CANADA'S GREEN PLAN

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C-2000 PROGRAM REPORT FOR CRESTWOOD CORPORATE CENTRE BUILDING NO. 8

PREPARED FOR:

The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
Ottawa, Ontario, K1A 0E4
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PREPARED BY :

Bentall Properties Ltd.
4 Bentall Centre, Suite 1800
P.O. Box 49001
Vancouver, British Columbia, V7X 1B1
Tel.: (604) 661-5000: Fax: (604) 661-5055

Bunting Coady Architects
171 Water Street, Suite 300
Vancouver, British Columbia
V6B 1A7
Tel.: (604) 685-9913: Fax: (604) 685-0694

SCIENTIFIC AUTHORITY:

Nils Larsson
The CANMET Energy Technology Centre (CETC)
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street
Ottawa, Ontario, K1A 0E4

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580 Booth Street, 13th Floor
Ottawa, Ontario,
K1A 0E4

or

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Department of Natural Resources Canada
562 Booth Street
Ottawa, Ontario
K1A 0G1

DISCLAIMER

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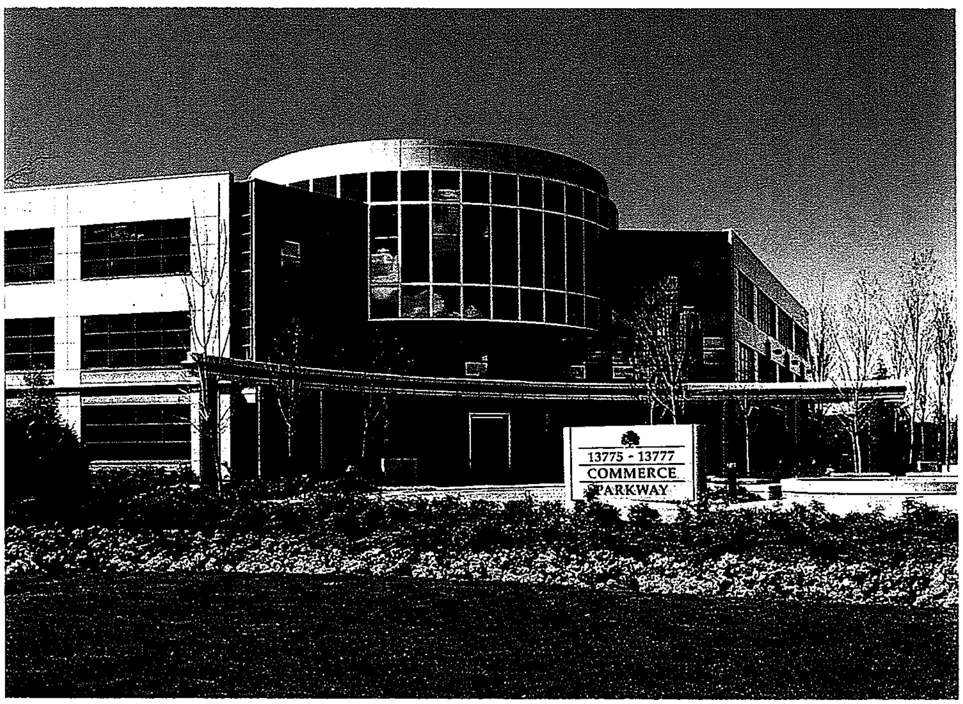
Arnold Nemetz & Associates Ltd. -	Electrical Engineer
Theodor Sterling and Associates -	Environmental Consultant
Aplin Martin Consultants Ltd. -	Civil Engineer
Sharp & Diamond -	Landscape Architect

C-2000 Program for Advanced Commercial Buildings Report

for the

Crestwood Corporate Centre Building No. 8

Richmond, B.C., Canada



March 1997

Submitted by

BUNTING COADY
ARCHITECTS

Introduction

The Crestwood Corporate Centre Building No. 8 is a feature project of the C-2000 Program for Advanced Commercial Buildings, sponsored by CANMET of Natural Resources Canada.

The Crestwood Corporate Centre Building No. 8 is an 80,000 square foot office building that has achieved a high level of design quality, energy efficiency and occupant comfort within an efficient budget. This project combines the economical properties of tilt-up concrete construction with good urban design principals, resulting in an attractive suburban office environment.

Energy Usage

Crestwood Corporate Centre Building No. 8 is built to the strict energy and environmental requirements of the C-2000 Advanced Buildings Program. It is modeled to operate at less than 50% of an ASHRAE/IES 90.1 Reference Building, the benchmark of good energy performance.

Major strategies for reducing the energy usage of Building No. 8 included the selection of a four-pipe fan coil secondary system and the reduction of the lighting density to 0.93 watts/ft^2. The elimination of reheat, reduced energy requirements with the compartmentalized system, and the reduced lighting density contributed approximately 80% of the energy savings. The lower building loads resulted in a reduced installed cooling capacity and substantial installed cost savings.

Incremental strategies included daylighting control of perimeter lighting, an automatic lighting control system and high efficiency boilers and chiller. Envelope design was designed to exceed ASHRAE/IES 90.1 prescriptive requirements for roof, wall and slab insulation levels. The window units are double pane glazed units with an effective mid-grade low-e coating in a thermally broken aluminum frame. Wider mullion spacing and resultant improved window performance were attained with external cosmetic mullions that match the appearance of the windows on Building No. 7.

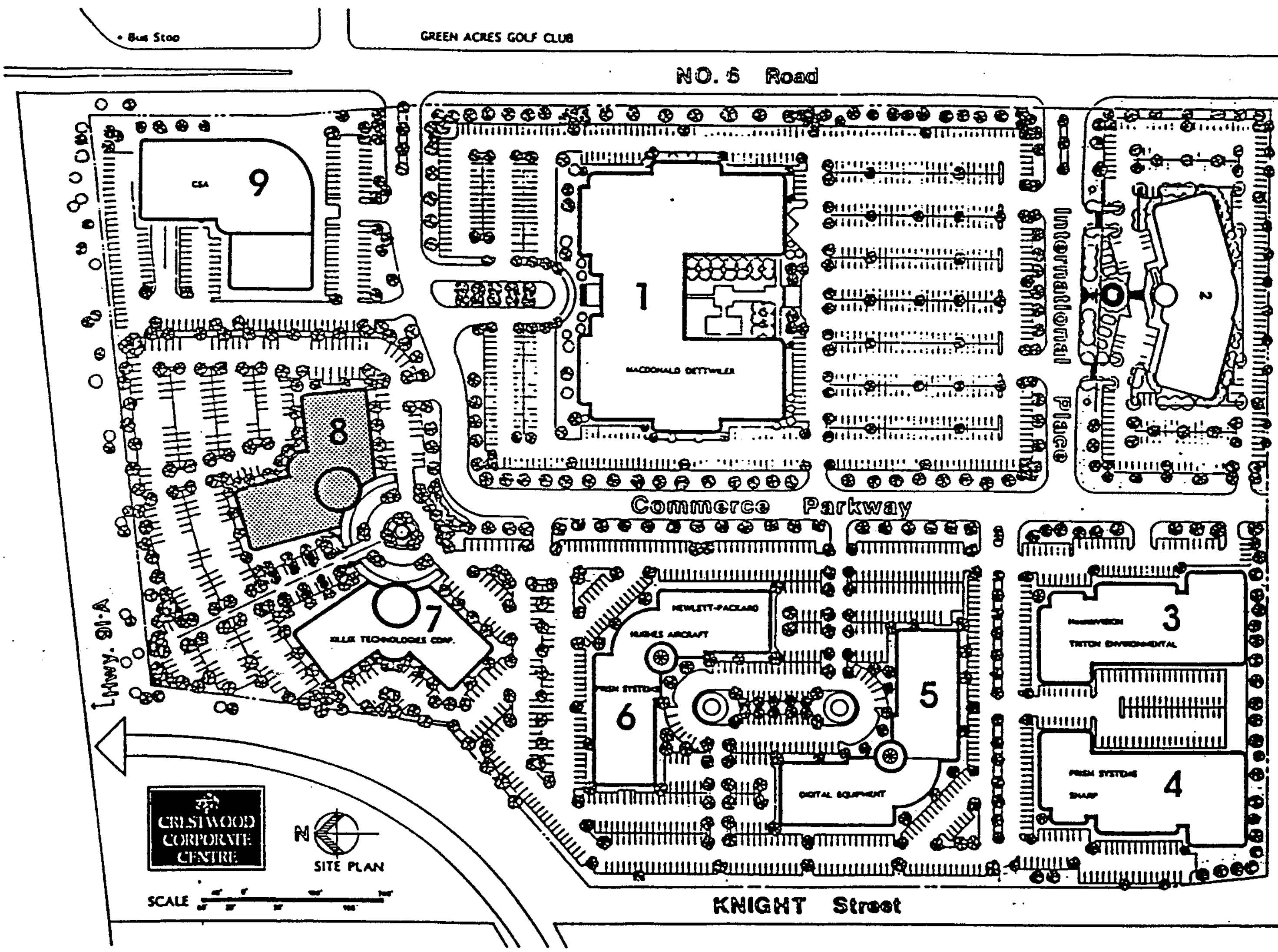
The performance of the Crestwood Corporate Centre Building No. 8 will be monitored over the next two years to provide feedback on some of the sophisticated building simulation tools now on the market. Results will be compared to Building No. 7 for analysis. The opportunity to measure the performance of two large twin buildings, built to different standards, has attracted widespread attention.

Monitoring will assess both energy efficiency and occupant health and comfort. Efforts have been made to develop an energy efficient, sustainable, healthy building in a real market environment, with easily transferable technology.

Crestwood Corporate Centre Building No. 8 represents a holistic approach to energy savings, and a commitment to the preservation of resources, with a special emphasis on the health and well-being of occupants.

Transportation Program

The Crestwood Corporate Centre is located near the Westminster Highway, which is a major transportation link as defined in Richmond's Go Green Plan that is intended to reduce commuters' reliance on the automobile and to support alternative forms of mass transit. With this in mind, the City of Richmond approved the reduction parking area standards from a norm of 4 per 1,000 square feet to 2.9 per 1,000 square feet.



Crestwood Corporate Centre Site Plan

Showers are provided to encourage building users to cycle to work. This site offers a jogging trail and a natural water course to encourage walking and jogging.

Indoor Air Quality

The materials for the Crestwood Corporate Centre Building No. 8 were selected to reduce potentially harmful off-gassing. Where ever possible, adhesives were eliminated and replaced with mechanical fastenings. The wall finishes were selected as water based coating materials throughout, instead of a high off-gassing wall vinyl. Floor vinyls were not used. The site was designed to help the building maintain cool, clean air, with thick shade trees and shrubs planted all around the building perimeter.

A ventilation strategy has been adopted that complements the material selection strategy. The initial ventilation rate is set at 30 CFM per person and is intended to assist with the initial surge of off gassing and particulate generation associated with a new building over the first two years. It is anticipated that long term indoor air quality testing and occupant comfort monitoring will allow the total average ventilation rate to be gradually reduced to 20 CFM per occupant, or lower, in accordance with current ASHRAE recommendations and energy performance projections. The ventilation system provides unmixed, unvitiated outside air directly to a four-pipe fan coil and ceiling diffuser system in each individual HVAC zone, using a roof mounted ventilation air handler. The outside air is mixed with local return air in the fan coil and provided directly to the space. The fan coil supplies a constant volume of conditioned air.

Every effort was made during construction to minimize dust contamination of the plenum spaces. All ducts were blocked off and all construction was sequenced to avoid contamination. The spray fireproofing to the underside of the steel deck was eliminated through careful design to codes.

Water Conservation

The plants selected for the development are low-water consumption and indigenous plants for the broad landscape areas. Plants were chosen for the Richmond area growing conditions of warm summers and quick drying soils. The selected plants require much less water than others, but still maintain the highly attractive corporate image of the Centre.

The feature area flower beds are fed by an irrigation system designed to use as little water as possible through controlling the watering program and by spacing the heads carefully. The irrigation water management program will have a significant impact on water conservation.

The plumbing fixtures selected are low flow water closets; lavatories are metering off and low flow. Shower heads are low flow fixtures.

The C-2000 Program for Advanced Commercial Buildings has established a target of 40% reduction in total water consumption from base building levels. On going monitoring will determine if the adopted strategies were successful.

Specific Environmental Considerations

The large trees on the site were recycled from the Expo '86 site, and provide a mature leafy canopy throughout the site.

Materials have been selected for their low embodied energy. The structure is concrete tilt-up which minimizes wooden form work and is durable to 100 years. The scored and painted facade mimics high embodied energy aluminum cladding, which was not used on this project. Where metal cladding was required at the columns and rotunda, low embodied energy zinc panels were used.

All cardboard, wood, glass and drywall were recycled on site. Form work was reused where practical. Recycled crushed concrete was used as an asphalt sub-base instead of gravel. Excess roof ballast was recycled as drain rock. The gypsum board and ceiling tile have a high recycled materials content. The floors are sealed concrete rather than vinyl tile in most service areas. The use of natural tropical hardwood was avoided. Plastic laminate was avoided where possible.

The building owner is committed to an extensive recycling program after the building is operational.

Costs

Funding for the incremental design costs and construction costs was provided by CANMET and B.C. Hydro, B.C. Gas, Bentall Properties Ltd. and Westminster Management Corporation. At this time, the incremental capital expenditure for energy and environmental measures is estimated at 5.13% of the total construction cost of Building No. 8. Analysis indicates a simple payback of 5.1 years based on energy savings.

