one stream can cause flash flooding. Run-off water can become contaminated with high concentrations of metals and suspended solids resulting in a situation where the receiving river or lakes suffer environmental damage In the situation of a river for example, excessive channel flows during periods of heavy rainfall can damage sensitive riparian areas due to sharp variations in the natural water cycles. [18]

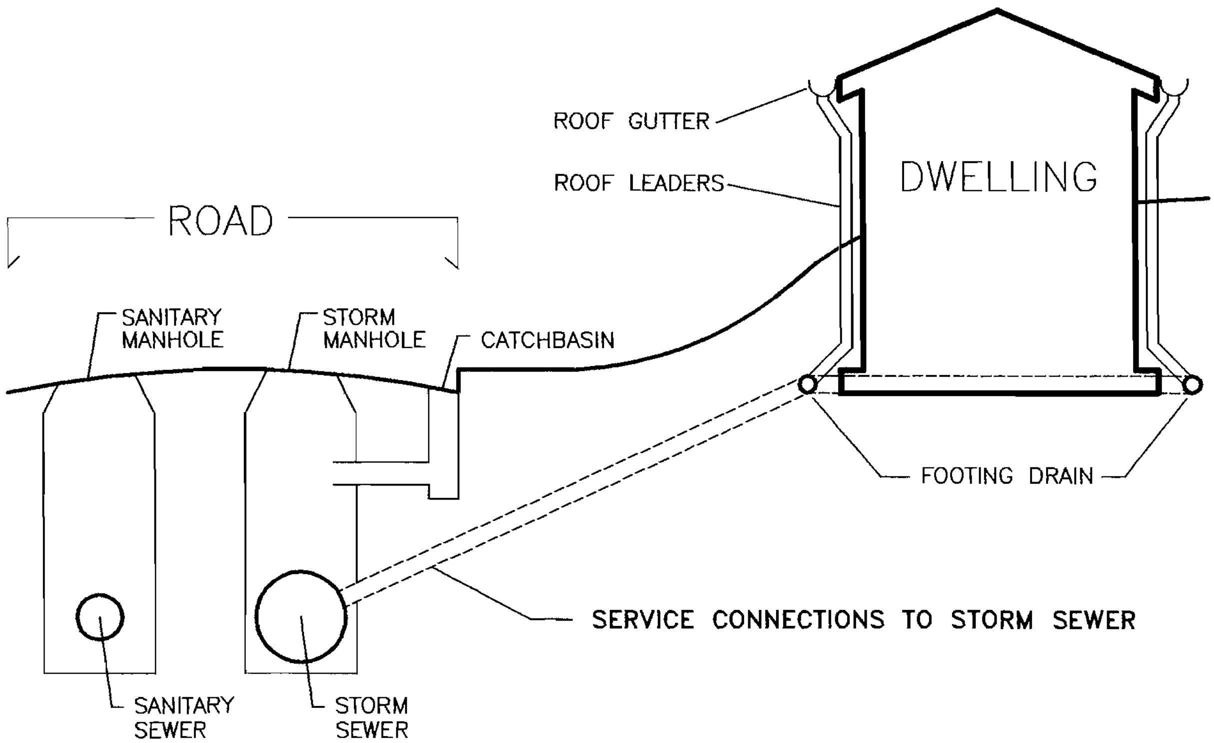
4.2 Conventional Collection Systems

A storm water system for housing can be broken down into three related parts: the drainage of ground surfaces (roads, lawns and driveways), the drainage of roofs and the drainage of building footings (Subsurface drainage or weeping tiles). A conventional system uses entirely structural [19] means to collect the run-off. The subsurface and surface drainage is gathered to feed into a gravity flow storm sewer. **(FIG.1)** The conventional system is very effective in collecting rain water however, it is quite expensive to construct. Cost for these systems exceed the costs for sanitary sewer systems because the pipe diameters are normally greater. In a survey of 6 fully serviced subdivisions ranging in size from 61 to 119 lots, the average cost for storm sewers alone was $4092 00 per lot [20] These systems efficiently remove the run-off away from the site thereby reducing the water that can be used to recharge the aquifer. Furthermore, the systems effectiveness in collecting run-off creates problems at the systems outfall. Disposing of the run-off water in an environmentally sensitive fashion creates a complex problem. Conventional systems provide no treatment of the effluent before releasing it the environment.

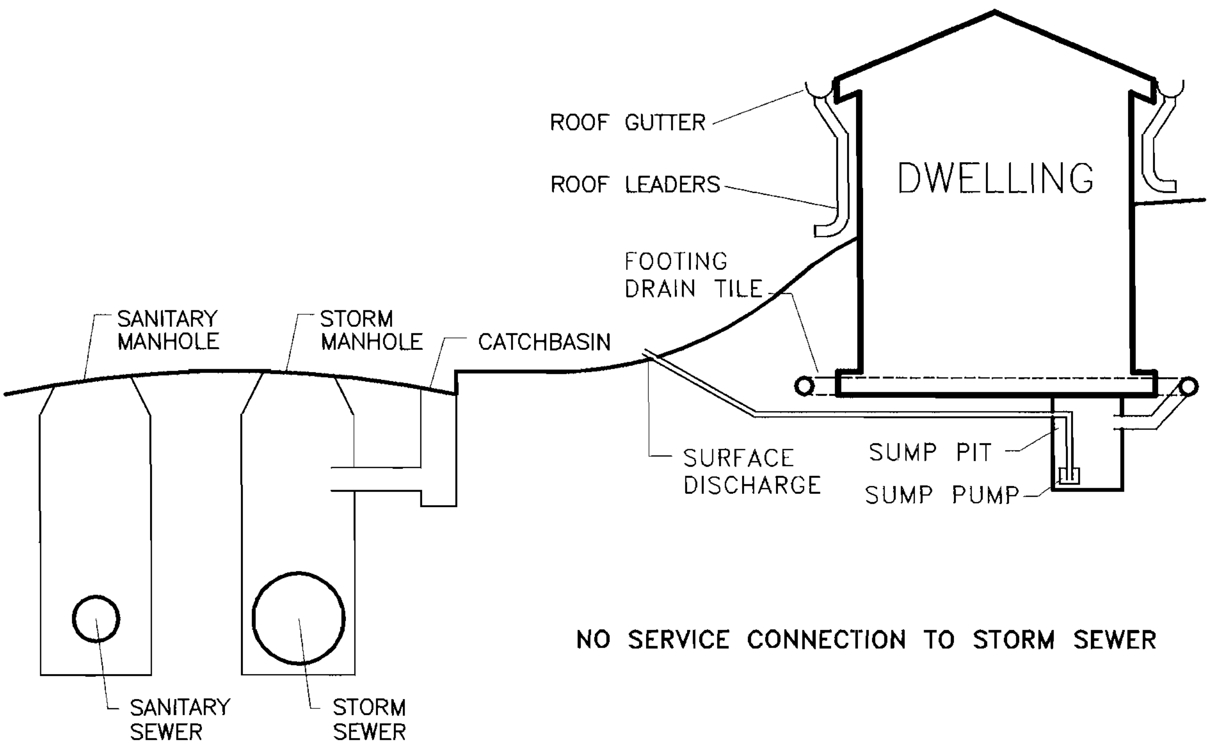
[18] Zsolt, John 1993

[19] Structural methods of collecting run-off involves catch basins and storm sewers versus non-structural methods such as open roadside swales

[20] Costing information courtesy T. Ruscica & Sons Ltd., Ontario.



CONVENTIONAL STORM WATER COLLECTION SYSTEM



MODIFIED CONVENTIONAL STORM WATER SYSTEM

In an effort to reduce and control the volume of water produced by storm water systems, basic modifications to the conventional system were proposed by Ontario's Ministry of Housing in 1976. The proposed standards involved the isolation of roof and footing drainage systems to a surface discharge onto the site adjacent to dwelling. **(FIG.2)** In this situation, the weeping tiles gravity feed into a sump pit and are pumped to an outlet on the surface. Based on the report's findings, these modifications coupled with higher densities would significantly reduce the flows of water into a storm system. [21]Although the modifications proposed for the conventional system will reduce costs (connection to the main line is not required), the system remains relatively capital intensive because driveways and roads are controlled through structural means.

4.3 Grassed Swales

As an alternative to curb and catch basins feeding into a conventional storm sewer system, some rural municipalities allow all common impervious surfaces to drain into roadside swales. Compared to a conventional system, this is a far more cost-effective method, however,if the swale is not properly designed and maintained, water stagnation can become a problem. This poses a small health risk and it provides an environment for the breeding of insects. Even if the system is working properly, during periods of heavy rainfall, water is still collected and directed into a local river or lake In the early spring, when the ground is still frozen, a system relying entirely on road side swales can easily become overloaded causing localized flooding. Depending on the municipality, in the rural districts throughout Ontario, variations of all of these systems exist.

4.4 Impoundment

Regardless of the collection system used, the disposed of run-off must be considered. Many rural municipalities in response to environmental pressures, are resorting to storm water impoundment as a method to control and treat storm water. Impoundment involves the construction of a retention facility or pond These ponds vary in size and depth depending upon whether they are classified dry or wet Wet ponds being deeper, contain water most of the time and are capable of containing the runoff produced by a 5 to 10 year storm. Impoundment ponds serve a dual purpose to control flash flooding and to improve water quality through settling and aeration. In a national survey of storm water impoundment facilities, most systems were found to require regular maintenance. Some problems experienced with these facilities are listed as follows:
> Necessary to control weed and algae growth
> The sedimentation build-up must be removed.
> Insect control a problem (mosquitos, some use insecticides)
> The ponds can be a safety hazard to children ,requiring physical constraints such as fencing.

[21] McBean, Edward.,Ellis, Hugh and Mulamoottil, George., 1982

Some facilities surveyed gave secondary uses for the ponds such as wild life habitat and recreation however the study concluded by questioning the systems ability to improve water quality. [22] The effectiveness of impoundment facilities to remove pollutants depends on the period of time the water is detained. [23]

4.5 Wetlands

Impoundment facilities are essentially engineered ponds designed as passive holding facilities. Generally, these systems are being phased out and replaced with other methods that allow for soil infiltration and natural treatment A variation of the engineered wet/dry pond is
a wetland system Utilizing a wetland, either natural or constructed, can provide a natural process to cleanse and retain the storm water while creating wildlife habitat **(FIG. 3)** Wet ponds designed with a shallow marsh at the bottom stage are capable of high pollutant removal. [24] These systems require less maintenance However a full scale wetland, without a detention pond requires a suitable site and much more land This is a cost consideration depending on the scale and type of development intended. Lastly, insects may remain a problem, particularly if a free water surface flow system is used (Refer to section 6.37 Constructed Wetlands.)

4.6 Infiltration Systems

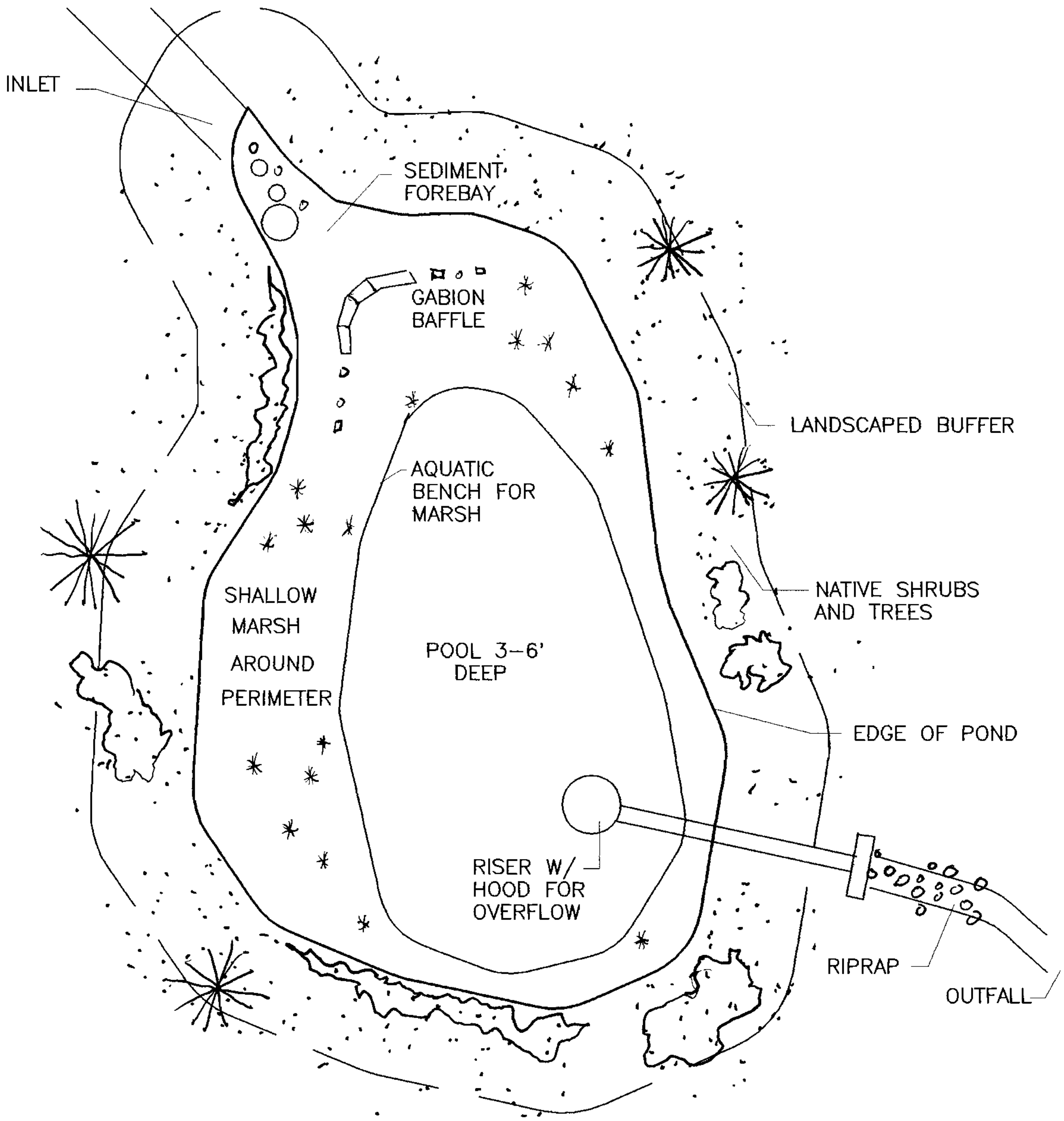
Infiltration systems are designed to allow surface runoff to permeate back into the ground, thus recharging the ground water. Many different systems exist that range from subsurface trenches and drywells to open basins

Subsurface systems collect runoff within an excavated depression which is filled with stone or gravel Runoff flows in over the surface or in through a culvert. The trench is allowed to fill during periods of heavy rain fall and the water then leaches into the ground **(FIG. 4)** Pretreatment occurs by allowing the runoff to pass over grass filter strip adjacent to the trench or the runoff can be treated using other methods prior to entering the trench. Within an open basin system, the runoff aerates in an open pond similar to a drypond were it is detained and allowed to percolate into the strata below **(FIG. 5)**

[22] Michaels, Sarah., McBean, Edward. and Mulamoottil, George., 1983.

[23] Schueler, Thomas., 1987

[24] Schueler, Thomas., 1987.



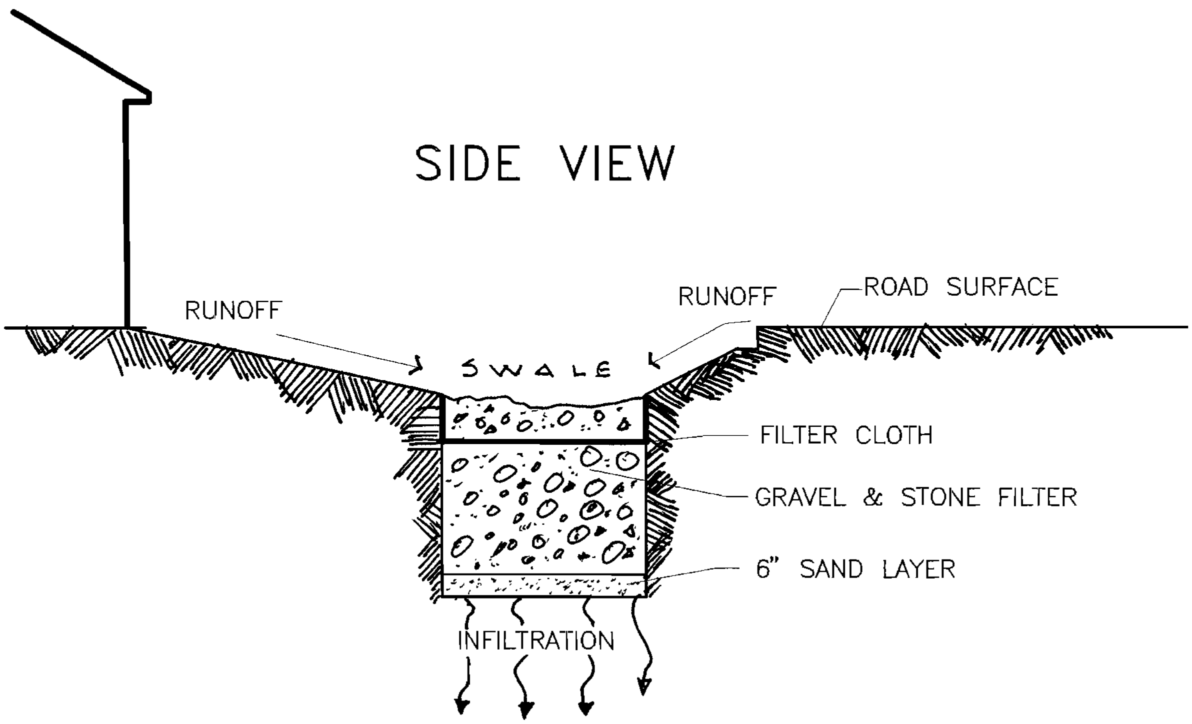
WET POND IMPOUNDMENT FACILITY

WITH INTEGRATED SHALLOW MARSH

Zsolt & Associates Limited

Environmental Design and Planning

FIGURE 3



ROAD SIDE INFILTRATION TRENCH

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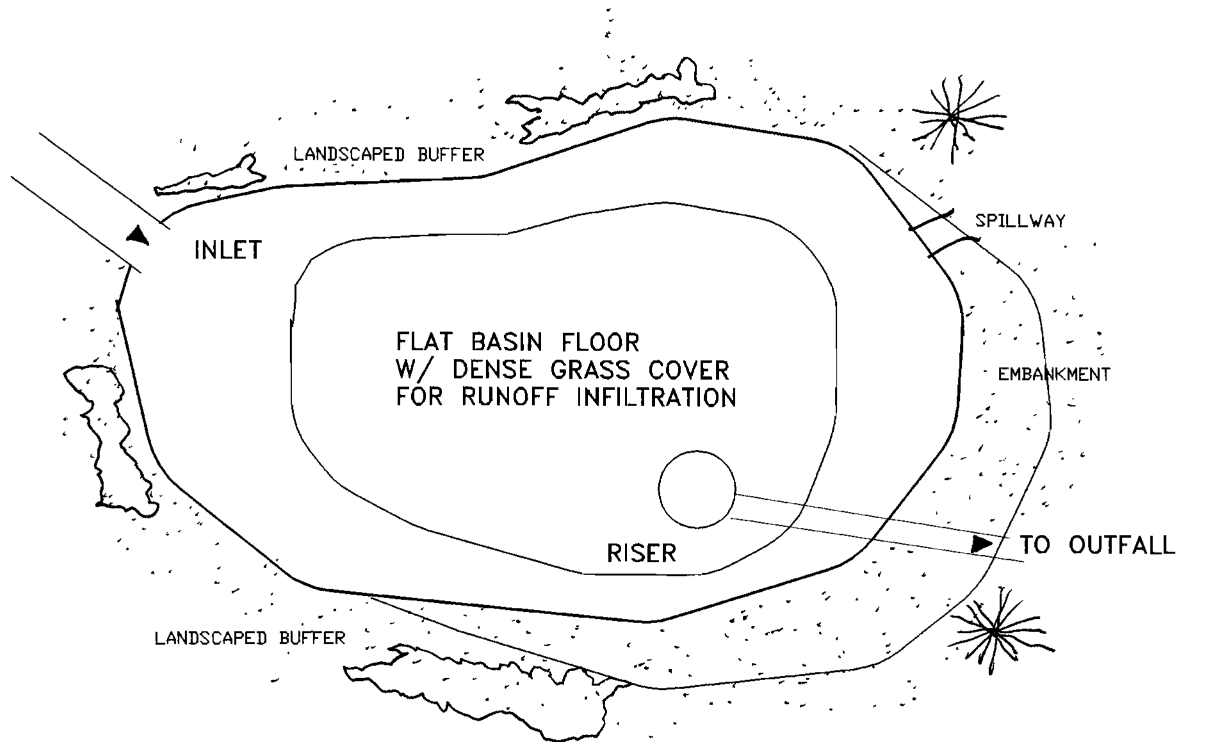
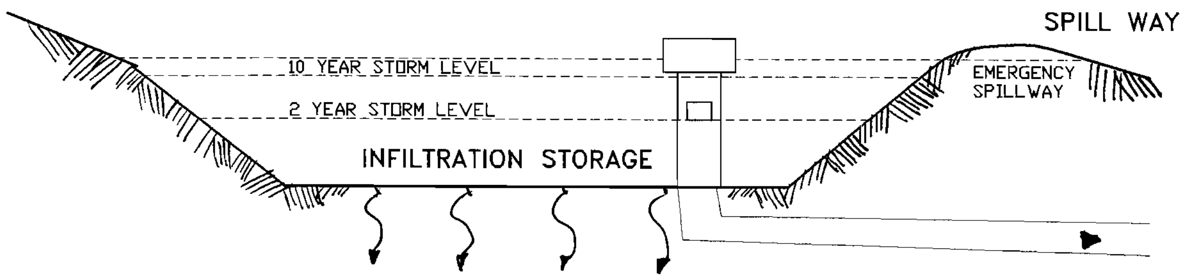
FIGURE 4



PLAN VIEW



CROSS-SECTION

INFILTRATION BASIN

Zsolt & Associates Limited

Environmental Design and Planning

FIGURE 5

If properly designed and constructed, infiltration systems, when integrated with other controlling devices, can lead to much runoff being contained within the surface boundaries of the site Rain water infiltration is necessary for the recharge of the aquifer Outside of the precambrian shield regions, streams under natural conditions are fed by ground water as opposed to surface runoff which is the case of developed areas If infiltration systems are used, the hydrological cycle can be brought back to predevelopment levels in which the flow levels of streams during dry summer periods are maintained Reinforcing the natural cycles helps to control stream erosion and preserves riparian areas

4.7 Site Considerations

When selecting the most appropriate system for stormwater control the characteristics of the site play an important role The following are key factors in system selection:

> Slope of terrain
> Proximity to bedrock, water table and building foundations
> Soil permeability
> Projected flows / area of land served
> Availability of a suitable water course for effluent disposal

Systems can be used in combination to suit varying site characteristics and situations Infiltration systems for example require soils with a good water permeability rate. This precludes their use on sites with high clay content soils. Similarly, wetponds do not function properly in sandy soils because water infiltrates too quickly not allowing sufficient time for treatment

4.8 Site and Building Design

Containment of storm water by utilizing certain site and building design techniques is one effective method to control run-off. Containing the problem at its source versus constructing expensive systems for collection, treatment and disposal is clearly a more sustainable approach. The following are building methods that can reduce surface run-off substantially:
> Reduce the building foot print by constructing homes in two stories versus one storey This decreases roof areas and the length of foundations to be drained
> The clustering of building reduces the length of exposed footings. A duplex requires up to 25% less weeping tiles in total length that two detached houses [25]

[25] This is based on two dwellings square in plan, having the same area

> Decrease roof areas by reducing over hangs and excessive roof slopes
> Utilize drywells and other infiltration systems to absorb water from footing drains and rain water leaders
> The clustering of buildings allow roads and roof areas to be concentrated on one portion of a site thus allowing more available area for landscaping and effective grading. This lessens the required roads and driveways, thus decreasing the site's total impervious area

4.9 Landscape Design

The design of the landscape is the single most important factor in controlling runoff. [26] In order to achieve zero runoff or full self-containment, the amount of over land flow must be decreased Essentially, the closer the design of a site can emulate a natural condition by allowing for infiltration, plant interception and uptake, the better. The goal is to simulate the natural hydrological cycle. This requires an approach to site design that is antithesis of conventional engineered approaches

> Minimize excessive slopes. Maintain existing grading and natural drainage patterns where possible
> Allow areas to naturally regenerate utilizing ground covers and shrubs extensively Provide cut grasses in play areas only. [27]
> Allow for hollows and depressions in level areas for infiltration to occur. Provide "check dams" [28] in areas with excessive overland flow such as a swale
> Maximise the use of woody plants such as tall deciduous trees to emulate forest cover The larger the trees, the more interception and the evapo/transpiration of rainfall

[26] Section 4 9 based on an interview with Fidenzio Salvatori OALA, Salvatori Consultants Inc., Toronto

[27] Wild grasses such as hay absorb 2-3 times as much runoff as regular cut lawn.

[28] "Check dams" are small blocking devices built into a surface channel. They allow water to puddle along various points providing an opportunity for the aeration, sedimentation and infiltration of the runoff

5.0 HEATING AND ENERGY

5.1 General

Unlike homes in urban areas which rely predominantly on electricity or natural gas for heat energy, homes in rural districts use a variety of energy sources To observe for example, a home utilizing three different sources simultaneously is common. In Ontario, electric power servicing rural communities is prevalent and up until recently quite cost effective as an energy source. Sharp increases in utility rates have created a problem for those without alternatives for home heating This has lead to the development and popularization of alternative technologies for more efficient home heating This section of the report will focus on the costs and problems associated with the different energy sources available to rural inhabitants for heating, cooling and appliance operation

5.2 Primary Home Heating Systems

5.21 Biomass

Biomass as an energy source is simply the combustion of organic materials to generate heat The term encapsulates such materials as wood, agricultural waste. In Canada the burning of wood as a primary energy source is quite common which is primarily due to the fact that wood is a renewable resource and is easily obtained. It is however, most often used as one of two heating systems usually in conjunction with electric heat. Advances in the design of wood burning stoves have created residential units of high efficiency These units are capable of heating detached 185 m2 home without any other heat source. [29]

The combustion of bio-fuels however, produce pollutants including carbon monoxide, nitrogen oxides and particulates such as soot and ash In cities like Denver, Colorado, restrictions have been placed on burning wood due the problems with air quality. [30] Smoke can become trapped under a layer of cool air when a temperature inversions occurs as in the example of urban smog, which can create a severe urban pollution problem. This problem is also experienced on a small scale if housing is grouped in a cluster or sub-division form, located in an area susceptible to fog. [31]

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[29] High efficiency wood stoves can generate in excess of 70,000 kj of energy over an 11 hour period

[30] Brower, Michael.,1992

[31] In parts of Switzerland tight restrictions exist for small valley communities on the burning of wood to heat homes due to problems associated with temperature inversions.

5.22 Electric

In the province of Ontario electricity as a primary home heating fuel accounts for 19.1%. [32] This figure is representative of urban and rural use together (rural usage is proportionately much higher) The extensive electric grid in Ontario provides stable energy source for most rural areas. This energy is generated by coal, hydro or nuclear generating stations. [33] Ontario hydro electricity is becoming increasingly expensive and it is expected that the costs may continue to increase

Of home heating electric systems the most commonly used are baseboard (radiant unit heaters) and electric furnace (part of a forced air system) Based on electricity provided at the rate of $.076 per kWh, a 2000 sq.ft. (186 m2) detached house in Barrie would cost $2,180 per year to heat which represents the most expensive heating option for the consumer.[34] The advantage to electrical heating however, is the systems complete versatility Duct work is not required for baseboard heating, which can be located anywhere in a house. However, new provincial code restrictions require homes with baseboard heating to be completely ventilated with an air duct system. This will limit the potential use of baseboard heating substantially.

5.23 Oil

In Ontario oil as a primary energy source for heating accounts for 12 8 %. [35] Again, this figure is proportionately higher in rural areas were no natural gas is available Oil heating systems are either furnace/forced air or boiler/hydronic. [36] High efficiency oil furnaces are available and they are more cost effective than electrical systems for daily operating costs Based on oil at a cost of $.37 per litre a 186 m2 detached house in Barrie would cost $1,270 per year to heat. Conversely, a cost comparison of an oil furnace system versus an electric furnace system for installation shows oil furnace systems are more expensive, $2,100 versus $1,600 for electric. Oil, being a non-renewable resource is the least desirable from an environmental perspective. Fossil fuel combustion accounts for more than 70% of all human carbon dioxide emissions thus playing

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[32] Ontario Hydro, 1993

[33] The debate continues over the question of nuclear power and its suitability as an energy source for Ontario. Anticipating formidable economic growth for the nineties, Ontario Hydro has already constructed the generating facilities to accommodate the provinces electrical energy requirements into the 21st century

[34] The Ontario Ministry of Energy, 1992.

[35] The Ontario Ministry of Energy, 1992.

[36] Hydronic systems use piped water or steam to distribute the heat throughout a building This is an ancient concept that is still highly regarded for its efficiency particularly for large or district heating systems

an important role in global warming [37] Oil requires a storage tank and must be brought in on a regular basis The energy required to fulfil this task coupled with the energy for refinement are reasons why oil is becoming increasingly less popular

5.24 Heat Pump

A heat pump is a machine that uses the refrigeration cycle to transfer heat energy from one medium to another **(FIG.6)** For heating purposes, heat pump systems remove heat energy from an outside heat source and move it to a high temperature indoor heat sink The media that heat is absorbed from is called the heat source and the source used defines the system classification.

Heat distribution systems for residential heat pump applications are most commonly forced air systems (air handling unit and heat pump provided in one unit). Heat Pump systems can also be integrated into a water distribution system Both methods can be used together and are capable of providing heating, cooling and hot water supply

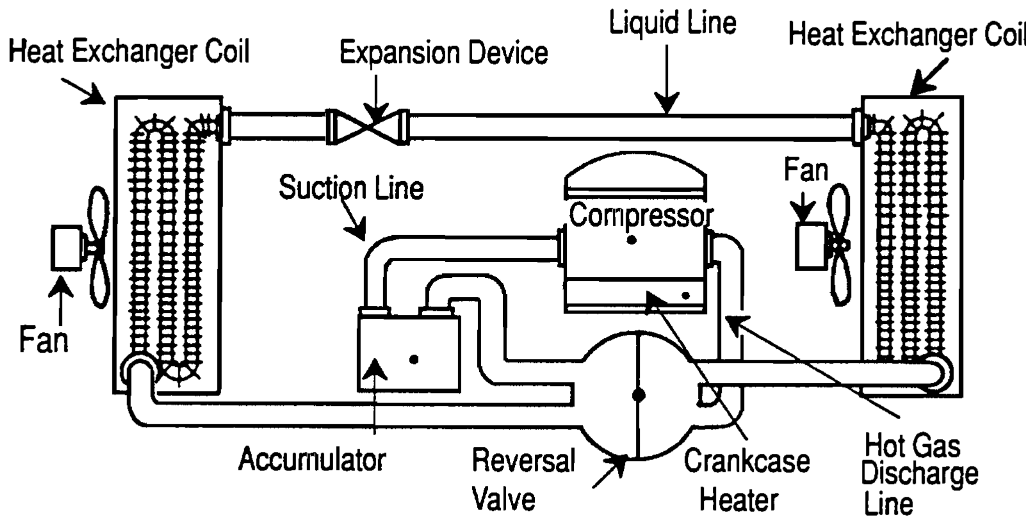
Water Source Heat Pump System

Water source heat pumps use water as a heat source. The water normally is taken from a ground water source (well). This is termed an open collection system as water is brought in, energy is extracted and then discharged at a lower temperature back into the environment. Water source systems are more efficient than air source systems and require less energy to operate

The problems associated with these systems involve the collection and disposal of source water A system relying on ground water requires the construction or up-grading of a well for supply and often a tile field or pressurized re-injection well to return it to the ground Getting the water back into the ground is often the greatest problem, depending on the sites' geology Water source systems however can be integrated into a communities waste treatment facility, extracting heat energy from waste water. [38] Successful large scale projects of this nature have been constructed in Sweden, often combined with a district heating system

[37] Brower, Michael., 1992.

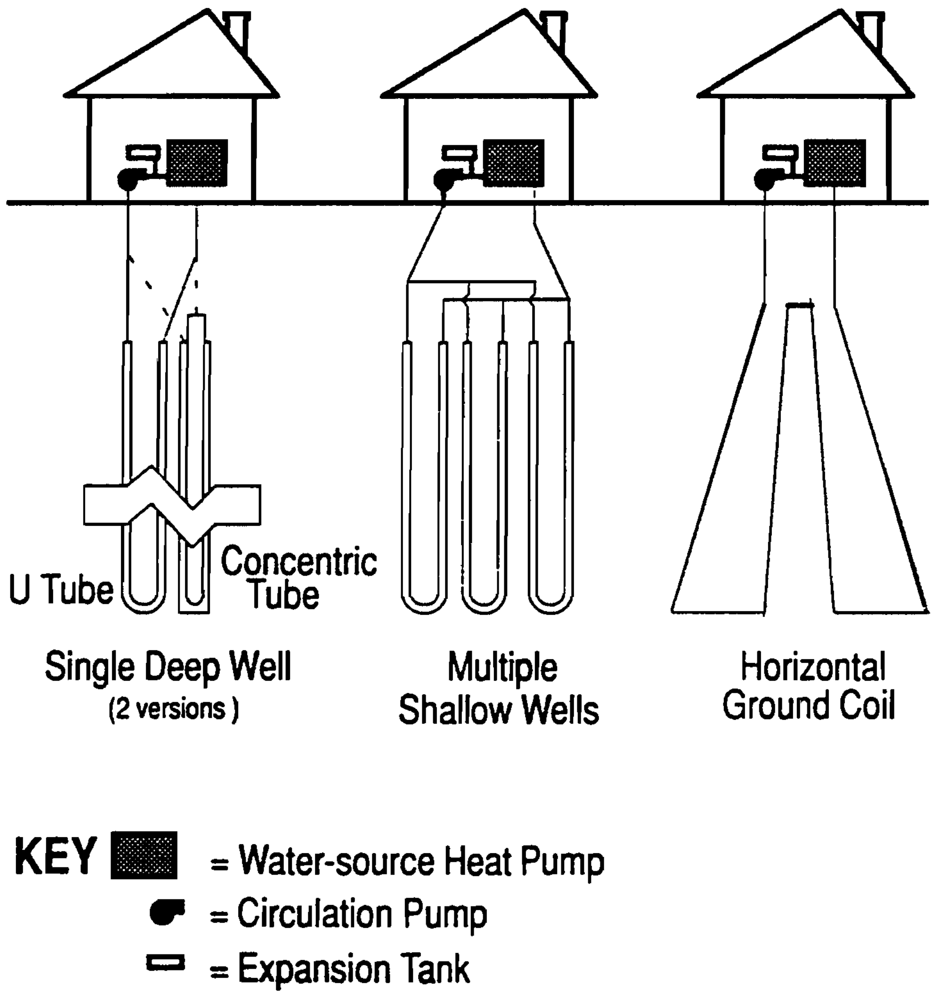
[38] CADDET/IEA/OECED Publications 5B.H01 1.88.SE & 5B.H01.4 88.SE



Components of a Heat Pump

TYPICAL HEAT PUMP SCHEMATIC

DRAWING TAKEN FROM
<u>HEAT PUMP REFERENCE GUIDE</u>
4TH EDITION , ONTARIO HYDRO 1991



GROUND SOURCE HEAT PUMP SYSTEMS

DRAWING TAKEN FROM
HEAT PUMP REFERENCE GUIDE
4TH EDITION, ONTARIO HYDRO 1991

Ground Source Heat Pump Systems

Ground source systems are termed closed collector systems. The ground media serves as a heat source as energy is extracted through a liquid media circulating in a contained continuous closed loop. This heat loop can be polyethylene coils buried in trenches [39] or a drilled well, with supply and return enclosed in a piped system Systems using plastic coils have been successfully tested by Canada's National Research Council and have demonstrated to be a more cost efficient method

The efficiency of these systems is similar to that of water source systems although they are more versatile and capable of operating in different conditions with different heat extraction systems to suit a sites geology **(FIG.7)** For these reasons alone it is considered most appropriate for residential applications. Some disadvantages of ground source heat pumps are the limited capacity, (maximum standard unit available is 5 tons, 60,000 BTU/Hr) [40] and relatively high installation costs, particularly for heat extraction systems

All heat pump systems require electric power in their operation to run compressors and pumps. Electrical costs for a detached 2,000 sq ft home in Barrie utilizing a ground source heat pump system with forced air distribution is $870 per year based on electrical rates of $.076 per kWh. [41] This represents the most efficient use of energy availiable to the comsumer

Common Characteristics

Heat pumps offer many advantages over the other energy sources available to rural areas.
> Systems can be used for cooling as well as heating
> Systems can supply hot water at annual electric costs less than electric systems [42]
> Heat pump systems can be combined with other systems quite effectively for such purposes as heat recovery from waste water and ventilation systems.
> Heat pump systems are easily modified for district heating systems. In combining the heating and cooling for a group of dwellings, a heat pump becomes more cost effective, allowing several dwellings to use one heat pump system (see District Heating)

[39] Svec, Otto , 1992.