The final tendering and construction costs were evaluated after construction. The construction cost of Crestwood Corporate Centre Building No. 8 was $5,150,000, including the cost of additional insulation, mechanical and electrical systems, improved glazing and other energy saving measures valued at $264,000. The construction value also included envelope testing during construction for $10,750. Additional monitoring costs of $100,000 over 2 years have been set aside for the project. The additional research, design and reporting costs relating to the C-2000 Program for Advanced Commercial Buildings totaled $75,000.

Summary

Base building work at Crestwood Corporate Centre Building No. 8 was completed in September 1996. As of January 1997, the building was 90% occupied by office and light manufacturing tenants.

Since its completion, Building No. 8 has been the recipient of a number of awards. The Urban Development Institute awarded the 1996 Award for Excellence in Urban Development (Office Park Development) and the Award for Environmental and Energy Efficient Design. The project also received the 1996 Pinnacle and Earth Awards from the Building Owners and Managers Association (BOMA). Most recently, the project was awarded the 1996 Power Smart Excellence Award from B.C. Hydro.

Introduction

L'immeuble n° 8 du Centre administratif Crestwood compte parmi les réalisations caractéristiques du Programme des bâtiments commerciaux performants C-2000 parrainé par Ressources naturelles Canada.

Le Centre Crestwood se présente comme un immeuble à bureaux de 80 000 pieds carrés qui offre une qualité élevée de conception, d'efficacité énergétique et de confort intérieur dans des limites budgétaires adéquates. Il s'agit d'une réalisation qui combine les caractéristiques économiques d'une construction en béton mis en place par relèvement avec les principes d'une conception urbaine adéquate, ce qui résulte en un attrayant milieu de travail en secteur de banlieue.

Consommation énergétique

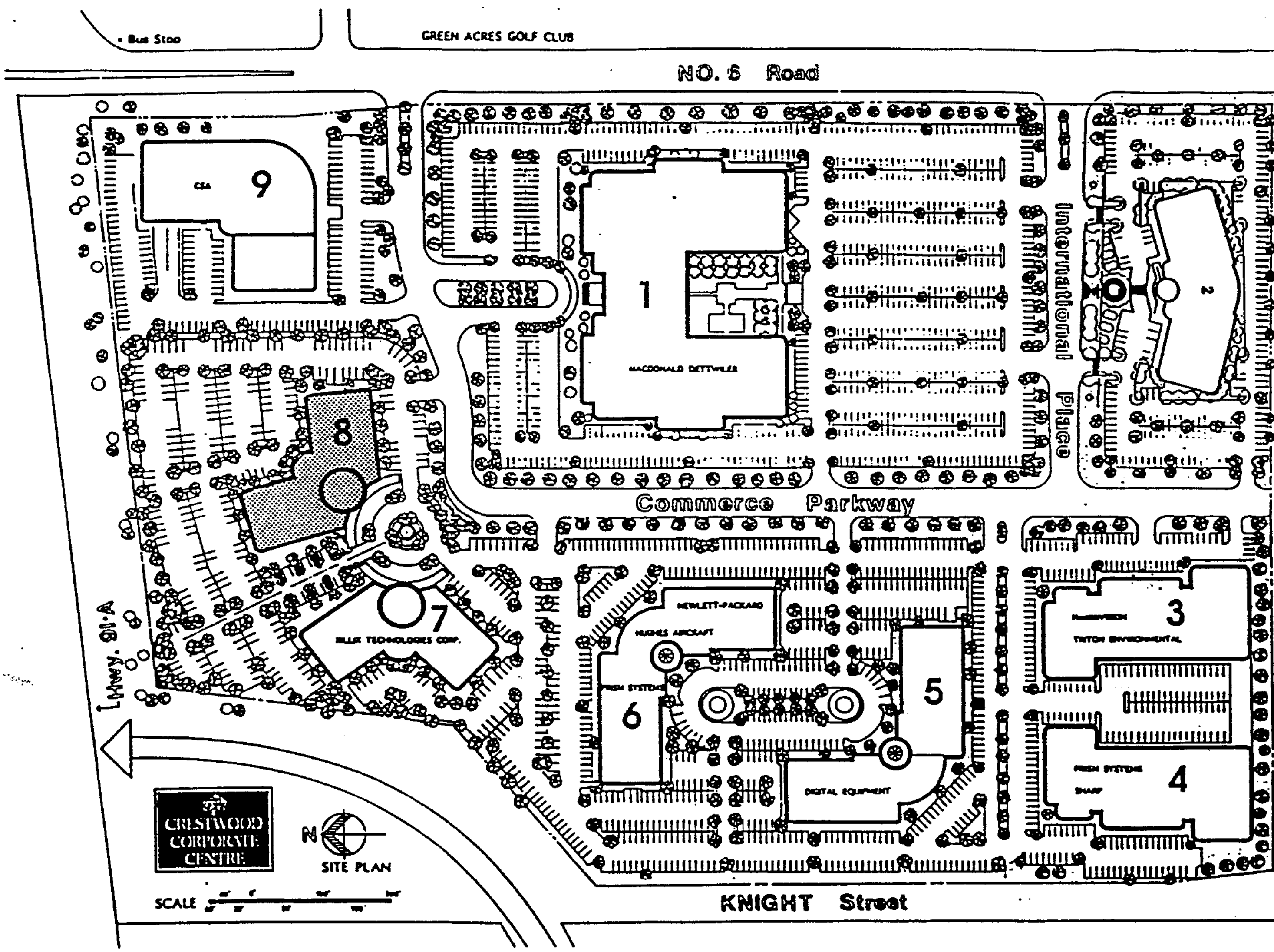
L'immeuble n° 8 du Centre administratif Crestwood est construit en fonction des exigences énergétiques et environnementales très strictes du Programme des bâtiments commerciaux performants C-2000. Il est conçu pour fonctionner à moins de 50 % d'un bâtiment de référence 90,1 de l'ASHRAE/IES, la norme de comparaison d'un bon rendement énergétique.

Les principales stratégies adoptées pour diminuer la consommation énergétique comprennent le recours à un système secondaire de ventilo-convecteur à quatre conduits et la réduction de la densité de l'éclairage jusqu'à 0,93 watts/pi^2. L'élimination du réchauffement, le fait de restreindre les exigences énergétiques grâce au système à cloisons et l'abaissement de l'intensité de l'éclairage ont contribué à près de 80 % des économies d'énergie. Les actions moins intenses imposées au bâtiment ont abouti à une réduction de la capacité de climatisation installée et à de substantielles économies de coûts en matière d'éléments installés.

D'autres stratégies prévoyaient le contrôle de la lumière du jour dans le périmètre éclairé, un système automatique pour contrôler l'éclairage, ainsi que des chaudières et des refroidisseurs à haut rendement énergétique. L'enveloppe du bâtiment a été conçu pour dépasser les exigences de la norme 90,1 de l'ASHRAE/IES en ce qui a trait aux niveaux d'isolation du toit, des murs et de la dalle. Chaque fenêtre possède des carreaux doubles vitrés dotés d'un revêtement à faible émissivité de moyenne catégorie dans un encadrement d'aluminium thermocentré. Des meneaux esthétiques à l'extérieur, qui ressemblent aux fenêtres de l'immeuble n° 7, permettent un espacement plus large et une amélioration du rendement des fenêtres.

Le rendement de l'immeuble n° 8 du Centre administratif Crestwood sera évalué dans les deux prochaines années afin de recueillir des données concernant certains des outils de simulation des bâtiments les plus perfectionnés actuellement sur le marché. Les résultats obtenus seront comparés à ceux de l'immeuble n° 7 à des fins d'analyse. La possibilité d'évaluer le rendement de deux grands bâtiments semblables, construits selon des normes différentes, a suscité un grand intérêt.

L'évaluation du bâtiment permettra d'en vérifier l'efficacité énergétique, de même que la santé et le confort des occupants. De fait, on s'est efforcé de concevoir un bâtiment sain, durable et à haut rendement énergétique, placé dans un milieu réel et disposant d'une technologie facile à transférer.



Plan de l'emplacement du Centre administratif Crestwood

La construction de l'immeuble n° 8 constitue le résultat d'une formule globale adoptée pour obtenir des économies d'énergie, en plus d'un engagement pris à l'égard de la préservation des ressources, avec l'accent mis spécialement sur la santé et le bien-être des occupants.

Programme de transport

Le Centre administratif Crestwood se trouve à proximité de l'autoroute Westminster, une importante voie de transport qui, dans le *Go Green Plan* de Richmond, vise à réduire la dépendance envers l'automobile lors des déplacements d'une ville à l'autre et à appuyer des moyens différents de transport en commun. C'est en ayant à l'esprit ces notions que la municipalité de Richmond a autorisé la réduction des normes relatives aux aires de stationnement qui sont passées de 4 par 1 000 pieds carrés à 2,9 par 1 000 pieds carrés. Des installations de douche sont offertes pour inciter les utilisateurs d'immeuble à venir travailler à bicyclette. De plus, l'emplacement comporte une piste de course et un cours d'eau naturel pour favoriser la marche et la course à pied.

Qualité de l'air intérieur

Les matériaux choisis pour la construction de l'immeuble n° 8 du Centre administratif Crestwood l'ont été en fonction de leurs capacités à diminuer les émissions de gaz éventuellement nocifs. Dans la mesure du possible, on a éliminé toute trace de colle et remplacé celle-ci par des accessoires de pose. Le fini appliqué sur les murs a été sélectionné en tenant compte de matériaux de revêtement à base d'eau, plutôt qu'en ayant recours sur les murs au vinyle à fortes émissions de gaz. On s'est abstenu du vinyle sur les planchers. L'emplacement lui-même est conçu pour aider à garder le bâtiment au frais et à profiter de l'air pur grâce à des grands arbres et arbustes à ombrage qui sont plantés tout autour de l'immeuble.

On s'est également tourné vers une stratégie de la ventilation qui vient compléter celle de la sélection des matériaux. Le taux de ventilation a d'abord été réglé à 30 pieds cubes à la minute afin d'appuyer l'évacuation préliminaire des gaz émis et des particules produites qui marquent un bâtiment fraîchement construit dans les deux premières années. On s'attend à ce que l'évaluation à long terme de la qualité de l'air intérieur et du confort des occupants puisse permettre de réduire graduellement le taux moyen total de ventilation à 20 pieds cubes à la minute par occupant, ou même en deçà de ce chiffre, en conformité avec les recommandations actuelles de l'ASHRAE et les projections du rendement énergétique. Le système de ventilation amène directement l'air extérieur, non mélangé et non vicié, vers un ventilo-convecteur à quatre conduits et un diffuseur plafonnier dans chaque zone de CVC grâce à un appareil de traitement d'air de ventilation logé dans le toit. L'air extérieur, mélangé dans le ventilo-convecteur avec l'air de retour local, est soufflé directement dans chaque espace. Le ventilo-convecteur apporte un constant volume d'air conditionné.

Durant la construction, on a mis tous les efforts nécessaires pour réduire au maximum la contamination des chambres de répartition d'air par la poussière. Ainsi, on a bloqué tous les conduits, alors que la construction s'est déroulée en séquences pour éviter la contamination. L'ignifugation par pulvérisation de la partie inférieure du platelage en tôle a été éliminée en s'en tenant à une conception soigneuse qui se conforme aux divers codes.

Économies d'eau

Les plantes choisies pour servir à l'aménagement paysager des grandes surfaces ne consomment que peu d'eau et proviennent de la région même. Elles ont été sélectionnées en fonction des conditions de plantation de la région de Richmond qui se distingue par des étés chauds et des sols séchant rapidement. En fait, ces plantes ont besoin de beaucoup moins d'eau que les autres, tout en préservant la très séduisante image de marque du Centre.

Les massifs caractéristiques de fleurs sont alimentés à l'aide d'un système d'irrigation conçu pour une utilisation maximale de l'eau grâce à un programme de contrôle et à l'espacement rigoureux des gicleurs. Le programme de gestion de l'eau d'irrigation influera d'une manière substantielle sur les économies d'eau.

Les dispositifs de plomberie choisis incluent des toilettes à faible débit, ainsi que des lavabos à dosage limité et à faible débit. Les pommes de douche présentent également un faible débit.

On a, dans le cadre du Programme des bâtiments commerciaux performants C-2000, établi un objectif de 40 % de la consommation totale d'eau à partir des niveaux de base des bâtiments. Une évaluation continue permettra de déterminer si les stratégies adoptées se sont avérées utiles.

Considérations environnementales particulières

Les grands arbres que l'on retrouve sur le terrain ont été recyclés de l'emplacement d'Expo 1986; ils fournissent une voûte de feuillage en pleine maturité partout aux alentours de l'immeuble.

Les matériaux ont été choisis en fonction de leur faible énergie intrinsèque. La structure faite de béton mis en place par relèvement, permettant ainsi de restreindre la construction de coffrages de bois, est prévue durer 100 ans. La façade peinte à entailles imite un bardage d'aluminium à énergie intrinsèque élevée que l'on retrouve nulle part dans la construction de l'immeuble. Lorsqu'il fallait recourir à un bardage métallique pour les colonnes et la rotonde, on se tournait vers des panneaux de zinc à faible énergie intrinsèque.

On a procédé au recyclage sur place de toute la quantité de carton, de bois, de verre et de cloisons sèches utilisée. Lorsque cela s'avérait pratique, les formes construites étaient réemployées. Le béton broyé recyclé a servi de fondation à l'asphalte en remplacement du gravier. Le lest de toiture en trop a également fait l'objet d'un recyclage à titre de cailloux de drain. Le placoplâtre et les carreaux de plafond sont faits de plusieurs matériaux recyclés. Dans la majorité des aires de service, les planchers sont recouverts de béton verni plutôt que de tuiles en vinyle. On a évité de faire appel aux bois tropicaux naturels et, autant que possible, au plastique stratifié.

Le propriétaire de l'immeuble s'est engagé à poursuivre un programme intensif de recyclage après la mise en service du bâtiment.

Coûts

CANMET, B. C. Hydro, B. C. Gas, Bentall Properties limitée et Westminster Management Corporation ont fourni les fonds pour couvrir les coûts additionnels de conception et les coûts de construction. Pour l'instant, les dépenses marginales de capital consécutives aux mesures prises dans les domaines de l'énergie et de l'environnement sont évaluées à un total de 5,13 % des dépenses globales de construction de l'immeuble n° 8. En se basant sur les économies d'énergie, des analyses indiquent que la période de récupération s'étendrait à 5,1 ans.

L'évaluation des coûts définitifs relatifs aux appels d'offres et à la construction s'est faite après l'achèvement des travaux. De fait, la construction du Centre administratif Crestwood a atteint un coût de 5 150 000 $, ce qui englobait un montant de 264 000 $ pour l'installation de matériaux additionnels d'isolation, de systèmes mécaniques et électriques, de vitrage renforcé et d'autre mesures d'économies d'énergie. Le coût de construction comprenait également la vérification de l'enveloppe au cours de la construction qui s'est chiffrée 10 750 $. On a également réservé 100 000 $ pour les deux prochaines années afin de procéder à un contrôle supplémentaire du fonctionnement du bâtiment. Finalement, les autres coûts reliés à la recherche, à la conception et au rapport dans le cadre du Programme des bâtiments commerciaux performants ont totalisé 75 000 $.

Résumé

Les principaux travaux de construction du Centre administratif Crestwood ont été achevés en septembre 1996. En janvier 1997, l'immeuble était à 90 % occupé par des locataires de bureaux et un fabricant d'appareils d'éclairage.

Depuis qu'il est terminé, l'immeuble n° 8 a été honoré par de nombreux prix. Ainsi, l'Institut canadien d'aménagement urbain lui a décerné le Prix 1996 pour l'excellence en aménagement urbain (aménagement d'un parc à bureaux) et le Prix de la conception respectueuse de l'environnement et de l'efficacité énergétique. De plus, la *Building Owners and Managers Association* lui a décerné ses *Pinnacle and Earth Awards* 1996. Finalement, B. C. Hydro lui a récemment accordé son *Power Smart Excellence Award* 1996.

1.0 Introduction

1.1 Overview

Crestwood Corporate Centre, Building No. 8, completes a recent phase of a commercial development in a campus style business park located in Richmond, British Columbia, Canada. Building No. 8 is a three storey building containing approximately 80,000 sq. ft of office facility and is twinned with Crestwood Corporate Centre, Building No. 7, which was completed in 1994. Building No. 7 was not designed as part of the C-2000 Program for Advanced Commercial Buildings.

The challenge for Crestwood Corporate Centre, Building No. 8, was to design a building identical in appearance to Building No. 7, but operating at the energy use and occupant comfort levels set for the C-2000 Program for Advanced Commercial Buildings.

1.2 C-2000 Program for Advanced Commercial Buildings

The C-2000 Program for Advanced Commercial Buildings is an initiative to promote the adoption of advanced technologies and management techniques in commercial buildings through pilot projects, monitoring and information transfer. The immediate goal of the C-2000 Program is to achieve high performance goals in pilot project buildings and to transfer the information gained to the industry. This report is an example of this information transfer.

The C-2000 Program for Advanced Commercial Buildings is more than just an energy conservation program. While it demands a high level of energy performance, the C-2000 program also emphasizes achievement of high performance in other areas including indoor air quality, lighting quality, environmental performance, adaptability to future changes, and ease of maintenance and operations. This "whole building" performance structure is based on the belief that energy and environmental agendas will be more readily adopted by the industry if a broad approach is taken.

The C-2000 Program has developed specific performance requirements for the following issue areas:

1. Energy Efficiency of the building and its sub-systems.
2. Environmental Impact of the buildings construction and operations.
3. Health, Comfort and Productivity of occupants and tenants.
4. Functional Performance of building systems.
5. Longevity of building systems.
6. Adaptability of building designs and systems to future requirements.
7. Operations and Maintenance issues related to building systems.
8. Economic Viability of the building, considered on a life cycle basis.

The requirements of each issue area are addressed in the pertinent sections of this report.

Along with the C-2000 requirement for specific performance levels, there is a requirement that the initial performance levels be maintained over a long period of time. Full commissioning of the project has ensured that the intended performance levels are reached and a 2 year monitoring program will ensure that levels are maintained. Monitoring reports will be issued after each year of operation.

1.3 Project Team Members

The project team consisted of the owner/developer and eight professional consultant members. A brief description of each member follows:

Bentall Properties Ltd. and Westminister Management - Owner / Developer

Crestwood Corporate Centre is a joint venture project by Westminister Management Corporation and Bentall Properties Ltd. Bentall took the lead role in the design and construction of the project. As both the developer and owner of the majority of its properties, Bentall understands the benefits of creating real estate projects of enduring value. Bentall Properties Ltd. manages 6.3 million square feet of space in approximately one hundred properties in California and Canada. With each new property opportunity, Bentall property managers work closely with the company's leasing divisions. Working together, these divisions fully deliver the performance promised to tenants and satisfy realistic expectations for clients and investors. The coordinated approach also provides a deeper insight into the leasing climate and helps keep Bentall at the leading edge.

Bunting Coady Architects - Architectural

Most of the buildings in the Crestwood Corporate Centre have been designed by and constructed under the supervision of the principals of Bunting Coady Architects. The firm is an innovative architectural practice based in Vancouver whose quality of design in this and other projects has been recognized by numerous design awards. Bunting Coady Architects are actively involved in the developing technologies relating to environmental design and energy engineering and have the will to incorporate this approach into any project when appropriate. Original research into the effects of building form and materials on the building systems requirements is at the heart of Bunting Coady Architect's commitment to a better design approach, balancing aesthetics, health concerns and energy demands. The principals of Bunting Coady represent the Architects of British Columbia on the BC Energy Council Advisory Panel, Chair the Architectural Institute of British Columbia's Energy and Environment Committee and guest lecture extensively throughout North America.

Tescor Pacific Energy Services Inc. - Energy

Tescor Pacific is highly active in the fields of energy conservation, energy analysis, alternative energy development and innovative HVAC design. Their project portfolio ranges from superwindow research to computer optimization of geothermal heat pump systems. They have conducted or supervised hundreds of energy audits, energy conservation retrofits and computer aided energy analyses for various building projects across Canada. They have also designed and presented national educational programs on building and energy technology, and are actively involved in the BEPAC program. Responsibilities for this project included development and simulation of energy performance strategies and HVAC functional performance. The primary energy analysis tools were DOE 2.1e and ancillary packages such as LBL Window 4.0. Tescor has been an advocate of the total performance building concept, recognizing that optimal performance reflects a reconciliation and balance of all performance objectives.

Choukalos Woodburn McKenzie Maranda Ltd. - Structural

CWMM has been involved in the design of most of the buildings in the Crestwood Corporate Centre. As a prominent consulting engineer in the rapidly growing Vancouver region CWMM is recognized as a leader in the industry. The firm was founded in 1955 and has focused on innovative designs that are tailored to reflect the needs and objectives of particular clients. From its original focus on structural engineering, CWMM has expanded the range of services it offers. CWMM offers a comprehensive engineering service in buildings, bridges and special projects, harbour developments and civil work. CWMM is also recognized for their work in materials handling and seismic assessment and upgrading.

VEL Engineering - Mechanical

VEL engineering has long been involved in the Crestwood Corporate Centre. VEL offers a comprehensive range of services including primary energy, environmental, fire protection and life safety, plumbing, sound control and building automation and controls. VEL also provides energy analysis, energy audits, feasibility studies, commissioning and preventative maintenance programs. VEL believes that satisfying the client's needs is the primary objective. This is accomplished by utilizing innovative design techniques and staying on the leading edge of systems technology. For this project, there was close integration between the mechanical and energy engineers to address the functional performance aspects of the HVAC system.

Arnold Nemetz & Associates Ltd. - Electrical

Nemetz & Associates has been an integral part of the Crestwood Corporate Centre team and has consistently worked to upgrade the building systems and fixtures to optimize the energy efficiency and cost effectiveness of the buildings. Actively involved with the latest local incentive programs like Power Smart, Nemetz & Associates stay at the leading edge of the developing technologies. The strength and experience of Nemetz & Associates covers all the major areas including electrical power system design, lighting system design, concept design, Power Smart technology, and energy management.

Theodore Sterling and Associates - Environmental

Theodore Sterling and Associates Ltd. is an organization composed of consultants and scientists that has pioneered an inter-disciplinary and innovative approach to the fields of environmental and building science and technology. Services include testing, evaluation, design, research and technical and scientific advice. Research has kept Theodore Sterling and Associates in a leading position in the fields of environmental and building science and technology.

Aplin Martin Consultants Ltd. - Civil

Aplin Martin has been involved in the site planning and services of Crestwood Corporate Centre from inception. Aplin Martin is a full service multi-disciplined technical and management consulting group. The practice provides service in municipal and land development engineering, site planning, legal and hydrographic surveys, landscape design, operations and maintenance management and project management. Aplin Martin prides itself on providing its clients with the most comprehensive consulting services available today. Its planning division stands at the leading edge of research and innovation in the planning field. Aplin Martin's role in capital works projects involves the preparation of plans for creek diversion, culvert installations and wetland mitigation and enhancement.

Sharpe & Diamond - Landscape

Sharpe & Diamond have designed the landscape of the Crestwood Corporate Centre. From high-density downtowns to rural, coastal and mountain environments, Sharpe & Diamond provide creative responses for clients in British Columbia and across North America. In addition to extensive work in park, and residential site planning, the firm specializes in the following areas: waterfront amenities, park and garden structures, public participation and urban design. Sharpe & Diamond is one of the leading landscape architecture and planning firms in Western Canada.

1.4 Financial and Corporate Strategy

Funding Commitment Of The Developer and Funding Partners

The Crestwood Corporate Centre was selected for the C-2000 Program as Building No. 8 is part of a larger pre-planned phased project. The Owner develops a new building in the park at the rate of one per year, depending on market conditions. Demand is high and the development of the park has been steady. The Owner is a major developer able to ride out minor fluctuations in market conditions.

CANMET, through the C-2000 Advanced Commercial Buildings Program, provided design and research funding for the initial stages of the project. Once incremental capital costs for the energy and environmental measures were assessed, CANMET provided additional capital funding for the project.

The Team secured a commitment from a major funding partner in the form of B.C. Hydro Power Smart Commercial Energy Management, through their New Building Design Program. BC Hydro matched the CANMET funds for the design phase and contributed significantly to the incremental capital costs.

1.5 Promotion and Technology Transfer

A key element of the C-2000 Program for Advanced Commercial Buildings was that the project was promoted and the technology transferred to key organizations. The purpose of information dissemination was to make the construction and development industries aware of the marketable success of the C-2000 Program so that it can be duplicated in future projects.

Crestwood Corporate Centre Building No. 8 has been promoted through seminars, presentations, journal articles, newsletter summaries and design competitions. The following is a list of these promotional efforts:

Awards

- Urban Development Institute Award for Excellence in Office Park Development-1996.
- Urban Development Institute Award for Environmental and Energy Efficient Design-1996
- 1996 B.C. Hydro Power Smart Excellence Award
- 1996 BOMA Earth Award

- 1996 BOMA Pinnacle Award

Seminars

- Real Estate Institute of British Columbia - Victoria 1997
- Building Quality Assurance Seminar - Vancouver, 1996
- Sacramento Municipal Utility District - Sacramento, CA, 1996
- TEEM '96 - Monterey, CA, 1996
- Quantity Surveyors Society of British Columbia - Vancouver, 1996
- Real Estate Board of British Columbia, Green Building Conference - Victoria, 1996
- North American Construction Conference - Tucson, AR, 1996
- American Institute of Architects, Los Angeles chapter - Evolving Awareness, 1995
- Urban Development Institute, San Diego conference - Evolving Awareness, 1995
- Architectural Institute of British Columbia, Vancouver - Sustainable Building Design, 1995
- Walt Disney Imagineering, Los Angeles - Sustainable Development, 1995
- Rand Corporation, Los Angeles - Eco Planning Sustainable Development, 1995
- Lawrence Berkeley Labs, Advanced Building Design and Site Planning, 1995
- American Lung Association, National Conference Guest Panel - Santa Fe, 1995
- Air Infiltration and Ventilation Centre, National Conference - Palm Springs, 1995
- BC Hydro, Vancouver - Design Integration, 1995
- N.A.I.O.P., Energy Code Implications to Industrial Buildings - Vancouver 1995

Journal Articles

- "Innovation in Richmond", Business in Vancouver, March 1997
- "Buildings for the Future", Business in Vancouver, September 1996.
- "Crestwood Corporate Centre: Setting the Standard for Business Parks", Canadian Property Management Magazine, vol. 4 no. 5, 1996.
- "Conservation by Collaboration", LD + A Magazine, December 1995.
- "Designing Whole Buildings: The C-2000 Program Integrates the Design Process", Advanced Building Newsletter, November 1995.
- "Intelligent Buildings; Smart Design" Award Magazine, July 1995.
- "Building Commissioning: A New Delivery Method For Ensuring Successful Building Performance Gains Ground", Architecture, June 1995.
- "Environment: Twin Buildings", Canadian Architect, November 1994.
- "CANMET Canada Award Winner", Energy Manager, August 1994.
- "Vancouver Leaps to the Forefront with Energy Efficient Buildings", The Vancouver Sun, June 1994.