[40] 10-15 Ton units can be specially manufactured for larger applications.

[41] The Ontario Ministry of Energy, 1992

[42] The Ontario Ministry of Energy, 1992.

5.25 Heat Recovery Ventilators

The most recent amendments to the Ontario Building Code [43] outline the necessity of all new homes to be properly ventilated ensuring that fresh air is brought into the home on an hourly basis to maintain indoor air quality In a cold climate this poses a problem because air that is exhausted contains much heat energy that is lost Heat recovery ventilators (HRV) were developed to address this problem Warm interior air to be exhausted, passes through a heat exchanger, providing the heat energy to warm the incoming cold air While some energy is inevitably lost, HRV systems are becoming increasingly efficient

An HRV is most effective when used in conjunction with a forced air system [44] These systems are best controlled on an individual unit basis as every home has different ventilation requirements, depending on size and occupancy. A forced air system can be constructed using all standard heat sources.

5.3 Alternative Energy

5.31 Energy Efficient Design

The most effective means to control energy usage for heating and cooling is through energy efficient design. Design innovations can effectively reduce the energy requirements for a home by a significant amount Energy conservation is simply the most direct path to energy self-sufficiency. Some of the ideas presented in this section were previously discussed in section 1.3 under sustainability however, given their potential for energy conservation warrant further elaboration

Building Design

The first steps to energy efficiency in housing is through the utilization of energy efficient building technology A good example of energy efficient design in housing is the Energy-Efficient Advanced House Project The Advanced House, in theory, is projected to use 30% of the energy required for an equivalent conventional home built in Ontario Subsequent initial testing of a pilot project has revealed energy usage equivalent to 38% of the energy consumption of a conventional

[43] The Ontario Ministry of Housing., 1993

[44] Mattock, Chris., Rousseau, David., 1988.

house [45] This technology which is being tested in 10 homes across Canada is a major improvement over the R2000 house and may be indicative of future possibilities for detached dwellings The Advanced House has integrated several systems to achieve its efficiency:

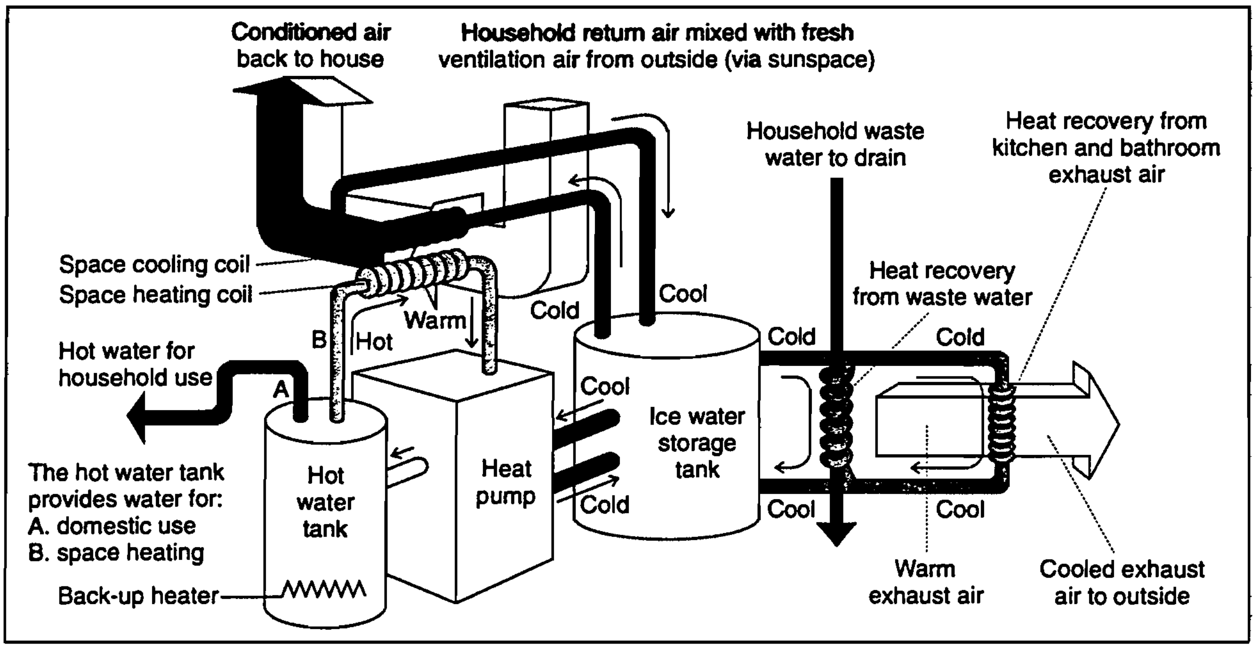
> Higher performance windows.
> Passive solar utilization
> Energy efficient lights and appliances
> High levels of installation and air tight construction
> An integrated mechanical system which is a heat pump appliance that supplies space heating, cooling, hot water heating and heat recovery from ventilation **(FIG.8)**
> The system is also capable of heat storage for later recovery

These systems, which were developed for an individual home could prove to be far more efficient if applied to a multiple housing development using district heating Larger systems are generally more efficient in terms of cost and energy usage

Passive Solar

Passive solar is a method of utilizing solar energy in a passive fashion through the implementation of specific building techniques This is done most commonly in the design of fenestration and building orientation to maximize the exposure to solar radiation. In a cold climate, it is critical to allow maximum solar energy gain during the winter months and minimal solar gain in the summer This is also necessary to avoid excessive cooling requirements which are usually controlled with shading devices In the winter, heat is retained by the use of interior materials having high specific heat on walls and floors to absorb the radiation or through other devices such as thermally massive heat sinks.

[45] Carpenter, Stephen., 1991.



INTEGRATED MECHANICAL SYSTEM

DRAWING TAKEN FROM
<u>ENERGY -EFFICIENT ADVANCED HOUSE</u>
<u>WITH INTEGRATED MECHANICAL SYSTEM</u>
CADDET / IEA / OECD MARCH 1992

Generally, U S studies have indicated that passive solar design technologies in a typical house can result in overall energy savings of 30 - 70% with additional costs in construction of 10%. [46] These construction costs could be much less in a development where there is more repetition of design Passive solar design can take many forms and the most effective methods are currently the subject of much debate [47] Furthermore, solar energy gains in a cold climate can be cancelled out by the heat loss through the windows In order to be effective, these two variables should approach a balance, taking into consideration design issues and interior natural lighting requirements In Canada, passive solar design is increasingly being regarded as a simple technique to offset heat loss

Site Design

The location of a building on a site can significantly effect its energy usage A building should be sited to prevent excessive exposure from cold prevailing winds while maximizing winter solar exposure The design of landscape can also play an important role. The planting of a cluster of coniferous trees on the north side of a building can protect it from exposure to winter wind Deciduous trees planted to the south can help reduce summer solar gain and thus reduce cooling requirements Similarly, the clustering of buildings is another effective method to reduce energy usage by reducing heat loss A two-storey townhouse for example, with identical dwellings on either side experiences 43% less heat loss than a similar detached house. [48] A conserving approach to energy usage often has other positive ramifications In this instance significant energy savings can also be realized by conserving materials and using less energy during construction

5.32 District Heating

District heating systems, if designed to minimize heat loss within the system, provide the most efficient means to distribute heat energy to a group of buildings. Many Canadian universities, for example, use district heating to heat campus buildings, distributing the heat in steam form through a system of pipes In many urban centers, where development densities are much higher, district heating systems are common. Downtown Stockholm and Toronto are good examples of district heating systems serving both residential and commercial applications.

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[46] Brower, Mikael , 1992

[47] Victor Olgyay in his book Design With Climate cites seven separate studies outlining the optimum orientation for maximum solar heat gain in buildings, each with different results.

[48] Friedman, Avi., 1991

For rural housing applications, a district heating system can be highly effective, provided that the houses are not distanced far apart. Heat energy generated by one plant is distributed through a series of underground conduits, piping hot water to individual homes Fan coil units or radiant heaters then distribute the heat throughout the home. The system, in concept, is very similar to those utilized in modern high rise condominium buildings The advantages are greater system efficiency and cost effectiveness provided the distribution system is not overly extended The more compact the form, the more economically feasible a district heating system can be.

5.33 Wind Power

In certain areas of the United States wind energy has quickly become a clean and popular method to generate power Electrical energy is generated by the use of wind driven turbines. Over the last decade efficiencies of turbines have been increasing however, in order to be effective, sufficient amounts of wind are required. In Ontario wind speeds average less than 15 Km/hr, [49] and in such an environment wind energy is not feasible to meet the primary energy requirements for a small community Furthermore, due to the excessive costs of a large wind turbine, a system designed to supply energy usage on an intermittent basis is also not feasible A 10 KW turbine unit costs approximately $25,000.00 for an entire system. [50] Operating at less than 20% efficiency, the electricity the system would generate could not warrant the cost of the system

5.34 Solar Power

Photovoltaic

For communal residential applications solar energy can be directly utilized using a photovoltaic system Photovoltaics is the conversion of solar radiant energy directly into electrical energy. This is accomplished through a solar collector, referred to as a module A typical solar panel module produces on average 50 watts of electricity (Direct Current) The energy is then stored in batteries and used in Direct Current form or converted to Alternating Current for standard residential appliances. Costs for a photovoltaic system are approximately $10 00 per watt. [51] For example, a 10 Kilowatt system would cost $100,000.00 This would include the solar panels AC\DC converter, batteries and controls.

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[49] Ontario Hydro

[50] Based on an interview with Per Drews, formerly of Ontario Hydro

[51] Ibid

A 10 KW system in Southern Ontario is capable of producing 1 0 to 1 3 KW on average If electricity is available at $ 08 per kWh and the system is generating 1 Kilowatt, the electricity generated would be equivalent to a $700 00 savings for one year. This savings does not justify a $100,000 capital investment for the system and is not yet a feasible alternative for community applications in Ontario that have the availability of electricity

Solar Water Panels

Another method of utilizing the suns energy for heating is based on a water system in which the solar panel contains a series of pipes or tubes through which water is circulated and heated The heated water, depending on the systems efficiency, [52] can be used for a variety of purposes including the provision of hot water for the dwelling or simply to be stored in a heat sink for recovery later to augment the homes primary heating system. These systems, which are also known as Solar Domestic Hot Water Systems (SDHW), can be quite complex, equipped with computer monitoring systems and preheating tanks Unfortunately, information with respect to the installation costs of a single home system is presently unattainable

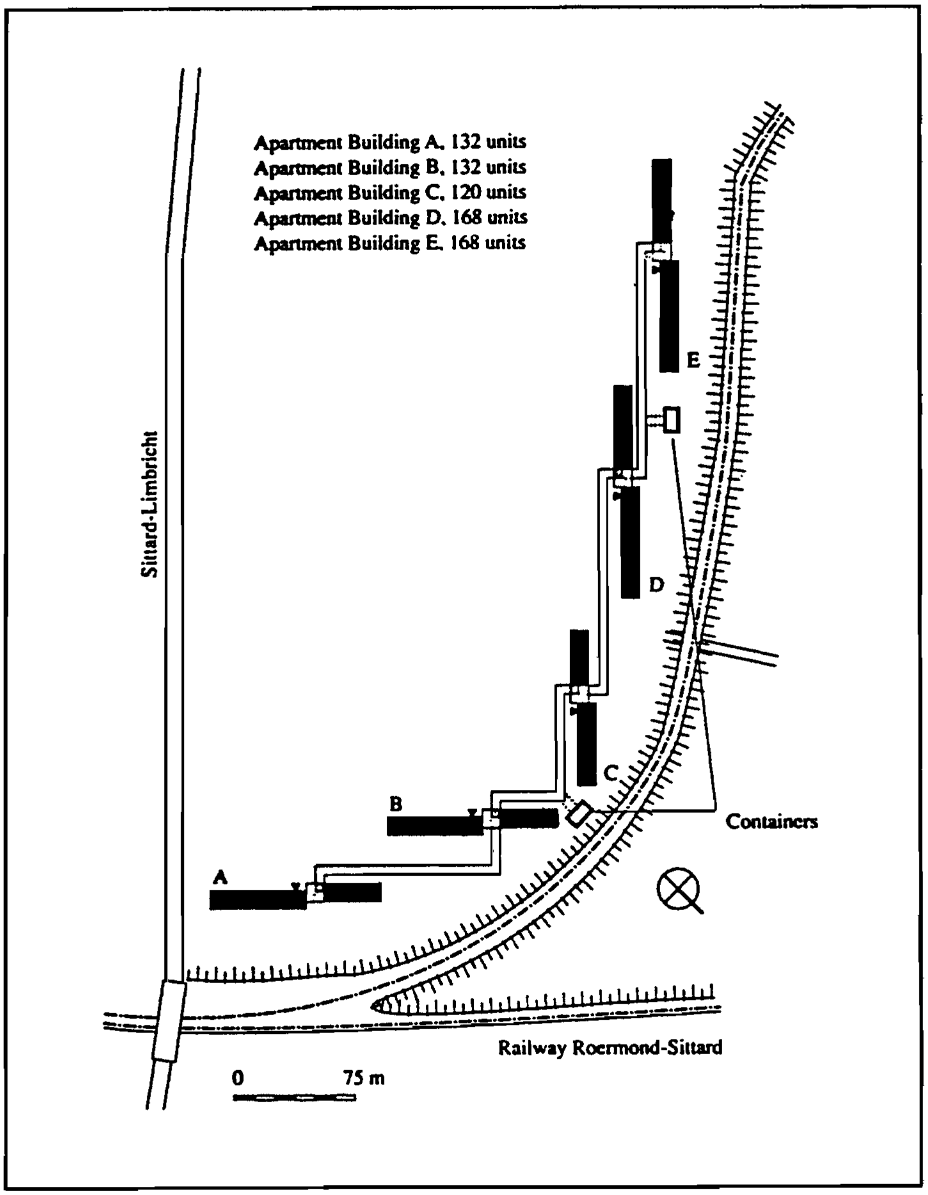
5.35 Cogeneration

Although the parameters of this project define that natural gas is not available to the site, Cogeneration is a future option that deserves some comment Cogeneration can be defined as " the sequential use of a primary energy source to produce two useful forms of energy, heat and electricity" [53] In conventional electrical generating system 60% to 70% of the heat energy is lost Basically, in a cogeneration system, excess heat energy from a gas driven electrical generator is contained in the form of steam or water and used to provide heat to a building or process This results in a total system efficiency of 80% or more The electricity generated is used on site with the excess being sold back to the local utility. With electricity costs increasing, Cogeneration is becoming a feasible option for all forms of development or industry that are high energy users. Cogeneration systems have been successfully implemented in the Netherlands. [54] **(FIG. 9)** The example shown is a 5 apartment complex powered by two gas driven cogeneration units, using a district heating system.

[52] Panel efficiency is a function of the design and the climatic conditions.

[53] Waukesha Power Systems, 1986

[54] CADDET/IEA/OECD , 1987.



DISTRICT HEATING COGENERATION SYSTEM

SITTARD, NETHERLANDS

DRAWING TAKEN FROM
<u>SPACE HEATING WITH COGENERATION</u>
<u>IN FIVE APARTMENT BLOCKS</u>
CADDET / IEA / OECD 1987

Zsolt & Associates Limited

Environmental Design and Planning

FIGURE 9

6.0 SEWERAGE

6.1 General

For the treatment of domestic sewage, homes in the unserviced districts of Ontario utilize on-site [55] waste treatment systems Ideally, the goal of sewage treatment in an area without servicing is self-containment Self-containment infers the treatment and containment of environmentally damaging substances produced by sewerage In essence, this is where the conventional methods of on-site waste treatment have failed because the systems are not capable of the performance that is required The problems associated with standard on-site tile field systems are numerous·

> If not properly maintained or installed they can cease to provide minimal treatment, releasing harmful bacteria into the aquifer [56]
> These systems are not capable of nitrate removal In areas with relatively high densities such as a rural subdivision, nitrate loading is concentrated which can lead to aquifer contamination. [57]
> The systems are extremely land use intensive. A house, well, septic tank and tile field requires a minimum lot, in average soil conditions, of approximately 1 5 - 2 0 acres [58]
> Tile beds require particular soil types to be effective The soils should have a good water permeability rate This is most characteristic of good quality farm land

If properly designed & installed, an on-site system involving a septic tank and tile field is an effective method of treating waste water for a single dwelling. It is however, not suitable for communal applications were 30 homes are sited on a single 50 acre section of land. Communal treatment systems, in order to be environmentally sustainable must be capable of nitrate removal In Ontario, the Ministry of the Environment's REASONABLE USE POLICY #15-08 has outlined that subsurface effluent disposal systems in excess of 4500 L\D must not exceed 10 Mg\L of effluent at the site boundary in the concentration of nitrates and nitrogen having the potential to

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[55]On-site treatment infers the collection, treatment and disposal of effluent within an area of land bound by a particular property Discharge into a river or stream is technically not considered on-site treatment

[56] It is not uncommon to discover drinking wells contaminated with faecal bacteria. The town of Oakwood near Lindsay, Ontario is a good example of an entire community that relies on bottled water for its drinking water due to this problem.

[57] High levels of nitrates in drinking water pose a health threat to infants leading to blue baby syndrome or methaemoglobinaemia.

[58] This is based on the Ontario Ministry of the Environment guidelines for tile field installation from "FACTS ABOUT SEPTIC TANK SYSTEMS" Pub. No. WFS3 The interpretation of MOE guidelines may vary from municipality to municipality.

be converted to nitrate [59] Several treatment systems, currently approved in Ontario are capable of meeting this treatment requirement for communal flows Many systems exist however, most have received little testing in Ontario's cold climate

The author of this report has gone to great lengths to provide a concise and accessible evaluation of the most suitable treatment systems presently available. The systems presented do not represent a definitive list. New systems are always being developed as the demand for feasible treatment systems are increasing In this study, to facilitate system comparison, daily effluent flows of 15,000 litres per day will be used This is based on 30 homes averaging 500 l/day [60]

Sewerage can be broken down into three parts: Collection, Treatment and Disposal.

> **Collection** refers to the system of manholes , pump stations and piped mains that gather the waste water and transport it to a treatment facility.
> **Treatment** is the process of removing sediments, chemicals and bacteriological elements in the waste water
> **Disposal** is the method of returning the treated effluent back into the natural environment

6.2 Communal Collection Systems

6.21 General

Urban development in North America has traditionally relied upon large diameter gravity flow sewers for a collection of waste water. Problems associated with these are basically costs. In a survey of 6 fully serviced subdivisions ranging in size from 61 to 119 lots the average costs for sanitary sewers alone was $1960 00 per lot [61] Conventional sewer systems require substantial trenching, man holes and lift stations to accommodate to suit varying terrain and facilitate gravity flow These systems can be designed to handle thousands of gallons of effluent on an hourly basis It is estimated that 70 - 80% of the costs of constructing sewerage systems is related to the collection system This is based on a conventional, gravity flow system. [62]

Small diameter sewer systems were developed as an alternative to conventional systems for

[59] The Ontario Ministry of the Environment, 1988., as cited in Oliver, Mangione, McCalla & Associates , 1992

[60] A water use study by the Regional Municipality of Waterloo indicated that an average household using a low flush toilet as the only conservation device used 550 L/D. With additional water conservation devices a reasonable projection of water usage fora sustainable community is a 500 L/D per dwelling.

[61] Costing information courtesy of T Ruscica & Sons Ltd.

[62] Cooper, Brian , 1993

smaller applications. Alternative collector systems are not new Installations are already in use in Ontario, Manitoba, Saskatchewan and British Columbia These sewers can be buried to shallower depths often laid with narrow trenching machines and generally cost much less to construct The piping, which is usually plastic, can be curved to follow site contours or roads The two most common systems are small diameter gravity sewers and pressure sewers

6.22 Small Diameter Variable Grade Sewers

In a Small Diameter Variable Grade Sewer [63] system (SDVG) raw sewage flows from its source into an interceptor tank (two compartment septic tank) where it undergoes clarification to remove solids and grease. The clarified effluent from this second chamber flows by gravity into the SDVG network The piping is designed to run at peak flows and pipe diameter increases as the flow is increased down the stream, which is similar to a conventional system

Advantages

> Operations and Maintenance (O&M) can be done by semi-skilled personnel.
> Power requirements are negligible, being the most energy efficient system for small flows.
> Reduced excavation costs compared to conventional systems (no man holes required).
> Partial treatment is done at its source reducing final treatment requirements.

Disadvantages

> Systems rely on gravity flow which affects trench depths and certain sites are not feasible due to the geography of the area
> Each house or grouping requires a septic tank, the maintenance of which is the responsibility of the home owner(s)
> Tanks require sludge removal which is an additional O&A requirements

Costs

> Based on the average costs of 12 projects in the U S. the cost per connection (home) was $5,353 U.S. This included all expenses. main line, clean outs, service connections and interceptor tanks. [64]

[63] Also known as Small Diameter Gravity Sewers

[64] The United States Environmental Protection Agency (US EPA)., 1992

> These figures are based on average densities This may be substantially less for homes that were tightly clustered due to the reduced number of interceptor tanks, clean outs and the length of required piping

6.23 Pressure Sewers

Pressure sewers are similar to small diameter gravity sewers except for the fact that effluent is transferred by pumping instead of gravity Pressure sewers fall into two categories· grinder pump systems (GP) or septic tank effluent pumping systems (STEP). In both systems domestic wastes are fed by gravity flow to a home pressure unit

In the grinder pump system, raw sewage flows to a holding tank equipped with a grinder pump **(FIG. 10)** which grinds the sewage up as it is pumped via small diameter piping to the point of treatment/disposal. In a GP system, effluent undergoes no primary treatment, consequently total treatment must occur at the treatment facility Energy requirements for the grinder pump motor is 75-3 8 KW This system is best suited for single homes attempting to discharge into a conventional sanitary main however, it is still effective for a cluster system, an example of which is operating on the Toronto Island. In Temagami Ontario, a small northern community, a grinder pump pressure system was constructed on rocky terrain, utilizing insulated piping buried to shallow depths with heat tracing to prevent freezing It was constructed for an estimated 1/2 the capital costs of a conventional system. After a 30 month monitoring program, the system was determined to be "very reliable" and quite effective [65]

A STEP system utilizes a two compartment septic tank which provides primary treatment at each connection **(FIG. 11)** Effluent from the home feeds into the tank by gravity. After it undergoes clarification it is pumped from the second chamber into the small diameter system This is all done in one compact unit which has the ability to accommodate several homes provided the flows are not excessive. Because of the clarification stage, sewage strengths in STEP systems are less than GP systems The pump does not require a grinder and the required energy required to operate it is 075 Kw - 75 Kw Alternatively, pumps for this system may be located in a separate pump chamber or in the basement of a home.

<u>Advantages (STEP System)</u>

> Gravity flow is not necessary, therefore the mains can follow the contours of the land, independent of slope.
> Manholes and interceptor tanks are eliminated because the entire system is pressurized.

[65] MacLaren, James., 1984. CMHC

> Excavation costs are less than gravity systems and if piping is insulated it can be laid at shallow depths. [66]
> The system can be used in conjunction with gravity flow systems

Disadvantages (STEP System)

> Each STEP tank must be pumped out every three to four years
> Pressurized systems require energy to operate pumps sources estimate STEP unit electrical costs are $1.00 U S to operate daily [67]
> The maintenance of the STEP tank is usually the responsibility of the individual home owner
> System is subject to periodical mechanical failure

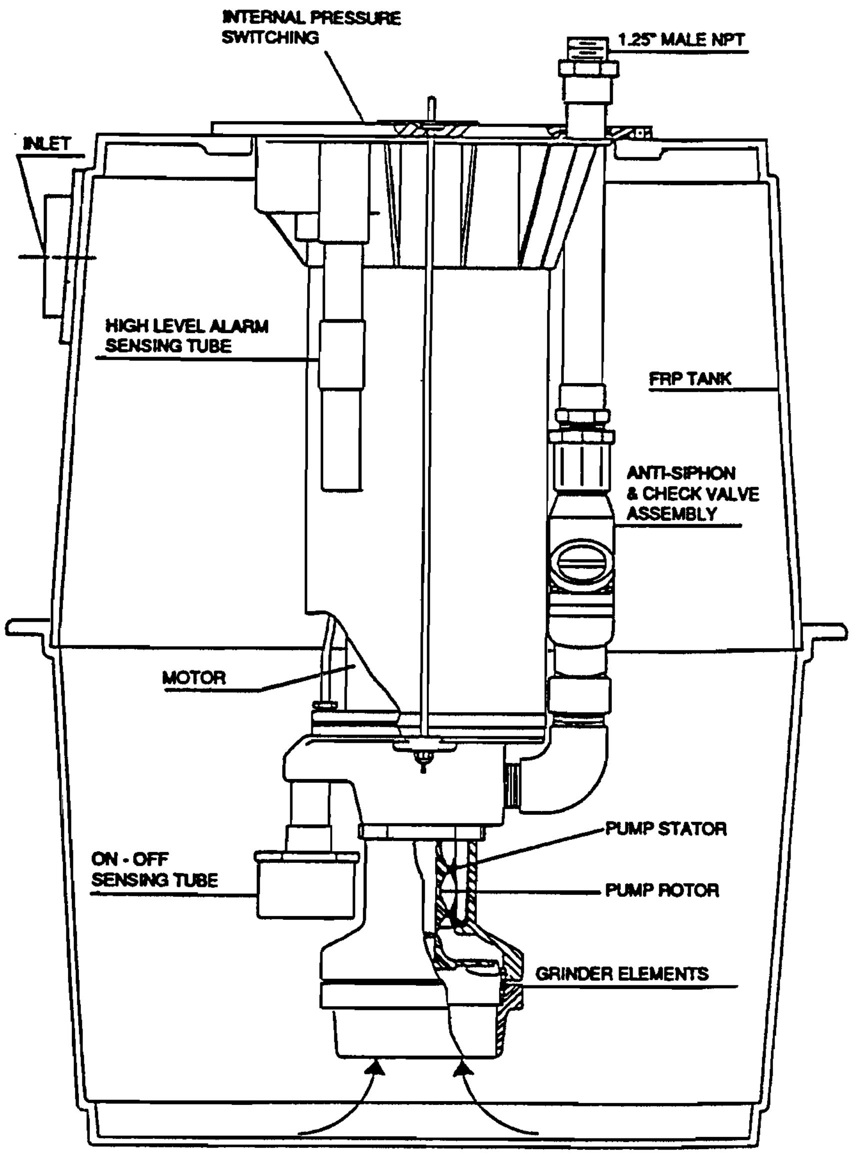
Cost (STEP System)

> Construction cost of a package step unit is $2,500-3,000 U.S. which would service 1 to 3 dwellings depending on the flows
> The cost for a pressure main 6 to 8 inches in diameter is $11 - $14 US lin.Ft.
> Additional costs due to system breakdown estimated at $100-200 U S per year per unit. [68]

[66] Standard PVC piping can be buried to depths as shallow as 0.6 M (2'-0") in a southern Ontario climate if insulated from above If a fully insulated pipe is used, it can be exposed completely This is common for communities in the far north

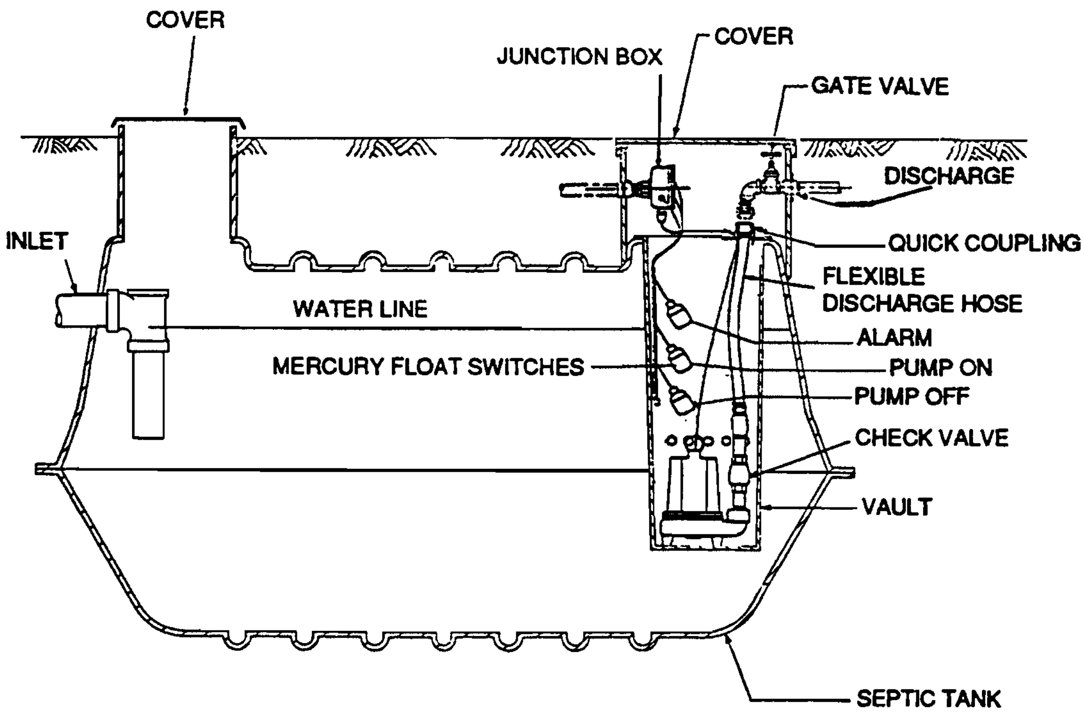
[67] US EPA., 1992

[68] Ibid.



GRINDER PUMP UNIT

DRAWING TAKEN FROM
ALTERNATIVE WASTEWATER
COLLECTION SYSTEMS
US EPA 1991



STEP TANK UNIT

DRAWING TAKEN FROM
ALTERNATIVE WASTEWATER
COLLECTION SYSTEMS
US EPA 1991

6.3 Communal Treatment Systems

6.31 General

The systems presented in the following section represent some of the viable options for small community applications All the systems listed show potential for nitrogen (nitrate) removal however, not all have demonstrated to do so in the Canadian climate. The evaluation of a treatment system's performance is based on the removal of several key parameters The less of the following elements that are found in treated effluent, the more effective the system

Suspended Solids (SS) solids that either float on the surface of, or are in suspension in, water, wastewater, or other liquids, and are largely removable by filtering [69]

Biochemical Oxygen Demand (BOD) the quantity of oxygen used in the biochemical oxidation of matter in a specified time, at a specified temperature and under specified conditions. [70] It is used as an indirect measure of wastewater strength. If BOD levels are high so is the biochemical activity

Nitrogen (N)· total nitrogen removal involves several chemical processes Nitrite (NO2) and nitrate (NO3) are produced from ammonia through nitrification during the treatment process. Nitrate is removed through a secondary process referred to as denitrification. Nitrite is reduced to nitrate and to elemental nitrogen in the process of denitrification by a broad range of bacteria

Phosphorus (P) an element found in waste water primarily from detergents and human waste In small amounts it has no serious affect on humans once consumed. Excessive volumes discharged into inland waters can cause natural levels of plant growth to accelerate This may cause an unwanted ecological imbalance

6.32 Batch Recirculating Bottom Ash Filter (BRBAF)

The BRBAF system is essentially a modified re-circulating sand filter which uses bottom ash as a filter media instead of sand Bottom ash being a by-product of coal fired power plants The system can treat effluent after receiving primary treatment The major components are simply an ash filter and a re-circulating tank **(FIG. 12)** The effluent is fed into the re-circulating tank and then through the filter media and back into the re-circulating tank This cycle repeats itself three

[69] American Society of Civil Engineers , 1967

[70] Ibid

or four times until the re-circulating tank is full and then the effluent is then diverted directly to a disposal system

Performance

Studies indicate that the BRBAF system is capable of producing an effluent of excellent quality.
> Reported removals - BOD 95%, SS 91%, N 85% [71]
> Reported removals - BOD 96%, SS 89%, N 88% [72]
> Hydraulic loading rates range from 83-210 L/m2/D. [73]
> Test systems revealed odour was not a problem [74]
> For a system processing 4542 L/D operating costs were approximately $20 00 per year with power costs of $ 08 per kWh. [75]
> Similar to sand filter systems in the sense that when temperatures fall below 6 degrees celsius, system performance decreases. ". because performance efficiency decreases with reduced temperatures, performance in Canada may be a problem unless appropriate modifications are incorporated into the system design and operation. These modifications could include modified process design parameters, insulation of the system, etc " [76]

Advantages

> Moderately inexpensive to construct.
> System does not require highly skilled personnel to operate
> System can be easily expanded by adding treatment modules
> Relatively low energy requirements

[71] Swanson, Samuel., Dix, Stephen., 1987

[72] Sack, W A., Warmate, N S., Dix, S P., 1991

[73] Hydraulic Loading rates give an indication of the volume of effluent (L) that can be applied over a unit of filter area (M2) in one day

[74] Swan, Dix. 1987

[75] Swan, Dix 1987

[76] Cooper, Brian 1993

Disadvantages

> Sand filter type systems appear to be temperature dependent.These systems require some form of thermal protection during the winter months either by constructing it underground or by building an insulated enclosure above grade
> Operations have indicated that lower temperatures also require lower loading rates [77]
> Very little testing done in a cold climate

Costs

> Unable to obtain accurate unit prices for this system type
> Estimates for complete single filter system are $8, 000 - $12,000 U.S ,
with no reference made to flows. [78]

[77] Parker, Mike., 1993

[78] Owen Ayres & Associates, Inc , as cited in The Cadmus Group, 1991

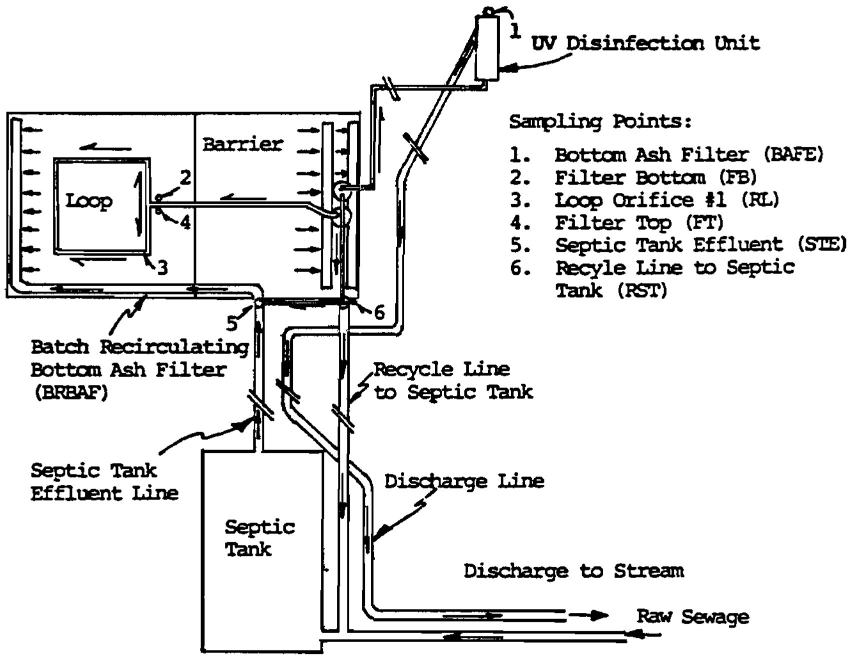


Fig. 1 Modified Recirculating Sand Filter (RSF^2) System Layout

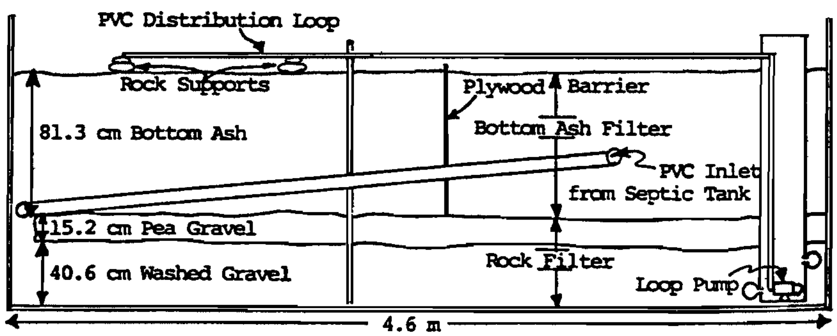


Fig. 2 Modified Recirculating Sand Filter (RSF^2) Component Details

BATCH RECIRCULATING BOTTOM ASH FILTER

DRAWING TAKEN FROM
SANDY SACK DIX 1987
ENHANCED NITROGEN REMOVAL USING A MODIFIED RECIRCULATING SAND FILTER
ASAE PROCEEDINGS 1987

6.33 RUCK System

Designed and patented by Rein Laak Ph D , P.Eng., the RUCK system is termed a passive nitrogen removal system Designed to be installed underground, black and grey waste water are separated into two separate septic tanks from the source Black water is passed through a single pass aerobic sand filter which is vented to increase aerobic activity. The filtered effluent is then mixed with the grey water (carbon source) in the de-nitrification anaerobic filter. This mixture after a short retention time is released into a standard tile field

Performance

Testing of the RUCK system has produced varied performance results
> Reported Removals - N 70-81%, BOD 85%, P 81% [79]
> Reported Removals - N 54% [80]
> Reported Removals - N 53% [81]
> Hydraulic loading rates 83 L/m2/D
> In 5 of 18 units studied owners complained of smells from the aerobic filter vents [82]
> Denitrification affectiveness directly correlated to the carbon source as grey water additives maybe necessary such as methanol to increase system performance
> System is less affected by temperature than the RSF type systems
> Reports of higher nitrogen removal in commercial applications 80 - 90%, possibly due to more detergents present in the grey water. [83]

Advantages

> System appears to be able to function quite well in cold temperatures without additional heating
> Does not require highly skilled personnel to operate and little monitoring required.