Television

- "Footprints on the Earth", The Knowledge Network, 1996.

Video

- "Crestwood Corporate Centre C-2000", 1997.

1.6 Functional Program Report

The design of the Crestwood Corporate Centre, Building No. 8, was a response to the requirements of three principal groups: the owners, the users, and the government regulatory bodies. The most recent response is embodied in the design for Building No. 7, completed in 1994, whose design was used as a touchstone.

Owner's Requirements :

1. Create a suburban office park development that provides a first rate indoor and outdoor working environment for the high-tech tenants locating there.

Strategies included:

- Maintain design and occupancy control of the buildings within the development
- Create a common architectural theme among the various buildings
- Provide generous coordinated and mature landscaping to the development
- Meet or exceed industry standards for a quality work place

2. Create a development providing an acceptable economic return for capital invested.

Strategies included:

- Maximizing floor space ratios
- Minimizing parking ratios and providing all at-grade parking
- Utilizing cost effective tilt-up concrete shell construction
- Developing in 80,000 ft^2 phases to minimize risk on unleased premises while maximizing economies of scale

User Requirements

The user requirements of an office park catering to high-tech companies included: locational adjacency to customers and housing; cost effectiveness of the space provided; work place quality and amenities to attract and keep skilled employees; flexibility of the space for changing layouts and functions; and, image enhancement of the company to its clientele.

Municipal Requirements

The municipal by-laws and building code considerations for the site provided an additional set of design criteria. By-law constraints that impacted the design included: building and landscape setbacks; building height; and parking ratios. The major code impacts related to defining building type, size, construction type, fire access, fire separations and, public safety issues.

Parameters for Crestwood Corporate Centre Building No. 8 Design

Responding to the combined requirements, the parameters for the building design were defined as follows:

1. *Architectural*

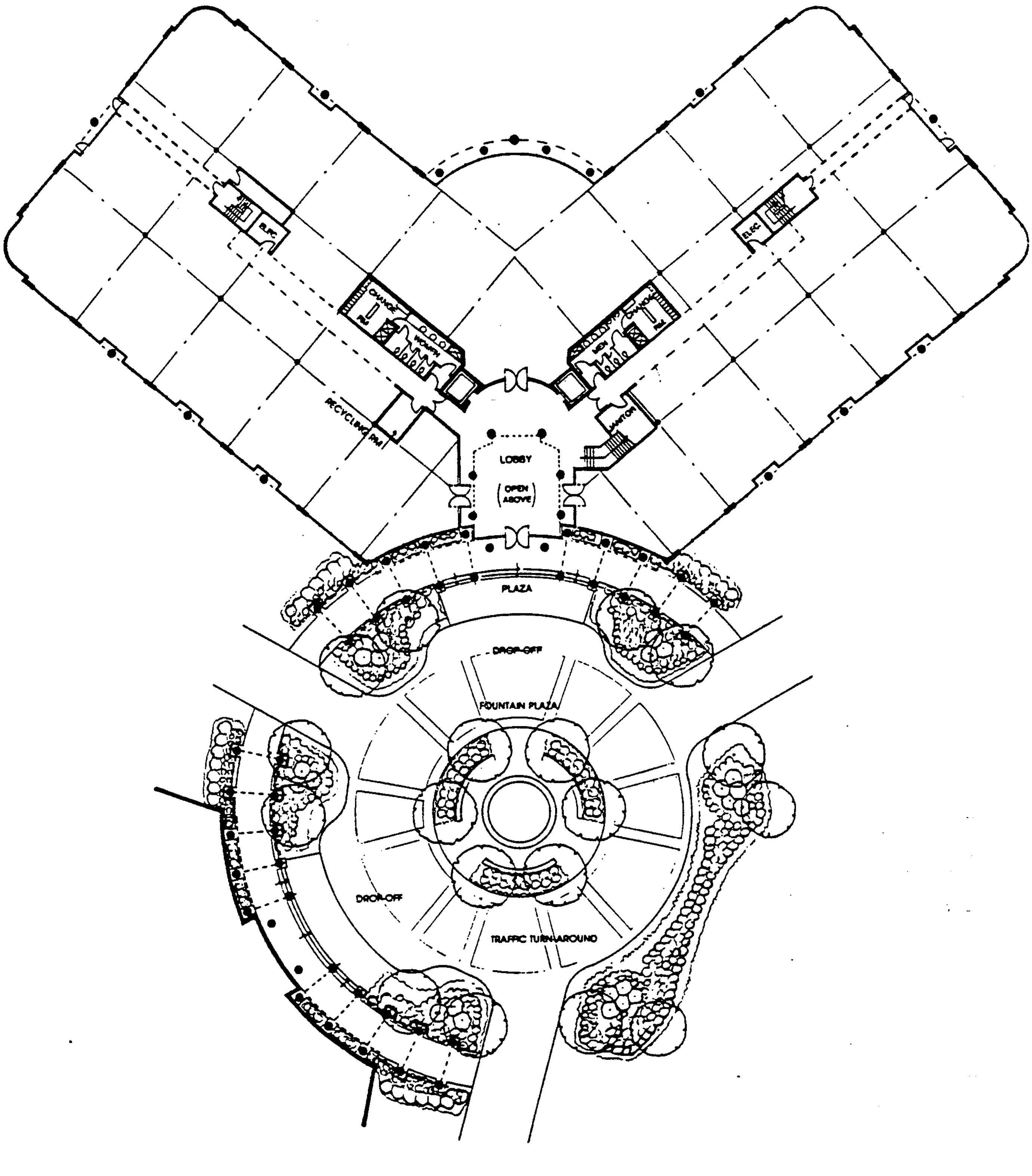
- Form to match Building No. 7
  - gross area of 80,100 ft^2
  - building height of 47'-6"
  - building depth maximum 96'-0"
  - orientation with entry to the fronting street
  - architecture to match other buildings
- Envelope to match Building No. 7
  - floor - ceiling ht. 8'-6" to 9'-0"
  - windows- continuous with 6'-0" to 7'-6" height; 50% light transmittance; double glazed low-e tinted with shading coefficient of 0.35
  - concrete tilt-up wall assembly
  - membrane roof assembly
- Floor Plate Layout to match Building No. 7
  - floor plate size of 26,400 ft^2 (avg.)
  - corridor to glazing depth of 30 to 40 ft.
  - central two-story entry lobby with 3 tenant entries per floor exposed to the lobby
  - sub-divisibility to minimum 2,000 ft^2 and to a maximum of the total floor plate
  - lobby forming 1 of 3 exits on each floor
  - minimize common areas
  - two elevators
  - washrooms each floor with showers and change rooms added to the main floor

2. *Mechanical*

- high level of IAQ through HVAC and materials selection strategy
- maintain constant volume air flow for comfort
- zoning to a maximum of 1,000 ft^2/zone on the interior space and 500 ft^2/zone exterior space
- flexibility to add further capacity and zoning to the HVAC system
- flexibility to operate zones independently
- cost efficient system based on life-cycle costing balanced with a low capital cost system

3. *Electrical*

- lighting layout to match Building No. 7
- office area lighting requirements set at 64 foot candles minimum



Ground Floor Plan Building 8

- switching for lighting to be zoned, including a perimeter zone with photo cell, fixtures to be non-glare with multi-level switching capacity
- flexibility to add to or modify the fixture layout is desired, a ceiling chase allows for flexibility of lighting, power and communications
- exterior lighting for parking areas for way-finding and security to be 1 to 1.5 foot candles/ft^2
- energy efficient fixtures
- power requirements for up to 2.5 watts/ft^2 for plug load to accommodate high tech users

4. *Landscaping*

- landscaping treated as a nécessary amenity.
- bermed lawn areas, mature trees and generous accents of shrubs and flower beds integral to the campus-style image.
- fountain features, outdoor seating, pedestrian-friendly links between buildings
- jogging path encircling the property.

Summary

In summary, the design of Crestwood Corporate Centre Building No. 8 was driven by the needs of a range of corporate users, molded by the vision and development criteria of the design team and the owners and constrained by the rules as defined by government regulation.

In the highly competitive Vancouver marketplace, incorporation of quality and value have allowed the Crestwood Corporate Centre some measure of success. Continued success will depend on testing new initiatives against user demand and acceptance, and on testing new designs against a rigorous cost/benefit analysis that ensures that product value is maintained.

2.1 Introduction

This section of the work provides an overview of the design strategy and development and outlines the work done in the concept design stage for Crestwood Corporate Centre Building No. 8. Further development of the design is described in Section 3.0, Building Systems.

2.2 Design Process

Team Involvement

The following section provides an overview of the design strategy and development for the project. Detailed elaboration is provided in the Energy Efficiency Performance section (section 4.1).

The entire design team was involved from the beginning of the concept design phase. At this time, critical information regarding energy budgeting, client parameters, site restraints and basic technical information was exchanged. Each member of the group was made aware of every other members concerns and ideas and contributed equally during the concept design process.

The energy and environmental goals were outlined in these early meetings. In deference to the fixed form and associated design constraints of Building No. 8, the intended approach was to achieve C-2000 performance levels using high performance, but relatively non-exotic technologies applied in innovative and effective ways. This resulted in a building that could be easily reproduced by the design community at large without highly specialized resources or the assumption of a high level of risk.

2.2.1 Design Process Summary

To achieve the complex goals of the C-2000 program, the design process was developed along the lines of an eight-step process involving the entire interdisciplinary team.

Step 1 - Orientation and Configuration

Roles:

Developer	• set site restrictions
Architect	• develop massing options
Energy	• model gross massing for energy efficiency
Architect	• develop internal volumes
Energy	• model and optimize volumes to self-balance

Results:

Site	• fixed

Step 2 - Envelope Design

Roles:

Developer	• set window, ceiling height minimums
Architect	• develop options
Electrical	• review daylighting potential
Energy	• models envelope on selected massing

Results:

Windows	• increase performance of glass
	• reduce mullions
	• fiberglass mullions
Shading	• provide sunshade on south wall
Insulation	• increase roof insulation to R-20
	• increase wall insulation to R-15

Step 3 - Lighting and Power

Roles:

Developer	• set minimum light level
Electrical	• develops lighting layout
Energy	• models lighting
Structural	• review impact of height
Architect	• co-ordinates
Electrical	• defines plug load

Results:

Lights	• optimize daylighting with lightshelves
	• reduce watts per square foot to 0.75 with better fixtures and layout

Step 4 - Heating and Cooling

Roles:

Energy and Mechanical	• develop, optimize and model, systems
Architect	• adjusts envelope to energy requirements

Results:

Heating	• optimized envelope thermal balance
	• optimized HVAC efficiency
Cooling	• reduce heat gain through lights

Step 5 - Ventilation

Roles:

Developer	• sets minimum CFM
Architect	• selects materials to reduce VOC's and particulate
Environmental	• tests ambient air quality
Energy and	• evaluates energy impacts of Mechanical ventilation rates
Mechanical	• develops air distribution strategies

Results:

CFM	• reduce heating and cooling
	• reduce VOC's to improve indoor air quality (IAQ)
	• maximize ventilation effectiveness
Windows	• 10% operable

Step 6 - Building Materials Selection

Roles:

Architect	• selects structural system based on embodied energy
Structural	• assists
Architect	• selects non-structural materials for durability, recyclability, health criteria
Environ-mental	• assists

Results:

Sustainable	• steel, concrete, selected woods, mineral fibre, recycled plastics
Unsustainable	• vinyl's, epoxies, enamels, oils, endangered wood species, asphalt, CFC foams

Step 7 - Site Design

Roles:

Architect	• optimizes natural features, develops alternates to asphalt
Landscape	• develops low water use planting plan
Mechanical	• develops drip irrigation and collection systems, develop groundwater return systems

Results:

Asphalt	• reduce/replace
Grass	• use tough low water species
Pavers	• use recycled bricks or rubber
Plants	• use low water perennials

Step 8 - Quality Assurance

The Team
- develop strategies to ensure quality control during construction
- develop strategies to ensure a smooth handover to operation and maintenance

2.3 Project Schedule And Organization Plan

Preliminary Building Schedule

Preliminary Design	March 1994
Final Design	July 1994
Contract Documentation	October 1994
Construction Start	February 1995*
Construction Completion	August 1995*
Occupancy	September 1995*

*All dates were met except for the last three. Market conditions delayed them for one year.

Organization Plan

All consultants, the owner and the funding partners were involved from the final design through the contract documentation, construction, commissioning and monitoring phases.