Disadvantages

> Requires the separation of black and grey water by two separate drainage systems and pumping

[79] Laak, Rein., 1987 as cited in Oliver, Mangione, Mccalla & Associates Limited , 1992

[80] Windisch, M A., 1990, as cited in Oliver, Mangione, McCalla & Associtès Limited , 1992

[81] Lamb, B , et al 1987

[82] Windisch, M.A., 1990 Ibid

[83] Laak, Rein , 1992

systems This is a potential additional cost not considered that could be quite substantial in a larger system.
> The system has a relatively low loading rate

Costs

> Accurate costing not available
> An estimate for a residential system to be $10,000 U.S [84]
> Another estimate based on 1986 costs $12,000 - $16,000 by Canadian study [85]

6.34 Peat Filter

The peat filter system was developed by Dr Joan Brooks at the University of Maine. The effluent after receiving primary treatment in a septic tank is passed through a filter (6 - 75 m thick) of peat moss built into an excavated pit or completely above ground **(FIG. 13)** The moss must be of a particular type, sphagnum peat, and should adhere to tight specifications. For denitrification, the system relies on the nitrogen removal capacity of the peat through various microbiological processes and fungi present in the peat. The system provides better denitrification during the months of winter because of the activity related to the fungi. [86] After a single pass over the filter the effluent is discharged to a disposal system or directly into the ground below if soil conditions suitable The effective size of a single peat filter is 10 -12 m2.

Performance

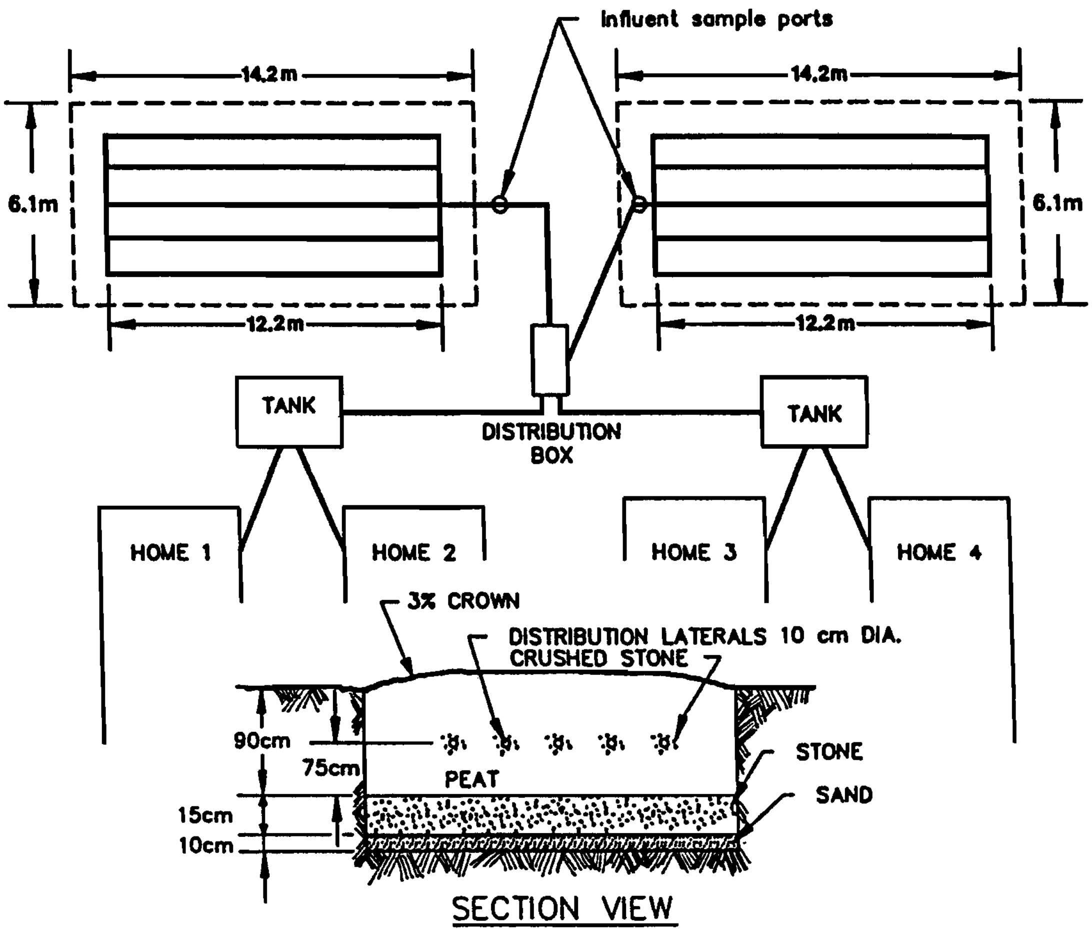
The peat filter system is capable of producing effluent of a very high quality·
> Reported removals. N 77-95%, BOD up to 100% [87]
> Seasonal variations reported to occur Apparently the system is more efficient during winter months as Nitrate concentrations in effluent were found to be less than 4 Mg/L
> System is basically maintenance free and does not require pumps if site is conditions warrant it
> Hydraulic loading rates 41 L/m2/D

[84] Owen Ayres & Associates Inc., Ibid.

[85] Oliver, Mangione, McCalla & Associates Limited , 1992

[86] Brooks, Joan , 1988

[87] Brooks,Joan., Mckee, John., 1992



PEAT FILTER SYSTEM

DRAWING TAKEN FROM
ROLE OF FUNGI IN THE SPHAGNUM PEAT WASTEWATER TREATMENT SYSTEM
Phd. THESIS JOAN BROOKS 1988

Advantages

> System performs well in cold climates Systems exist in Maine, Ontario, Alberta and Alaska
> Requires little maintenance due to its simplicity
> Extremely reliable, no moving parts if gravity fed.

Disadvantages

> Pedestrian or vehicular traffic over beds not recommended This requires that the beds must be isolated
> Peat Filters alone require relatively large area which could be a problem for larger applications
> Sphagnum peat of the quality required is not produced in Canada

Costs

> For a single residential system the estimated cost is $5,800 U S ($3,000 for the peat bed alone) [88]
> Refer to Analysis for costing information based on a 15,000 L/D system.

6.35 Sequencing Batch Reactors

Description

A Sequencing Batch Reactor (SBR) is a mechanical system that performs the treatment of effluent in one tank. The SBR process is a variation of the conventional Activated Sludge Process which is common in North America It works on a 5 stage cycle in which aeration, sedimentation and decant functions are performed SBR systems usually require 2 units for large flows, 1 tank is filling while the other is under-going another treatment process. The system is effected by low temperatures therefore the tank should be buried underground or enclosed in a heated structure The mechanical aeration systems can be purchased from several manufacturers of proprietary designs and no additional carbon source is required for denitrification The process control is provided by a small computer system which can be located off site connected by a modem

[88] Owen Ayres & Associates Inc., Ibid

Performance

SBR systems are capable of producing effluent of a high quality.
> Reported Removals - N 89%, BOD 94%, SS 96%, P 88% [89]
> Waste sludge production is relatively low.
> Tank volumes .5 - 2 0 x average daily flows
> System cycles 4 to 20 hours

Advantages

> A reliable system proven capable of producing high quality effluent
> System easily expandable
> Vendors of SBR equipment provide substantial amount of technical support and design with the sale of an SBR unit.
> Units often come complete with 1 to 2 year warranty.
> Hundreds of units presently operating in the United States.

Disadvantages

> The system requires continual operation and maintenance by skilled operator This includes the removal of sludge periodically and the blowers, aerators and pumps must be continually monitored and maintained

6.36 Slow Rate Land Application

Description

This is a form of land treatment that is a good seasonal option for rural community needs. The system utilizes partially treated waste water to irrigate crops that are not required for human consumption A selection of crops applicable to this system range from grasses to mixed hardwood trees. The waste water undergoes pre-treatment by use of a package treatment plant. [90] This is done to remove BOD, bacteria and solids only Final treatment occurs in the field as waste water is further purified by filtration, microbial action and plant uptake The removal of nitrogen and phosphorous is achieved primarily by plant uptake

[89] US EPA., 1992

[90] Package treatment plants are manufactured and installed by a variety of companies, the most common in Ontario being AQUAROBICS LTD.

Performance

Slow rate land application is capable of providing high levels of treatment.
> Reported removals N 65-95 %, BOD 94-99%, P 75-99% [91]
> This system can not operate below freezing temperatures.
> Land requirements vary with soil type, slope, geology, and crops used.
> On average 25.2 - 220 Ha. is required to treat 1 million gallons (3.8 million litres) of effluent. [92]
> Operation costs are limited to the pre-application treatment system and crop maintenance which is predominantly labour.
> Systems odour is controlled by the quality of the pre-application treatment system.

Advantages

> System provides ground water recharge without the construction of a tile field for subsurface discharge
> Crops can be used to generate an economic activity. Profits can be generated by specialty activities such as tree farming
> Plants help to control erosion and maintain soil permeability. [93]
> System can be used as a secondary or back-up to a main treatment facility for periods of maintenance or during summer months
> High hydraulic loading rates are possible depending on system's design

Disadvantages

> The system can operate only during warm months, the system usage follows the growing seasons
> Irrigation must be suspended during periods of heavy rainfall

Cost

> Other than the land, plant material and labour requirements a mechanical package treatment plant handling 15,000 L/D would cost $ 30-45,000 00 installed, excluding the cost of the collection system. The systems O&M requirements would amount to roughly $1000.00 annually. [94]

[91] US EPA , 1981 as cited in US EPA , 1992.

[92] US EPA , 1992.

[93] Ibid.

[94] Costing information provided courtesy of J & A Services, an authorized dealer of AQUAROBICS LTD.

6.37 Constructed Wetland Systems

Description

Wetlands naturally occur in areas where the water permeability of the soils are low and becomes saturated. In order to be called a wetland the frequency and depth of water coverage should be sufficient to maintain specific types of vegetation. Constructed systems work on basically the same principles as natural systems and can be an effective method of waste treatment. The effluent, after receiving primary treatment, is passed through the wetland, usually for a set period of time. The wetland modules usually include an impermeable liner at the interface of the native soil and the saturated layer to prevent ground water contamination Effluent is treated through various physicochemical and bacteriological processes. Oxygen is provided to promote these activities through the plant root structure. The plant types normally used are bulrushes, reeds and cattails (non-woody macrophytes)

Wetland systems can be broken down into two types. Free Water Surface Flow (FWS) and Sub-Surface Flow (SF) **(FIG 14)** FWS systems work much like a natural wetland: water flow is over the marsh bed, exposed to the elements. The vegetation is rooted in the soil and emerges above the water surface. Subsurface Flow systems (SF) which are also known as Vegetated Submerged Bed systems work differently in the sense that the water passes through a permeable layer of saturated soil or gravel. The soil saturation point is at the surface of the bed which does not allow the effluent to be openly exposed to the atmosphere. Plant roots penetrate to the bottom of the bed which is normally 0 5m deep. Unlike FWS systems, SF systems are capable of operation in cold climates. [95] Both systems are usually laid-out in compartmentalized fashion to allow flows to be directed through the system in a controlled manner and to regulate retention times. Wetland systems are well suited as a secondary system to provide polishing following another treatment system

Performance (SF systems)

SF systems are capable of reasonable levels of treatment
> Reported removals: N < 30 %, BOD 80-90 %, P < 30 % [96]
> Reported removals N < 50 % [97]

[95] Grover, Nancy., 1993.

[96] US EPA., 1992.

[97] Water Pollution Control Federation., 1990.

> The addition of further primary treatment by a package plant has produced higher quality effluent, possibly due to the additional oxidation. Reported removals from a system in Alabama using a package treatment systems· N 88%, BOD 92%, SS 95%, P 95% [98]
> Land area required and hydraulic loading rates vary due to water depths, site characteristics and detention time in system
> Hydraulic loading rates: 8 - 62 L/m2/D
> SF systems are capable of treatment through winter months; oxygen is passed through the plant to the root system below.
> During the winter months denitrification is reported to drop off significantly. [99]

Advantages

> Low construction costs.
> System is most appropriate for low land sites that have organic or clay soils that would other wise make the operation of a tile field for discharge purposes difficult.
> Low O&M requirements; needs weekly inspection.
> Wetlands can form an excellent wildlife habitat and a pleasant site amenity if designed to be integrated into the site.
> The system can be designed to also receive surface run-off.

Disadvantages

> Site must have a suitable lake or river for surface discharge or a system must be devised for ground infiltration
> Surface discharge is not possible on many sites in Ontario as restrictions on the effluent quality can be quite high or it is not permitted at all.
> High land area requirements
> Wetlands provide breeding grounds for insects, which may be considered to be undesirable for residential applications.

Costs

> Relative to other mechanical options the costs, excluding the land costs are quite low This would be difficult to assess in general terms, much would depend on the site conditions.
> Similar to Slow Rate Land Treatment in mechanical requirements
> Requires primary treatment (septic tank effluent) however further pre-treatment is desirable such as a package treatment plant Refer to section 6.36 under costs

[98] Watson, J.T., 1990 , as cited in Oliver, Mangione, McCalla & Associates Limited., 1992.

[99] Grover, Nancy , 1993.

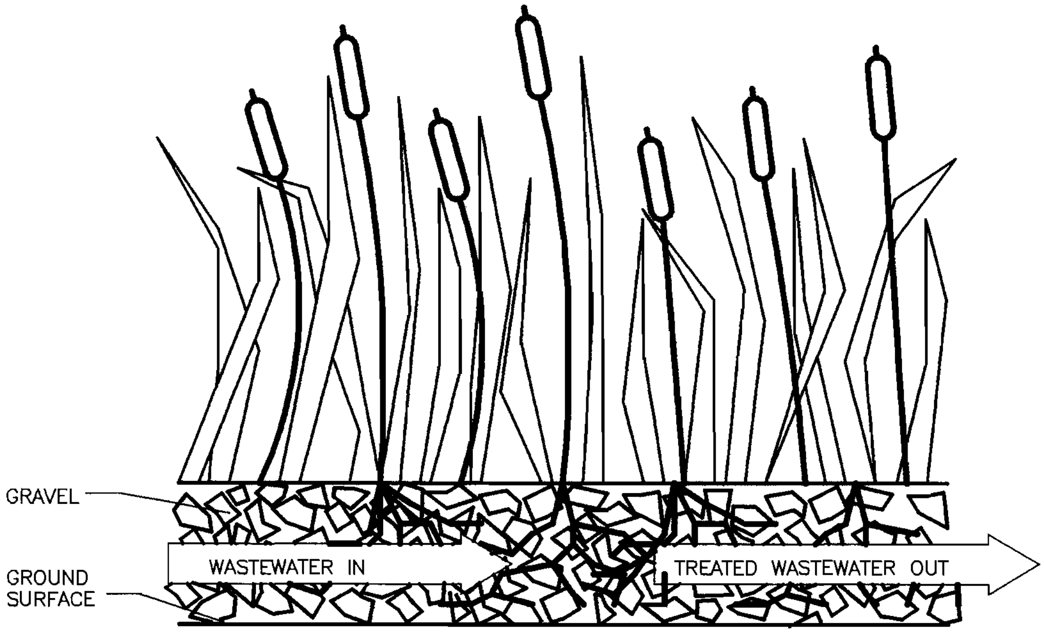


FIGURE A: SUBSURFACE FLOW CONSTRUCTED WETLAND

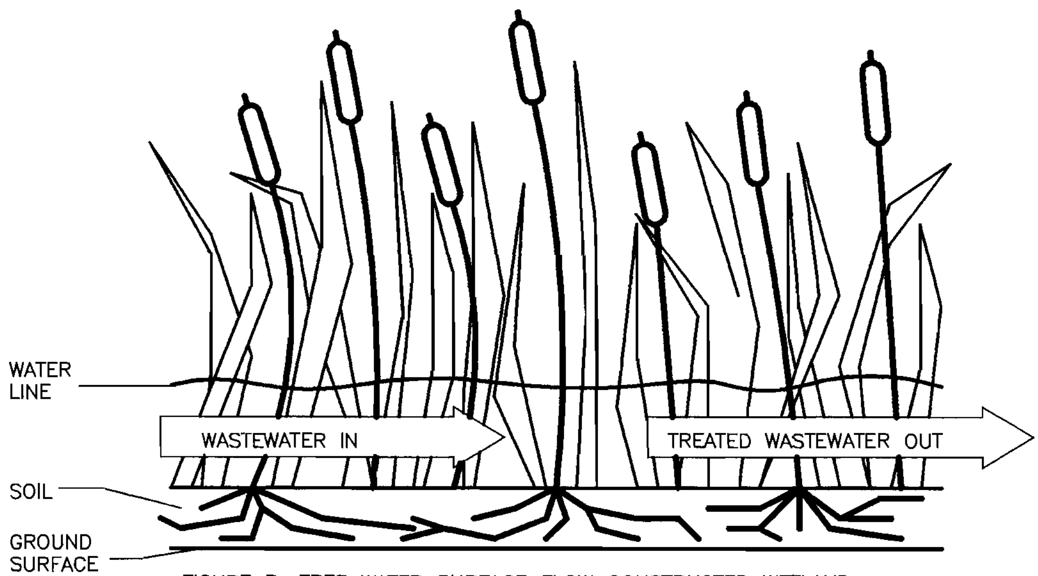


FIGURE B: FREE WATER SURFACE FLOW CONSTRUCTED WETLAND

WETLAND TREATMENT SYSTEMS

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Environmental Design and Planning

FIGURE 14

6.38 Solar Aquatics TM

Description

This concept was developed by John Todd Phd. of the Centre for the Restoration of Waters, Ocean Arks International. The name Solar Aquatics is a trade mark held by ECOLOGICAL ENGINEERING ASSOCIATES who also hold the patent for the system. The Solar Aquatic System (SAS) is similar to a wetland system in the sense that it relies on a broad range of biological processes for treatment. Enclosed in a greenhouse type structure are a series of tanks and small ponds which house a variety of microbes, plants and animals. In a condensed form, the compartments mimic natural conditions found in a small pond and marsh ecosystem. The effluent, after undergoing primary treatment is passed through a variety of tanks, silos and wetland type environments. One stage, comprised of clear cylindrical silos contains fish, snails and other plant life. The different stages remove different substances Treated effluent is then disposed of in a manner that is suitable to the site conditions. **(FIG. 15)**

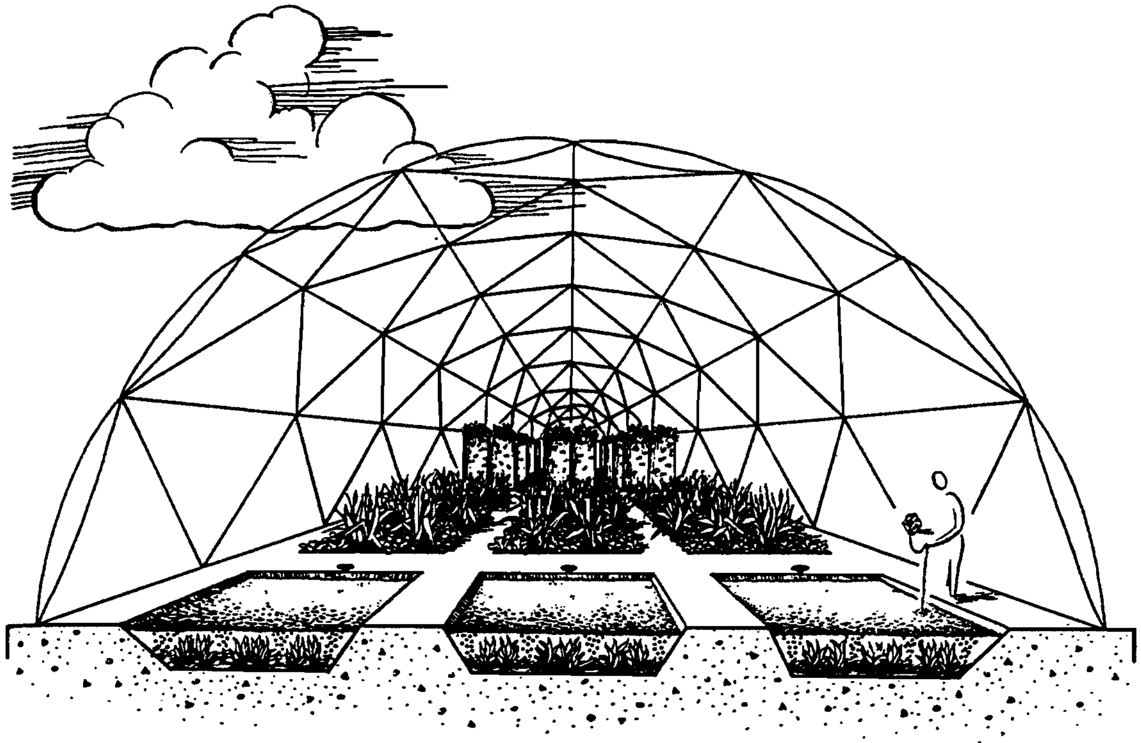
Solar Aquatics provides the added benefit of experience. The greenhouse is open and lush with vegetation This provides an accessible space for people of all ages to learn about the natural processes that can treat waste. By definition, this idea opposes the "out of sight, out of mind" mentality characteristic of conventional servicing systems Instead, it becomes a focus of the community, particularly if the green houses are expanded to accommodate other plants for other purposes

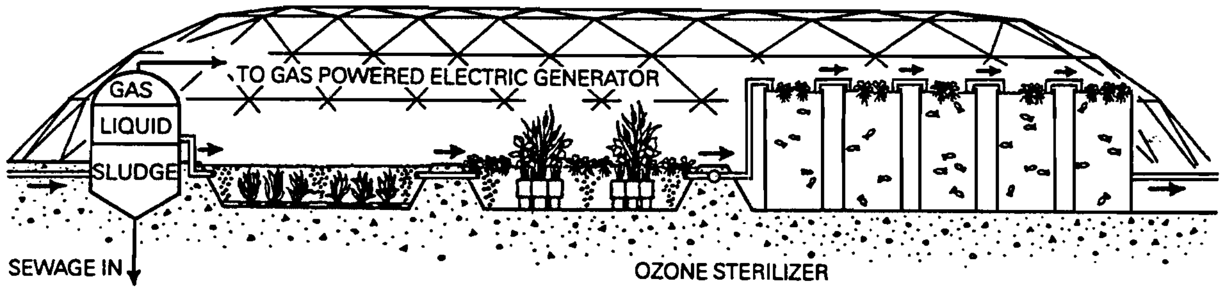
Two installations are in existence in Ontario. Both systems are designed to treat the wastes produced by single buildings, a small school and a factory for the Body Shop company. A larger installation in Providence, Rhode Island is treating approximately 90,000 L/D of residential sewage

Performance

> Testing has indicated that the Solar Aquatic System is capable of producing effluent of a high quality with the advantage of heavy metal removal
> Reported removals: N 64%, BOD 98%, SS 99%
> Reported removals of metals:Lead 93%, Cadmium 41%, Zinc 77%, Copper 73%, Nickel 67%, Silver 60% [100]

[100] Todd, John., et al 1993.





SOLAR AQUATIC SYSTEM

DESIGN CONCEPT

DRAWINGS TAKEN FROM
BIOSHELTERS, OCEAN ARKS, CITY FARMING: ECOLOGY DESIGN
J & N TODD 1984

Advantages

> It is a natural treatment system that produces biomass from sewage waste and plant material
> Does not require a skilled person to monitor the system
> Low energy requirements
> Aquatic plants can be harvested for soil amendments or to supplement livestock feeds
> Solar silos can be used for fish hatcheries
> System has great educational uses
> The system is a total treatment facility capable of processing solid wastes such as residual sludge

Disadvantages

> The system some maintenance as the vegetation must be cared for and harvested
> System requires more testing
> The system has relatively high energy usage to operate pumps and blowers

Costs

> Refer to Analysis for costing information based on a 15,000 L/D system

6.4 Disposal Methods

6.41 General

In a conventional on-site waste treatment system (septic tank and tile field) the tile field provides a means for the treatment and disposal of waste water The effluent is absorbed into the soil and eventually makes its way into the aquifer below. A soil absorbtion treatment system takes advantage of the micro-organisms in the soil and the soils characteristics to provide additional treatment and/or polishing of the effluent

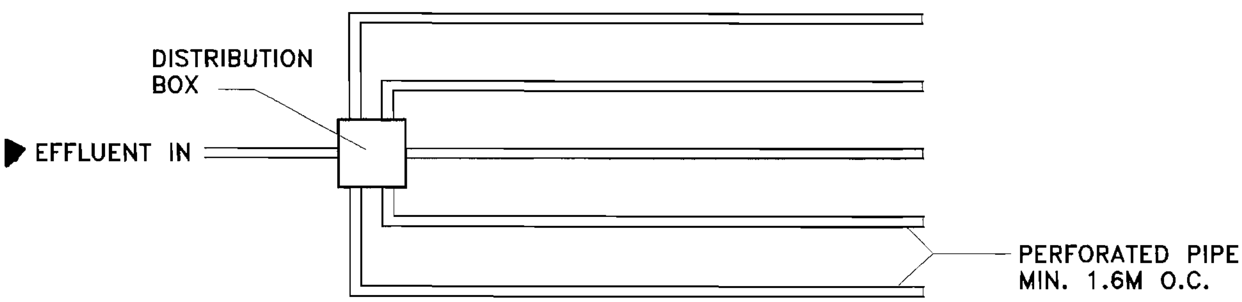
In the case of a communal treatment system, the effluent produced from an effective treatment system is capable of being returned to the aquifer without any further treatment This opens up a broad range of disposal options that would otherwise not be permissible in a conventional system Ideally, if a community relies on a ground water source for its potable water supply, treated waste water should be returned to the ground to replenish the aquifer. The same rule might apply to a surface water supply system if the site conditions warrant it. Striving to maintain an ecological balance is important in this regard and often the site constraints will determine what is most appropriate or feasible. Regardless of the disposal method used however the same standards for waste treatment should be upheld. Site constraints play an important role in the system selected.

6.42 Subsurface Discharge Systems

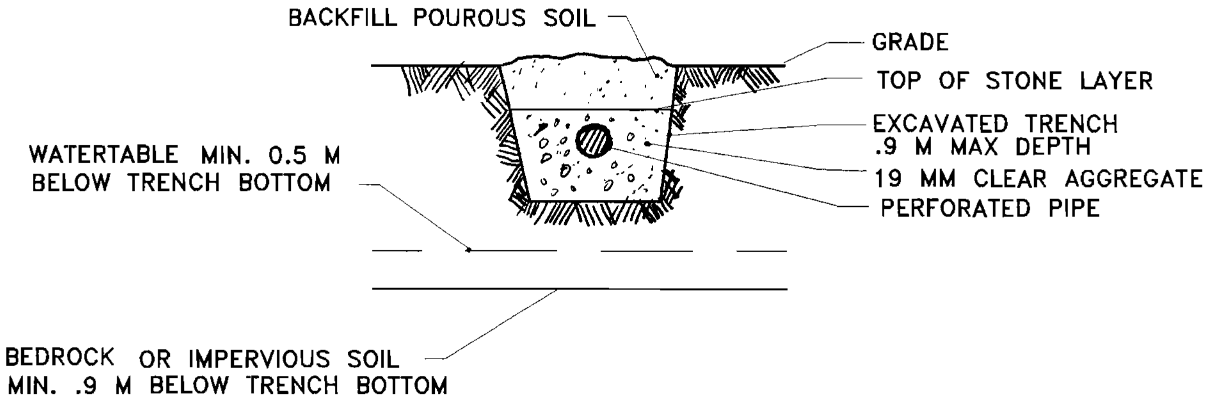
Subsurface Discharge systems or soil absorbtion systems as they are commonly known, rely on the soils ability to take in water. Generally, the soil types best suited for this purpose are sandy soils Clay and organic soils are usually the opposite, with low permeability rates The water permeability rate of the soil on a particular site will determine the size and type of disposal system used. Furthermore, a site can be improved by replacing the existing soils with imported granular fill This can be effective although comparatively costly. A large variety of soil absorbtion systems are available, the most common of which is the simple tile field which consists of a series of buried perforated pipes that are dosed on an intermittent basis **(FIG.16)** The other systems available are a variation on this concept

6.43 Surface Discharge

Surface discharge involves the disposal of treated effluent into surface water such as a lake or river or on to the ground surface itself. This is generally not suitable for large flows in a context where environmental sensitivity is an issue. A problem can arise in the disruption of natural water cycles unless a suitable buffer is provided in the form of a marsh or landscaped amenity. As was discussed earlier, certain rivers in Ontario for example are too sensitive for any form of discharge however, larger bodies of water can provide a suitable discharge area provided the effluent is of a high quality



LEACHING BED PLAN



TYPICAL TRENCH DETAIL

CONVENTIONAL SUBSURFACE DISPOSAL SYSTEM

TYPICAL LEACHING BED

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Environmental Design and Planning

FIGURE 16

7.0 ANALYSIS

7.1 Hypothetical Community: HAMLET CO-X

7.11 General

In order to provide a framework for analysis of the different systems, the theoretical community **HAMLET CO-X** is presented in the following section. The community design does not follow any existing planning guidelines in the province of Ontario for rural residential development This is predominantly due to the fact that existing guidelines for housing simply do not adhere to the criteria set for sustainability as described in Section 1.3 A second and equally important reason for the design of HAMLET CO-X is to demonstrate the feasibility of communities based on sustainable principles and to serve as an example for future development. **(FIG. 17 - 19)**

7.12 Design Principles

The principles that form the basis for the design of HAMLET CO-X correspond to the Criteria for Sustainable Communities described in section 1.31:

DIVERSITY

The community program described in section 7 13 is written using the Cohousing model as a guideline. The housing component of this complex is designed to sustain social diversity in the sense that the dwellings are configured to accommodate a broad social spectrum. The houses range in usable area from 46 to 151 m2 and each unit type can be internally modified to suit different needs. [101] Each home faces into the public space with the Common Building at its center Within the portions of the community that are shared, certain spaces are provided for a variety of potential economic activities These commercial spaces, as described in the program, are suitable for offices or work shops, thus providing a framework for further economic diversity.

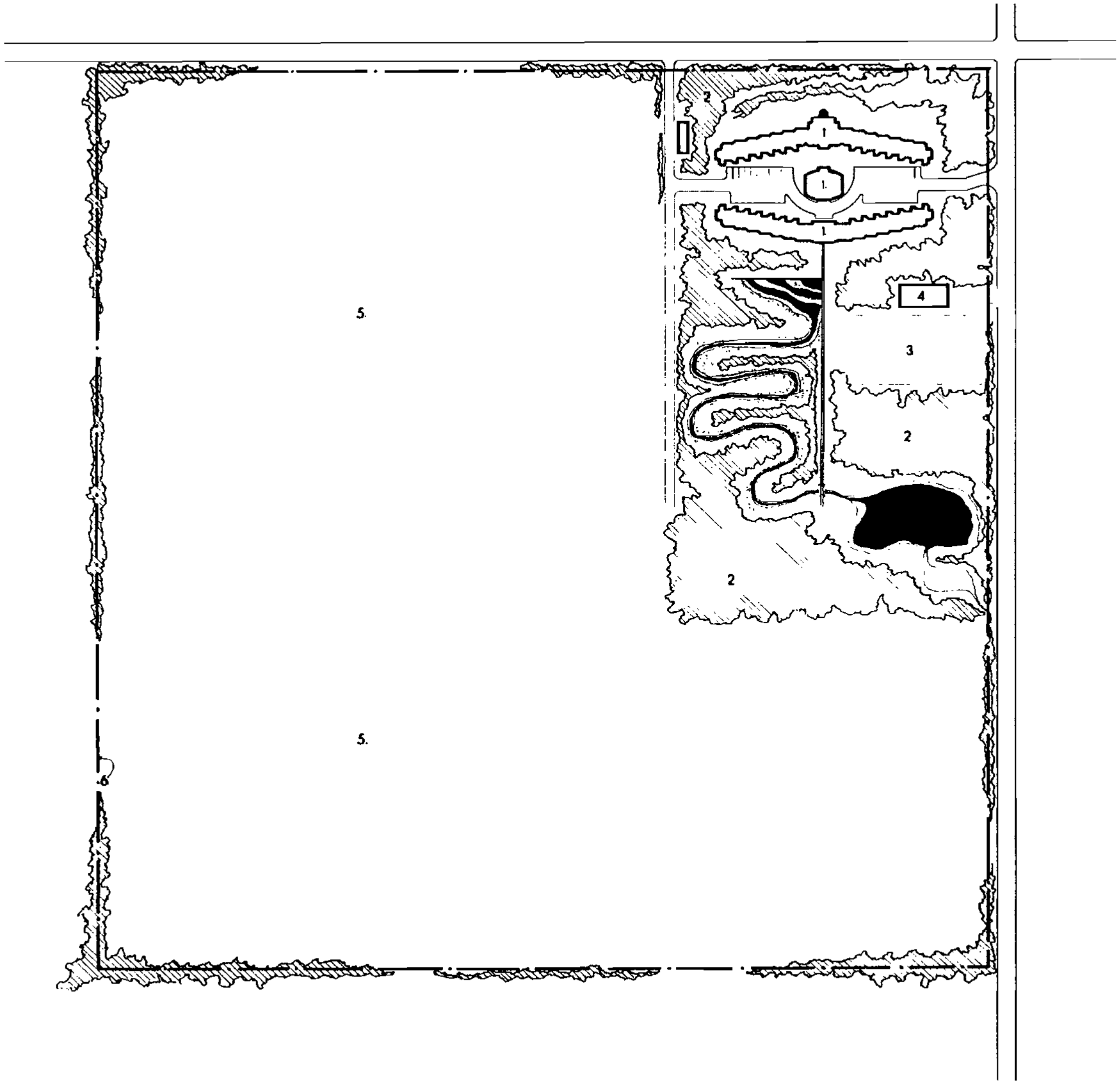
[101] In HAMLET CO-X what is essentially provided for each dwelling is a structural, highly insulated shell. Any interior plan or layout is feasible for any of the four unit types provided the external and common walls are not altered This allows individual family needs to be met and modified when required without increasing the buildings volume.

ENVIRONMENTAL CONTROLS

The specifics relating to the site of HAMLET CO-X can only be formulated in a hypothetical fashion which is displayed in the communities Site Plan which is set on a 50 acre (20 Ha) section of land in a typical rural Ontario setting The site is gently sloping to the south-west with the complex oriented on a north-south axis. The buildings are tightly grouped to reduce spatial impact while providing each unit with an unobstructed view of the surrounding countryside. Storm water is managed more efficiently in this housing configuration as excess run-off, from roads and roofs is contained to one area, leaving the remaining portions of the lot for other common amenities. Deciduous trees shade each block from the hot summer sun to the south, while coniferous trees provide protection from the winter winds to the north. The portions of the property that have no specific use, other than farming, are left to regenerate naturally as wildlife habitat.

ENERGY EFFICIENCY

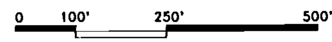
This complex is designed to reduce construction materials, heating requirements and increase the efficiency of servicing The north and south blocks are connected through an underground tunnel The dwellings extend in an east-west direction designed to maximize solar exposure and minimize heat loss. The north block provides a wind break, protecting from the winter winds the common internal area and the units to the south. The glazing in each dwelling is designed to minimize heat loss on the northern exposures while the glazing for the southern exposures has a greater surface area to maximize winter solar gains. South facing fenestration is designed with shading devices that project out 6 m to minimise summer heat gain. Each dwelling is insulated to levels beyond those required for R-2000 standards.



LEGEND

1. HOUSING & COMMON BUILDINGS
2 NATURAL REGENERATION AREAS
3 PLAYING FIELD
4. OUTBUILDING
5. CROP LAND
6 PROPERTY LINE

HAMLET CO-X
SITE PLAN



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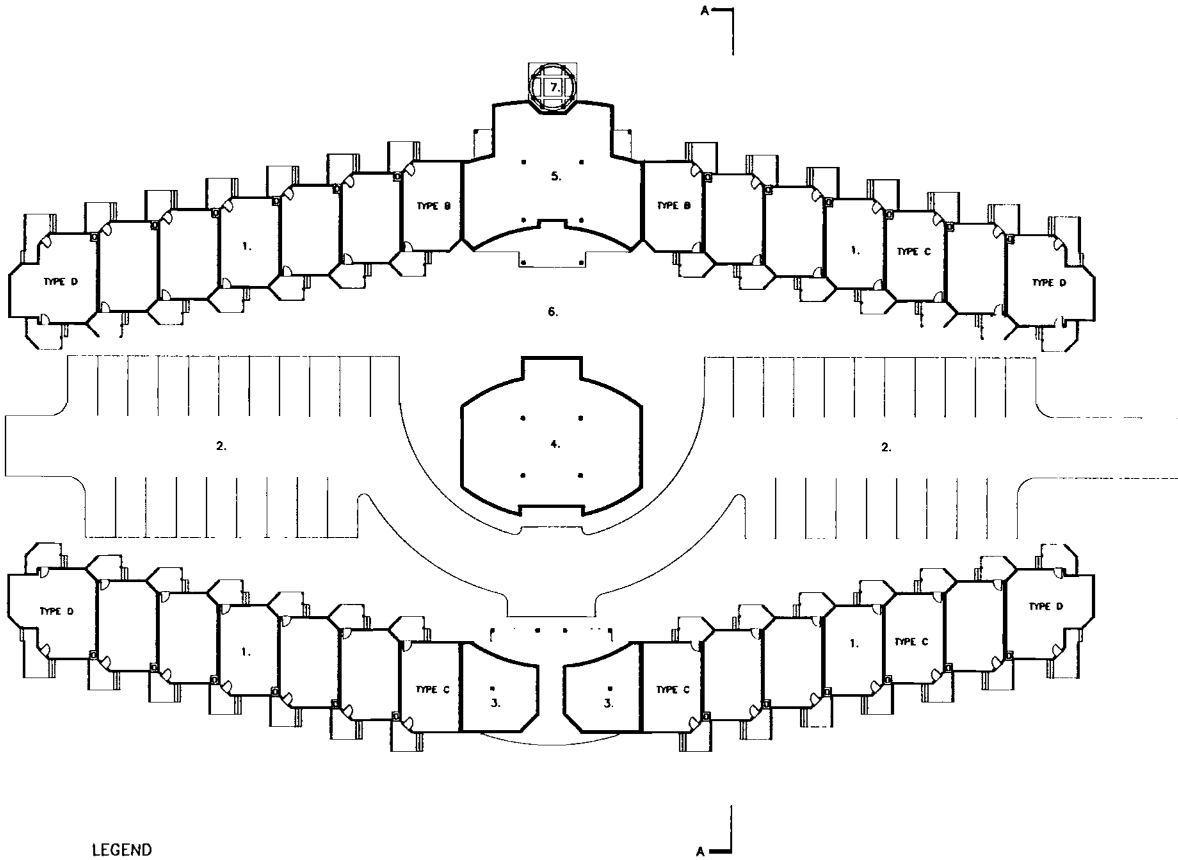
JANUARY 1994

FIGURE 17



LEGEND

1. LIVING UNITS
2. PARKING
3. PUBLIC COMMERCIAL SPACE
4. COMMON BUILDING
5. COMMUNAL SPACE (DAYCARE, ADMIN)
6. PLAY AREA
7. WATER TOWER

HAMLET CO-X

GROUND PLAN

0' 25' 50' 100'

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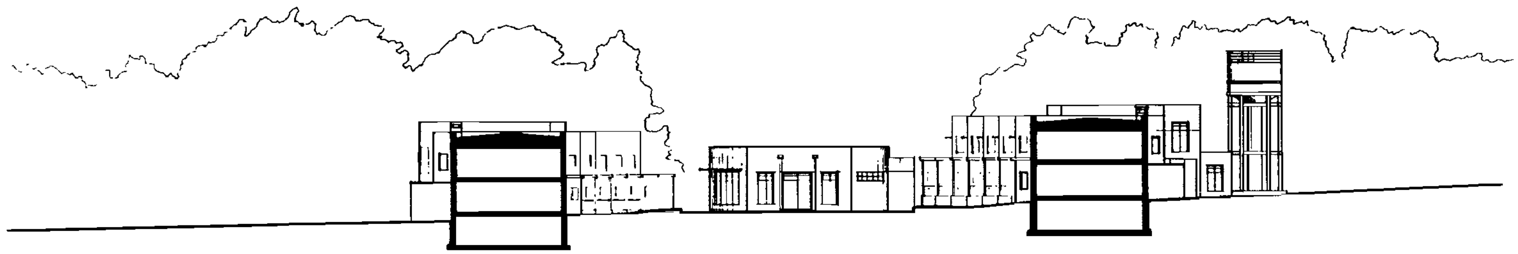
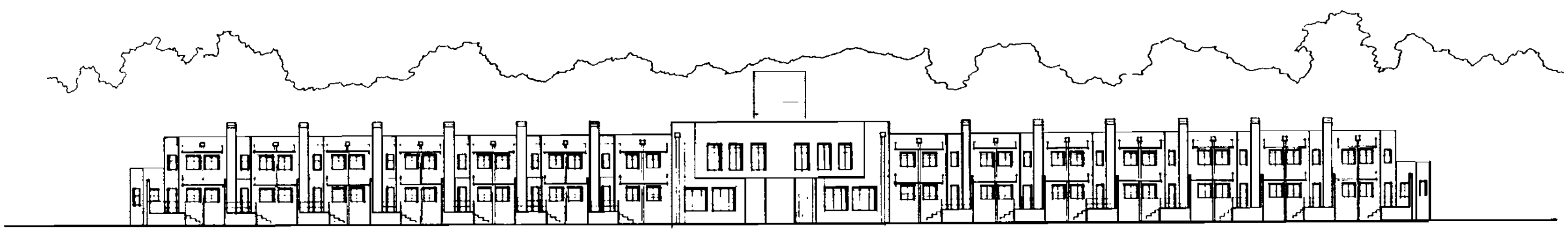
FIGURE 18



SECTION A - A



SOUTH ELEVATION

HAMLET CO–X

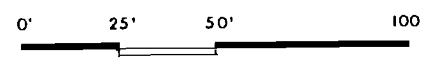


FIGURE 19

7.13 HAMLET CO-X Community Description

PROGRAM

A DWELLINGS

			NO.
Unit Type A (1 Level)	Max Usable Area [102]	46.4 m2 (500 s.f)	2
Unit Type B (1 Level)*	Max Usable Area	92 4 m2 (995 s.f)	2
Unit Type C (2 Level)*	Max Usable Area	139 2 m2 (1500 s.f.)	22
Unit Type D (2 Level)*	Max Usable Area	151.2 m2 (1627 s f)	4
		Total	**3**

* Units include full basement

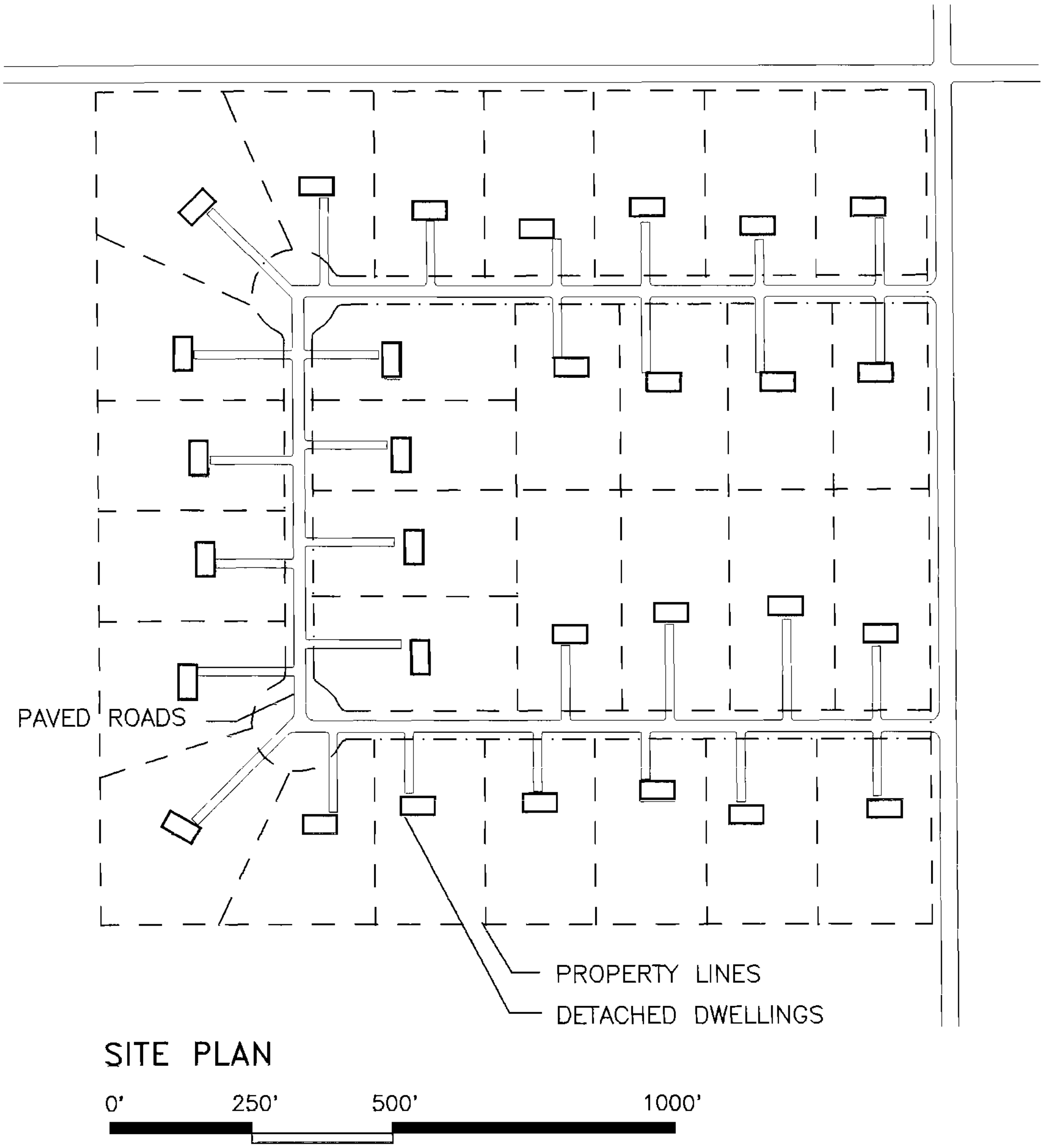
COMMON BUILDINGS	**TOTAL AREA**
Common Space	517 m2
Commercial Space	517 m2
Lower Level/Mechanical	451 m2

B SITE & BUILDING STATISTICS

Site Area	20 ha (50 acres)
Total Parking on Site	40 cars
Parking Surface Areas	1610 m2
Secondary Road Areas	270 m2
Coverage Housing Portion [103]	1800 m2
Coverage all other Structures	706 m2
Roof Surface Areas - Housing	1800 m2
Roof surface Areas - Other	706 m2
Estimated Water Usage Housing (500 L/D per Dwelling)	15000 L/D

[102] All areas provided to include basements, vertical penetrations, stairs, washrooms and circulation spaces

[103] Coverage infers the total footprint of the building, including projecting elements such as covered porches.



CONVENTIONAL RURAL DEVELOPMENT

30 SUBDIVIDED LOTS

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FIGURE 20

7.2 System Comparison

7.21 General

The purpose of the system comparison is two fold. Firstly, it is necessary, where possible, to compare the servicing requirements of **HAMLET CO-X** with that of a conventionally designed rural subdivision of 30 homes A detailed description of a standard subdivision is provided in the design site plan **(FIG. 20)** and the information provided below This development is based on the specifications of an average [104] development of detached homes designed in accordance with the prevalent zoning and servicing guidelines of Ontario for a rural site

CONVENTIONAL RURAL DEVELOPMENT	**FIGURE 20**
Total Development Land Area	20 ha (50 Acres)
Number of Severed Lots	30
Average Lot Area	0 67 ha (1.6 Acres)
Coverage for a Single Dwelling [105]	84 m2
Roof Surface Areas [106]	
(30 x 84 m2)	2420 m2
Secondary Road Areas	5800 m2
Driveway Surface Areas[107]	3120 m2
Water supply	Individual Wells
Sewage treatment System	Individual (On-Site)

The other objective of this section is to evaluate each system individually with other systems This will be based on the parameters of performance, cost, [108] system integration and overall advantages. A further emphasis will be placed on the suitability of a system for a typical development scenario in terms cost and development feasibility to ensure relevance to contemporary market conditions

[104] What is average for Ontario, has not in this instance been statically proven however, this is based on site observations for recent rural developments in the Greater Toronto Area.

[105] The standard dwelling for this development is based on a 167 m2 (1800 sq ft.) detached home, single storey with a full basement.

[106] Roof areas are base on what is assumed to be a flat roof with no over hangs.

[107] All driveways are assumed to be 23 x 4 5 m (75 x 15 ft.)in dimension which is equal to 104 m2

[108] Costing information provided is based on current market conditions in average circumstances and should be interpreted as such. This is provided for the purpose of discussion only and should not be used for the costing of an actual system

7.22 WATER

ANALYSIS

Assuming average site conditions exist and the ground capable of providing the required water for a communal system, ground water supply provides the most feasible option Most rural sites do not have the availability of a suitable surface water supply. Furthermore, the additional cost required for filtration does not make it feasible particularly if ground water is available.

A comparison of a communal system versus individual systems with respect to construction costs is clear when evaluating HAMLET CO-X and 30 individual well systems

30 INDIVIDUAL WELLS

100' DRILLED WELL PUMP & PRESSURE TANK	$6000 00 (per system)
TOTAL COST (30 systems)	**$180,000.000**

HAMLET CO-X

2 - 150' 6" DRILLED WELLS	$20,000 00
PUMPING SYSTEM	$5,000 00 [109]
CHLORINATION SYSTEM	$10,000.00 [110]
WATER TOWER (40,000 litre tank)	$50,000 00
MACHINE ROOM 100 SQ FT (3m x 3m)	$1000 00 [111]
DISTRIBUTION PLUMBING	$5000.00
TOTAL COST	**$91,000.00**

[109] Drilling and pump costs courtesy Northern Well Drilling Limited.

[110] Chlorination system costs courtesy Peel Region Works Department.

[111] Machine room to be located in basement of communal buildings. Costing is based on $100.00 per square foot construction costs.

The cost analysis indicates the communal system is the more cost effective system in this situation. If applied to a larger number of dwellings this difference may be more pronounced. Unlike the individual systems, water quality is controlled to meet health standards This is considered to be an important argument supporting their use. These systems can be modified to provide additional treatment such as nitrate removal. In addition, the water tower requires only one pump operating at one time A tower insures an emergency water supply is present for fire fighting purposes.

A more cost effective alternative is a submerged pressurized concrete tank which was not considered in this exercise Submerged tanks require more energy to operate and they do not insure the immediate operation of a fire fighting system when power is off This method is more common for systems of this scale and is less expensive to construct than a water tower. Given the relatively low cost of this system, a tower can be justified.

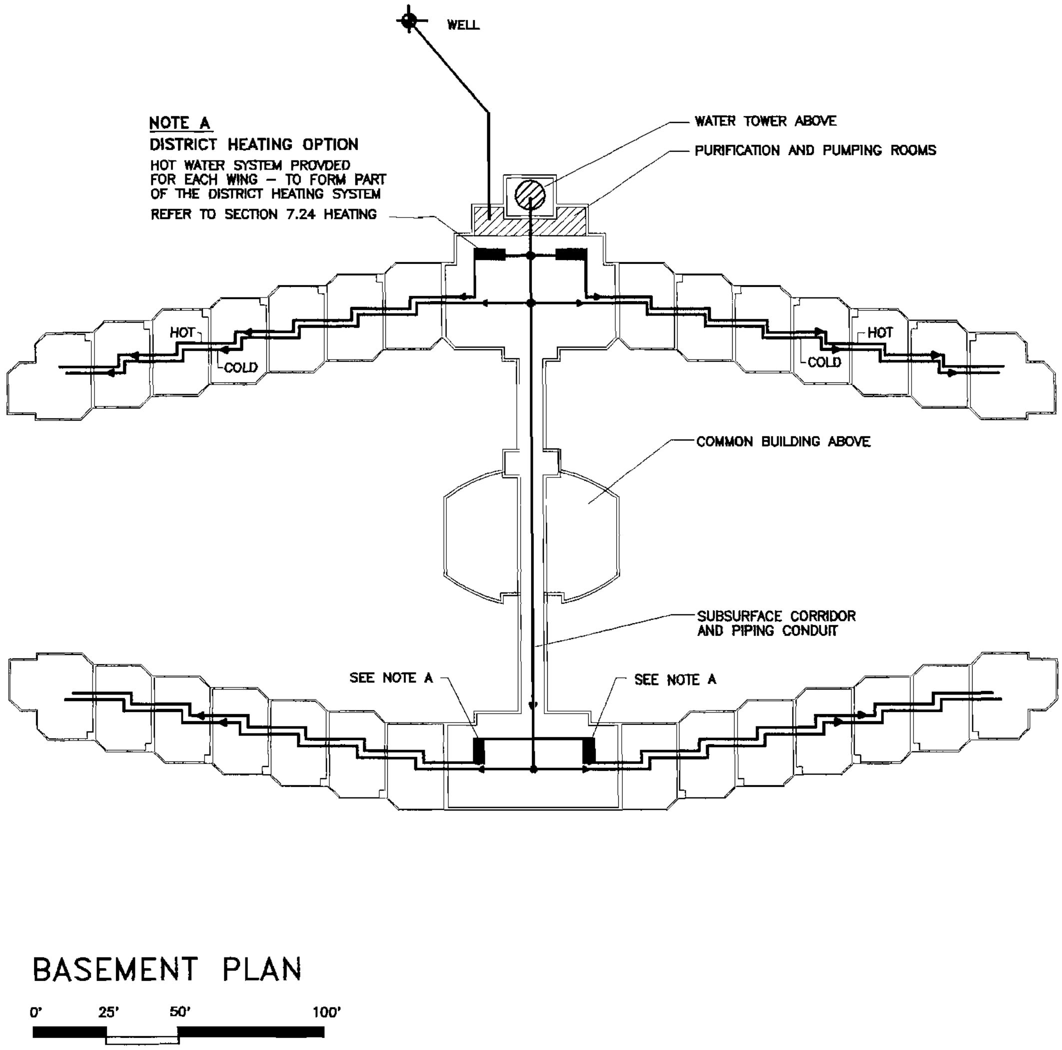
RECOMMENDATIONS

The water system proposed for HAMLET CO-X **(FIG. 21)** is relatively simple**.** Water is pumped from the well into the purification room were it is treated and then transported to the water tower above. The water is then distributed by gravity through conduits on the basement level to the dwellings in the community. Depending on the heating system used, hot water is provided on an individual unit basis or as the drawing indicates it can be integrated into a district heating system. This is the most efficient means to provide hot water for a tight grouping of homes. The distribution piping system must be well insulated to reduce heat loss.

The purification system for the water should use ozone or ultraviolet treatment. This is due to the negative environmental issues associated with chlorine. Chlorine reacts chemically with organic matter to produce TRIHALOMETHANES which are suspected to be powerful carcinogens.[112] Because these systems are not common, pricing information was not available.

The communal system does require monitoring. This could be worked into the operating costs of the entire complex and managed by a single person with minimal training or by the local municipality

[112] Coffel, Steve., 1989.



WATER SYSTEM

DESIGN SCHEMATIC

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FIGURE 21

7.23 STORM WATER

ANALYSIS

It is difficult to compare HAMLET CO-X to a conventionally designed development with respect to storm water control Both designs represent completely different approaches in planning. In one instance there is an attempt to decrease runoff where possible by designing the site to reduce overland flow and impervious surface areas. The conventional development approach does not make any provisions for runoff reduction Without a clear indication of the detailed landscaping in each instance, the amount of surface runoff cannot be calculated. Consequently, a comparison of approximate impervious surface areas may suffice to give a rough indication of the amount of runoff expected

STANDARD DEVELOPMENT (30 LOTS)

ROOF SURFACES	2420 m2
ROAD SURFACES	5800 m2
DRIVEWAY SURFACES	3120 m2
TOTAL IMPERVIOUS SURFACES	**11,340 m2**

HAMLET CO-X

ROOF SURFACES (housing only)	1800 m2
ROAD SURFACES	270 m2
PARKING LOT AREA	1610 m2
TOTAL IMPERVIOUS SURFACES	**3,680 m2**

Equally difficult to compare are the storm water collection systems. If, for example, a structural system for runoff collection is used in a conventional development versus grassed swales, the construction costs could be significantly different. Based on the pricing provided in section 4 2, a conventional stormwater collection system for a 30 lot standard development would cost approximately $120,000.00. Related development costs that are not part of this servicing system could be substantial The quality of grading and road construction that is required for a conventional storm water system are substantial costs In HAMLET CO-X due to the reduced road surface areas, construction costs in this regard would be much less. Although considered to be part of site work, road construction is an important consideration in developing a site.

The method of containing and treating runoff is another area for analysis. The options open to a conventional development are limited when compared to HAMLET CO-X. In the conventional approach to planning, provisions for the containment of runoff are designed after the scale and type of development has been determined. The volume of runoff generated and the limited amount of land available due to the sprawling form, create a situation where treatment options are limited to impoundment facilities unless additional land is provided for natural treatment systems.

The approach to design demonstrated in HAMLET CO-X works on a different principle. In a sustainable approach, the site determines the scale and type development that can be sustained This should be done without disrupting natural systems and the ecological balance of the area. The site is designed to ensure overland flow is minimized therefore requiring minimal efforts for runoff control and treatment. Storm water management techniques should be based on this approach. Conventional or structural collection systems should only be utilized in circumstances that absolutely require their use, such as a parking lot or roofs with large surface areas A site should be designed to contain all surface runoff within its boundaries accept in the most extreme situations such as a 5 or 10 year storm Both systems represent the most capitally intensive options available and therefore should be limited in scale

Effective landscape design provides the best approach to managing runoff The methods described in section 4.9 are cost effective devices to control, contain and treat runoff using natural systems. In a conventional development, the design of landscape is difficult to control. In a situation like HAMLET CO-X, the land is owned by one controlling body, be it a condominium corporation or co-op. This insures that design control is maintained and a natural environment is created. In this type of environment, a variety of ecosystems can be recreated. These can be a strong concept when marketing alternative communities to the public. Deciduous forest, meadows or wetland areas can support a variety of uses. These uses can include wild life habitat and year round recreational activities. The additional costs incurred in a comprehensive landscape design would be offset by the construction and operational costs that would be required for a conventional storm system, serving a conventional development.

Infiltration systems are other management techniques that can be very effective provided they are used on a suitable site and in conjunction with natural systems In locations where small concentrated amounts of run-off are collected, methods for infiltration can be devised in a simple fashion to ensure excessive overland flow is directed into the ground. These systems should be used in situations where the landscape is not capable of absorbing the surface flow such as a swale condition along a roadside or in the final stages of a small wetland system or pond. Efforts should be made to avoid polluting the ground water by allowing rapid infiltration of improperly treated runoff. Again, the design of the landscape should insure that these systems remain small, intercepting overland flow from impervious surfaces These systems, in order function properly should suit the soil and site conditions

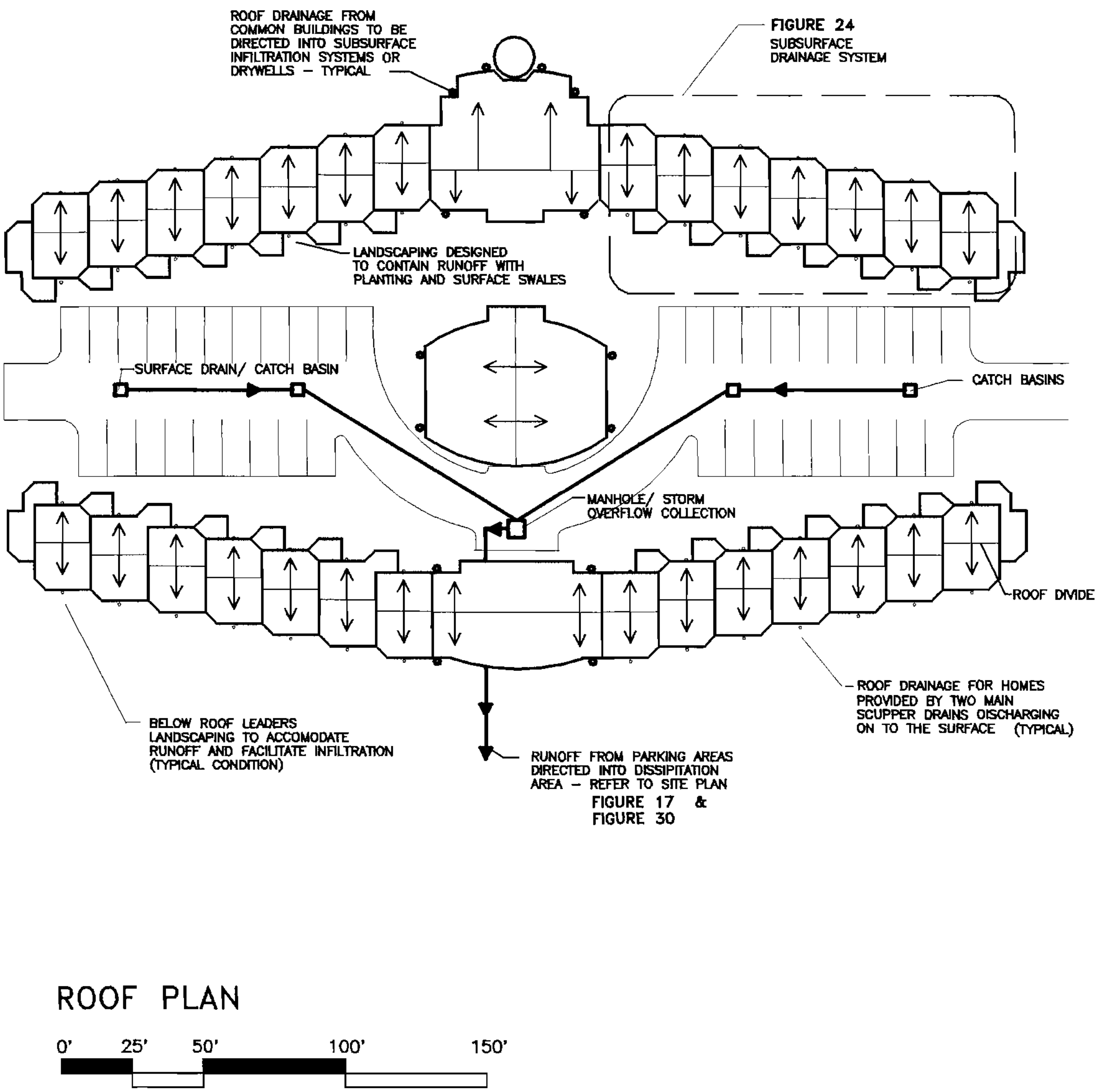
RECOMMENDATIONS

The storm water system for HAMLET CO-X relies on a variety of methods to manage runoff and use it to the advantage of the community The surface drainage of the immediate site **(FIG. 22)** is controlled using alternative and conventional methods The roof of each dwelling is designed with a single ridge and low slope It is drained with roof leaders at the front and back of every house discharging onto the surface into a landscaped depression to allow for infiltration and plant absorbtion. The common building roofs, which will provide significantly more concentrated runoff, are tied into drywells for immediate infiltration These are located to intercept water from the rain leaders, away from the building to avoid overloading the footing drainage system. The roof surfaces of the buildings are not of a material that is subject to breakdown such as asphalt shingles. Rubberized roofing membranes provide the most durable option available.

The paved roadways on the site are lined with grass swales with infiltration systems set in at critical points to contain water and allow for infiltration Large areas of impervious surfaces such as the parking lots and require structural means to collect rain water due to the potentially large amounts of water collected during a storm Runoff from these surfaces is directed into a wetland systems integrated into the design of the site **(FIG. 30)** This system works in three stages allowing for the settlement, treatment and infiltration of the runoff water The design presented is essentially a conceptual proposal Actual site conditions will dictate the scale of these systems and their positioning on the property

In the first stage, the water passes through a dissipation area were sudden surges are controlled in a series of pools that increase in size. As each pool fills, the water moves from one pool to the next **(FIG. 23)**This system provides initial settling, partial treatment and aeration of the runoff As the example shown illustrates, this type of facility can become beautiful addition to the landscape, supporting a wide variety of plant life. The second stage is a meandering, free water surface flow wetland This system provides the final treatment of the runoff and a specialized wildlife habitat The last stage is essentially a recreational pond with devices for infiltration present This type of system will work in most conditions allowing versatility for a variety of soil types If for example the soils are high in clay content and infiltration is not possible, the final stage can be modified into an overland system allowing for plant absorbtion.

Provided the sites water table is low, the footing drainage system for the building **(FIG. 24)** utilizes a series of submerged drywells to allow water collected by the weeping tiles along the foundation edge to infiltrate into the ground, away from the footing. The drywells are hollow concrete or plastic cylinders buried to levels slightly below the elevation of the footing and are fed by gravity If however, the water table is high, the weeping tiles must drain into a conventional sump pit and be pumped mechanically to an area for surface discharge This area would be similar to what would be required for the roof drainage system of dwelling in terms of landscaping



SURFACE DRAINAGE

SYSTEM SCHEMATIC

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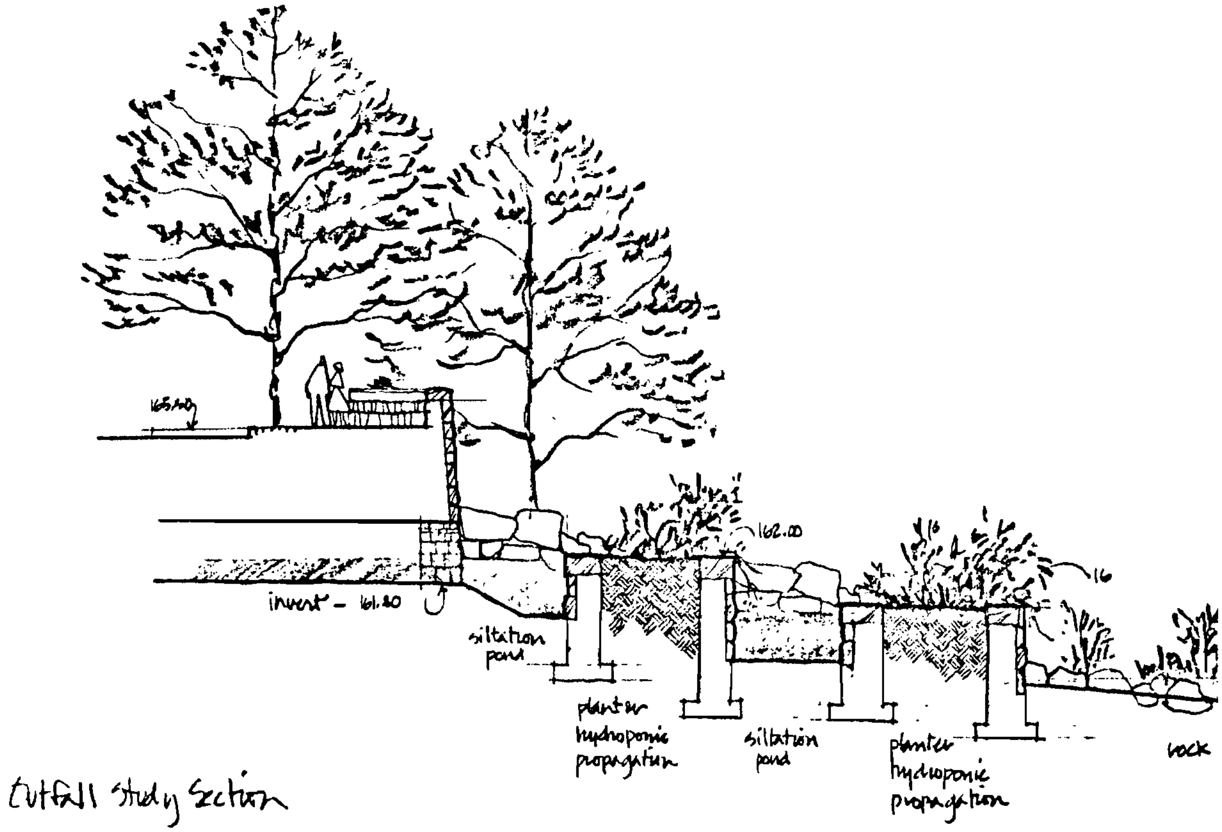
FIGURE 22



STORM WATER OUTFALL

DISSIPITATION AREA

DRAWING PROVIDED
COURTESY SALVATORI CONSULTANTS INC.
OAKVILLE UPTOWN CORE COMPETITION

FIGURE 23

7.24 HEATING & ENERGY

ANALYSIS

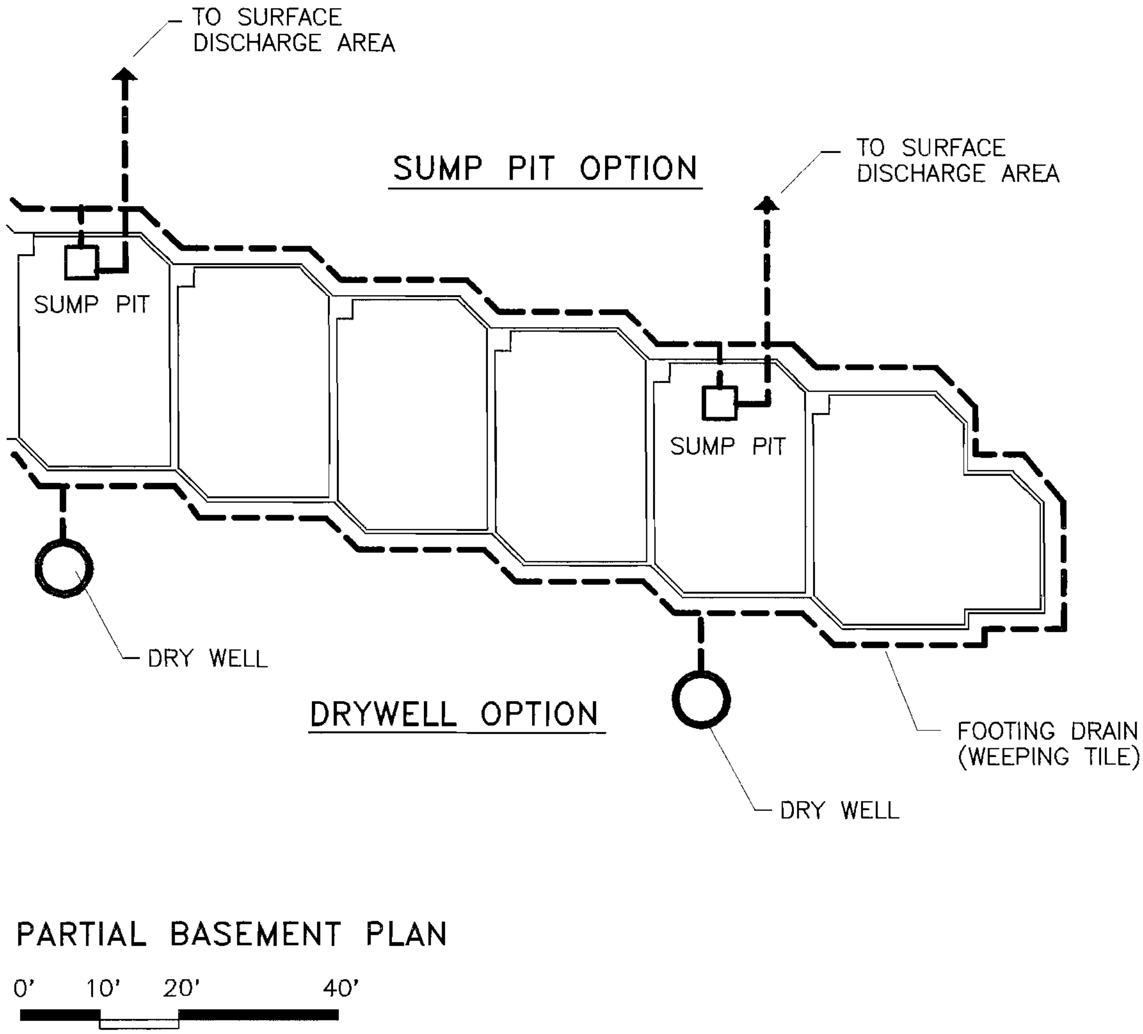
The most sustainable and efficient approach to low energy usage is achieved by design. In a sense, the same rules that apply to controlling storm water are relevant when reviewing methods to reduce energy consumption for home heating All attempts should be made first to decrease the base amount of energy required to heat a home by ensuring the building is properly designed and well insulated with passive solar attributes Utilizing standard building techniques and insulation levels slightly beyond an R-2000 standard, the typical dwelling in HAMLET CO-X requires relatively little energy to heat. A detailed energy analysis of two typical units using a the HOT-2000 [113] computer program is provided in Appendix A of the report with a complete breakdown of the RSI values of the building shell This program data is used to provide the expected heat and energy loading for the residential portion of the community only For the purpose of this report, only the heating requirements for the housing is considered The common and commercial spaces have completely different patterns of use and are not essential elements of the community

The most important factors affecting the design heat loss of the interior living units, is that they share common walls and are 2 stores in height allowing no heat loss in the parting walls. Basements were provided because the market conditions indicate that people like to have them. An insulated slab on grade is more energy efficient with the basement walls accounting for 7 51 % the annual heat loss in an interior unit. The estimated annual space heating energy consumption of a typical interior unit (Type C) is 64 % of a home with an equivalent volume designed to meet the R-2000 standard

DESIGN HEAT LOSS
(at -17 2 C)

UNIT TYPE C	3756 Watts (12,814 Btu/h)
UNIT TYPE D	4293 Watts (14,646 Btu/h)

[113] Hot-2000 version 6 0 program is designed to take into consideration all factors relating to heat loss and energy usage, including passive solar gains, domestic hot water and general electrical requirements



FOUNDATION DRAINAGE

SYSTEM OPTIONS

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FIGURE 24

Due to the efficiency of the design, UNIT TYPE C for example requires only 5401 MJ of energy annually to heat according to HOT-2000. Of the annual gross space heating load for this unit (25680 MJ), usable internal gains [114] account for 66 3% (17016 MJ) of the heat energy required. Passive solar gains account for an additional 12 7 % (3263 MJ) of the heat energy required. Important to note however, the heat loss from the windows accounts for 17.95 % of the annual total

Because each dwelling requires ventilation on an individual basis, the heating system is normally integrated into the air circulation system in an energy efficient house. An integrated mechanical system such as the one used in the advanced house **(FIG. 8)** is not appropriate for this application Arguably, this technology is too sophisticated and potentially costly at the present date for general use by the housing development industry Technology for individual domestic systems should be relatively simple, using components that have been tested and are available. This is necessary to avoid excessive operational costs and potential system failures The R-2000 program in Canada has created a market for the development of standard mechanical units for energy efficient heating and ventilating systems for housing of this type Quality proprietary systems therefore offer the most realistic options available. An in depth analysis of these systems is beyond the scope of this report however, it is necessary to demonstrate a potential unit system so that the energy usage of the homes in HAMLET CO-X can be determined if necessary

Of the energy sources available to rural housing the ground source heat pump is the most sustainable option The system uses the least amount of non-renewable energy, it operates cleanly and has the added advantage of hot water heating. Using a ground source heat pump as an energy source, two options are available for unit heating in HAMLET CO-X, a district system or individual domestic systems

A domestic heat pump system incorporates an integrated air handling unit as part of a single component providing heating and cooling Unlike a district heating system, an individual unit system can be operating on cooling mode while the adjacent suite is on heating mode As a result, individual heat pumps require a dedicated ground loop. Conversely, district hydronic systems can only provide heating or cooling at one time A ground source system can provide the necessary heating using minimal amounts of external energy According to the Hot-2000 program, UNIT TYPE C with an individual ground source heat pump system [115] requires only 1210 kWh of electricity annually for space heating. This takes into consideration all potential heat losses including the heat recovery ventilation system. With electricity costs at $.08 per kWh, the dwelling will be heated for $97.00 annually

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[114] Usable Internal Gain: the heat energy generated by the appliances and dwellings occupants.