2.4 Option Development

The design process was organized about a series of key investigations that could be carried on by pairs within the group simultaneously. The areas of investigation that were developed and modeled were:

2.4.1 Building Orientation & Configuration architect/mechanical/energy

The Crestwood Corporate Centre Building No. 8 is the physical twin of Building No. 7, and given the site constraints and the clients requirements for Building No. 8, no changes to the shape were considered. This shape was modeled on DOE-2.1E and analyzed for energy efficiency using common envelope design values for insulation, percentage glazing, glass type and shading.

Any models that were clearly inefficient were discarded. The architectural massing options to be developed further by the Architects were limited by energy efficiency.

Parking on the site was reduced by 25% to increase amenity areas and to provide cool vegetation areas.

2.4.2 Internal Volumes architect/energy/mechanical/environmental

A functional premise of Building No. 8 was the provision of an entry lobby volume. While the configuration of Building No. 8 was fixed, a number of entry lobby strategies were evaluated with the objective of developing a highly-glazed space that would be relatively benign in terms of overall impact on the building's thermodynamic performance. It was hoped that a volume could be developed that would complement the proposed low-volume HVAC strategies of Building No. 8.

Recognizing that conventional atria configurations offer limited potential in this respect, a number of innovative and viable glazed volume spaces were proposed and evaluated using DOE 2.1E.

2.4.3 Envelope Design
architect/energy/mechanical

The optimization of opaque envelope R-values was a comparatively easy process. The base model met the prescriptive requirements of ASHRAE/IES 90.1 and would use high performance, yet relatively mainstream, fenestration systems. In this regard, a range of state-of-the-art fenestration products were evaluated from the perspective of appearance, thermal performance, architectural suitability and cost. Integrated with this evaluation was the investigation and development of exterior shading/light shelf systems as well as interior shading products.

Exterior shading was considered to change the appearance of the Crestwood Corporate Centre Building No. 8 too dramatically, relative to Building No. 7, and was quickly dropped from the investigation.

2.4.4 Daylighting
architect / electrical

Detailed envelope design for each exposure was developed at the glazed areas. Sections to investigate the effect of exterior only and interior exterior combination light shelves were drawn up. Options for higher ceiling, clerestorey and skylighting were reviewed. Some validation modeling was done on DOE-2.1E and reasonable options were maintained for modeling during later phases.

2.4.5 HVAC
architect/energy/mechanical/environmental

The HVAC options for Building No. 8 were predicated on the fundamental concept of maximum compartmentalization of HVAC functions. Meeting thermal and ventilation requirements on a highly local basis eliminates the intrinsic zone control (i.e. reheat), ventilation, and energy transport inefficiencies of conventional central HVAC systems, while offering an extremely high level of individual zone control and flexibility.

2.4.6. Power & Lighting
architect / energy / electrical / environmental

Low power density power and lighting systems options for Building No. 8 were developed to suit the multi-tenant nature of the park. The parameters to match the grid and lighting type of Building No. 7 were dropped. A deep cell parabolic in a staggered grid and a direct/indirect fixture were evaluated. Light levels not requiring task lighting were adopted.

2.5 Results Of Option Analysis

2.5.1 Configuration & Orientation

Only one configuration option for Building No. 8 was developed due to context constraints. Variations in envelope design, daylighting design, lighting layout, heating and cooling, fresh air, power and lighting were then integrated with the basic configuration and modeled to create an optimized selection of building options for review and consideration in the next phase.

Crestwood Corporate Centre Building No. 8 is an L-shaped building in the northeast corner of the site. This building configuration was fixed, as it would be a twin to its pair opposite, Building No. 7. Building No. 8 has a good envelope to floor area ratio. It was better oriented with the two cool sides (east, north) and the two warm sides (south, west) architecturally paired.

2.5.2 Internal Volume

Building No. 8 has a building standard entry lobby comparable to Building No. 7. Investigation into internal volumes, dubbed volariums, did not result in a self balancing space for the Crestwood Corporation Centre Building No. 8, although modeling indicated such a space was viable with a different shape and orientation.

2.5.3 Envelope

The options investigated included glazing and framing modified to provide differing levels of shading coefficients insulation as modeled for walls, roof and floor, and shading devices on south walls only to reduce high incident direct solar gain. External shading could not be applied to Building No. 8 as its external appearance had to match Building No. 7.

Envelope Insulation

The envelope insulation levels to the walls, floors and roof were designed to exceed the prescriptive requirements of ASHRAE/IES 90.1. According to the ASHRAE/IES standard for the climate of Southeastern B.C., the insulation value for the walls is R-11 and R-15.6 for the roof. The actual insulation value for the roof was increased to R-20 to meet industry standards and the walls were improved to R-15 to increase occupant comfort. A 2" perimeter slab insulation system was also provided.

These are effective and appropriate insulation values for a climate similar to Vancouver but modeling was done on high performance insulation levels. The results indicated that over insulating either the roof or the wall, but especially the roof, would not be not an effective strategy.

The design strategy was to achieve true R values by detailing wall and roof structures to avoid thermal bridging. This resulted in an additional layer of rigid insulation between the concrete walls and the steel studs.

Envelope Glazing

Seven different types of glazing and framing were modeled. All systems reduced energy consumption and the differences between each were incremental. Daylight transmittance of the glass was kept at about no less than 50%, as this had been a satisfactory standard in previous buildings. Daylighting is treated independently in an upcoming section.

Low-e- double pane - This glazing was modeled as the base case with a shading coefficient of about 0.43. Modeling indicated that it was sufficient for Building No. 8.

Triple glazed - tint & reflective - These glazing options were based on a curtain wall system and provided ideal results in the energy modeling. Costs for installing a triple glazed system exceed the building standard but are not as excessive as the costs for Visionwall. This system was not carried.

Vision wall - This glazing option had similar results to the triple paned reflective & tinted options and was not carried as a viable solution due to its excessive cost.

Triple pane clear- This system had a shading coefficient of 0.55. It was better than the base low-e system but not as good as the triple glazing options with tint and reflective glass. This system was not carried.

Reduced glazing areas - This option was investigated to see the effect of reducing the overall area of glass on the building to a 5'-0" high section rather than the base building standard of 7'-6" high. The results were a significant reduction in both heating and cooling load assuming a wall insulation value of R-12. This option was under consideration as cost effective and energy efficient. It was discarded in preference for the advantages of larger areas of vision glass within the spaces and the need to match the existing twin building, Building No. 7.

Envelope Glazing Options Summary

The best performing solution for Building No. 8 was a triple glazed curtainwall system with low-e glass. However, there was little justification for the increase in capital. While not providing the best energy performance a double pane glazing system with a mid range low-e coating was deemed the most cost effective system and was selected.

It should be noted that in the rest of Canada a building with a similar amount of glazing would require perimeter heating. In the case of Building No. 8, perimeter heating was not required due to the mild Southwestern B.C. climate

Exterior Window Shades

Modeling indicated that Building No. 8 would have a lower cooling load if an exterior shade were introduced, but the proposal to go with an optimized cooling system within the building did not support the additional expense of the shading device. Also, the addition of the device to the exterior made Building No. 8 visually different from it's twin building, Building No. 7. No exterior shading device was recommended for Building No. 8.

Interior window shades

This option was modeled and proved to be effective. Architecturally, the preferred shade was a finely perforated mesh that allowed through vision while deflecting low sun angle glare. The shades work best in conjunction with an exterior shade on the south wall. Building No. 8 has standard interior shading on all windows conforming to the performance standard of the park.

2.5.4 Daylighting

The study of the daylighting options was started in the concept design phase at the Lighting Design Lab in Seattle.

Interior lightshelf

An interior lightshelf was investigated. While not as effective as an exterior lightshelf, it was considered to be an effective option for Building No. 8, which was restricted in its use of exterior devices. However, modeling results were not initially encouraging as the cost of the shelf outweighed the benefit in reduced lighting requirements.

Clerestorey above third floor

Options to raise the roof in parts of the third floor were investigated to determine whether or not any significant advantage in terms of required lighting would result. Small restricted clerestoreys over the corridor were thought to have a good functional effect but were found to let in little daylight as they were too narrow. Larger area clerestoreys had an effect but as the cost of the clerestorey construction did not offset the cost of lights replaced it was not recommended. A clerestorey also restricted the layout flexibility of the spaces.

Daylighting Options Summary

All of the daylighting options investigated had advantages with the exception of the narrow corridor clerestorey. All options did not involve top lighting as it was difficult to control the solar heat gain. An interior lightshelf for Building No. 8 was not recommended. Clerestorey lighting on the top level over open plan areas was recommended, providing it suited tenant layout restrictions. However, this proved not to be the case.

2.5.5 Ventilation

Options for ventilation were not modeled separately but formed an intrinsic part of the considerations for the building. As other options were investigated, the following opportunities for improving the level of fresh air in the building became apparent.

Operable Windows

Although the Pacific Region has a mild climate, air handling system design is generally based on sealed building design and no modeling program for operable windows exists. Data from the Jack Davis building in Victoria was used for detailed information.

The HVAC system proposed for Building No. 8 was an optimized and efficient system. Operable windows were not as effective in this system but were thought to be cost effective if they eliminated the need for back up ventilation systems.

Ventilation Systems

The ventilation system proposed was one that would provide unmixed, unvitiated outside air directly to a four-pipe fan and ceiling diffuser system in each individual

HVAC zone using a roof mounted ventilation air handler. The outside air would be mixed with local return air in the fan coil that would then be provided to the space. The fan coil would supply a constant volume of conditioned air. The design goal at this point was to achieve a healthy and comfortable built environment.

Initial ventilation rates were set at 30 CFM per person. It was assumed that rates would drop to 20 CFM or lower to meet ASHRAE recommendations.

Reduction of Contaminants

Materials selected for construction and interior fitting would be restricted to eliminate those with known emission problems or particulate problems. Emission includes off-gassing of harmful vapors commonly found in carpet glues and wall vinyl and some paints. Particulates result from the fine breakdown of unstable materials such as insulation and cloth fabrics and carpets.

It was understood that air supply was tested and intakes located to prevent the intake of CO_2 or other contaminants. Air handling systems would be simple and would eliminate the potential for microbial contaminants.

Ventilation Summary

The recommended options of operable windows and direct-ducted fresh air system were proposed to meet air quality goals for Building No. 8. The air quality would be ensured through the restriction of materials and through adequate commissioning procedures.

2.5.6 HVAC Options

Building No. 8, in deference to realistic envelope and lighting performance objectives, and the desire to produce a C-2000 building with readily applicable technology, used proven HVAC design concepts and currently available equipment. The proposed secondary system options for Building No. 8 were based on maximum compartmentalization.

The secondary system selected was a four-pipe heat/cool fan coils (one per zone), with overhead distribution, local recirculation, and hard-ducted ventilation air. Economizer capability for the secondary system was evaluated but rejected as not being cost effective due to the increased costs associated with the duct work. The energy savings associated with the economizer were minimal..

A variety of Primary/Plant Systems were evaluated. They were as follows:

1. High efficiency boiler/chiller plant, conventional configuration.
2. Heat recovery chiller and boiler plan.
3. Central ground source heat pump plant with boiler hybrid operation.

The heat recovery chiller/boiler and the central ground source heat pump options were rejected as not being cost effective. Consequently, a conventional configuration using high efficiency hot water boilers and chiller was selected.

A variety of ancillary technologies such as ventilation heat recovery and evaporative cooling were also evaluated. All were rejected because as they were not cost effective.

These issues are dealt with in greater depth in Section 3.

3.1 Development Priorities

The following sections detail the design development through the preliminary design phase and outline the functional and aesthetic intent of the design, the nature of the materials and systems selected, and the selection criteria.

Generally, systems and materials were chosen based on the following selection criteria system shown in order of decreasing priority:

1. Aesthetics, Functionality and Durability
2. Occupant Comfort
3. Energy Efficiency
4. Sustainability Benefits

All decisions were tested against this set of priorities to maintain a realistic and market transferable project.

3.2 Orientation And Configuration

Crestwood Corporate Centre Building No. 8 is an L-shaped structure located in the north-east corner of the site. Under normal circumstances orientation and configuration can play a significant part in achieving energy efficiency strategies. However, in this case, the building location and orientation was fixed as it is the second of a two phase building project. Simulations of the two buildings indicated that Building No. 7 shaded Building No. 8 from the low west sun greatly reducing solar gain. Building No. 8 has a long north face exposure to maximize daylighting potential. It was resolved that Building No. 8 had a good orientation and configuration and could support the objectives of the C-2000 Program for Advanced Commercial Buildings.

3.3 Site & Landscaping

Specific environmental considerations were made in regard to the site and landscaping. The large trees on the site were recycled from the Expo '86 site and provide a mature leafy canopy throughout the site. The trees against the building provide shade in the summer and lose their leaves in the winter to allow daylight. The existing watercourse and wildflower border was protected and maintained. The site also offers a jogging trail to encourage walking and jogging.

The plants selected for the site are of the low water consumption variety while maintaining the highly attractive corporate image of the Centre. The plants were selected to complement the Richmond area growing conditions of warm summers and quick drying soils.

The benches are made of a cedar that is locally supplied. The planters are concrete.

3.4 Building Structure

Structural System

The structural system for Building No. 8 is a combination of structural steel (columns, beams and joists) and concrete (perimeter tilt-up concrete panels and interior cast in place concrete walls). Two studies of embodied energy of building types, done at the University of British Columbia, indicate that there is little or no difference in the embodied energy of a concrete building structure versus a steel building structure.