[115] Canadian Geo-solar Model #1500

The heating of domestic hot water is an area of considerable energy usage. Because of the minimal heating requirements for a typical unit in HAMLET CO-X, the energy required for hot water heating is proportionally high The domestic hot water energy usage for a typical dwelling is calculated in the Hot-2000 program for Units Type C & D, based on standard occupant loads and hot water usage The computer program makes no provisions for heating domestic water with a heat pump system. It calculates electrical usage based on a standard hot water tank. The estimated annual electrical usage is calculated for Unit Type C to be 4033 kWh. This does not take into consideration any devices for energy conservation. This is almost four times the amount of energy required to heat UNIT C

A heat pump system, such as the one proposed for the individual units, has the additional capability to heat domestic water A heat pump cannot be used as a primary water heating system because it has some temperature limitations and it heats the water only during periods of operation In the domestic system proposed by William Maddock, [116] this energy is used to preheat the water from the well temperature to approximately 120 degrees F., then stored in an insulated tank The primary system, a standard electric tank, then draws on this water and heats it to 145 degrees F for domestic use It is estimated that this system will save approximately 2555 kWh of electricity annually in the domestic hot water system, decreasing the projected electrical usage by 63 %.[117]

The greatest problem associated with the individual unit system is cost. The following is a complete cost summary of a unit heating, ventilating and hot water system

<u>GROUND SOURCE HEAT PUMP</u>
INDIVIDUAL UNIT SYSTEM

HEAT PUMP UNIT	$6000.00
GROUND LOOP	$2500 00
HEAT RECOVERY VENTILATOR & ALL NECESSARY DUCT WORK	$2800 00
HOT WATER HEATER	$170.00
PRE-HEATER TANK	$150 00
TOTAL COST PER UNIT	**$11,620.00**

[116] Refer to Appendix B, Letter of William Maddock

[117] Ibid.

In this instance, the capital cost per unit is high The estimated heating and ventilating system costs for the entire complex would equal $ 348,600.00 or $ 87,150.00 for each wing The total electrical usage of this system for hot water and space heating annually is approximately 2688 kWh Compared to an all electrical system for space and water heating, the electrical usage is much less An all electrical system by HOT-2000 calculations requires 4033 kWh annually for hot water heating and 2048 Kwh for space heating totalling 6081 kWh This does not include summer cooling, for which an all electric system would be high Based on $.08 kWh, an individual unit ground source system will save $271 00 annually over an all electric system providing space and water heating

A comparison of this system to an all electric one, demonstrates the relative costs involved. An all electric individual unit system with air conditioning, ductwork and heat recovery ventilator, for example, averages $5,500 00 in capital cost The buy-back period for the heat pump would therefore be well over 15 years if electrical costs averaged $ 10 per kWh during that period This long buy-back period is partially the result of the low heat energy requirements for the dwellings Clearly, the greater the heat load requirements, the more feasible ground source systems become

The excessive capital costs of an individual unit heat pump system is a strong disadvantage A district heating and cooling system provides a better option for a community of this scale and density A district ground source heat pump system works similarly to an individual system. The energy provided by 7 separate heat pumps can be generated by one larger system. The heat plant requires roughly the same lineal footage of ground loop however, it can be concentrated in one area Water is distributed using a piped system to each unit. On heating mode, the heat pump provides hot water to each unit where it passes through a small fan coil within the air handling system of the dwelling On cooling mode the heat pump is reversed, warm air passes over the fan coil which absorbs the heat energy This is directed back to the heat pump, which intern transfers the heat back into the ground Although there is some heat loss experienced in the distribution system, less electrical energy is required because fewer heat exchangers are operating at any one time

The hot water heating for a district system is similar to a unit system but operates on a larger scale. One large insulated tank can serve an entire wing and is heated with an dedicated heat pump that is design to operate a higher temperature The water is then distributed in the same piping conduit as the other water systems.**(FIG. 21)** This uses energy more efficiently than individual systems and is similar in concept to the unit system proposed by William Maddock The greater the volume of water, the greater its thermal storage capacity. The additional components aside from the heat pump and water tank are the ground loop and distribution piping. It is estimated that this system, serving a single wing of the HAMLET CO-X complex would cost over $14,000 00 Given the extreme low cost of domestic hot water heaters, it is difficult to justify this capital expense

A ground source heat pump system provides the advantage of summer cooling without any additional capital costs to the system As unit cooling is not an essential element in the servicing of housing, it is not considered in the energy analysis of this report However, it is an important cost consideration when comparing ground source heat pumps to other systems. A comparison of the total capital costs of a ground source heat pump district system to an individual unit system reveals the advantage of district heating

GROUND SOURCE HEAT PUMP
INDIVIDUAL UNIT SYSTEM

TOTAL COST PER WING	**$87,150.00**

GROUND SOURCE HEAT PUMP
DISTRICT HEATING SYSTEM

UNIT AIR SYSTEMS	
TOTAL COST PER WING	$24,000 00
HOT WATER TANKS [118]	$1275.00
HEATING PLANT[119]	$30,190 00
TOTAL COST PER WING	**$55,465.00**

Using a District System, as compared to individual unit systems, the cost difference for each wing is $31,685 00 or $126,740 00 for the entire development The cost per unit, under the district system equals $7395 00 This demonstrates that ground source heat pump systems can be cost effective when compared to other domestic heating and cooling systems

Although the individual unit system proposed by William Maddock uses less energy, the excessive costs involved would not be acceptable in a typical development scenario. The arguments put forth in the appendix of the report against the use of a district heat pump system are flawed when

[118] Although each wing of HAMLET CO-X has the same total design heat loss, two of the wings will contain 8 dwellings and the other two 7 dwellings Therefore, the average cost for each wing required for the individual unit systems was calculated by totalling the cost for 30 dwellings and then dividing by four

[119] Refer to Appendix B for complete breakdown of the components included in this figure

reviewed in more detail [120] Systems very similar to those proposed by CANADIAN GEO-SOLAR have been successfully implemented in rural areas using rural single phase power.[121] The additional concern regarding the amount heat energy produced by a heat pump as being insufficient for a district system is similarly unfounded. The living units of HAMLET CO-X are highly insulated and require very little energy to heat. It is estimated that the system proposed by GEO-SOLAR would easily suffice to provide enough heat energy to maintain comfortable heating levels. Furthermore, any heat lost in the distribution system would be absorbed by the space through which the piping passes

FUTURE CONSIDERATIONS

Waste Water Heat Reclamation

Utilizing a heat pump system, heat energy can be easily extracted from the waste water of the community The most common system type, works on an individual unit basis involving only the grey water, which carries the most heat energy An example of this type of system can be seen in the Integrated Mechanical System of the Advanced house On the scale of a community system, heat reclamation from grey water alone is not feasible. This would require dual drain systems separating the black and grey water Several successful projects have been completed in Canada and Europe involving reclamation of heat energy from sewage water, often with the heat pump systems completely integrated into the sewage treatment plant. [122] In small communal treatment systems, this can cause a problem if too much heat energy is extracted from the water prior to treatment. Depending on the treatment system used, the heat energy may be required to augment the treatment process itself

If the heat energy is required for the sewage treatment process, the energy can be extracted using a water source heat pump after the treatment process is complete This can also be integrated into a ground source system with a mechanism that would allow for heat exchange between treated waste water and a ground loop. A system of this type could be developed that integrates a ground source spiral loop for a heat pump and the subsurface disposal system for treated waste water. The installation of both systems could be done at the same time with the spiral loop being buried directly below a drain tile The presence of the drain tile would insure the soil around the loop

[120] Refer to W. Maddock, Appendix B

[121] Based on a conversation with Jeff Markle, Canadian Geosolar.

[122] CADDET/IEA/OECD , 1988

below is being continually saturated with water. This would increase the thermal conductivity of the soil around the ground loop and thus potentially improving the systems overall efficiency. [123]

Clearly, heat reclamation from waste waster in an application the scale of HAMLET CO-X , is an area that deserves greater investigation. In order to be cost effective and efficient however, the system must be integrated into the communities entire water, heating and sewage systems in the design stage of the project. This degree of investigation is beyond the scope of this report.

Solar Domestic Hot Water Heating

Solar Domestic Hot Water (SDHW) systems offer another potential means for further energy conservation and should be a consideration for further study. Due to the proportionally high amount of energy required for a standard hot water system, an SDHW system can provide the additional water heating to reduce electrical usage substantially In the case of the system proposed for HAMLET CO-X, the solar panels could be located on the roofs of the individual dwellings Solar heated water would then be circulated through an insulated preheating tank inside the unit The electric water heater would then draw on this preheated water thus reducing the systems energy requirements. Although these types of systems have been successfully implemented for individual dwellings, information regarding performance and their application for large scale systems was not evident from our research. Proprietary system do exist and can be purchased for approximately $1500.00 for a single dwelling. Given the low cost of electric hot water tanks a significant amount of energy savings would be necessary to justify the costs of a proprietary system in a typical development scenario

RECOMMENDATIONS

The heating system proposed for Hamlet Co-X is a district or zoned system comprising of four heat plants, one serving each wing of the community. **(FIG. 25)** Utilizing data provided by the Hot-2000 program, estimated design heat loss are determined for each of the four wings, comprising of 7 or 8 dwellings, to be 26,829 Watts (91,537 BTU/H) for heating

Based on this design heat loss for each wing, in the system designed by CANADIAN GEO-SOLAR[124] the heating plant **(FIG. 26)** proposed is comprised of two 5 Ton heat pumps. By providing two heat pumps this insures a backup in case one system fails. The water is then distributed in the district system shown in Figure 25. Because water to water systems are more

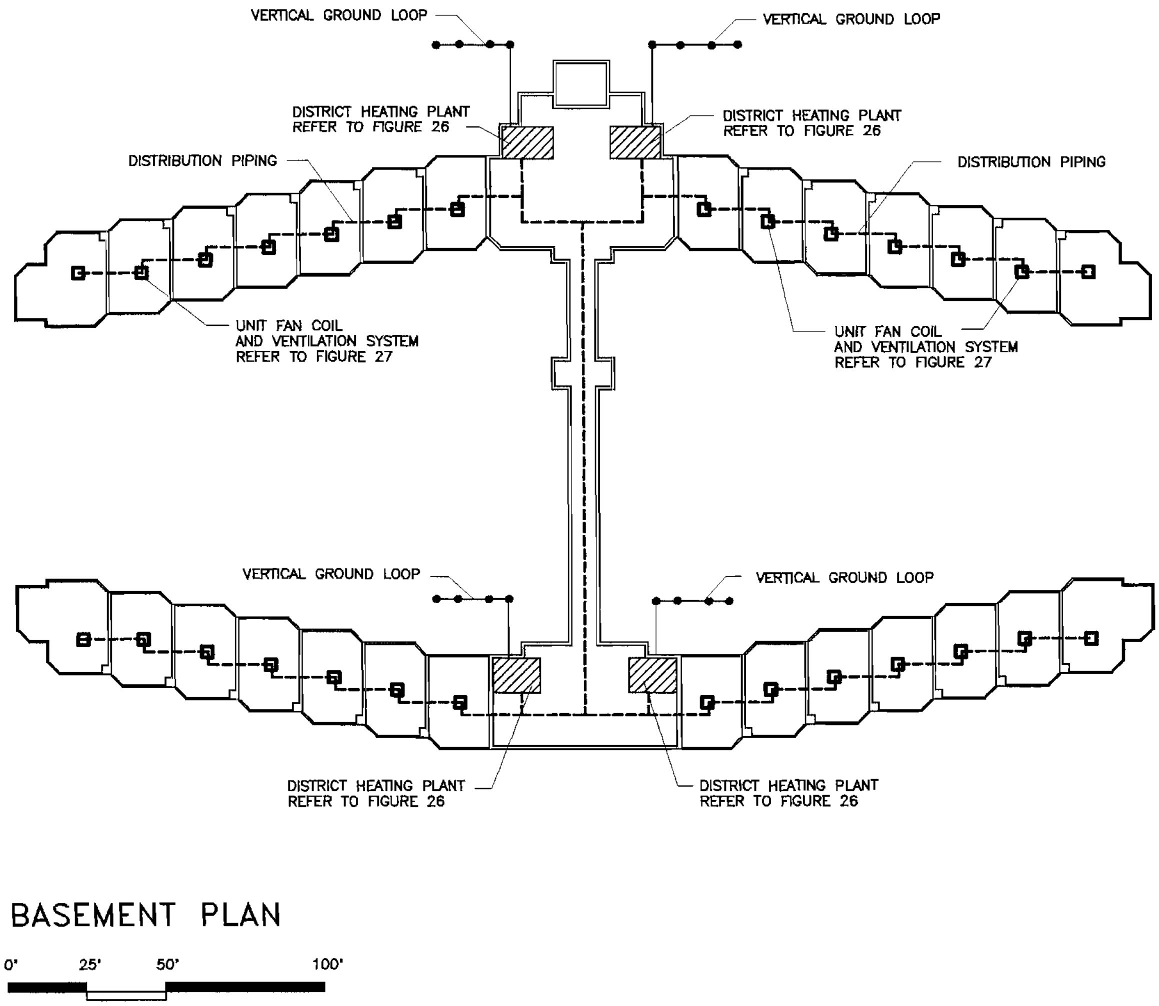
[123] Based on telephone interview with Dr Otto Svec

[124] Refer to Appendix B, letter of CANADIAN GEO-SOLAR.

efficient, it is estimated that the coefficient of performance for the heat pumps to be over 5 0 Unless this system is fully engineered a precise calculation of its operational electrical usage is not possible

As the schematic within the Appendix shows, the water distributed through the district system supplies and removes heat energy from each unit through a loop that is circulating continuously. A typical unit system **(FIG.27)** is comprised of an air handling unit, a heat recovery ventilator [125] and ductwork, which are all standard manufactured components. The air handling unit is designed with an electrical backup system in the event of a mechanical failure in the heating plant The water is circulated through a fan coil over which the air passes. Hot water is provided to each unit using individual hot water tanks As water conservation would be an important program associated with a sustainable community, excessive hot water usage would be discouraged.

[125] Heat Recovery Ventilator: VANEE model 1000 VLDE



DISTRICT HEATING SYSTEM

DESIGN SCHEMATIC

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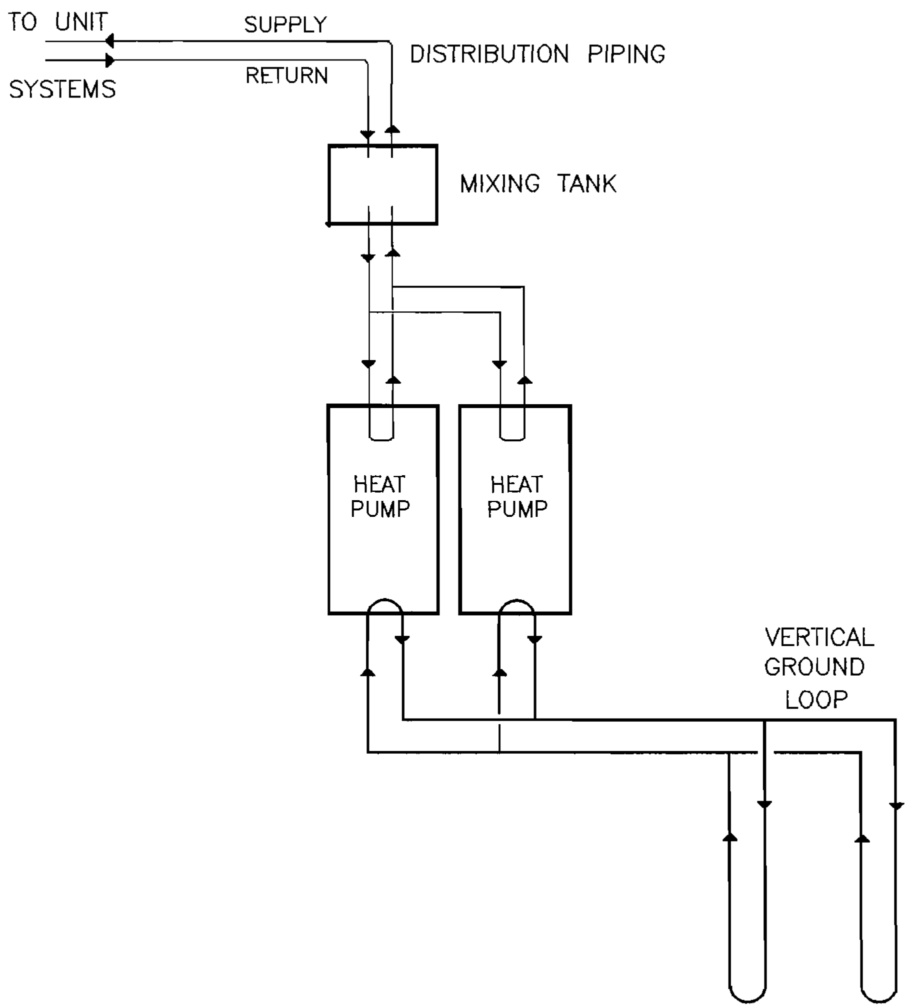
FIGURE 25



DISTRICT HEATING PLANT

DESIGN SCHEMATIC

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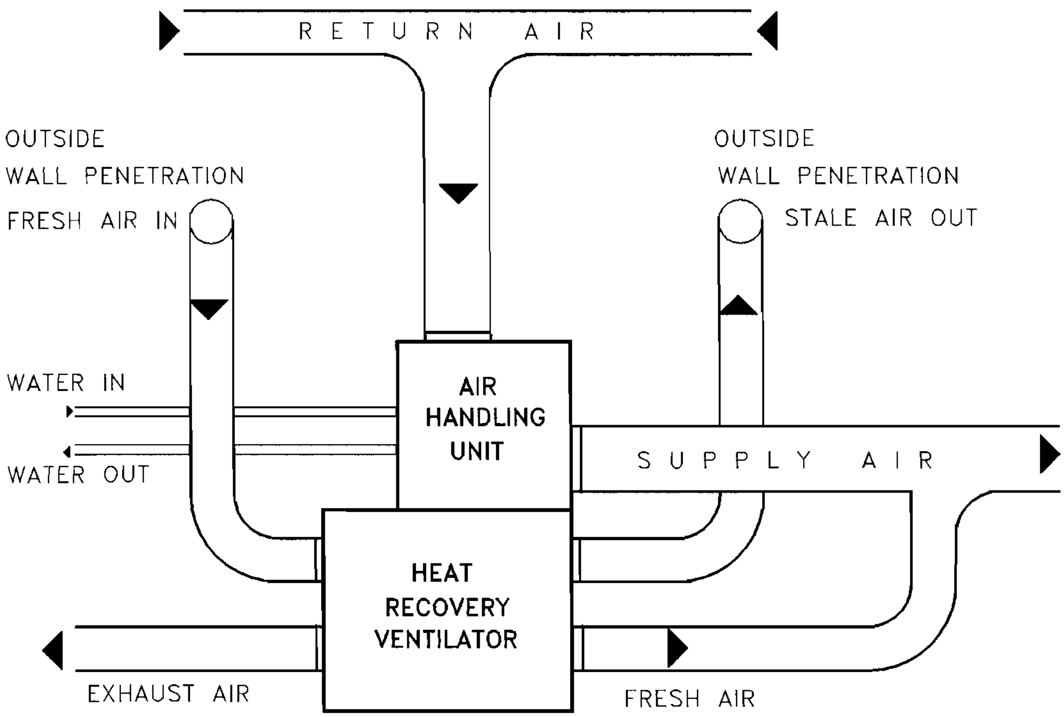
FIGURE 26



HEATING & VENTILATION SYSTEM

TYPICAL UNIT DESIGN SCHEMATIC

7.25 SEWERAGE

ANALYSIS

Collection Systems

Of the small diameter systems reviewed in this report, all represent feasible options for small community systems Hundreds of successful SDVG, GP and STEP installations exist throughout North America This is technology that is not new and has been proven effective Each system has particular attributes that serve will a given situation effectively

Clearly, small diameter variable grade sewers are the most desirable from the perspective of construction and operational costs. Being a gravity flow system, pumps are not required therefore no energy usage and little maintenance considerations. Because the system works with minimal grades, the site cannot be sloped excessively and interceptor tanks are necessary to remove solids so that the effluent will flow without constriction This is why SDVG sewers are commonly used in conjunction with pressure systems

Grinder pump systems are the least desirable from the perspective of energy usage. They are however, the most cost effective option, in terms of capital costs if primary treatment is not a consideration Solar Aquatic and Sequencing Batch Reactor systems do not require pre-treatment for example The STEP system offers primary treatment in each STEP tank which may be necessary again depending on the treatment system. Both STEP and SDVG systems accumulate sludge in the their tanks. This must be removed and disposed of every 1-2 years to insure proper system operation In a large development this is an operational cost that could be considerable

As in a conventional sewer system, the less number of components required such as manholes and lift stations, the less costs are involved. When a STEP tank is provided for each home in a development, the construction and operational costs can be relatively high however, if, for example, the system is designed to allow a group of homes to gravity feed into one large tank, some costs can be controlled

Collection systems should be selected on the basis of site characteristics, community layout and the treatment system proposed. Because different systems require varying degrees of pretreatment, the collection system for HAMLET CO-X should be considered as part of the total sewerage package, to suit a particular treatment option

Treatment and Disposal Systems

The BRBAF system provides excellent treatment with low energy usage however, it is still relatively experimental Having not been used to our knowledge in a multiple housing development, accurate costing is not available. Filter systems of this type tend to be temperature dependent possibly requiring a heated enclosure during winter months Because filter system can generate methane gas this poses a health risk and is an additional consideration for the construction of any type of enclosure Government regulations regarding acceptable levels of methane gas in an enclosed space may render enclosures of this type not possible.[126] The treatment system was calculated to be approximately 2000 sq ft. in area, based on hydraulic loading rates of 100 L/m2/D. This is relatively compact and quite suitable for development of this scale however, the system needs to be tested in an actual development

The RUCK system, according to external testing does not perform to acceptable treatment levels This is in conflict with the inventors reports The system displays relatively low loading rates and it requires the separation of black and grey water which is not feasible for a communal system To our knowledge, the RUCK system has not been used for a multiple dwelling communal system

Sequencing Batch Reactors provide proven, excellent quality treatment Unfortunately, for a community of this scale they are not really feasible. An SBR system serving this scale of development would cost approximately $ 300,000.00. [127] This price does not include the cost of sludge disposal or an infiltration system. SBRs are best suited for larger scale applications where the additional operating costs can be carried

Slow Rate Land Application and Wetland systems are seasonal treatment options that yield acceptable treatment levels with less maintenance requirements Both exhibit the benefit of providing an additional site amenity that can contribute to the quality of a development. Their presence adds to the biodiversity of the area however, they require substantially more land and are only seasonal options. These systems could be integrated into the design of a site where possible to provide final treatment of effluent or runoff during the warmer months

The two treatment systems that offer the most viable options for this type of development are the Peat Filter and the Solar Aquatic system Each of these systems present completely different attributes that may serve one development better than another

[126] Based on a telephone conversation with Brian Cooper, M O.E E

[127]

Of all the systems reviewed, the Peat Filter provides the best treatment performance, using the least amount of energy It has been tested in Ontario and in cold temperatures provides denitrification quite effectively The system has the added advantage of being a treatment system and tile field in one The filters are doused and treated effluent infiltrates into the ground below A separate treatment facility is not required

The peat filter has some disadvantages The filters are sensitive to compaction and should not be placed in high traffic areas. This is a design consideration which is not a desirable attribute of the system, particularly if every inch of the site is to be used The total filter area required is similar to what is necessary for a standard tile field. It is estimated that for HAMLET CO-X, the total filter area will equal 2000 m2 or an area of 150 ft X 150 ft. [128] If referenced to the design Site Plan **(FIG. 17)**, 2000 m2 would be equivalent to approximately half of the playing field surface area. Lastly, the peat must eventually be replaced, which is a capital cost equivalent to approximately 30 % of the costs of the system Because this a relatively new treatment method, the life span of a peat filter is not known however it is expected to be similar to a conventional tile field which is minimally 15 - 20 years.

The estimated installed costs for a Peat Filter system designed for HAMLET CO-X is $120,000 to $180,000. [129] The broad price range given is to account for varied site conditions that may be encountered and does not include provisions for a collection system or land usage. Because the land cannot be used for any other purpose it is a cost that has implications for development Contrasting other package treatment systems a subsurface infiltration system can be built under a playing field or parking lot

The Peat Filter System is designed to treat septic tank effluent therefore the collection system best suited for this treatment option is the SDVG method, a Small Diameter Variable Grade System feeding into a lift station or large STEP tank **(FIG. 28)** The effluent gravity feeds into interceptor tanks [130] and then flows to a lift station where it is then pumped to the treatment areas elsewhere on the site Because of the short distances involved and the relatively low flows per dwelling it is assumed that one large interceptor tank can handle the effluent of a group of 7 - 8 dwellings.

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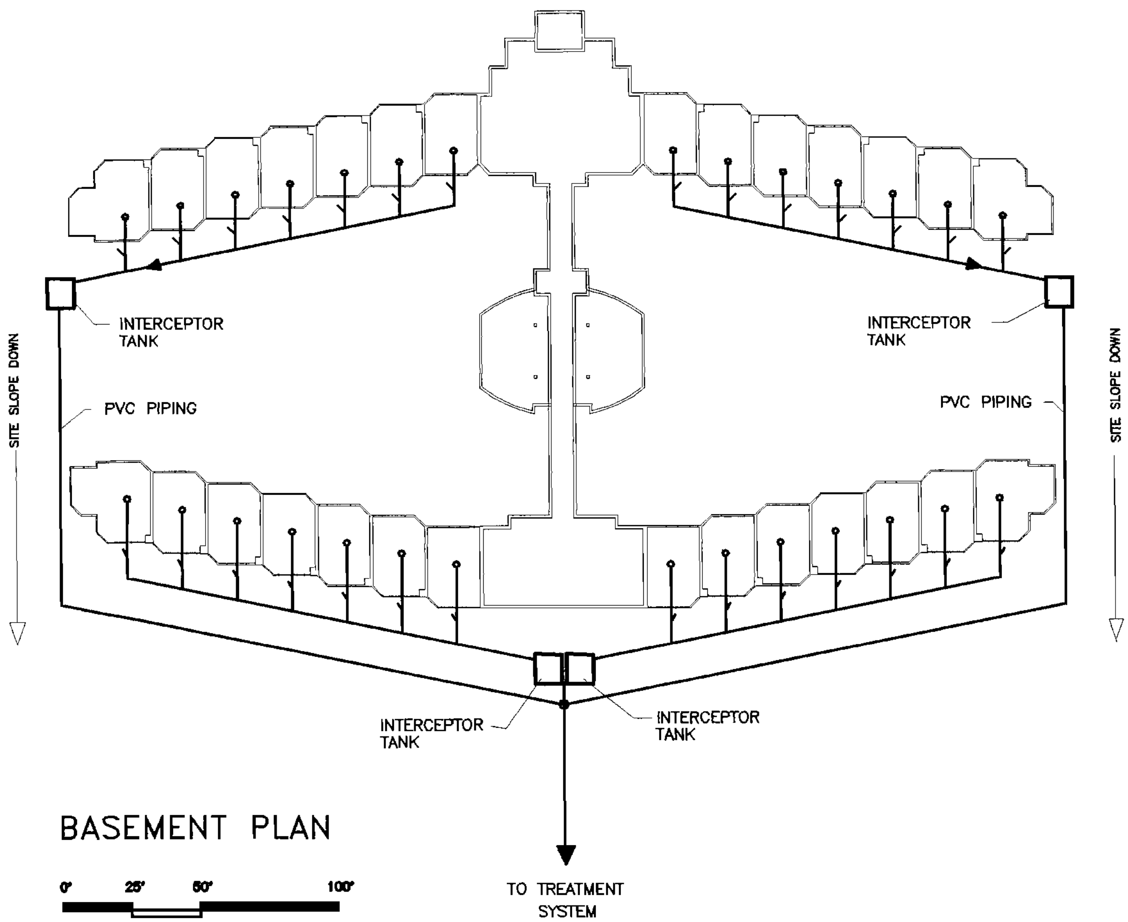
[128] Refer to Appendix B, letter of Oliver, Mangione, McCalla & Associates Limited

[129] Ibid

[130] The piping exiting each dwelling is located 5'-0" below grade to decrease excavation costs. Sanitary drains located in the basement can not be accommodated without additional pumping



SEWAGE COLLECTION SYSTEM

SMALL DIAMETER VARIABLE GRADE SEWER OPTION

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FIGURE 28

HAMLET CO-X **SDVG SEWER SYSTEM**

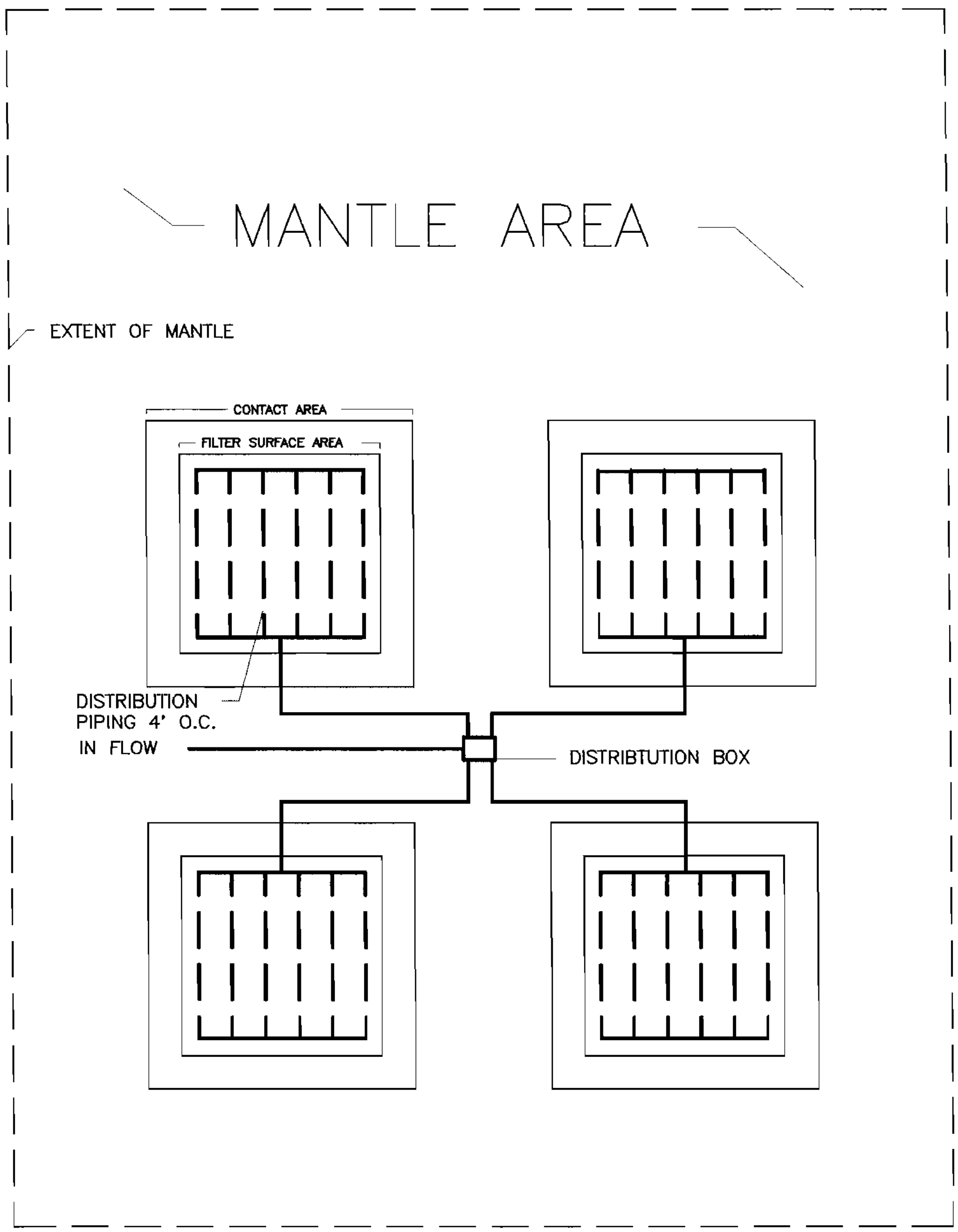
4 - 10,000 L INTERCEPTOR TANKS ($3000 00 Ea)	$12,800.00
1500 Ft - 4" MAIN PVC PIPING ($12 00/ft)	$18,000 00
PUMPING LIFT STATION	$4000 00
CLEANOUTS & SERVICE CONNECTIONS	$6000 00
TOTAL COSTS	**$43,800.00**

Although this system uses little energy, the 4 interceptor tanks must be maintained. The sludge accumulations in each tank should be pumped out every year and be disposed of by a service company To perform this task it is estimated to cost $ 900.00 annually for the proposed four tanks.