A cost analysis was done of the extra cost associated with a concrete structure on Building No. 8. The premium was approximately $100,000 over the established cost of a steel structure like Building No. 7. As steel is less expensive, faster to erect and has no discernible embodied energy penalty, it was decided to stay with the steel structure typical of other buildings in the Crestwood Corporate Centre.

Vertical Structure

The exterior wall system is a tilt-up concrete panel system. This is a panelized system resulting in reduced form work and a faster erection time than poured in place concrete. The concrete system has a projected life span exceeding 100 years and lends itself to the flexibility of reuse, if necessary.

Interior vertical supports are a combination of steel and cast-in place concrete walls. The embodied energy study noted above also supports the choice of concrete in this application. Furthermore, the mass of the walls have the added benefit of storing thermal energy.

The perimeter tilt-up wall panels and the interior cast-in place concrete walls were designed to resist lateral forces from both wind and seismic actions.

Horizontal Structure

The floor system is composed of a 1-1/2" steel deck and a 2-1/2" concrete topping. This is a durable system with longevity rated at over 100 years. The floors may be easily cut or modified to suit future use requirements. This system does not need to be under sprayed for fire protection to conform to the use and occupancy building code requirements for the building height and size. There is, therefore, a reduced potential for air contamination with particulates through the return air plenum in Building No. 8. The floor system also provides good acoustic sound separation and forms a finished surface for final floor finishes. It is a complete and simple system that is appropriate, functional and durable.

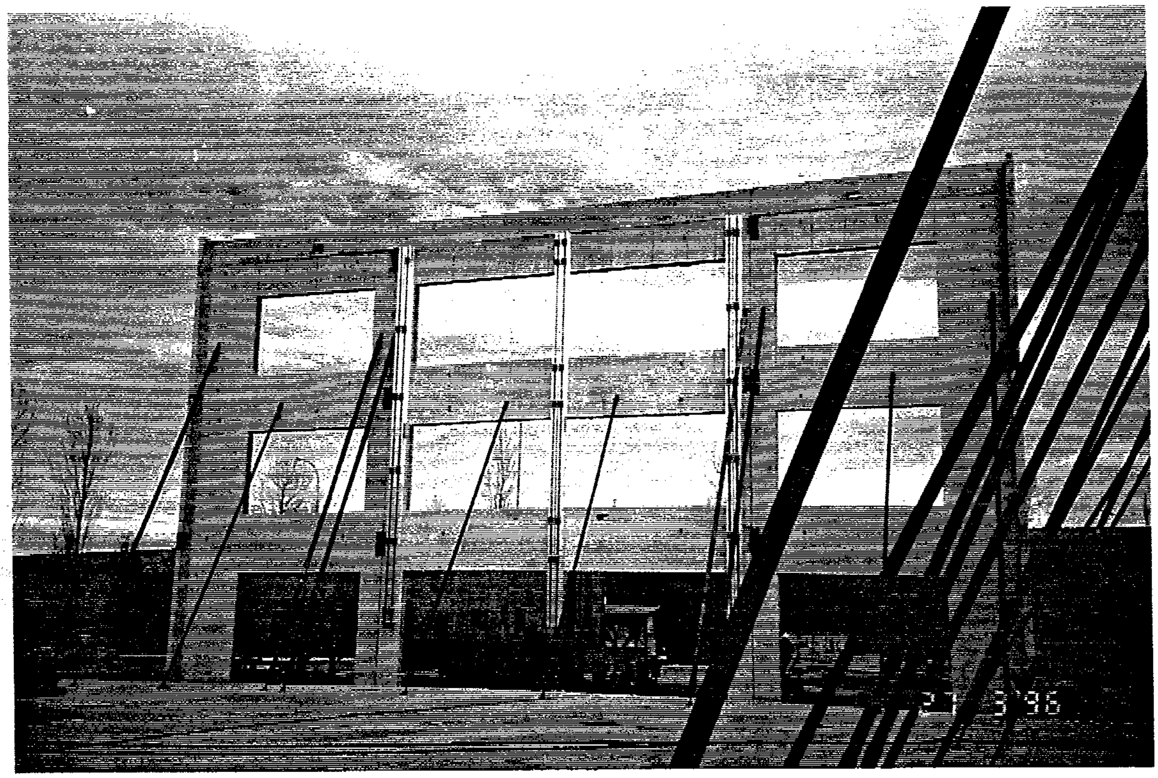
Building Cladding & Finishes

The exterior finish of the building is painted concrete. The paint selected was an exterior grade with the Canadian Ecologo or equivalent designation.

Some small areas of the building are clad in zinc composite cladding material. It has been applied in areas that cannot be constructed in concrete including balcony parapets, entry overhangs, rotunda parapet, and feature columns.

The benefit of zinc is that it is a natural, non-toxic, 100% recyclable material with a low embodied energy content. An OECD study was commissioned to measure how many tonnes of hard coal are required to produce the electrical energy necessary to produce one tonne of a basic element. Below are some of the results:

Aluminum	6.3 tonnes
Copper	4.4 tonnes
Polyethylene	3.0 tonnes
Zinc	2.6 tonnes



Erection of Tilt-Up Concrete Panel
March 1996

Polyvinylchloride 2.4 tonnes

It takes 21 kWh of energy to produce a 1m^2 sheet of 7.0mm thick zinc panel. In pure energy terms, zinc compares very favorably to most construction products on the market.

3.5 Building Envelope

Roof

The roof is a loose laid single ply EPDM roofing system designed with an insulation value of R-20. This is a common roofing system type for a large span office roof and is durable to at least 35 years with on going maintenance.

The roof assembly consists of steel deck with rigid insulation bonded to the decking. The insulation was installed in two layers with shiplap joints rated at R-20. A single ply of EPDM is loose laid to the substrate of the rigid insulation. The membrane is installed with EPDM elastofoam flashing and is reinforced at the perimeter parapet. The EPDM is extended vertically up the parapet wall and over the wood cap flashing blocking for a continuous seal. A gravel ballast is installed over the full area of the roof and the EPDM to provide full coverage and protection.

The wall air seal sheet on the panel joints is extended up to at least the level of the roof air seal membrane and lap the upturned roof EPDM sheet. The connection of the roof structure and the tilt-up concrete panel is further sealed with sprayed on polyurethane insulation around the building perimeter.

The insulation is expanded polystyrene. Unlike the extruded polystyrenes and the polyisocyanurates, the expanded polystyrene is expanded with a hydrocarbon (pentane), not a CFC or an HCFC. The top layer of insulation is attached with hot asphalt to eliminate thermal bridging associated with mechanical fasteners.

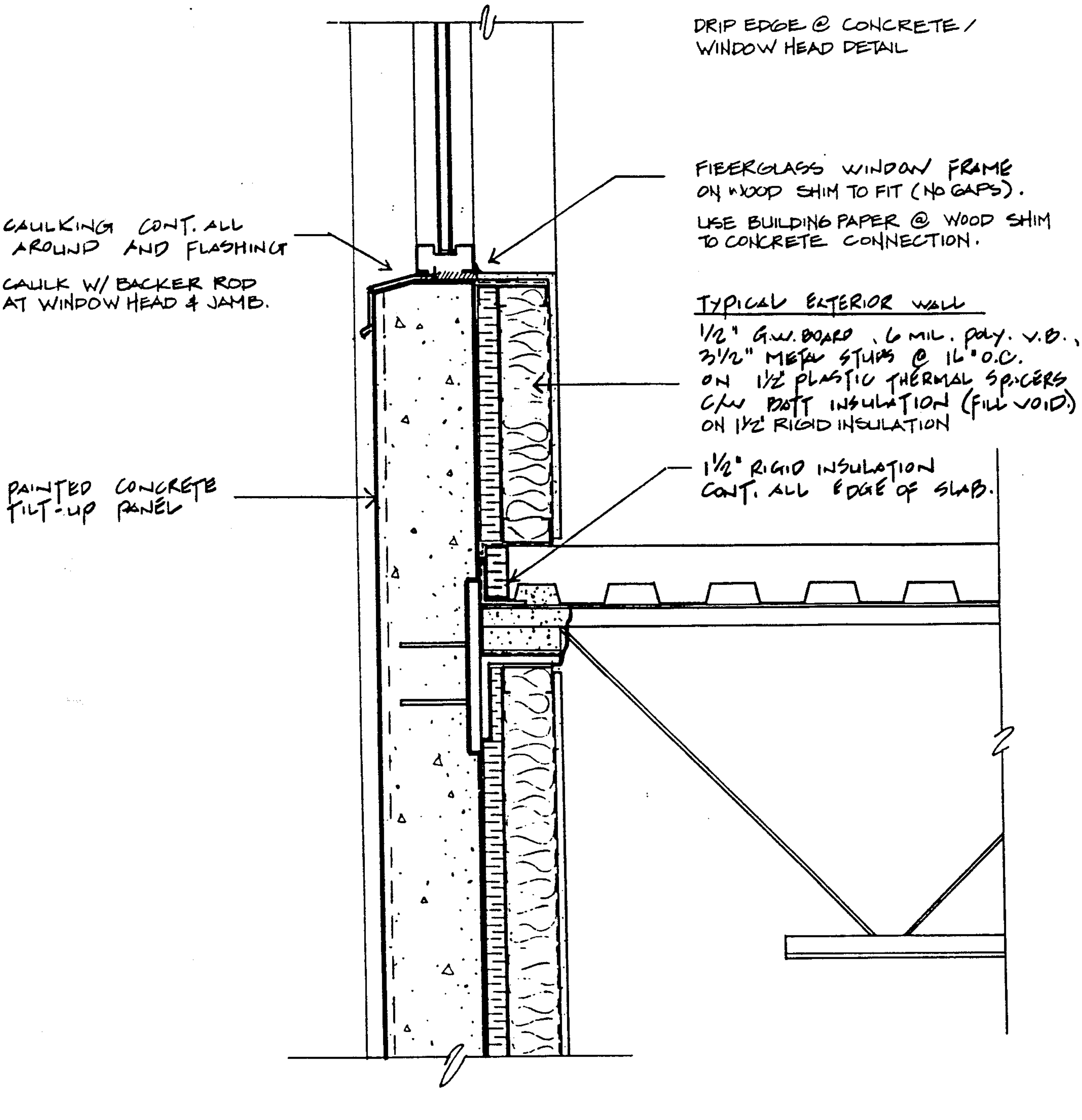
Walls

The exterior wall system is made up of a concrete exterior panel, 1-1/2" rigid insulation, horizontal spacer bar on clips and non-structural steel studs and gypsum wall board. The insulation is a fiberglass type batt insulation rated at R-12. A cellulose batt alternative was considered. However, based on its tendency to degrade, absorb moisture and compress over time, it was rejected.

The addition of continuous rigid insulation between the concrete and the steel studs compensates for potential heat losses due to thermal bridging caused by the steel studs. The addition of rigid insulation rated at R-7.5 give the exterior walls an overall effective insulation value of approximately R-15.

The window frames are aluminum with improved condensation resistance and thermal transmittance performance capabilities. The flashing on the window sill rests on a membrane fastened into the glazing system. All spandrels have an insulated pan.

Tilt up wall construction is very efficient from a time, cost and embodied energy point of measure. The panels are poured atop the slabs on grade thereby reducing the form work required and the resulting wood waste. The mass of the concrete gives the building a longevity of at least 100 years. The thermal mass of the concrete reduces



Typical Wall/Sill Detail

the heating and cooling extremes of the climate. Finally, the look of the panels mimic the appearance of aluminum making it a viable aesthetic alternative to aluminum.

An exterior coat of paint on the concrete panel prevents rain absorption. The painted concrete forms the air barrier and weather seal. The panel joints are caulked on both sides and protected by a peel & stick membrane on the inside surface of the concrete. Any structural steel penetrations coming from the warm side through the drywall are caulked at the joint. The vapour barrier is 6 mil poly located on the warm side of the insulation.

The roof parapet is insulated under the roof membrane to prevent any heat loss through the concrete section and to ensure the continuous thermal performance of the envelope.

Testing for air leakage of the wall assembly was a construction requirement. Testing was performed by an independent agency and testing complied with the C-2000 guidelines. Refer to the Appendix for the results.

Soffit

The soffit is an integral part of the envelope system and is insulated with a batt fibre type insulation. All pot lights are thermally insulated and fire stopped. The finish material is an insulating stucco assembled with wire mesh, building paper and exterior grade concrete board. The supporting steel frame structure is separated from the concrete face panels by rigid insulation to prevent thermal bridging. The insulation and soffit areas are separated from the return air plenum by the interior drywall sheathing running above the ceiling to the underside of the structure above.

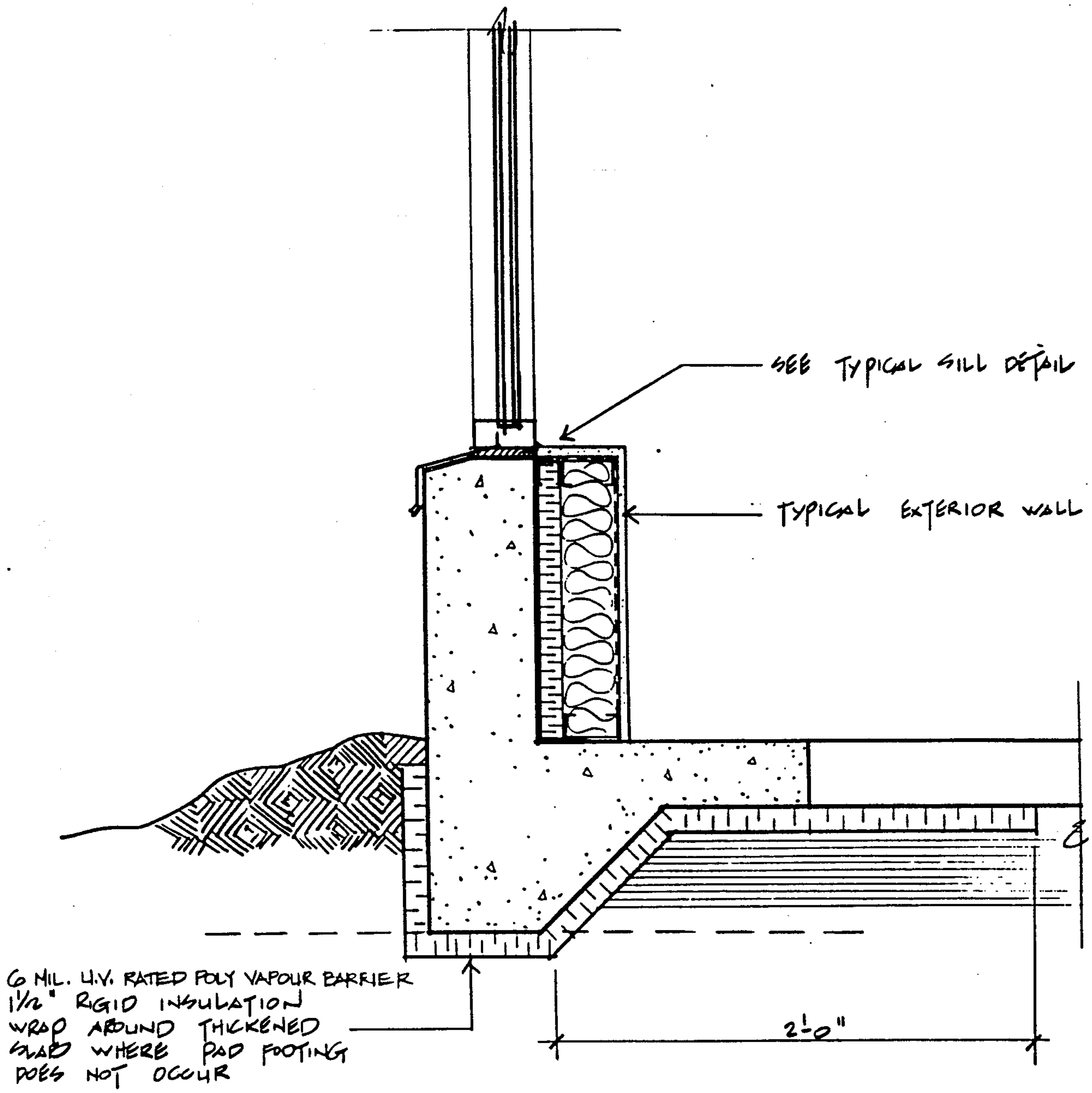
Balconies

The interior of the building is designated as a non-smoking area. However, two balconies are provided per floor to serve as outdoor smoking areas. This prevents smoke from contaminating the interior spaces. The exterior balconies are insulated and protected with a membrane system similar to the roof. The balcony has exterior grade concrete pavers.

Foundation

The construction of the tilt-up concrete panel walls used the flat building foundation slab as a bed to place the concrete. This substantially reduced the amount of form work and reduced the size of the construction area. The floor is a slab on grade with spread footings under the perimeter column system. The footings were damp proofed with a membrane to prevent heat loss through the ground. No membrane was installed under the slab perimeter due to the configuration of the footings. Insulation was placed under the slab around the perimeter for a depth of 4'.

Initially, waste glass was proposed as an aggregate substitute for drain rock around the perimeter. However, it was discovered that the intended source of this material no longer exists. Excess roof ballast was recycled as drain rock instead. No gravel fill was required under the building as a base due to the bearing capacity of the soils and the size and type of foundation.



Typical External Slab Detail

Sealants

The sealants in the building were caulking for windows and doors, joint and patch compounds for concrete and drywall work, mortar and grout for tile work, and adhesives for the attachment of flooring, wallboards and wallpaper. The reduction of a large amount of the potential for volatile organic compound (VOC) off gassing in the building was achieved by the aggressive reduction of inappropriate sealant materials.

The interior caulking for the setting of the windows and doors is a low toxicity caulking formulated with synthetic resins, that contain little or no hazardous solvents or fungicides. The exterior caulking is latex based since these products have a smaller health risk than acrylic caulking compounds.

Non-toxic joint and patching compounds were specified. These are gypsum combined with mica, talc, limestone and clay products and do not contain vinyl or toxic additives. The need for joint patching was reduced as much as possible by the architectural detailing. The interior drywall finishing work was well ventilated to prevent dust build-up and exposure to workers minimized through the use dust masks. All installations included a thorough clean-up after drywall finishing work was completed and prior to tenant fit-out work.

The mortar and grout mixes are cement based non-toxic substances. Acrylic resins, colors, fungicides and epoxies with high levels of toxicity were avoided. The grout was sealed to prevent staining and bacteria growth.

Adhesives are major source of VOC's in buildings. As a result, products that require adhesives were minimized. For example, the more traditional vinyl wallpaper was replaced with a high grade low VOC paint. Also, sheet vinyl flooring was not used. Whenever possible products like wallboard, sheathing and piping were mechanically fastened. When adhesives were used, they were either low toxicity wet adhesives or factory applied dry process adhesives. Adhesives for the carpeting were solvent free, low odor and low VOC content. In addition, the carpet manufacturer took back the backing sheets for recycling.

Generally, sealants have attracted a great deal of attention for their off gassing potential and new products that are environmentally friendly are being developed rapidly. Alternate products were considered throughout the project if they were proven to be more effective and/or less toxic than the product specified for the application.

3.6 Windows , Doors & Openings

Windows & Doors

The majority of the doors and windows for Building No. 8 are AFG Low-e double glazed green float in a Kawneer ISOWEB high performance frame. This profile does not match the standard set in Building No. 7, the existing twin building, but the glass and frame are slightly improved. The glass is set to the outside. The shading coefficients for the glazing is about 0.36 and the light transmittance is 0.49. Both of these standards are in general use throughout the park and give an acceptable level of light penetration into the space without distortion of colour. Although the C-2000 Program calls for at least 50% daylight transmittance, glazing with this spectral characteristic combined with a shading coefficient of 0.35/0.36 was not available at the time of design in the blue/green colour range.

Glass characteristics are tabulated below (Note these measurements are at Centre of Glass (COG)) :

1	Green Dble Low e Main Glass (77% of Total)	u = 0.31 v.t.= 0.49 sc = 0.36
2	Green Dble Curved Corners (11% of Total)	u =0.48 v.t.=0.66 sc=0.57
3	Silver on Green Dble Reflective Curved above entrance @ 2 & 3 rd Floors (7% of Total)	u =0.41 v.t.=0.19 sc =0.11
4	Copper on Bronze Dble Reflective 2nd & 3rd surrounding entrance (5% of total)	u =0.31 v.t.=0.14 sc =0.13

The windows in Building No. 8 are not operable.

Frame Types

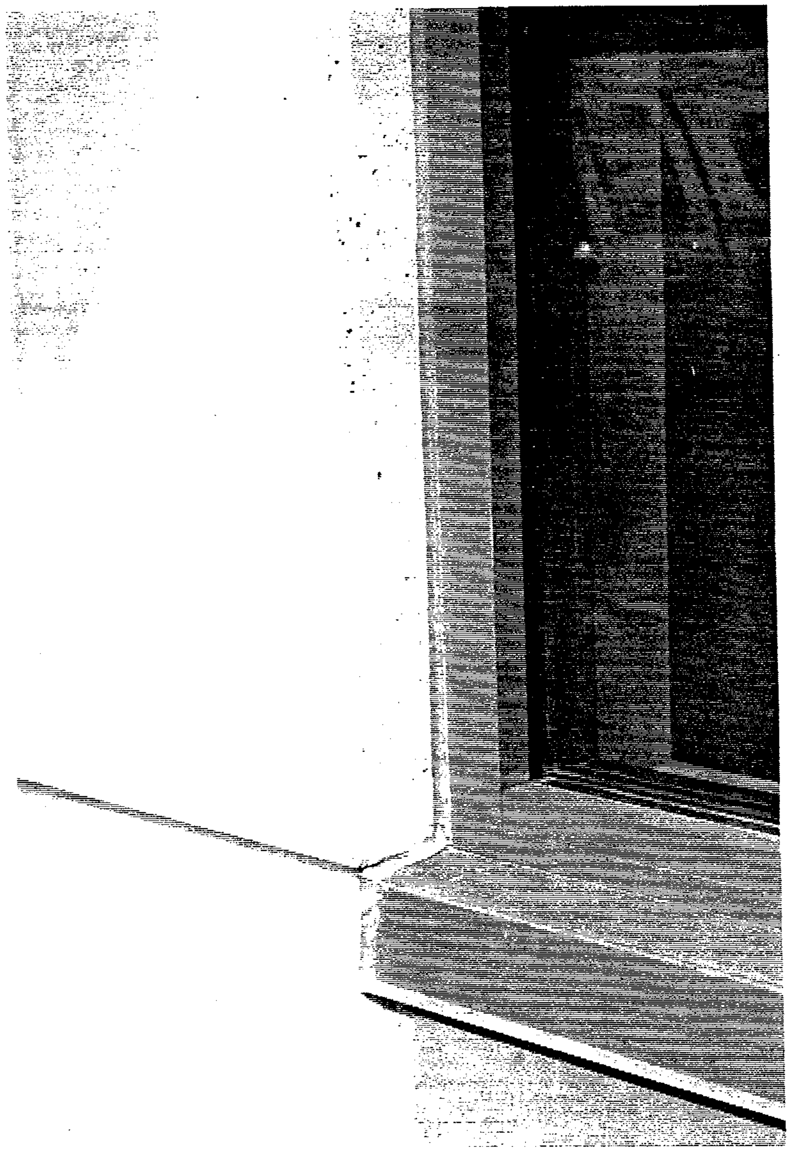
Although aluminum is durable and requires no finishing or maintenance, it is a high embodied energy consumer. It is estimated that 25% of the world's hydro-electric generating capacity is dedicated to aluminum production. Conversely, fibreglass requires substantially less embodied energy during its production cycle. Fibreglass window frames have also proven to be better insulating than aluminum. Nevertheless, due to quality control issues there is no recycled content in fibreglass frames. Currently, in Canada, there is no recycled aluminum content in Kawneer frames, although it was requested for this project.

The final decision regarding the use of an aluminum and fibreglass frames was not made until construction had started. After a great deal of analysis it was decided by the team to use the aluminum Kawneer 5500 series. The reasons are as follows:

1. *Energy Performance and Costing*

   On a cost based analysis of energy performance and with the adopted energy strategies and modeling parameters in place at that particular time the Alta-Therm fibreglass frames initially showed some advantage over the Kawneer 5500 Series. For the same premium of $76,000 over the basic Building No. 7 system, the Kawneer frame resulted in a building performance at 51.8% of ASHRAE/IES 90.1 while the Alta-Therm fibreglass resulted in a 50.6% performance.

   It should be noted that the results on the two frame types is specific and incremental to this building at its particular state and level of design. The results of the frame types would change with different HVAC plant systems and/or different envelope.



Caulking Detail at Window Frame and Flashing

2. *Product Performance*

A number of major installation concerns arose with the fibreglass frames. These included:

- "fat" vertical mullions every 4 feet that reduced visibility and impacted the aesthetics of the strip window design.
- unresolved water proofing details at the sill, head, jamb, weep holes and double mullion cover strips.
- absolutely no construction tolerance for the actual size openings in the concrete tilt-up wall openings.

The following are the minor installation concerns with the fibreglass frames:

- the inability of the frame to accommodate a full 1" sealed glazing unit.
- unresolved break shape and connection details at corners and columns
- actual stability of the Duracron finish on the fibreglass

These installation concerns were all addressed by the Kawneer system, which has uniform horizontal and vertical mullions appropriate for strip windows, an air lock barrier to prevent water infiltration under negative pressure, good, adjustable construction tolerance and uniform break shape and connection details.

The overall performance of both systems did not meet the C-2000 goal of 50% without false horizontal mullions. Using warm edge technology in the Vancouver climate increased costs approximately $14,000 and improved performance by 0.1%. Warm edge technology was not used for this reason. False horizontal mullions were recommended and developed by Kawneer and the installer to suit the project.

3. *Optimization*

Both products were repriced and remodeled for energy performance using false horizontals for the Kawneer system only and improved detailing on the Alta-Therm system. The results were:

- Kawneer 5500 ISOWEB at 51.1% ASHRAE/IES 90.1 for a $76,000 premium over the basic Building No. 7 system.

- The Alta-Therm frame at 50.5% ASHRAE/IES 90.1 for a $ 93,870 premium.