The Solar Aquatic system is the other feasible option for HAMLET CO-X. As compared to the Peat Filter it provides a holistic and somewhat more complex alternative. The Solar Aquatic system proposed for HAMLET CO-X is a complete treatment facility capable of processing all of the waste including sludge The system designed by ECOLOGICAL ENGINEERING ASSOCIATES is clearly described in the appendix [131] of the report with descriptive drawings. The cost of the treatment components alone is estimated to be $108,000 00 This price includes 100% redundancy in the system with each component being provided with a full back up unit. This also includes the cost of generator in the event of a power failure

This system can provide varying degrees of treatment. After undergoing partial treatment the waste water can be directed into a wetland or an overland treatment system such as a nursery for polishing. The partially treated effluent will be free of solids however it will still contain amounts of nitrogen and phosphorus that the natural system require to sustain growth This option helps to reinforce biodiversity on the site by supporting other natural systems Although the Solar Aquatic System does not provide the same degree of Nitrate removal as a the Peat Filter its ability to remove high levels of heavy metals is a major advantage The only waste product produced is inert biomass that can be used as fertilizer The system does have additional energy

[131] Refer to Appendix B, letter from Ecological Engineering Associates.



SUBSURFACE INFILTRATION SYSTEM

REFER TO APPENDIX C
FOR SIZING CALCULATIONS

Zsolt & Associates Limited

Environmental Design and Planning

FIGURE 29

requirements to operate pumps and blowers which are estimated to require 36,000 kWh annually.[132]

To enclose the treatment system, a 140 m2 (1500 sq.ft) green house type structure is required. This is an added construction cost which requires energy to heat. A standard green house building would cost approximately $17 00 per sq ft to construct or $25,500.00 total The greenhouse vegetation does not require large amounts of sunlight therefore the structure need not be all glass. Energy efficient green houses that use much less glazing have been developed for Canadian climates. [133] These buildings can be earth bermed to conserve energy and blend into the landscape.

Unlike the Peat Filter, the system requires a separate disposal system to discharge the effluent after treatment This does not need to be designed like a standard tile bed Due to the quality of the effluent, no additional treatment is required to occur in the tile field itself. Provided the soils are permeable enough, many infiltration systems can be used in theory Ontario regulations require a subsurface disposal system to adhere to the guidelines set for the construction of sand filter systems in which granular B type material is substituted for sand. **(FIG. 29)** Provided the soil conditions on the site have an average water permeability, this system for a 15000 L/D flow is estimated to cost approximately $35,000.00. [134]

Because this option offers total treatment, the collection system required for the Solar Aquatic plant is a conventional gravity flow or a grinder pump pressure sewer Compared to the SDVG system designed for the Peat Filter option a grinder pump pressure sewer would require slightly less capital cost however the energy usage would be more and the pumps require additional servicing We estimate that for the purpose of system comparison the difference in the two systems in total costs would be minimal

A cost comparison for the two systems excluding the collection system reveals the that the two systems are closely priced

<u>PEAT FILTER SYSTEM</u>

TOTAL SYSTEM COSTS	**$120 - 180,000.00**

[132] Based on a conversation with Susan Peterson, Ecological Engineering Associates

[133] Refer to Appendix C, Solar Max Diagram #1.

[134] Costing information courtesy of J & A Services.

SOLAR AQUATIC SYSTEM

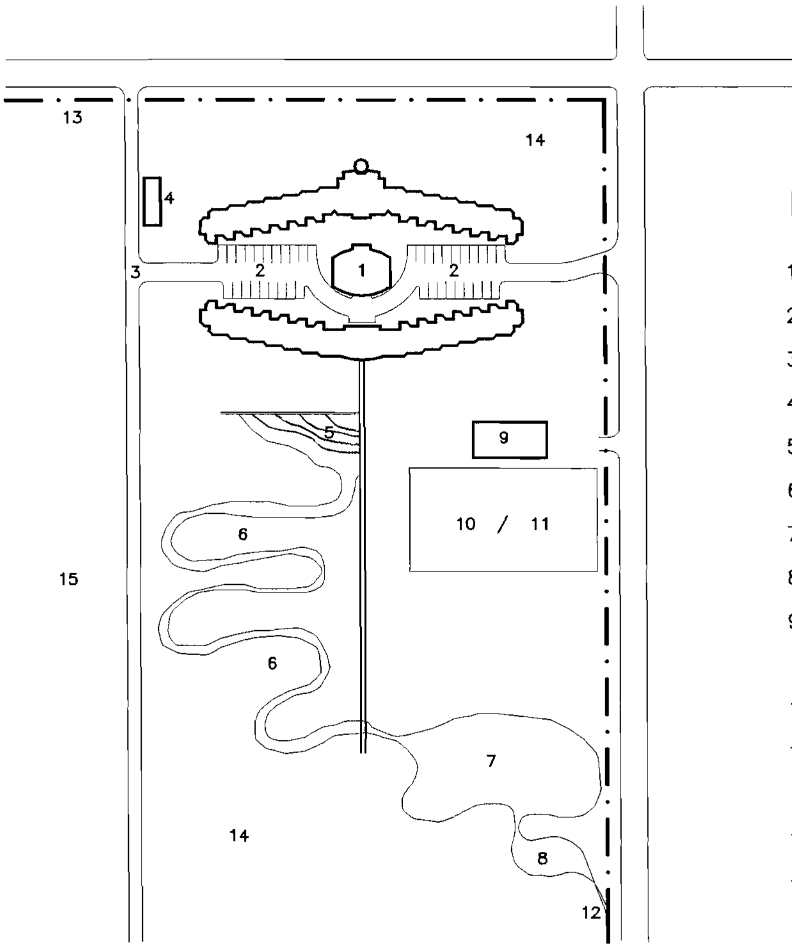
SYSTEM COSTS	$108,000.00
GREENHOUSE BUILDING	$25,500 00
INFILTRATION SYSTEM	$35,000.00
TOTAL	**$168,000.00**

In Ontario, within a conventional rural development **(Fig. 20),** regulations dictate the size of septic systems and tile fields for individual dwellings. The cost of these systems for an average home is approximately $10,000.00, based on typical site conditions. To service 30 dwellings this would total $300,000.00 or approximately $100,000 00 more than the system proposed for HAMLET CO-X if the collection system is included.

The general precepts of sustainability dictate that the environmental, economic and social aspects of any issue regarding development should be taken into consideration when assessing a particular option. Clearly, the two systems reviewed, the Peat Filter and Solar Aquatics are both sustainable options to serve HAMLET CO-X. Because of the different operating principles behind each system they are difficult to compare The specific needs of a community and the constraints of an actual development would provide a more suitable forum for evaluation.

RECOMMENDATIONS

For HAMLET CO-X, the Solar Aquatic system is proposed Although the systems energy requirements are high, its social, economic and environmental attributes provide the most desirable solution It is a more flexible system to integrate into a development and provides the opportunity to reinforce other natural systems The Partial Site Plan **(FIG. 30)** provides a more precise depiction of all the systems involved in a development of this nature The green house building is located adjacent to the playing field for good southern exposure and in close proximity to the subsurface infiltration system under the field The building is depicted roughly twice the size than what would be necessary to house the system. This provides additional space for growing other plants to serve the communities landscaping needs. Across the promenade is the constructed wetland, which aside from treating the runoff, is capable of receiving some of the partially treated effluent during the summer to help sustain its plant growth.



LEGEND

1. HOUSING AND COMMON BUILDINGS
2. PARKING AREAS
3. SERVICE LANE
4. COMPOSTING FACILITY
5. STORM WATER DISSIPATION AREA
6. CONSTRUCTED WETLAND
7. POND
8. INFILTRATION BASIN (OPTIONAL)
9. GREEN HOUSE / OUTBUILDING
10. PLAYING FIELD
11. SUBSURFACE INFILTRATION AREA
12. 5 YEAR STORM OVERFLOW
13. PROPERTY LINE
14. NATURAL REGENERATION AREAS
15. CROP LAND

PARTIAL SITE PLAN

H A M L E T C O – X

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Environmental Design and Planning

FIGURE 30

7.3 FINDINGS

1 0 WATER

1 1 A communal ground water system designed for HAMLET CO-X complete with chlorination system and water tower could be constructed for an estimated 50% of construction costs of 30 individual well systems In a communal system of this type, total energy consumption and system maintenance is less and has a high degree of quality control

2 0 STORM WATER

2.1 Effective site and landscape design is the single most important factor in controlling storm water runoff This is achieved most notably by reducing impervious surfaces where possible and providing effective planting in conjunction with proper site grading

2.2 A wide variety of stormwater management techniques exist to handle excessive overland flow that appear to be potentially effective in allowing for the treatment and ground infiltration of runoff water These techniques can be integrated into developments provided they are part of a full storm water management strategy at the projects inception

2 3 Landscape design in conventional forms of housing development is difficult to control because of freehold land ownership These sprawling forms of housing have substantial amounts of impervious surfaces from driveways and roads with often little land set aside for storm water retention or treatment areas

3 0 HEATING & ENERGY

3 1 Energy efficiency in housing is achieved most effectively through design and proper construction techniques

3 2 Complex mechanical systems and other energy saving devices must be reviewed thoroughly to access capital costs and operating requirements For this reason, many specialized systems are often not feasible for general applications in the building industry The potential energy savings cannot justify the capital costs involved when applied to single family dwellings.

3 3 Given the parameters of this project, the most sustainable system for home heating, is a ground source heat pump Individual home heat pump systems provide excellent performance but, remain quite expensive when compared to other standard heating options

3 4 The tight clustering of the dwellings in HAMLET CO-X provides an opportunity for a district heating system This allows for greater efficiency with less redundancy. Using a ground source heat pump energy source in a district heating system versus individual home systems reduces the total capital installation costs for this project by an estimated 36 % Using a district heating system, a ground source heat pump can be an effective heating option for higher density housing in a rural context.

4 0 SEWERAGE

4 1 Small diameter sewer systems offer a good alternative to conventional gravity flow collection systems These systems are proven effective for residential applications both in terms of cost and performance Of the three types reviewed, each system has different characteristics to suit different situations Collection systems should be selected based on the design of the project, the terrain of a site and the treatment system used

4 2 The SOLAR AQUATIC SYSTEM and the PEAT FILTER are both good options for the treatment of waste water in a small community. The two systems are similar in cost however differ greatly in operating principles

4 3 The PEAT FILTER offers the highest degree of denitrification using the least amount of energy The filters must be separated from pedestrian traffic and can only treat septic tank effluent

4 4 The SOLAR AQUATIC SYSTEM provides the most comprehensive, processing all the waste and removing heavy metals For land development purposes this system more flexible to implement and has the potential to provide additional social and economic amenities Although its energy requirements are high it is the option that is most desirable from a sustainable perspective

4 5 It is estimated that a communal sewage system for HAMLET CO-X, using either treatment method, will cost approximately $100,000 less than individual septic/tilefield systems serving a development with an equal number of dwellings

7.31 CONCLUSIONS

1 0 Exiting standards for the planning and the provision of servicing for housing in rural areas do not address the goals of a sustainable approach to land development and are an important factor in restricting the formation of alternative and more diversified communities

2.0 In order to create communities that are economically and environmentally sustainable, the physical design and the provision of servicing for a housing development must be viewed holistically This requires an approach to planning and development that is the antithesis of conventional and accepted methods In a sustainable approach, natural systems, programmatic requirements and servicing must be fully integrated.

3 0 Clustered, higher density housing forms in rural areas, can result in less environmental impact and provide the opportunity for servicing shared with notable cost and performance advantages

4 0 For rural applications, a very large number of options exist for both the physical forms a community can take and the types of servicing systems that can be used The research revealed that very few of these options have been explored or tested in Canada.

5 0 The final analysis of the options available for the servicing of rural housing was carried out using a specific community model, HAMLET CO-X, which was intentionally designed to maximised efficiency of systems and to minimize environmental impact Conclusions can be drawn about the suitability of specific systems to a general situation however, an alternative community form in a different context will provide varied design constraints and possibly different systemic requirements

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APPENDIX A

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***************************************
*                                     *
*               Hot2000               *
*            Version 6.02             *
*               CANMET                *
*  Energy, Mines and Resources CANADA *
*            July 1, 1991             *
*                                     *
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House Data Filename=C:\H2K\USER\HAMXS1.HDF

Weather Data is for TORONTO, ONTARIO

Builder Code =Zsolt Asc. Data Entry by:jaz

Client name:	Hamlet Co-x		
Street address:	Unit Type C		
City:	Toronto Area	Region:	
Postal code:		Telephone:	

*** GENERAL HOUSE CHARACTERISTICS ***

House type:	Triplex
Number of storeys:	Two storeys
Wall construction:	Double stud wall

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (B) Wood frame construction, 50 mm gyproc walls
25 mm gyproc ceiling, wooden floor

Occupants : 2 Adults for 50.0 % of the time
2 Children for 50.0 % of the time

*** HOUSE TEMPERATURES ***

Heating Temperatures	Main Floor	= 21.0 C
	Basement	= 18.0 C
	TEMP. Swing from 21.0 C	= 3.5 C

*** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

Foundation Construction	Attachment Sides	Insulation Placement
Full Basement	None	Exterior

*** WINDOW CHARACTERISTICS ***

Direction	Seq #	Location Code	# of Windows	Type	Window Width m	Window Height m	OverHang Width m	Header Height m	SHGC
South	1	M3	4	233212	1.000	.910	.600	.000	.5117
	2	B3	2	233212	.600	.450	.000	.000	.3623
Southeast	1	M4	1	233212	.600	.910	.000	.000	.4521
North	1	M2	3	333212	.600	.910	.000	.000	.4069

*** WINDOW PARAMETER CODES SCHEDULE ***

	Code	Description (Glazings, Coatings, Fill, Spacer, Type, Frame)
1	233212	Double (DG), Low-E .35(Hard2), 13 mm Argon, Insulating, Hinged, Wood
2	333212	Triple (TG), Low-E .35(Hard2), 13 mm Argon, Insulating, Hinged, Wood

*** USER DEFINED WINDOW CODES SCHEDULE ***

	Code	Description	R-value RSI	Solar Heat Gain Coefficient
1	OB		.00	.000

*** BUILDING PARAMETERS ***

Component		Area (m2) Gross	Net	RSI	Heat Loss MJ	% Annual Heat Loss
Above Grade Components						
Ceiling						
C1		46.40	46.40	7.61		
	TOTAL:	46.40	46.40	7.61	2660.5	10.36
Main Walls						
M1		8.75	8.75	8.90		
M2		24.33	20.89	8.90		
M3		24.33	20.69	8.90		
M4		8.75	6.40	8.90		
	TOTAL:	66.16	56.74	8.90	2585.9	10.07
Doors						
D1 Location:	M2	1.80	1.80	.53		
D2	M4	1.80	1.80	.53		
	TOTAL:	3.60	3.60	.53	2963.8	11.54

Component	Area (m2_) Gross	Net	RSI	Heat Loss MJ	% Annual Heat Loss
Basement walls above grade					
B1	1.05	1.05	6.62		
B2	2.92	2.92	6.62		
B3	2.92	2.38	6.62		
B4	1.05	1.05	6.62		
TOTAL:	7.94	7.40	6.62	397.4	1.55
Full Basement Area					
Upper Basement Walls					
	7.94		6.57		
TOTAL:	7.94		6.57	224.0	.87
Lower basement walls					
	15.88		6.57		
TOTAL:	15.88		6.57	1307.4	5.09
Perimeter area					
	13.10		3.68		
TOTAL:	13.10		3.68	1338.8	5.21
Centre area					
	33.30		3.68		
TOTAL:	33.30		3.68	906.8	3.53

WINDOWS

Orientation Location	Number	Type (Code)	Total Area(m2)	RSI Window	(Shutter)	Heat Loss MJ	% Annual Heat Loss
South							
M3	4	233212	3.64	.48	(.20)		
B3	2	233212	.54	.47	(.20)		
TOTAL:			4.18	.47	(.20)	3216.5	12.53
Southeast							
M4	1	233212	.55	.47	(.20)		
TOTAL:			.55	.47	(.20)	421.7	1.64
North							
M2	3	333212	1.64	.64	(.20)		
TOTAL:			1.64	.64	(.20)	970.7	3.78

Ventilation

House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
343.36 m3	.47 ACH	8686.5	33.83

*** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area	=	190.7 m2
Air Tightness Level is Energy tight (1.5 ACH @50 Pa.)		
Building Envelope is NOT Sheltered from the Wind.		
Estimated Equivalent Leakage Area	=	185.4 cm2
Normalized Leakage Area	=	.9720 cm2/m2
Estimated Airflow to cause a 5 Pa Pressure Difference	=	12 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference	=	18 L/s
ELA used to calculate Estimated Airflows	=	74.2 cm2

F-326 VENTILATION REQUIREMENTS:

Kitchen,living,dining:	3 rooms @ 5 L/s	= 15 L/s
Bedrooms:	1 rooms @ 10 L/s	= 10 L/s
Bedrooms:	1 rooms @ 5 L/s	= 5 L/s
Bathrooms:	1 rooms @ 5 L/s	= 5 L/s
Basement Rooms:		10 L/s

F-326 Required continuous ventilation rate	=	45.0 L/s (.47 ACH)
Average Ventilation Supply Rate (Balanced)	=	40.0 L/s (.42 ACH)

Ventilation System:	Heat recovery ventilator (HRV)
Manufacturer:	Vanee
Model Number:	1000VLDE

Fan and Preheater Power at .0 C	=	69. Watts
Fan and Preheater Power at -25.0 C	=	69. Watts
PreHeater Capacity:	=	0. Watts
Sensible Heat Recovery Efficiency at .0 C	=	67. %
Sensible Heat Recovery Efficiency at -25.0 C	=	58. %
Total Heat Recovery Efficiency in Cooling mode	=	19. %

Low Temperature Ventilation Reduction	=	4. %
Low Temperature Ventilation Reduction: Airflow Adjustment	=	0 L/s (.3 %)

NO Vented combustion appliance specified

Gross Air Leakage and Ventilation Energy Load	=	24347.1 MJ
Seasonal Heat Recovery Ventilator Efficiency	=	65.8 %
Estimated Ventilation Electrical Load: Heating Hours	=	1975.2 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours	=	200.8 MJ
Net Air Leakage and Ventilation Energy Load	=	9674.1 MJ

*** SPACE HEATING SYSTEM ***

PRIMARY Space Heating Fuel	:	Electricity
Space Heating Equipment	:	Ground Source Heat Pump
Manufacturer	:	CANADIAN GEOSOLAR
Model	:	1500
Capacity at 8.3 C	=	5.5 kW
COP at 8.3 C	=	3.10
Crankcase Heater Power	=	1.0 watts
Heat Pump Temperature Cut-Off	:	Unrestricted Cut-Off

SECONDARY Heating Fuel	:	Electricity
Equipment	:	Forced air furnace
Manufacturer	:	
Model	:	
Output Capacity	=	5.5 kW
Steady State Efficiency	=	100.0 %

Fan Mode : Auto Fan Power 373. watts

*** ANNUAL SPACE HEATING SUMMARY ***

Design Heat Loss at -17.2 C = 10.94 Watts/m3	=	3756. Watts
Gross Space Heating Load	=	25680. MJ
Sensible Daily Heat Gain From Occupants	=	2.40 kWh/day
Usable Internal Gains	=	17016. MJ
Usable Internal Gains Fraction	=	66.3 %
Usable Solar Gains	=	3263. MJ
Usable Solar Gains Fraction	=	12.7 %
Ventilation Equipment Electrical Contribution	=	988. MJ
Auxiliary Energy Required	=	5401. MJ
Space Heating System Load	=	5401. MJ
Heat Pump and Furnace Annual COP	=	2.267
Heat Pump Annual Energy Consumption	=	1930. MJ
Furnace/Boiler Annual Energy Consumption	=	100. MJ
Annual Space Heating Energy Consumption	=	2030. MJ

*** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY Water Heating Fuel : Electricity
Water Heating Equipment : Electric tank

Manufacturer :
Model :
Tank Capacity = 136.0 Litres
Seasonal Efficiency = 93.0 %

*** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

Daily Hot Water Consumption = 186.0 Litres /day
Estimated Domestic Water Heating Load = 13502. MJ

PRIMARY Domestic Water Heating Energy Consumption = 14518. MJ

*** LIGHTING AND APPLIANCES SUMMARY ***

Total Electrical Load = 16.0 kWh/day
Average External Electrical Load = .0 kWh/day
Total Annual Energy Consumption = 5840. kWh

*** FAN OPERATION SUMMARY (kWh) ***

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	548.7	98.0	.0
Neither	55.8	.0	.0
Cooling	.0	.0	.0
Total	604.4	98.0	.0

*** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption	=	2030. MJ =	563.8 kWh
Ventilator Electrical Consumption: Heating Hours	=	1975. MJ =	548.7 kWh
Estimated Annual DHW Heating Energy Consumption	=	14518. MJ =	4032.9 kWh
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	=	18523. MJ =	5145.4 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET	=	39336. MJ =	10926.8 kWh
Estimated Annual Base Electrical Energy Consumption	=	21024. MJ =	5840.0 kWh
Ventilator Electrical Consumption: Non Heating Hours	=	201. MJ =	55.8 kWh

*** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel	Space Heating	Space Cooling	DHW Heating	Appliances	Total
Electricity (kWh)	1210.5	.0	4032.9	5895.8	11139.1

****

Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

The calculated heat losses and energy consumptions are only estimates, based upon the data entered and assumptions within the program. Actual energy consumption and heat losses will be influenced by construction practices, localized weather, equipment characteristics and the lifestyle of the occupants.

```
**************************************
*                                    *
*              Hot2000               *
*            Version 6.02            *
*               CANMET               *
*  Energy, Mines and Resources CANADA *
*            July 1, 1991            *
*                                    *
**************************************
```

House Data Filename=C:\H2K\USER\HAMXS2.HDF

Weather Data is for TORONTO, ONTARIO

Builder Code =Zsolt Data Entry by:jaz

Client name:	Hamlet Co-x		
Street address:	Unit Type D		
City:	Toronto Area	Region:	
Postal code:		Telephone:	

*** GENERAL HOUSE CHARACTERISTICS ***

House type:	Duplex
Number of storeys:	Two storeys
Wall construction:	Double stud wall

SOIL TYPE: Normal Conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (B) Wood frame construction, 50 mm gyproc walls
25 mm gyproc ceiling, wooden floor

Occupants : 2 Adults for 50.0 % of the time
2 Children for 50.0 % of the time

*** HOUSE TEMPERATURES ***

Heating Temperatures	Main Floor	= 21.0 C
	Basement	= 18.0 C
	Crawl Space	= 15.0 C
	Calculated Crawl Space	= 16.3 C
	TEMP. Swing from 21.0 C	= 3.5 C

*** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

Foundation Construction	Attachment Sides	Insulation Placement
Closed Crawl Space	1 Side	On Grade
Full Basement	1 Side	Exterior

*** WINDOW CHARACTERISTICS ***

Direction	Seq #	Location Code	# of Windows	Type	Window Width m	Window Height m	OverHang Width m	Header Height m	SHGC
South	1	M3	5	233212	1.000	.910	.600	.000	.5117
	2	B3	2	233212	.600	.450	.000	.000	.3623
Southeast	1	M4	2	233212	.600	.910	.000	.000	.4521
North	1	M2	4	333212	.600	.910	.000	.000	.4069

*** WINDOW PARAMETER CODES SCHEDULE ***

	Code	Description (Glazings, Coatings, Fill, Spacer, Type, Frame)
1	233212	Double (DG), Low-E .35(Hard2), 13 mm Argon, Insulating, Hinged, Wood
2	333212	Triple (TG), Low-E .35(Hard2), 13 mm Argon, Insulating, Hinged, Wood

*** USER DEFINED WINDOW CODES SCHEDULE ***

	Code	Description	R-value RSI	Solar Heat Gain Coefficient
1	OB		.00	.000

*** BUILDING PARAMETERS ***

Component		Area (m2) Gross	Net	RSI	Heat Loss MJ	% Annual Heat Loss
Above Grade Components						
Ceiling						
C1		46.40	46.40	7.61		
C2		12.00	12.00	7.61		
	TOTAL:	58.40	58.40	7.61	3348.5	10.76
Main Walls						
M1		8.75	8.75	8.90		
M2		24.33	20.35	8.90		
M3		24.33	19.78	8.90		
M4		8.75	5.86	8.90		
M5		20.12	20.12	8.90		
M6		4.37	4.37	8.90		
M7		4.37	4.37	8.90		
M8		10.65	10.65	8.90		
M9		7.22	7.22	8.90		
M10		3.00	3.00	8.90		
	TOTAL:	115.89	104.46	8.90	4761.3	15.29

Component		Area (m2) Gross	Net	RSI	Heat Loss MJ	% Annual Heat Loss
Doors						
D1	Location: M2	1.80	1.80	.53		
D2	M4	1.80	1.80	.53		
	TOTAL:	3.60	3.60	.53	2963.8	9.52
Basement walls above grade						
B1		1.05	1.05	6.62		
B2		2.92	2.92	6.62		
B3		2.92	2.38	6.62		
B4		1.05	1.05	6.62		
B5		1.10	1.10	6.62		
B6		.36	.36	6.62		
	TOTAL:	9.40	8.86	6.62	475.9	1.53
Crawl Space Area						
Crawl space wall area						
		1.59		6.60		
		1.59		6.60		
		3.87		6.60		
		2.62		6.60		
	TOTAL:	9.67		6.60	489.5	1.57
Perimeter area (1 M or 3.3 Ft wide)						
		10.65		3.68		
	TOTAL:	10.65		3.68	335.4	1.08
Centre area						
		1.35		3.68		
	TOTAL:	1.35		3.68	34.4	.11
Full Basement Area						
Upper Basement Walls						
		1.05		6.57		
		2.92		6.57		
		2.92		6.57		
		1.05		6.57		
		1.09		6.57		
		.36		6.57		
	TOTAL:	9.39		6.57	265.0	.85
Lower basement walls						
		2.10		6.57		
		5.84		6.57		
		5.84		6.57		
		2.10		6.57		
		2.19		6.57		
		.72		6.57		
	TOTAL:	18.79		6.57	1429.7	4.59

Component		Area (m2) Gross	Net	RSI	Heat Loss MJ	% Annual Heat Loss
Perimeter area						
		13.10		3.68		
	TOTAL:	13.10		3.68	1137.9	3.66
Centre area						
		33.30		3.68		
	TOTAL:	33.30		3.68	906.8	2.91

WINDOWS

Orientation Location	Number	Type (Code)	Total Area(m2)	RSI Window	(Shutter)	Heat Loss MJ	% Annual Heat Loss
South							
M3	5	233212	4.55	.48	(.20)		
B3	2	233212	.54	.47	(.20)		
TOTAL:			5.09	.47	(.20)	3915.8	12.58
Southeast							
M4	2	233212	1.09	.47	(.20)		
TOTAL:			1.09	.47	(.20)	843.5	2.71
North							
M2	4	333212	2.18	.64	(.20)		
TOTAL:			2.18	.64	(.20)	1294.2	4.16

Ventilation

House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
379.36 m3	.44 ACH	8930.6	28.69

*** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area = 279.9 m2
Air Tightness Level is Energy tight (1.5 ACH @50 Pa.)
Building Envelope is NOT Sheltered from the Wind.
Estimated Equivalent Leakage Area = 200.9 cm2
Normalized Leakage Area = .7178 cm2/m2
Estimated Airflow to cause a 5 Pa Pressure Difference = 13 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference = 20 L/s
ELA used to calculate Estimated Airflows = 80.4 cm2

F-326 VENTILATION REQUIREMENTS:

Kitchen,living,dining:	3 rooms @ 5 L/s	= 15 L/s
Bedrooms:	1 rooms @ 10 L/s	= 10 L/s
Bathrooms:	1 rooms @ 5 L/s	= 5 L/s
Basement Rooms:		10 L/s

F-326 Required continuous ventilation rate = 40.0 L/s (.39 ACH)
Average Ventilation Supply Rate (Balanced) = 40.0 L/s (.39 ACH)

Ventilation System: Heat recovery ventilator (HRV)
Manufacturer: Vanee
Model Number: 1000VLDE

Fan and Preheater Power at .0 C	= 69. Watts
Fan and Preheater Power at -25.0 C	= 69. Watts
PreHeater Capacity:	= 0. Watts
Sensible Heat Recovery Efficiency at .0 C	= 67. %
Sensible Heat Recovery Efficiency at -25.0 C	= 58. %
Total Heat Recovery Efficiency in Cooling mode	= 19. %

Low Temperature Ventilation Reduction = 4. %
Low Temperature Ventilation Reduction: Airflow Adjustment= 0 L/s (.3 %

NO Vented combustion appliance specified

Gross Air Leakage and Ventilation Energy Load	= 24591.3 MJ
Seasonal Heat Recovery Ventilator Efficiency	= 65.8 %
Estimated Ventilation Electrical Load: Heating Hours	= 1975.2 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours	= 200.8 MJ
Net Air Leakage and Ventilation Energy Load	= 9918.2 MJ

*** SPACE HEATING SYSTEM ***

PRIMARY Space Heating Fuel : Electricity
Space Heating Equipment : Ground Source Heat Pump

Manufacturer : CANADIAN GEOSOLAR
Model : 1500

Capacity at 8.3 C	= 5.5 kW
COP at 8.3 C	= 3.10
Crankcase Heater Power	= 1.0 watts
Heat Pump Temperature Cut-Off	: Unrestricted Cut-Off

SECONDARY Heating Fuel : Electricity
Equipment : Forced air furnace
Manufacturer :
Model :
Output Capacity = 5.5 kW

Steady State Efficiency = 100.0 %

Fan Mode : Auto Fan Power 373. watts

*** ANNUAL SPACE HEATING SUMMARY ***

Design Heat Loss at -17.2 C = 11.32 Watts/m3 = 4293. Watts

Gross Space Heating Load	= 31132. MJ
Sensible Daily Heat Gain From Occupants	= 2.40 kWh/day
Usable Internal Gains	= 18218. MJ
Usable Internal Gains Fraction	= 58.5 %
Usable Solar Gains	= 4507. MJ
Usable Solar Gains Fraction	= 14.5 %
Ventilation Equipment Electrical Contribution	= 988. MJ
Auxiliary Energy Required	= 8408. MJ
Space Heating System Load	= 8408. MJ
Heat Pump and Furnace Annual COP	= 2.292
Heat Pump Annual Energy Consumption	= 2986. MJ
Furnace/Boiler Annual Energy Consumption	= 133. MJ
Annual Space Heating Energy Consumption	= 3119. MJ

*** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY Water Heating Fuel : Electricity
Water Heating Equipment : Electric tank

Manufacturer :
Model :
Tank Capacity = 136.0 Litres
Seasonal Efficiency = 93.0 %

*** ANNUAL DOMESTIC WATER HEATING SUMMARY ***

Daily Hot Water Consumption	= 186.0 Litres /day
Estimated Domestic Water Heating Load	= 13502. MJ
PRIMARY Domestic Water Heating Energy Consumption	= 14518. MJ

*** LIGHTING AND APPLIANCES SUMMARY ***

Total Electrical Load	= 16.0 kWh/day
Average External Electrical Load	= .0 kWh/day
Total Annual Energy Consumption	= 5840. kWh

*** FAN OPERATION SUMMARY (kWh) ***

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	548.7	152.6	.0
Neither	55.8	.0	.0
Cooling	.0	.0	.0
Total	604.4	152.6	.0

*** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption	=	3119.	MJ =	866.3	kWh
Ventilator Electrical Consumption: Heating Hours	=	1975.	MJ =	548.7	kWh
Estimated Annual DHW Heating Energy Consumption	=	14518.	MJ =	4032.9	kWh
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	=	19612.	MJ =	5447.9	kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET	=	41535.	MJ =	11537.6	kWh
Estimated Annual Base Electrical Energy Consumption	=	21024.	MJ =	5840.0	kWh
Ventilator Electrical Consumption: Non Heating Hours	=	201.	MJ =	55.8	kWh

*** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel	Space Heating	Space Cooling	DHW Heating	Appliances	Total
Electricity (kWh)	1567.5	.0	4032.9	5895.8	11496.2

****

Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

The calculated heat losses and energy consumptions are only estimates, based upon the data entered and assumptions within the program. Actual energy consumption and heat losses will be influenced by construction practices, localized weather, equipment characteristics and the lifestyle of the occupants.

ZSOLT & ASSOCIATES LIMITED

HAMLET CO-X
RSI values Residences

Slab on Grade (Basements)		RSI
- Horizontal Air Film		.03
- 19mm Wood Flooring		02
- 19mm Air Space		.03
- 152mm Concrete Slab		087
- 102mm Polystyrene		3 52
	Total	**3.68**

Below Grade Foundation Wall		
- 51mm Polystyrene		1.76
- 190mm Core Insulated Conc. Block		81
- 152mm Batt Insulation		3 8
- 13mm G.W B.		08
- Inside Air Film		12
	Total	**6.57**

Above Grade Foundation Wall		
- Outside Air Film		.03
- 13mm Sand Plaster		.02
- 51mm Polystyrene		1.76
- 190mm Core Insulated Conc Block		.81
- 89mm Batt Insulation		3.8
- 13mm G.W.B.		08
- Inside Air Film		.12
	Total	**6.62**

Exterior Wall		
- Outside Air Film		.03
- 19mm Wood Siding		.18
- 13mm Plywood Sheathing		.11
- 2x4 Stud Wall, 89mm Batt Insulation		2.3
- 6" Space, 152mm Batt Insulation		3.8
- 2x4 Stud Wall, 89mm Batt Insulation		2.3
- 13mm G W B.		.08
- Inside Air Film		.12
	Total	**8.9**

Ceiling		
- Horizontal Air Film		03
- 13mm G.W B.		08
- 305mm Batt Insulation		7.5
	Total	**7.61**

APPENDIX B

CMHC Report.

CONCERNING THE HEATING, COOLING & VENTILATION OF CLUSTER HOMES.

<u>Position Taken.</u>

The use of a central ground/water source heat pump to service the space heating needs of 28 - 30 homes as described in the data sent to me, and from your verbal description, does not in my opinion provide optimum coverage of the needs of the Condominium. My reasons are as follows:

1...The design heat loss, as indicated by the Hot2000 analytical print out, varies from 12,000 to 16,000 btu per hour, credits from occupants, (passive solar gain etc. notwithstanding), and I suggest that a margin for both weather aberrations and error should be included in any design allowance for the heating of the homes. This will mean, if original plan is followed, the provision of four ten Ton or eight five Ton Heat Pumps. If the former is used, three phase, 208 or 550 volt power will be required. Whilst the latter can operate on a single phase, 220 volt supply, my experience rules against the use a five ton motor compressor (five Horse Power, in this instance) on single phase power. It must be noted that alternating current induction motors have an inherently low starting torque, and all require a so called rotating magnetic field to operate.

A three phase supply provides this by virtue of the displacement between the phases. For single phase operation it is created via the use of capacitors, but in a less efficacious manner. The inrush current for such a motor is (comparatively) very high, moreover Rural Power Supplies are more prone to voltage variations, all in all resulting in a climate for a much higher than needed potential for major component failure.

2...The temperature of the water leaving the heat exchanger of a ground source heat pump is not high, probably below 120^{o}F., and it is reasonable to believe that despite excellent

insulation levels on the piping, the length of the runs will lead to an unacceptable drop in the delivered temperature, far below a usable level. Too low for either space heating or for domestic hot water without some form of additional energy use.

3...This means that in effect no provision has been made for the supply of domestic hot water, except perhaps by an implied use of conventional electrically powered water heaters

4...The failure of one large unit, serving a number of dwellings, has to my mind, an obviously negative connotation. I will qualify this as follows. From a Societal or Humanistic point of view, and adopting the premise that a unit is one electro-mechanical device, the failure of a large version of same supplying 5 to 7 homes, meaning 5 to 7 families, or perhaps 10 to 15 people has a greater impact than the failure of an individual unit serving one home, of perhaps 3 people. I couple this to the information provided earlier concerning the statistically supported failure rate of large single phase motors in a rural setting, and add that few servicing contractors, or indeed, Wholesalers, carry stock of 5 ton Motor Compressors, which reinforces my stated point of view. I do feel that the instance of the first motor - compressor failure is the wrong time to become acquainted with a number of irate home owners/occupants!

Especially when I believe such a confrontation can be avoided.

5...My understanding of the plan as written in the draft sent to me, does not make provision for summer energy recovery, for no mention of domestic water heating is made, neither is air conditioning. The two functions can complement each other.

6...If my recommendations listed below are followed, air conditioning will form an ipso facto component of the overall package, moreover the reclaimation of energy from the air conditioning function will be a reality. A brief explanation of this claim, together with my version of an annualized approach to the provision of same and the associated cost to do so, follows.

Using the figure quoted by you, and originating with Ontario Hydro, which suggests an annual usage of 4,033 KW per annum for water heating, or an expenditure of 13,764,629 btu per (average) home, or 11 KW and 37,711 btu/day, I will rationalize as follows:
A 1.5 ton heat pump, of the type proposed for use in the project should have available for total heating, approx 23,000 btu per hour, of this total approx 35% is in the form of superheat, an amount subscibed to by the electrical heat of the motor, the heat of compression and friction.
It is this heat which may be used to contribute towards the domestic water heating, with a majority balance going to space heating.
The breakdown 35/65 is 8,000 to 15,000 btu/hr. With 8,000 available for the pupose under discussion.
One can therefore theorize that the unit will need to run 37711/8000 or 4.7 hours per day to provide hot water, on average, the year round. Albeit at a temperature too low to use in a Dish Washer, for instance, and to remedy this, some extra heat is required.
From the electrical consumption, and taking the specific heat of water as unity, and with a gallon of water weighing 10lb. (Imperial Gallon) we can calculate the volume of water used by this average household.I will use 38,000 btu or a nom. 11 KW/day as a base set of figures. The final water temperature is 145^{O}F. Incoming water @ 50^{O}F. The volume of water will be proportional to: 38000/(145-50)x10 or 40 gallons. Inasmuch as the heat pump can raise the water temperature to 110^{O}F it can contribute as I have noted, energy in the gross amount of 8,000x4.7 or 37,600 btus. Or 11 KW. Co-incidentally the required gross amount. However, the temperature of the water is too low to be of practical use ex the heat pump, and the energy needed to boost the temperature to a usable level must be considered. This will amount to a figure proportional to: (145-110)x40x10 or 14,000 btu/day, or 4.1 KW. As this will replace some of the heat pump energy, it is reasonable to conclude that the heat pump will contribute 11-4.1 or 6.9 KW of the daily load. It was this calculation that I did in my head during one of our telephone conversations.

The only consideration yet to be taken into account is the run time of the heat pump IF it is to be taken as coincident with a call for heating or cooling. Short of tabulating the bin records for the particular geographical area it is hard to pinpoint those times when either heating or cooling would not be required. However it is possible to dedicate the heat pump output to water heating alone, using appropriate controls and in cooperation with Geo Thermal

The accompanying sketch AE609a provides a piping diagram showing the arrangement within the heat pump and the inter-connection of the two tanks as called for below.

All of the foregoing is addressed in the following expression of my preferences in regards to the selection of equipment, and the method of utilization of same. viz:

Item #1...1 pc. Geo Thermal Model 1500 W/S heat pump. In EACH residence.

Item #2...1 pc. vanEE Model 1000 VLDH Energy recovery Ventilator.

Item #3...1 pc. 30 (or 40) Gallon Water Tank, non powered.

Item #4...1 pc. 30 (or 40) Gallon Water Tank, c/w electrical element.

The diagram, which is based upon data published by Geo Thermal, indicates the creation of thermosyphonic circulation within the non heated tank, and the desuperheater, thus heating the water to a temperature commensurate with the discharge temperature of the compressor. If, as and when water is drawn from the system, make up water enters at the bottom of the same tank.The water drawn, exits to the faucet from the heated tank, at a (normal) usable temperature. In my example, 145^{o}F.

I trust that this information is without ambiguity, but if any clarification is needed please call or fax,

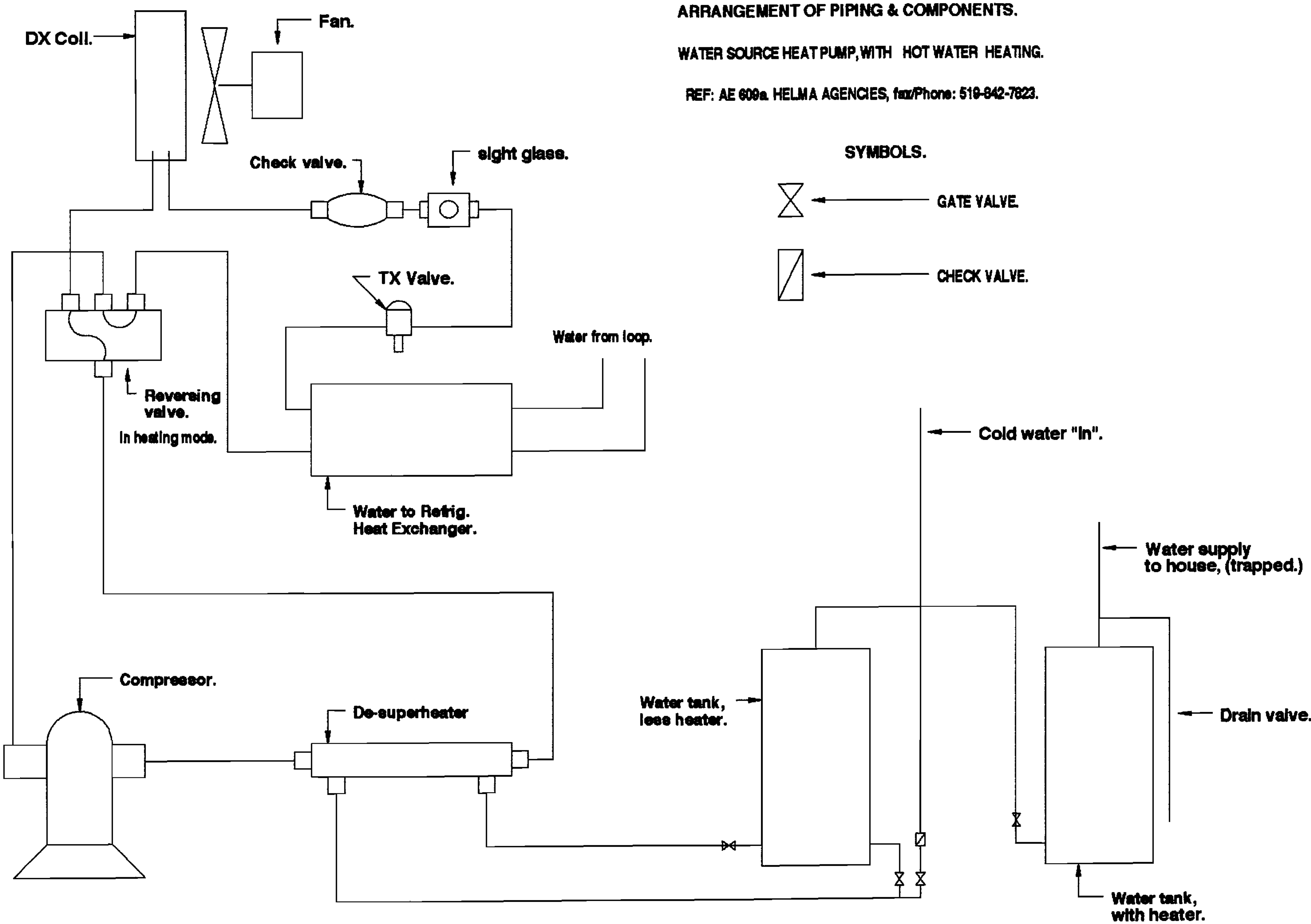
yours very truly,

William W. Maddock.

ARRANGEMENT OF PIPING & COMPONENTS.

WATER SOURCE HEAT PUMP, WITH HOT WATER HEATING.

REF: AE 609a. HELMA AGENCIES, fax/Phone: 519-842-7823.



CANADIAN GEO-SOLAR
Box 249, 640 Gartshore Street,
Fergus, Ontario N1M 2W8

CANADIAN Geo Solar

GROUND & WATER SOURCE HEAT PUMPS

Bus: (519) 843-3393
Fax: (519) 843-6944

Wednesday, March 30, 1994

Mr. John Zsolt,
Zsolt & Associates
7 Fraser Avenue, Studio 11
Toronto, Ontario
M6K 1Y7

Dear Mr. Zsolt,

Thank you for the opportunity to assist in designing the geothermal heating and cooling system for the CMHC External Research Program *'HAMLET CO-X'*.

The installation of ***CANADIAN GEO-SOLAR*** *Ground Source Heat Pumps* in a compact community like *HAMLET CO-X* is certainly advantageous for the all involved: homeowners, neighbours, the utility company and the environment. We look forward to working with you on this and future projects.

Sincerely,

Jeff Markle,
Vice President

MADE IN CANADA FABRIQUÉ AU CANADA

Mr. John Zsolt,
Zsolt and Associates Limited

Project: Communal Heating & Cooling
Hamlet CO-X

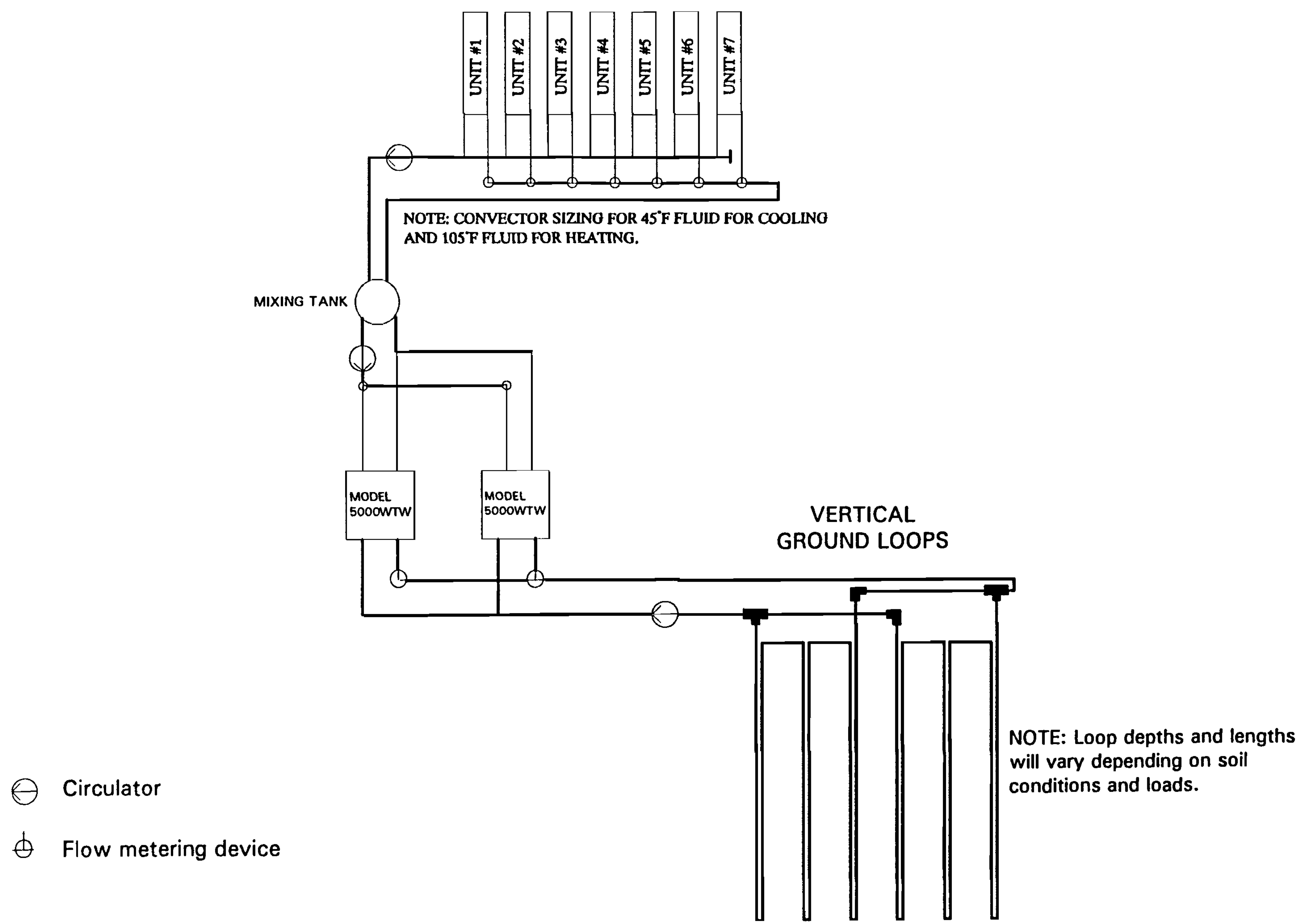
Estimated System Costing
For Each Wing of Hamlet CO-X

CMHC External Research Program

Two model 5000 WTW heat pumps @ $5145.00	$10290.00
Two circulators	1000.00
Two flow meters	300.00
One 100 gal. mixing tank	600.00
Vertical loop 1335 feet of bore hole	10000.00
Excavation	1500.00
Antifreeze	300.00
Labour	2500.00
Distribution piping	3700.00
Total	$30190.00

Note: Air handlers are not included.

HAMLET CO-X
COMMUNAL HEATING AND COOLING



AER-O-FLO ENVIRONMENTAL INC.
"Your Environmental Solution Company"

1175 Appleby Line, Unit B-2
BURLINGTON, ONTARIO, CANADA L7L 5H9
Phone (905) 335-8944
Fax (905) 335-8972

December 06, 1993

Mr. John Zsolt
Zsolt & Associates Limited
Environmental Design and Planning
Suite 11
7 Fraser Avenue
Toronto, Ontario
M6K 1Y7

Dear John,

RE: CMHC - SEQUENCING BATCH REACTOR CONSIDERATIONS

I apologize for the delay in getting a response back to you.

We have reviewed the documentation you have provided and the description of the hamlet and, therefore, the treatment system that would be required for this type of an application.

In our review of the commercial viability of sequencing batch reactors, we have noted that systems can easily be developed technically for projects of this size. A problem would occur, however, when the commercial side of this is pursued. Sequencing batch reactors do not seem to competitively priced compared to other conventional carbonaceous BOD removal systems down at this low level of flows.

Typically, any SBR below 50,000 USGPD would not see any significant change in price, as the components necessary for the operation of an SBR do not change very much in size and since you still need one of everything, there is no major change in price unless a sacrifice is made in terms of quality of the materials for the system.

Preliminary designs have been developed for other such application. These were not considered viable due to the costs associated with the systems. We have always advocated that for denitrification and biological phosphorous removal, there is nothing superior to a sequencing batch reactor, specifically our own CASS Cyclic Activated Sludge System Design. This design is the culmination of 20 years of research and development with the standard operational protocols that were originally written into the text books. Full scale operational use of every type of aerator, decanter, and operational protocol has lead to the developments of patented, proven, optimized methodologies and devices that allow us to deliver a superior performance, a simplified operation, and the confidence of a secure and positive treatment system.

Over the years, we have noted that there is demand for this type of treatment on these smaller applications. It CAN be done. The commercial aspect of this, again, is the limiting factor.

For this scale of system, we have not been able to identify how we can reduce the cost to make it more attractive to the end user. We are not willing to sacrifice in materials, as we do not believe that this is a positive effort in any way. It would be a temporary "false economy".

Pricing for pre-engineered plants for these types of applications is in the $300,000.00 (Canadian) ballpark. Should you wish to pursue these stringent requirements with an excellent technology we would very pleased to work with you and demonstrate our superior technology on your project.

We trust this report will be sufficient for your needs at this time. We would appreciate your comments and feedback and we look forward to speaking with you again. If we can be of further service, please call.

Yours truly,

AER-O-FLO ENVIRONMENTAL, INC.

GEORGE S. PASTORIC

GSP/es

OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

R JOHN OLIVER, B Sc , P Eng , F E I C
JOSEPH B MANGIONE, B Eng , P Eng , M C S C E
JOHN H McCALLA, B Eng , D I C , P Eng , M C S C E
WILLIAM H KERR, B Sc , P Eng
PAUL G WHITWILL, B Eng , P Eng , M C S C E
JOHN N SAWARNA, B A Sc , P Eng , M C S C E
D FARRELL McGOVERN, M Eng , P Eng
STEPHEN J PICHETTE, B A Sc , P Eng

December 3, 1993

Mr. John A. Zsolt, B.E.S., M.Arch
Zsolt & Associates Limited
Studio 11, 7 Fraser Avenue
Toronto, Ontario
M6K 1Y7

Re: Peat Sewage Disposal Systems
CMHC Evaluation Alternative Waste Water Treatment Systems

Dear Mr. Zsolt:

Further to your correspondence to Dr. Joan Brooks dated September 16, 1993, we are pleased to provide the following information with respect to peat on-site sewage systems to serve a proposed 30 unit townhouse development. It is understood that the projected daily flows from the development are 15,000 L/day. It is assumed that the total development would be serviced by one sewage treatment system.

For your information, on-site peat sewage systems are constructed and operate in a similar manner to conventional septic tank/leaching field systems such as those permitted under existing Ontario Regulation 374/81. Sewage is treated in a conventional septic tank, the effluent which is directed to the peat leaching field by gravity or alternatively dosed with the use of pumps. The leaching field is similar to a conventional system with the exception that peat is used in place of sand as a treatment medium.

With respect to the cost for construction, it is our experience that it varies from area to area dependant upon the experience and confidence of local contractors. On the basis of eleven systems constructed to date in Ontario, the per unit cost ranges from approximately $7.70 to $12.00 per litre. This is for the complete system including septic tank pumping systems and leaching field. For a 15,000 L/day system, the estimated cost would range from $115,000 to $180,000.

The area requirements of a peat leaching bed are similar to that for conventional septic tank leaching field sewage disposal systems. For your information we estimate that the area required for a 15,000 L/day peat leaching bed is 2,000 m^2.

154 COLONNADE ROAD SOUTH, NEPEAN, ONTARIO, K2E 7J5

TELEPHONE (613) 225-9940
FAX No (613) 225-7337

There are essentially no energy requirements for operation of a gravity system. If effluent dosing pumps are used, the energy requirements would typically be that required to operate a 1/2 horsepower pump from any where from 90 to 120 minutes per day.

Yours very truly,

John A. McKee, M.Sc., P.Eng.
OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

JAM:mw

EEA ECOLOGICAL ENGINEERING ASSOCIATES
13 Marconi Lane, Marion, MA 02738 Tel. (508) 748-3224 Fax (508) 748-9740

John A. Zsolt
Zsolt & Associates Ltd.
Studio 11
7 Fraser Avenue
Toronto, Ontartio M6K 1Y7

20 January, 1994

416-516-9841
416-516-0316 fax

Dear Mr. Zsolt:

This is a response to your letter to John Todd dated September 13, 1993 and to your late October telephone conversation with Phillip C. Henderson of EEA.

I attach a description and some drawings for a complete Solar Aquatics™ wastewater treatment system which includes receiving, equalization, treatment, disinfection, sludge stabilization and sludge composting.

Please feel free to call next week with questions.

Sincerely,

Susan Peterson

Susan Peterson
President

**SOLAR AQUATICS SEWAGE TREATMENT SYSTEM
FOR CANADA MORTGAGE AND HOUSING CORPORATION
15 M3/DAY**

FROM

**ECOLOGICAL ENGINEERING ASSOCIATES
13 MARCONI LANE
MARION, MA 02738**

508-748-3224
508-748-9740 **FAX**

INTRODUCTION

Ecological Engineering Associates developed the Solar Aquatics technology because there is a clear demand for appropriate, cost effective, biological waste water treatment technology. From the 1960s through the 1980s, the cost of wastewater treatment rose while the technologies remained stagnant.

EEA's goal is to treat ALL of the contaminants in the wastewater, not just those currently regulated. A powerful, biological system such as Solar Aquatics™ uses a broad mixture of bacteria to degrade organic contaminants into carbon dioxide and water and sequester inorganic contaminants in known places in the process. The technology is consonant with the environment, mimicking, compressing, and enhancing processes of degradation which occur naturally.

Technology alone does not solve a community's problems related to wastewater treatment. The cost and siting Our costs are lower than competing technologies and our technology is attractive and effective; the treatment facilities are frequently visited by school and civic groups. Our goal is to educate the public about wastewater so that individuals can be aware of how their behavior at home and at work effects the environment. Paint thinner, cleaning fluid, lubricants and used oils poured down the drain do not disappear. With SAS technology, we degrade those contaminants, but for a conventional treatment facility, those contaminants will likely end up in the soil or the water or both.

EEA is in the clean water business and guarantees that effluent from the facility will meet the design specifications. EEA's operators know how to make our integrated biological systems work well under a wide range of temperature and weather conditions <u>and</u> to maintain a physically attractive environment for visitors.

TECHNICAL DESCRIPTION

The Solar Aquatics System (SAS) duplicates, under controlled conditions, the natural purification processes of fresh water streams, meadows and wetlands. Using greenhouses to enhance the growth of bacteria, algae, plants and fish, sewage flows through a series of clear-sided tanks, lagoons and constructed marshes where contaminants and/or nutrients are metabolized or bound up. Because of the small size of the facility, the sewage treatment process is sized for 4 days detention time within the greenhouse with 2 days capacity in the surge tank.

The SAS proposed here is designed to perform under these conditions:

Operating time: 24 hours/day, 7 days/week, 52 weeks/year
Total Flow of Wastewater: 15,000 liters per day average
Waste Characterization

BOD5	<300 mg/l
Total Suspended Solids	<300 mg/l
Total Nitrogen	< 45 mg/l
Total Phosphorus	< 10 mg/l

Effluent Discharge

	Effluent
BOD5	< 15 mg/l
Total Suspended Solids	< 15 mg/l
Total Nitrogen	< 5 mg/l
Total Phosphorus	< 5 mg/l
Fecal Coliform	< 100 counts/100 ml

Sludge (3% to 5% solids) production rate estimate: <.15 m3 per day

SYSTEM DESCRIPTION AND MAJOR COMPONENTS

Surge Tank

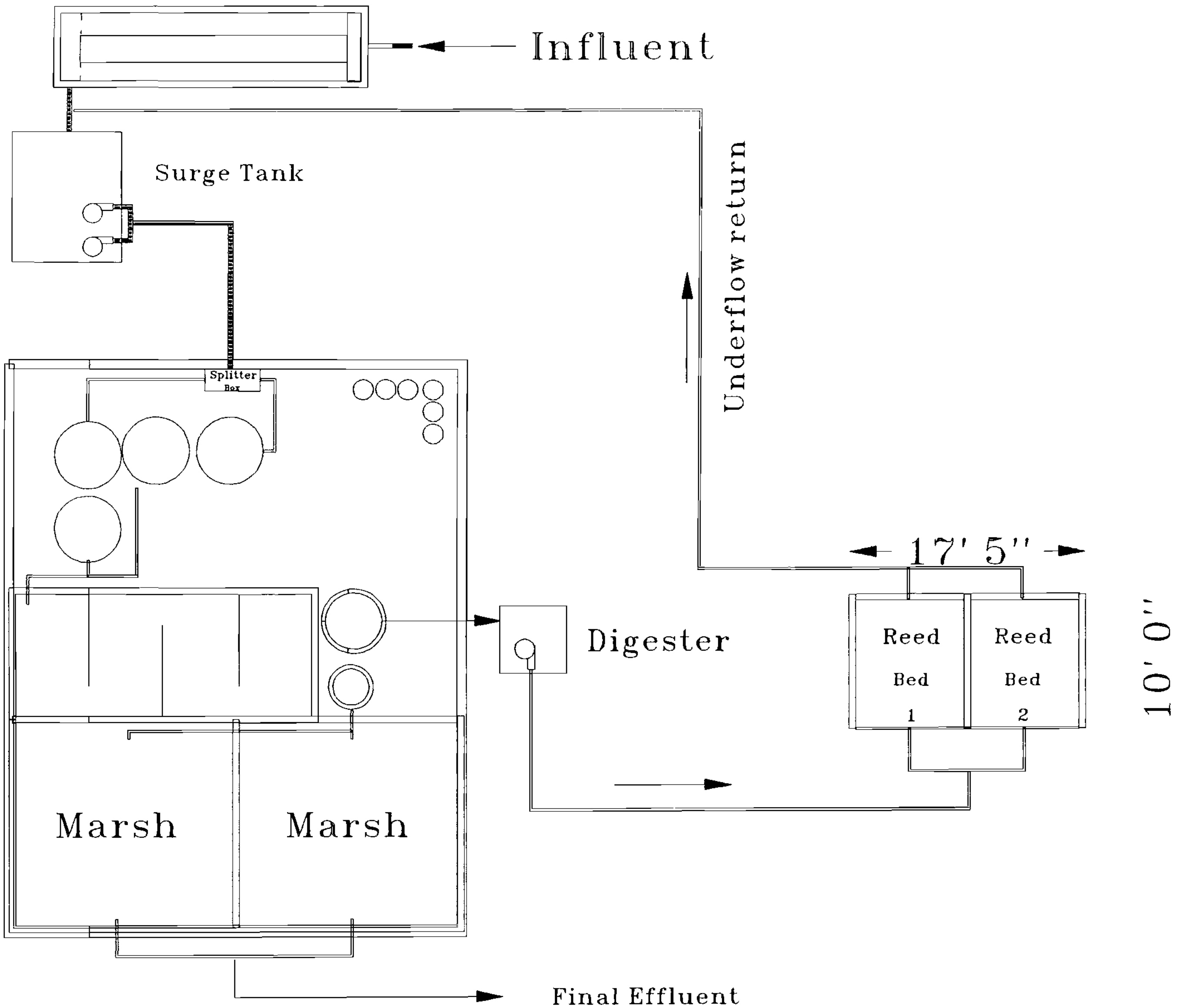
This tank is in-ground concrete tank with cover and a 2m x 2m hatchway. The tank is fitted with piping and aeration. The tank can be poured in place or purchased prefabricated in sections and assembled on site. The tank may be built above grade and landscaped around, but considerable heat loss would be anticipated.

Solar Silos

The Solar Silos are 1.75m high and 2m in diameter. They are clear-sided tanks, with flexible connecting piping and aeration systems. The tanks are planted with floating and racked vegetation and seeded with microorganisms, fish, and snails.

Solar Pond

The solar pond or aeration basin is 3 m deep, aerated and baffled. It is planted with similar materials to the solar silos.



13 MARCONI LN
MARION
MA 02738

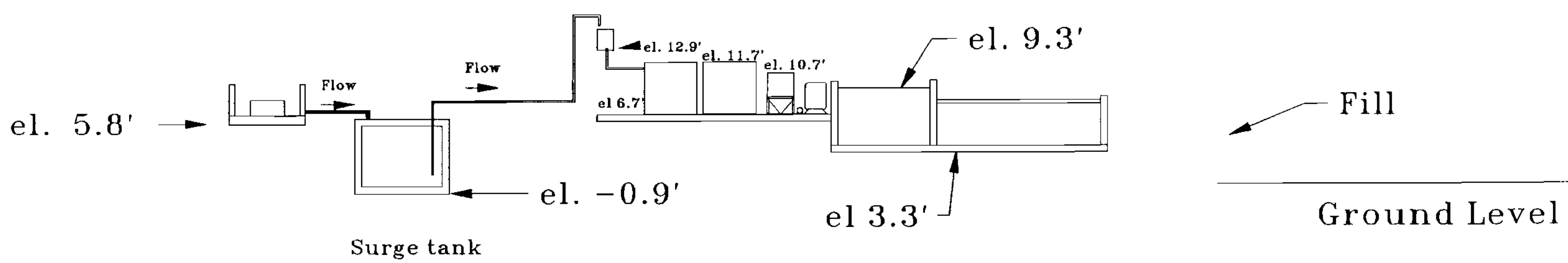
DRAWING NO. C–007

CMHC. Canada 14m x 10m

EEA
13 MARCONI LN
MARION
MA 02738

DRAWING NO. C-006

Hydraulic Profile, relative elevations



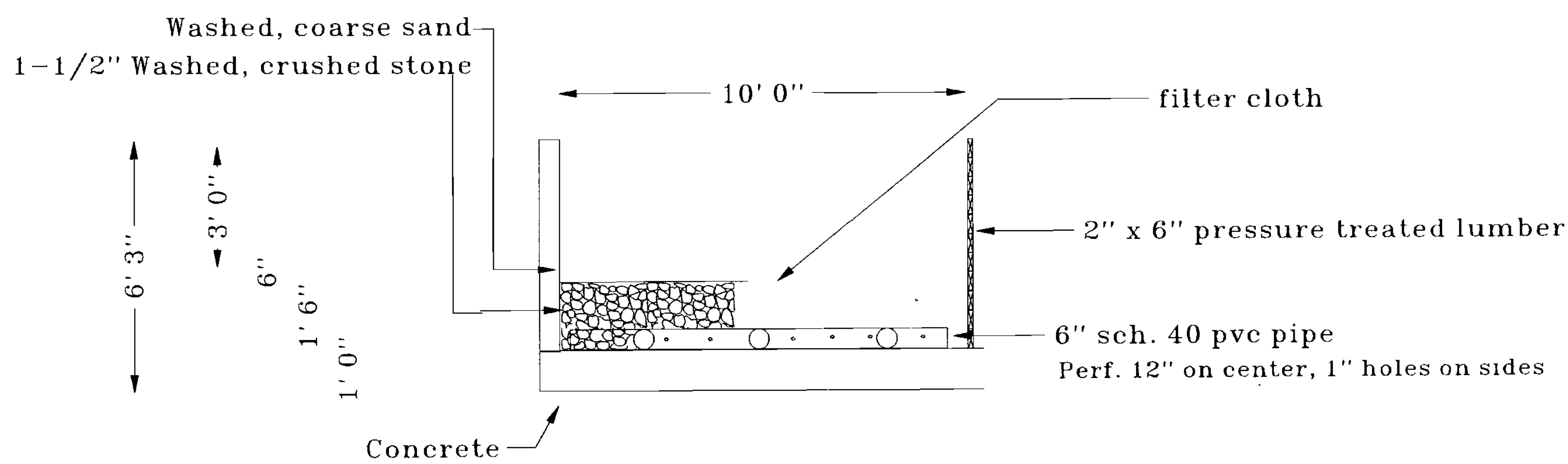
14m x 10m

CMHC, Canada

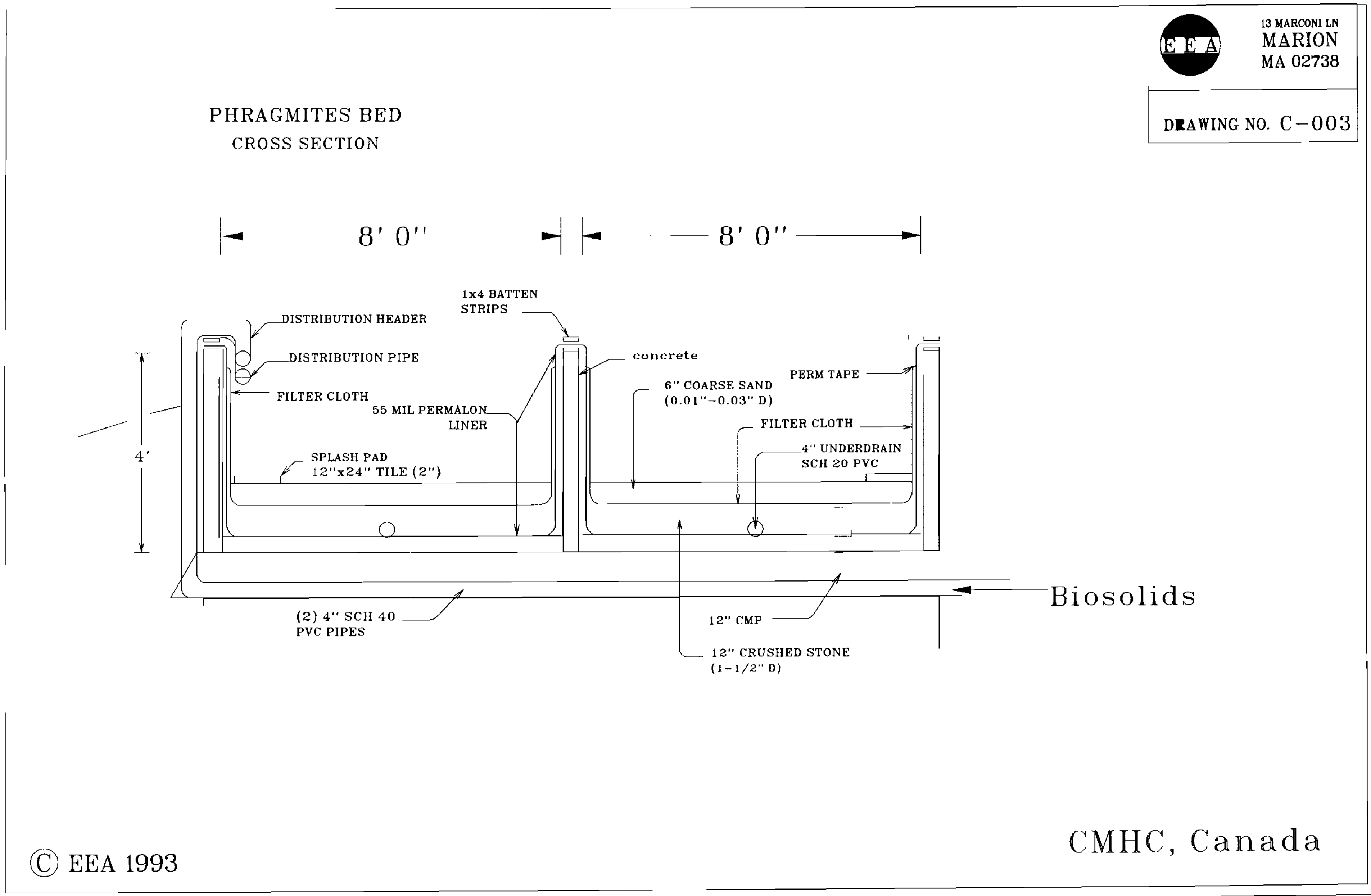
CMHC, Canada

13 MARCONI LN
MARION
MA 02738

DRAWING NO C-005

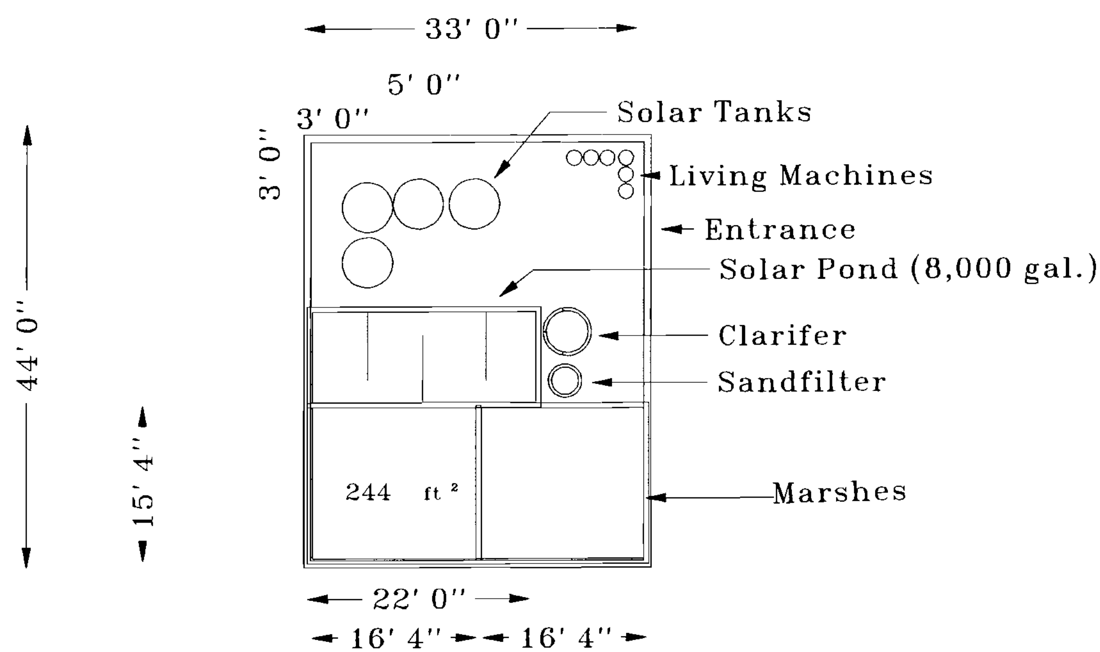


Phragmites Reed Bed
Midline Elevation


13 MARCONI LN
MARION
MA 02738
DRAWING NO. C–003
PHRAGMITES BED
CROSS SECTION
8' 0"
8' 0"
1x4 BATTEN STRIPS
DISTRIBUTION HEADER
DISTRIBUTION PIPE
FILTER CLOTH
55 MIL PERMALON LINER
concrete
6" COARSE SAND (0.01"–0.03" D)
PERM TAPE
FILTER CLOTH
4" UNDERDRAIN SCH 20 PVC
SPLASH PAD 12"x24" TILE (2")
4'
(2) 4" SCH 40 PVC PIPES
12" CMP
12" CRUSHED STONE (1-1/2" D)
Biosolids
CMHC, Canada

13 Marconi Ln
MARION
MA 02738

Drawing No. C-002



$1452\ ft^2$

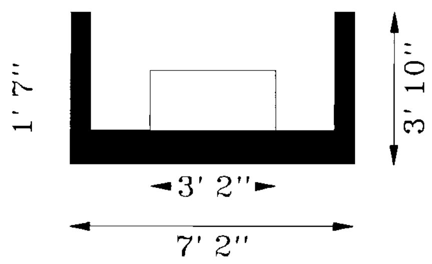
14m x 10m

CMHC, Canada

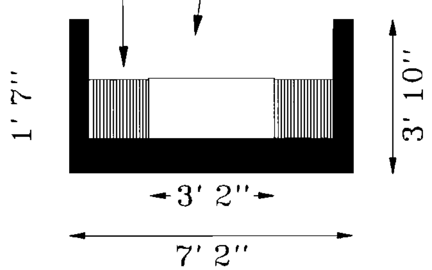
Grit Channel

13 MARCONI LN
MARION
MA 02738

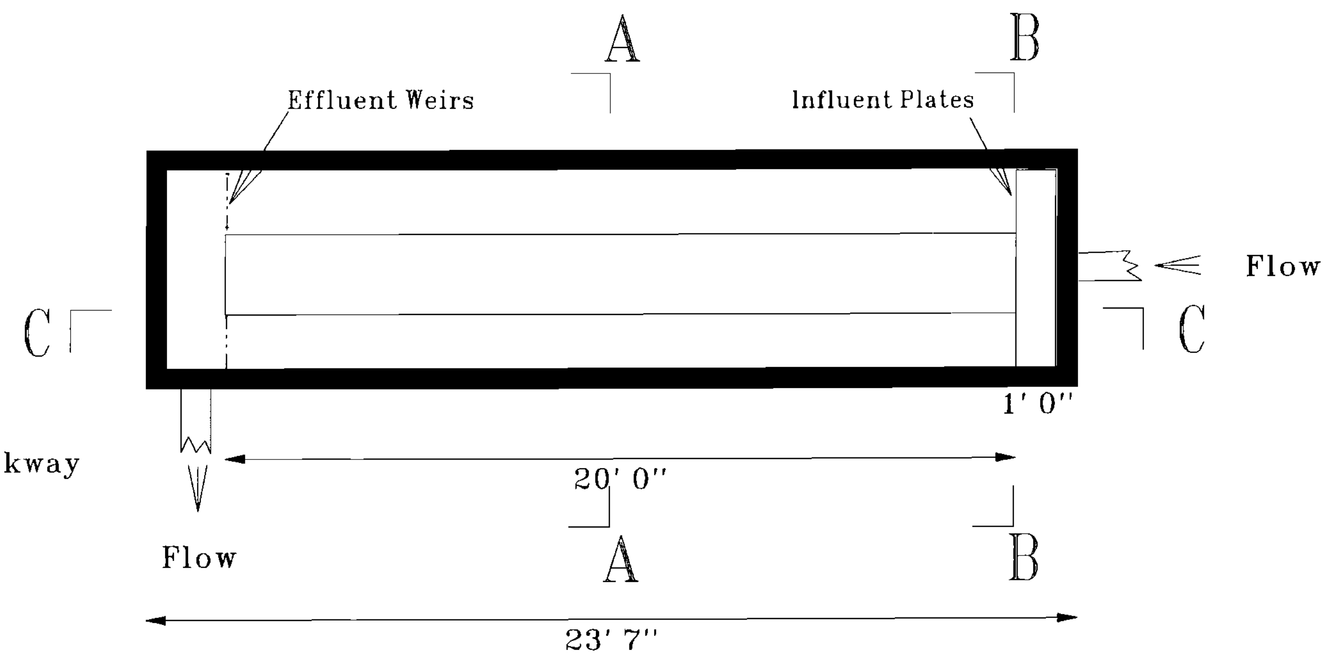
DRAWING NO C-001

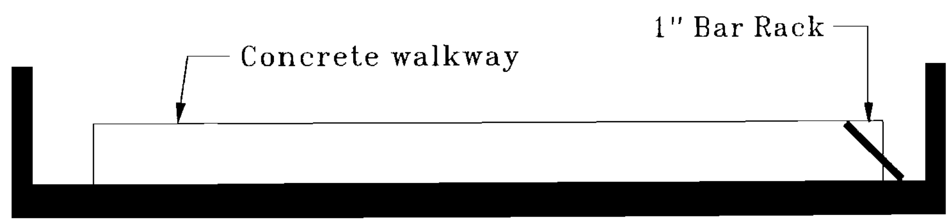


Sec. A–A



Sec. B–B





1 Foot

Sec. C–C

Process Equipment

Process equipment includes incubators, composting bins, flow meters, air meters, pumps, diffusers, headworks, piping and fittings, distribution weirs.

Electricals

Electricals include wiring, command & control, communications, outlets, lighting, and electrical board.

Biotic Components

Plants, animals, bacteria.

Disinfection

Ultraviolet light with extra bulbs

Lab Equipment

Meters, analytical testing equipment

Equipment Shed

The shed houses mechanical equipment, electrical board, and spare parts.

OPERATION AND MAINTENANCE REQUIREMENTS

O & M is divided into three basic categories: Physical plant maintenance including servicing mechanicals (oil, grease, clean, replace); Process maintenance including measuring and adjusting parameters within the system including dissolved oxygen, pH, temperature, alkalinity, vegetation density; and Water Quality sampling and testing. Operator attention required for the SAS is estimated, on average, at two hours per day, 7 days per week.

An O & M manual would be prepared and the operator trained by EEA. A High School diploma is the minimum educational background for an operator.

SAS are built with rugged, reliable components and with proper care the down time and need for replacement parts should be minimal. Recommended spare parts will be listed in the Operating Manual. Complete backup of all major mechanicals are included in the system design as they will likely be required by the permitting agency.

iss/CAN/ontzsolt/19i94

Clarifier

The clarifier is sized for 6 hours residence time at peak flows.

Sandfilter

The sandfilter is a commercial units adjacent to the clarifier and either can handle 100% of peak flows.

Marshes

The marsh is made up of two cells of the same size, each filled to a depth of 1.3m with 4 cm washed gravel and planted with a range of wetlands plants, grasses, and small shrubs. The wastewater enters the marsh subsurface and flows through the marsh with approximately 1+ days detention time. The area of the marsh is suitable for a commercial horticulture system using hanging baskets or potted plants.

Sludge Stabilization

The in-ground sludge stabilization tank is concrete, prefabricated, covered and aerated. The tank is piped to receive gravity thickened sludge from the clarifiers.

Sludge Composting

The stabilized sludges can be pumped to a segmented reed bed if on-site composting is desired. The reed bed is earth bermed, double lined, with an underdrain. The base is sand and gravel. As the reeds grow, they maintain a healthy environment for microbes which slowly compost the sludges. The materials in the bed typically are allowed to accumulate and compost for up to 5 years before being harvested for soil amendment.

Greenhouse

The greenhouse for sewage treatment is specified as a sturdy commercial structure of 375 m2 or 550 m2 with climate and operational control equipment. There are several greenhouse suppliers and designs from which the customer may choose. The greenhouse includes heating and ventilation systems to maintain winter temperatures above 10 degrees C.

Process Instrumentation Section

The facility could be controlled by DOS-based machines with greenhouse environmental management software. The system uses a 200 KHz datalink between the computer and the probes and controllers which obviates the need for direct control wiring. The system provides all controls, electrical switching and disconnects, climate control, and process monitoring.

Aeration

Blowers supply air to the system via manifolds. Diffusers in the Solar Silos and pond provide aeration and mixing; there are diffusers in the sludge and surge tanks.

APPENDIX C

Ideas

Rural Transformations: Residential Developments in the Hinterland of Toronto

John A. Zsolt

Southern Ontario witnessed unprecedented economic growth during the 1980s, with every sector of the regional economy experiencing significant change. Clearly, the epicentre of this boom was Toronto, and its explosive growth sent out waves that were felt throughout the entire region. The resultant shortage in housing was aggressively capitalized upon by the development industry. The number of new housing starts during this time surpassed any previous boom period of this century in Ontario. The small communities in the hinterland of Toronto did not escape the pressures of new development, being directly influenced by market forces both regional and local in origin. Detached from Toronto yet an integral part of its housing market, these communities continue to be in a state of transformation, caught between rural and urban existence.

Prior to the 1970s, the majority of residential development in Southern Ontario occurred on serviced land. The city and its satellite towns expanded into land that could be serviced through the existing infrastructure. Land was easily attainable and most development was confined to the defined limits of the urban municipalities. Other than the infringements that had already occurred, rural land was predominantly left untouched. In response to skyrocketing land costs, increased development restraints and a reduced amount of vacant urban land, developers began looking for other opportunities, which they found in rural municipalities. Slowly, small residential 'communities' began emerging throughout southern Ontario in farming districts outside of our urban centres. Unlike the community forms that existed in these areas, these new developments were modeled after the common suburban subdivision.

In the 1980s, this type of development became increasingly popular in rural districts throughout the greater Toronto area (GTA). Targeted to appeal to a principally middle income "exurban" group, these developments initially offered an affordable alternative to city living. With our culture indoctrinated into the North American ideal of owning a country property, city people were prepared to endure the hour long drive to work every day to own a 2500 sq. ft. house on a 1 acre lot. With many rural districts in southern Ontario in decline, most new developments met with little opposition and were often perceived as positive by local business people and politicians. Furthermore, many municipalities did not have a mandate through which to assess development; re-zoning decisions were made by the local municipal councils or, when consensus could not be met, legal action would be taken resulting in an Ontario Municipal Board ruling. The process was best described by a prominent rural politician as the "crisis management" approach to planning. The Region of York for example had no official plan to direct its growth during the 1980s. In that period, the population of the regions of Halton, York, Peel and Durham increased by one million people, a 50 percent increase.

Viewed on a regional level, the cumulative effect of decentralized development in the GTA is not well understood. With the recent formation of the Commission on Planning and Development Reform in Ontario chaired by former Toronto mayor, John Sewell, these issues are currently under review. However, the commission has put forth a series of guidelines for the future planning in this province that appear to display a general misunderstanding of significant key problems. An analysis of land development in Ontario should not be focused on regional issues alone; it requires a clearer understanding of the problems that effect local municipalities directly. Moreover, further planning policies should not be formulated without assessing the total effect on the local communities. Ideally, new development should be equally sustainable from social, economic and environmental perspectives.

For several years now, I have studied the problems associated with rural development at the community scale. Initially, my interests were directed in understanding how the forces of new development can transform a rural community. In the fall of 1989, Christel Burke and I conducted a study of the Ontario township of Scott as part of our graduate studies in human community at York University in Toronto (Figure 1). Holistic in scope, the study looked at many aspects of the township from its inception, revealing the multitude of problems these communities now face. This research continued throughout my thesis and has become part of a continuing body of work in sustainable community planning. In this paper, using Scott as a vehicle, some of the key issues that confront residential development in rural Ontario will be reviewed.

The Historical Township of Scott

As a political entity, the municipal township of Scott no longer exists. In 1973, as part of a major restructuring of municipalities in the GTA, the township came under the jurisdiction of the newly formed regional government of Durham and the expanded municipality of Uxbridge. Scott is now known to provincial archivists as a geographical township, a surveyed grid imposed on the countryside over 150 years ago. Situated 40 miles north-east of Toronto, Scott is an area within the "commutershed" that has experienced relatively little new development within the past 20 years. With only four small hamlets within its boundaries (Figure 2), it has remained predominantly rural in character with a strong

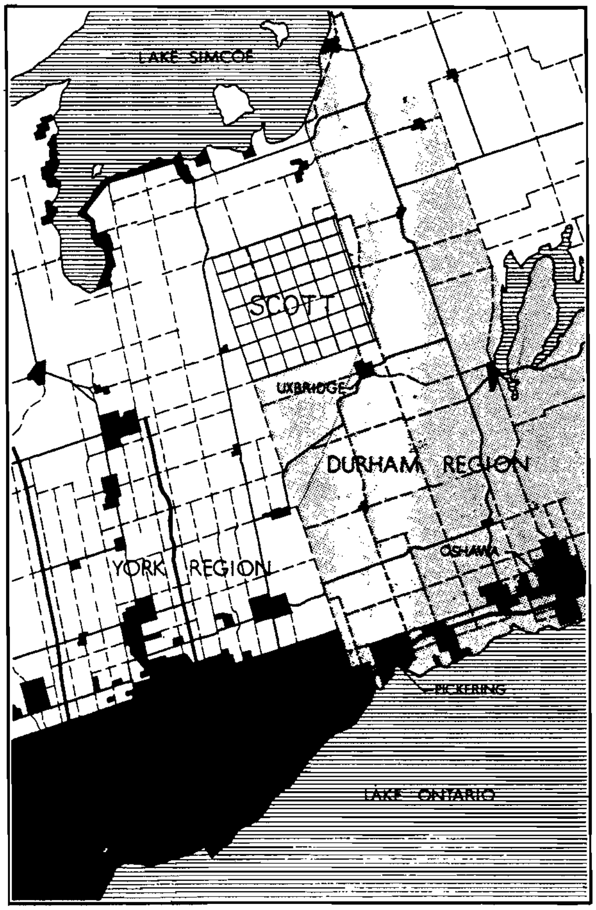


Figure 1: Scott and Surrounding Area

farming population. Given this, we had the opportunity to observe the forces affecting its change quite clearly. Situated in direct line for the next wave of development, we witnessed a community on the edge of a dramatic period of change.

At the turn of the century, Scott supported all forms of economic activity; manufacturing, mixed farming, and a diverse service industry. With full rail service, further centralization of manufacturing and eventually the advent of the automobile, many of the secondary and tertiary economic activities disappeared. Today, farming is the only significant economic activity in Scott and typical of farming activities within the GTA, is in decline. In 1989, for example, productive farms of 100 acres in size were sold for a market value of well over one million dollars to developers and foreign investors. Even though much of this land was not permitted to be developed under the existing municipal bylaws, it was purchased in anticipation that restrictions would be lifted in 10 to 20 years as development became more prevalent in the area. With farmers yielding to market pressures, increasingly vast tracks of Class 1 and 2 farm land were left unattended. Furthermore, with hobby or estate farms becoming more popular, land was often kept solely as horse pasture or left vacant. Renting land to local farmers was considered either undesirable or there was no one to farm it.

During the 1980s, the increase in property value was quite significant within the local housing sector. In 1989, the average value of a residential property in Scott exceeded $250,000. A highly picturesque terrain, relatively low density and a growing market for estate properties made Scott one of the most desirable rural districts in Ontario. These market forces lead to a process of gentrification within the old township. While statistically the population remained constant over the previous decade, the original rural population was in decline. Conversely, there was a marked increase in subdivision inhabitants. In 1986, the latter group represented approximately 30 percent of the townships total population. In 1989, 70 percent of those surveyed in subdivisions had settled there within the last ten years. Not surprisingly, these market conditions contributed to the extinction of all low cost housing within the area. This situation coupled with virtually no rental accommodation and few jobs, forced the out-migration of the young rural population to nearby urban areas.

We observed that the entire social structure of the community was changing; family farms were in decline as were various community organizations including churches. Our study revealed that with an influx of new inhabitants into the community, social assimilation was not occurring. In contrast to the original population, the majority of exurban settlers did not work nor socialize in the area. In fact, 35 percent of all inhabitants surveyed worked in Metro Toronto or in adjacent districts. The emergence of a separate social group represented by the new population became apparent. This group displayed different values and social backgrounds. The failure for these two communities (rural and exurban) to mix was observed in social institutions such as local churches and clubs. Subdivision inhabitants tended to socialize within the subdivision supporting the notion of the physical distinction of two separate communities.

Characteristic of most new development in northern Durham Region, subdivisions have been added to existing hamlets, with the hopes of reinforcing the existing community and historical patterns of settlement. As discussed earlier, this has proven from a social perspective to be ineffective . Furthermore, these land-use policies have encouraged the speculation in farmland acreage. Hamlets initially evolved to serve the local farming population through the provision of goods and services. They tended to be centrally located within farming districts, often in the middle of the highest quality agricultural land (Figure 3). These nodes normally grew very little; the hamlets in Scott for example experienced slight change over a 50 year period prior to the 1970s at which time the first subdivision appeared. Historically, hamlet size was controlled by what the local area could sustain. Thirty years ago they were the centres of social and economic activity in the township. Today, that activity is modest in comparison, even though hamlets occupy well over ten times their original area.

As defined by the Durham regional plan, all new development in Scott had been restricted to subdivisions for single family dwellings, with the maximum allowable number of dwellings per hamlet set to 150 (Figure 4). With no infrastructure in place, restrictions on septic systems and wells for an average dwelling in good soil conditions required a lot approximately one acre in size. This restriction coupled with municipal bylaws setting minimum floor areas for homes, further confined the market for these properties to families whose incomes were far above the average for the area. These policies, aside from discouraging social and economic diversity, basically made these settlements into bedroom communities, furthering the economic centralization of the region.

Typical of rural planning restrictions, other aspects of the community are often affected. For example, from the developers' perspective, in order to make an estate subdivision feasible under existing guidelines, the land should be cleared, be relatively level and contain soils with a good water permeability rate. This is important in order to facilitate proper septic field installation and control costs of clearing, grading and road construction. Unfortunately, the land best suited for this purpose is often Class 1 farm land. Fortunately, at present, the local municipal council intends to uphold the existing limit of 150 dwellings per hamlet. In the future, however, another council could easily vie for more growth, as in the adjacent township of East Gwillimbury, part of York Region, where recent development is far more prevalent.

Aside from their alienating characteristics, major concerns with subdivision-type developments stem from the environmental problems they create. This particular form of habitation is best suited for an urban context; designed to be fully serviced for water, sanitary and storm water run-off. A conventionally designed subdivision works much like a large catch basin; with increased hard surfaces such as roads, driveways and roofs, surface run-off is increased. In a rural area, this concentrated run-off is normally directed into nearby streams and rivers, dramatically increasing the channel flow during periods of heavy rainfall. Run-off from development in Scott and surrounding areas has significantly increased the volume of rivers flowing into nearby Lake Simcoe. This has led to the disruption of important processes within stream ecosystems and other riparian areas because of alterations in the natural water cycles. Similarly, pollutants ranging from road salt to lawn fertilizer threaten the Lake's water quality. The severity of this situation has forced all new developments to provide storm water retention facilities on-site. This, however, is a short term solution to a problem that is inherent within the form of the development itself. Furthermore, these facilities often fail, requiring continuous maintenance.

Another serious environmental concern in many rural districts of North America relates to the problem of nitrate contamination of ground water. Excessive levels of nitrates in drinking water can pose a serious health threat to infants. In 1990, a proposed subdivision in Sanford was delayed due to high levels of nitrates found in the local wells. General concern with this matter has led to tighter restrictions on high density developments throughout the province, but many feel that septic fields are not the real problem. It is generally agreed that some nitrate contamination stems from septic system failure, however, researchers attribute the principal reasons for this problem to farming practices, such as excessive fertilization and improper animal waste management. Indeed, although farming is often cited as one of the greatest polluters of surface and ground water in rural districts, farming practices are exempted from the Environmental Protection Act. This luxury has not been bestowed upon the development industry.

Emergence of the environmental movement, has left interest groups with a considerable amount of clout in the planning process. While it is true that the development industry has not been able to effectively address any of the issues presented here, neither have the involved regulatory bodies. Governments' inability to form new policy dealing with these issues has created a problem that has reached new heights in Scott. Restrictive guidelines set on development have resulted in a situation where it is impossible to build a grouping of homes under the existing zoning allowances and provincial environmental restrictions. This is typical in rural districts throughout the province.

Solutions

In areas such as Scott Township, new development is desperately needed if the original community is expected to survive. Unfortunately, this will not happen if the status quo continues. What is required is a new approach to planning and development that serves to reinforce the existing community, not contribute to its decline. New zoning parameters are needed to encourage further social and economic diversity at the community scale. Similarly, land use policies should exclude arable land for development purposes.

A simple land use study using a system of overlays shows how this could be achieved in Scott. Imposed over the grid of the original township are the potential areas for future development defined by parameters that exclude Class 1 and 2 agricultural land, environmental protection zones, flood plains and lowland marshes. The resultant hatched areas are representative of a formidable amount of land when one considers that the township's total area is slightly under 50,000 acres. These amorphous tracks of land could represent opportunity for a community in decline and new areas for future growth (Figure 5).

In refining this new approach for rural habitation, the exploration of different housing forms is required. The final image encapsulating this paper (Figure 6) demonstrates a simple alternative to conventional North American forms of housing. Based on a co-housing model, this clustering of homes can represent future possibilities. Designed for a site in Scott, the grouping of six dwellings shown here are one of four interconnected clusters, all part of a single development. In order to reduce spatial impact and to preserve farm land the

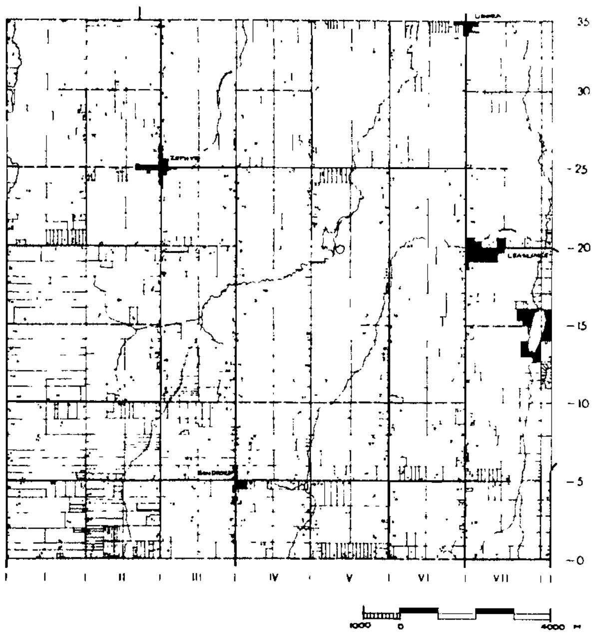


Figure 2: The Old Township of Scott: shown are hamlets, roads, land divisions and buildings.

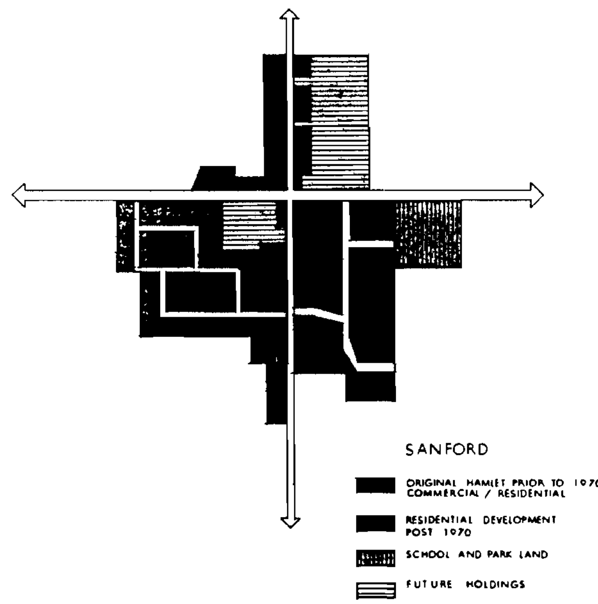


Figure 4: The Hamlet of Sanford: the relative spatial impact of the original hamlet compared to the present.

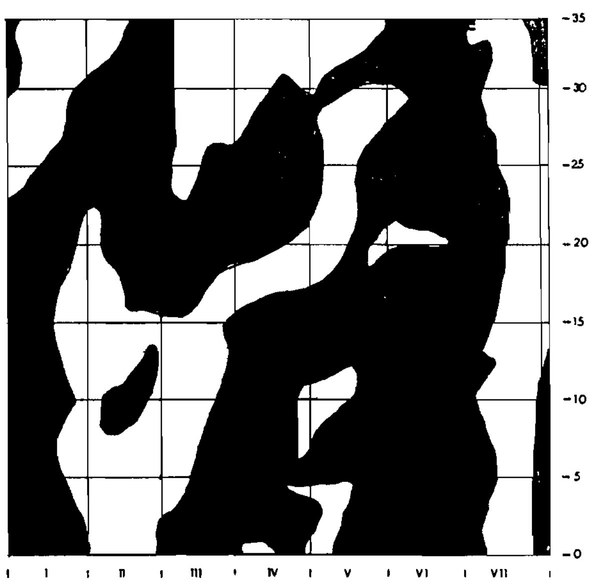


Figure 3: The relationship of hamlet location to Class 1 and 2 farmland.

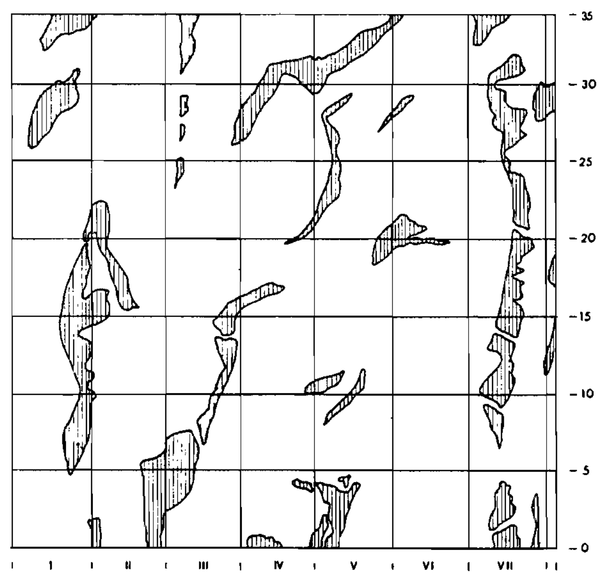


Figure 5: Scott Landuse Study: the hatched portion indicates potential areas for future development based on sustainable parameters.

houses are densely grouped in a wooded area. The complex is sited to work with existing contours, avoiding the disruption of natural drainage patterns. The well and sweerage system is shared to increase efficiency; water is recycled and nitrate pollution is eliminated through the use of a nutrient uptake system. The dwellings vary in floor area, designed to accommodate a full social spectrum from a single person up to a family of five. Similarly, the garage buildings opposite each dwelling provide loft space for other activities, making work at home arrangements more feasible. Finally, the four clusters share a common building that provides social and recreational facilities such as a daycare. With communal ownership of the surrounding land, wildlife habitat is preserved and a sense of community is developed.

Sensitive forms of development can be realized in a manner that is economically feasible. Small, self-contained development provides several advantages over

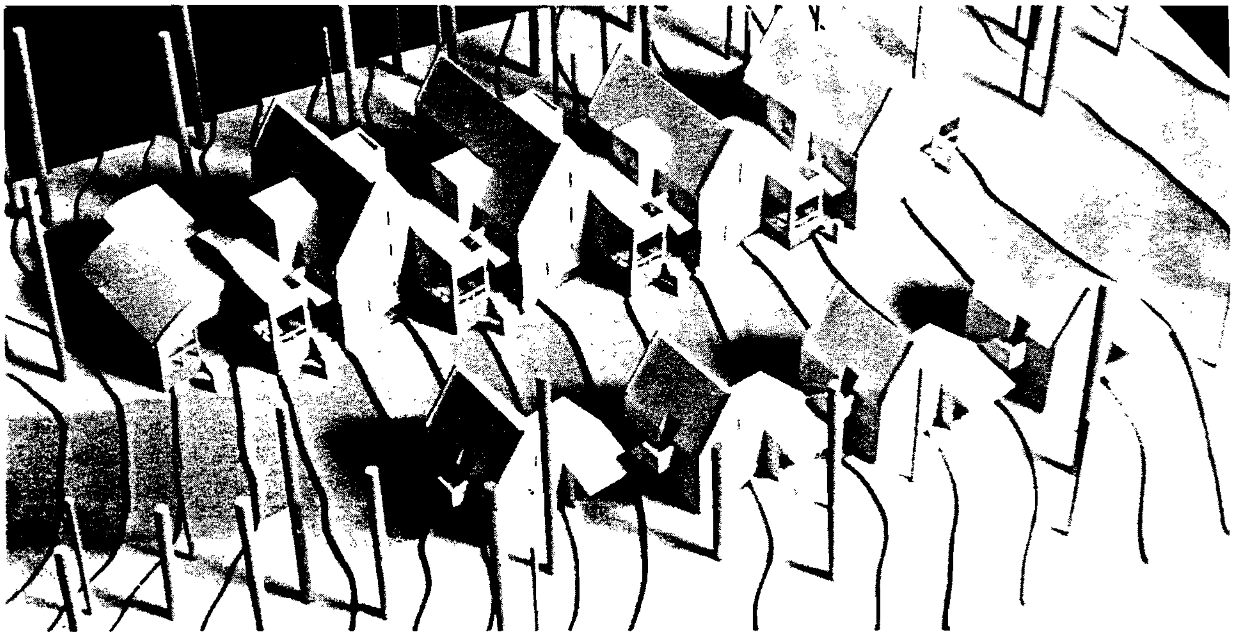


Figure 6: Co-housing: a viable alternative to conventional forms of habitation. (Drawings and housing design by John Zsolt)

centralized infrastructure, even in an urban context. Community on-site systems are less costly to construct than centralized systems. The waste water, after undergoing proper treatment can be recycled or used for other purposes such as plant watering or wetland creation. New systems are being developed that are capable of virtually eliminating nitrate infiltration through innovative treatment methods. Similarly, surface run-off can be contained without retention if consideration is made in the design of the landscape for proper grading and planting. Both measures recharge the local aquifers and help maintain the natural ecological balance. If conceived from an holistic perspective and thoughtfully designed, new development can become an environmental asset, helping us reclaim from nature what we have lost.

Conclusion

With a major part of our population nearing retirement age in the next 10 years, it is expected that rural properties will be in much greater demand. If this were to happen, the problems affecting communities such as Scott could easily extend far beyond the commuting zones surrounding our urban centres. Rural districts throughout Ontario have already begun to experience similar pressures and this will only intensify unless alternative strategies are established soon. Contrary to the methods of the past, planning for rural districts should be approached in a manner that ensures the preservation of existing communities and their natural systems. This mandate need not exclude new development; what is required are innovative methods. If our commitment to sustainable development is to be upheld, social, economic and environmental concerns require equal consideration in the planning process.

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IMPORTED FILL MATERIAL FOR
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T = 8 PERCOLATION TIME

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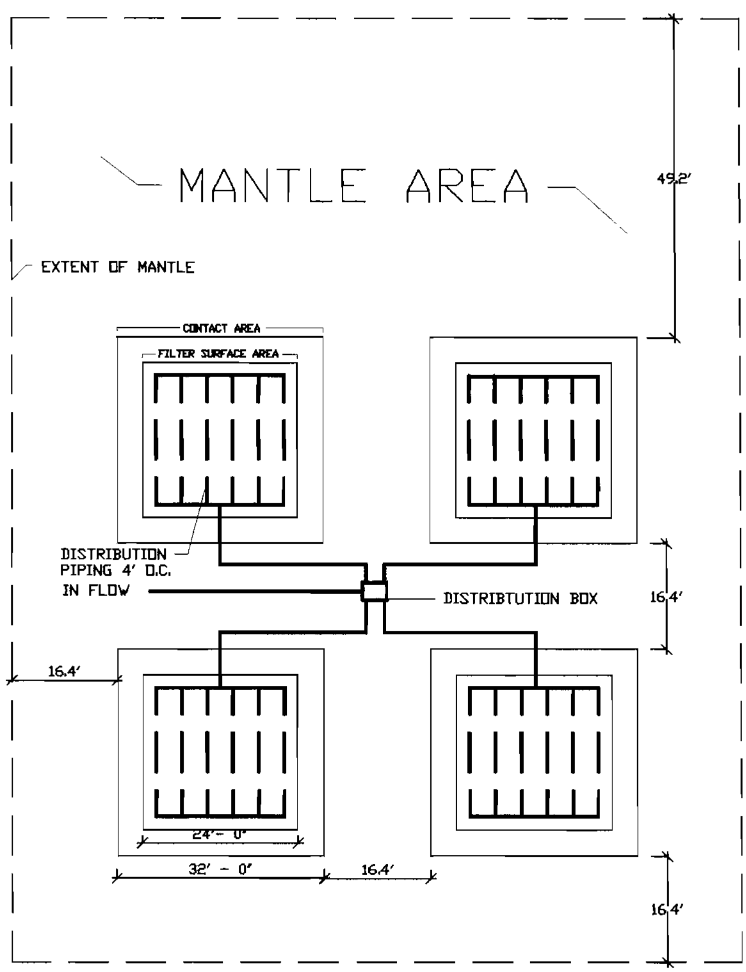

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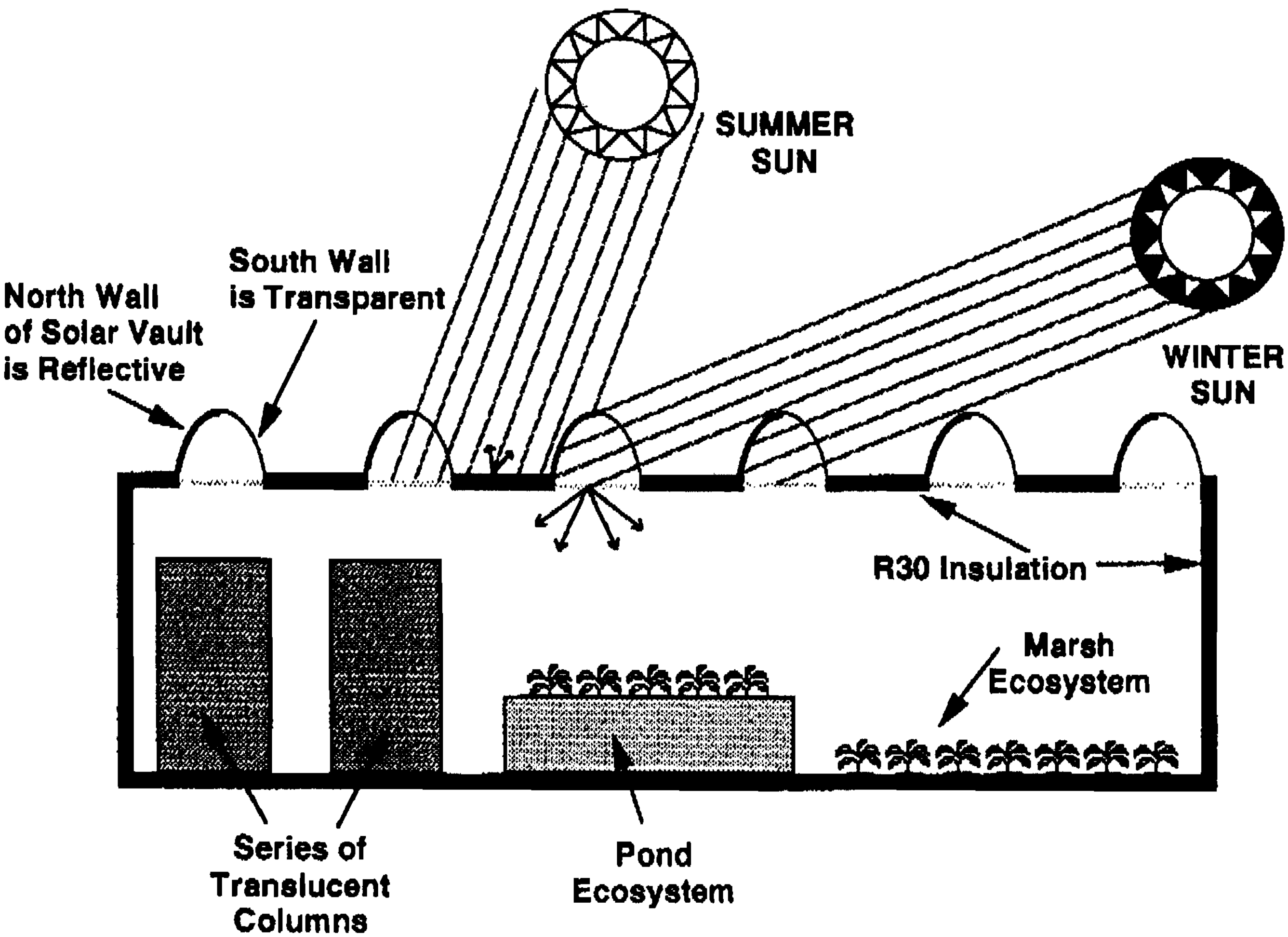

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