4. *Summary*

Overall, the issue of fiberglass versus aluminum frames was based on environmental and economic rather than energy concerns since the incremental energy difference was marginal. Therefore, based on the above, the decision was made to go with the Kawneer 5500 ISOWEB system with false horizontals and metal spacers.

Skylights / Atria Glazing / Volarium

Building No. 8 has a central skylight that provides daylight to the upper floor lobby. However, because of tenant flexibility requirements, the introduction of a general area clerestorey was not considered feasible. Preliminary modeling results on the skylight or clerestorey in the tenant areas showed them to be an energy burden with very little real daylighting gain.

3.7 Non-Structural Architectural Systems

Ceilings

The ceiling in Building No. 8 forms the underside of the return air plenum. For this reason the composition of the suspended acoustic ceiling tile was important. The space above the ceiling does not have any sprayed fireproofing and because the building is sprinklered no fire rating of the steel deck is required. Inert spun mineral fibre was used instead of fibreglass batt for all areas requiring fire stopping in shaft areas. Intemmescent paint fireproofing was proposed for the high hazard service room protection areas where the steel deck above the return air plenum would otherwise be sprayed.

The ceiling tile for the open plan and office areas in Building No. 8 was chosen to reduce the potential for particulate in the spaces. The collection of dust on the upper side of the ceiling in Building No. 8 in the return air plenum can be a problem and was minimized by controlling construction sequencing to ensure that the ceiling tiles were installed after drywall sanding. The system has an excellent sound absorption factor and assists in reducing noise levels.

Floors

The use of a raised floor system to accommodate the electrical runs and the air supply and return was considered. It was rejected due to its excessive cost as a market transferable item.

The floor system for Building No. 8 is a simple concrete topping on a steel deck finished with carpeting supplied by the tenant. The building has small areas of painted concrete floor. All paint was specified to the Ecologo Canadian standard. Vinyl sheet flooring was eliminated due to its tendency to off gas and the nature of the adhesive material required to affix it. The tenant guidelines recommend cork or jute flooring materials as substitutes.

The rest of the general floor areas have either ceramic tile, marble tile or carpet flooring. The grouts and mortar beds used to set the tiles are discussed in the section on sealants. The marble flooring in the lobby of Building No. 8 matches Building No. 7 and is set in a mortar bed to increase its life.

The ceramic washroom tile in Building No. 8 matches that of Building No. 7. Although the processing of ceramic tile is high in energy consumption, it is a good environmental choice due to its durability and wide availability of raw materials. Ceramic tile manufactured from recycled glass products was considered. For example, Quail Stone in Ontario distributes an American glass bonded ceramic tile composed of 70% recycled glass. Summitville Tiles, Ohio, manufacture porcelain pavers constituted mainly of the waste products generated by the tile industry. The Stoneware Tile Company manufactures a product called Traffic Tile that is composed of 70% glass from post industrial and post consumer waste glass. Presently, these tiles are not cost effective.

Carpets are installed in the lobby of Building No. 8 to match those in Building No. 7. Most of the concern with carpets involve the off-gassing of VOC's contained in the adhesives, backing and cushioning materials. The carpet for Building No. 8 was leftover from Building No. 7 and, because of its existing backing, solvent free low odour and low VOC adhesives were used, rather than a mechanical fastening system.

Tenant Flooring

Tenant guidelines developed for Building No. 8 make recommendations for alternate carpet systems. Generally, the performance of a carpet depends on the durability of the product and on its tight loop construction and resistance to creating loose particulate that contaminate the air. Carpet manufacturers have found that 'weaving' the fiber wastes less fiber and creates a more durable carpet. Whatever carpet product is used, its VOC emissions can be reduced by asking the mill to 'bake' the carpet order a little longer than usual so that remaining chemicals are removed from the manufacturing process. BASF is currently making a new nylon fibre carpet that is recyclable and durable for ten years. In regard to recycled carpet it should be noted that carpets spun from recycled drink box plastics are popular but are not durable enough for commercial installations. Latex or woven backings are to be avoided due to their ability to harbor dust.

The adhesives used in carpet are a major VOC concern. For that reason a number of manufacturers have introduced carpets that do not require adhesives. Peerless Carpets have developed a Tac Fast system that uses Velcro strips and does not require adhesives or an under cushion. Heuga has created an environmentally sound backing system called System Six that reduces adhesion requirements and enables removal and recycling through their own carpet recycling program.

If the tenant opts for more of a traditional carpet system, Tenant Guidelines recommend the use of low VOC and low odor carpet adhesives.

Carpet cushion for this building was not required. Where a tenant needs carpet underlay, a carpet cushion made from recycled tires is recommended. It is a product that eliminates quantities of waste tires and is made in Canada by Dura in Montreal.

Walls

A typical wall is constructed as part of a non-combustible building type requiring steel studs and gypsum board. Gypsum is very safe from a toxic standpoint but is an environmental concern when it finds its way into landfills, especially those located in a wet climate. Nevertheless, gypsum is 100% recyclable and local manufacturers use up to 26% recycled material in their products depending on availability. The board is screwed into place to avoid the use of adhesives. Installation procedures minimized the health risks to installers through the use of masks and ventilation to reduce fine dust contamination.

The interior wall finish is paint with some architectural wood working. Vinyl wall coverings were avoided due to environmental concerns. Vinyl is high in VOC's and can increase the contamination of the air and the need for more fresh air supply. Further, vinyl is made from petroleum, using a polymerization process, that creates a serious risk of chemical exposure for workers and produces hazardous waste. If a tenant insists on a wall covering, a natural product like sisal or a paintable recycled paper product is recommended. Genon (Naturally Genon) and Guard Contract Wall coverings have vinyl wall products designed to reduce some of the VOC emission levels.

The interior paints used met the Ecologo standard. In Canada, the paint industry has responded positively to the Ecologo program and modified their products to conform to strict environmental guidelines. The wall coating material for the building is manufactured by Zolatone and is highly durable, low in VOC's and give the appearance of a wall covering.

The woods specified for use as decorative finish products in architectural work were 'farmed' rather than forested and harvested wood products. For this reason cherry wood was used as a substitute for mahogany. The finishes were natural oils and wax to avoid VOC emissions.

Miscellaneous

The elevator cab interiors have some plastic laminate surfaces. The product is a durable wall finish material for high use areas with good accent colour potential. For these areas, paint or wood are not appropriate substitutes. Although the production of plastic laminates is a highly polluting process, government regulating authorities are doing much to streamline and reduce the impact of the production process. However, as laminates are durable and the best product for certain uses, put in context with alternate surfacing materials, decorative laminates are acceptable if used appropriately. Plastic laminates were installed with low emitting adhesives.

Consideration was given to plastic laminate type of material called Environ from Phenix Biocomposites. This is a product that has the appearance of granite but works like wood and refers to itself as a new generation of hardwood. Made from recycled and renewable resources it does not contain hazardous or toxic substances including formaldehyde. It is an excellent alternative to plastic laminates and is highly durable and appropriate for use within a heavily trafficked elevator. This product was not used because it was too small for the specified elevator and the cost of this product is very high.

3.8 Plumbing And Sanitation Systems

Water Reduction Schemes

Less than one-half of 1 percent of the earth's water is fresh and drinkable. With this in mind, water reduction is an important part of the C-2000 program.

Unlike public buildings, Building No. 8 does not service a large number of people except for the tenants. Consequently, the building is a relatively low water consuming type of occupancy. Several water-use reducing schemes were reviewed and this report outlines the pure economic first cost and cost saving analysis.

Sub Metering

Two meters are provided. One system meters the irrigation while the other meters the rest of the building. Sub meters were incorporated to allow detailed monitoring of water consumption by various systems.

Water Fixtures

Low water-use plumbing fixtures and trim were installed throughout the building. Water use from plumbing fixtures meet or exceed the fixture performance outlined in the C-2000 Guidelines.

Sensor Controls

Electronic sensor controlled faucets and urinals were reviewed and the water savings would have been insignificant in this application in comparison to manual closet single lever low flow lavatory faucets or low flow shower heads. However, the lavatories are controlled by an automatic "off" push button type metering faucets. Vandal proof aerators are provided and the use of water efficient kitchen appliances have been recommended in tenant guidelines.

Rain Water

Rain water collection for reuse in irrigation was investigated and was found to have a high first cost (approximately $18,000.00 to $20,000.00) for relatively low savings (approximately $100.00 per year). Investigations indicated that it would be more practical to reduce water use by using different types of irrigation such as drip pipes that could save approximately $150.00 per year. Lower water use by reducing the length of time that irrigation is run and/or providing water less often will be experimented with to further reduce water use. It should be noted that our rainy season coincides with the time of year we do not run the irrigation systems.

Gray Water Reuse

Reuse of sink or gray water was also found to follow the same pattern as above and raised the issue of water treatment and health concerns. It was not recommended.

3.9 Vertical Transport

There are two elevators located in the building lobby serving all floors that also function as delivery and passenger lifts. The elevators are hydraulic and rated at 3,500 lbs. and of the high efficiency variety to reduce energy consumption. An attempt was made to reduce the capacity to 3000 lbs. but due to building code requirements the larger capacity was used.

Unlike most commercial buildings the elevator of Building No. 8 is not the centre of attention in the lobby. Instead, the lobby stairs are featured prominently within the building to encourage occupants to walk rather than ride the elevator. This strategy required sprinklering to meet code equivalency requirements but in spite of the extra cost was pursued to reduce energy consumption.

3.10 Thermal Storage Systems

The use of thermal storage systems was considered at various points in the Concept Design and Design Development processes of the project, but was not actively pursued for the following reasons:

- The concept is contrary to the overriding objective of maintaining simplicity in the building system configuration and energy efficiency strategies.
- Comparatively low building thermal loads did not portend a favorable economic return on thermal storage systems.
- Energy performance targets could be met without complex and expensive thermal storage systems.

3.11 Thermal Generation Systems

The primary thermal generation systems of Building No. 8 consist of two 1,000 MBH pulse combustion condensing boilers supporting a closed hydronic heating system operating at comparatively low temperatures (nominal 90 F return water). The secondary HVAC system is a four-pipe heat/cool fan coil. Each boiler is sized for about half of the building design heating load to provide efficient part load operation as well as backup capability. A single screw-type R-22 (0.05 ODP) air-cooled chiller of nominal 125 tons capacity was selected for its high efficiency throughout the operating range. A plan to utilize a 134a screw chiller were suspended due to the delayed development and release by chiller manufacturers. It is interesting to note that air-cooled condensers are proving to be considerably more efficient in the humid Vancouver climate than the more conventional wet cooling towers.

3.12 Solar Energy Systems

Solar energy systems were not seriously considered at either the Concept Design and Design Development phases of the project for the following reasons:

- The concept is contrary to the overriding objective of maintaining simplicity in the building system configuration and energy efficiency strategies.
- Comparatively low building thermal loads did not portend a favorable economic return on thermal storage systems.
- Post-installation monitoring of large commercial solar energy installations has usually indicated disappointing performance.
- Energy performance targets could be met without complex and expensive solar energy systems.

3.13 Thermal Recovery And Transfer Systems

An integrated water loop heat pump system is used in the base, or market building scenario. This type of system has been used in other buildings located in the Crestwood Park. Consequently, the energy performance of this configuration was accurately assessed as a matter of course and is discussed further in the Energy Efficiency Plan.

Ventilation heat recovery was considered at various stages of Concept and Design Development, but was abandoned for one or more of the following reasons:

- The economically and functionally effective plan of relieving the HVAC systems locally at various points on each floor does not lend itself to exhaust/relief heat recovery strategies.
- Ventilation loads in the moderate Vancouver climate are not as high as in colder regions of the country, yet ventilation heat recovery capital costs are comparable. This drastically cripples cost-effectiveness in this application. Furthermore, the planned strategy of air quality monitoring may allow additional reduction in ventilation loads.
- The complexity of ventilation heat recovery is contrary to the overriding objective of maintaining simplicity in the building system configuration and energy efficiency strategies.
- The energy performance targets could be met without ventilation heat recovery.

3.14 Ventilation Systems

The ventilation system in Building No. 8 provides unmixed, unvitiated outside air directly to a four-pipe heat/cool fan coil unit and ceiling diffuser system in each individual HVAC zone using a roof-mounted ventilation air handler with hot water pre-heat. The outside air is mixed with local return air in the fan coil and subsequently provided directly to the space. Positive ventilation delivery directly to the zone avoids the loss of overall ventilation effectiveness associated with centralized systems such as VAV. Combined with the constant volume air flow characteristics of the fan coil system, the estimated net ventilation effectiveness is 0.90. Passive relief air dampers in the ceiling space outside wall at several locations on each floor provide system trim balancing in conjunction with mechanical washroom and other specialized exhaust (e.g., photocopy rooms, kitchens, etc.). The system is fully flexible to accommodate tenant improvements, and includes accessible exhaust risers for tenant connection.

System capacity can provide a net effective ventilation rate of up to 30 CFM per person for initial and periodic building flush out purposes. The actual operational rate is anticipated to be 20 CFM per person. Ongoing air quality monitoring may allow the rate to be reduced further. Gross fan coil air supply can provide a minimum zone air circulation rate of 4 air changes per hour.

Given the relatively simple ventilation configuration and the associated ease of maintenance, provision for backup ventilation was not considered economically justifiable. For example, the most catastrophic failure would consist of a motor replacement that could be accomplished in a few hours.

Outside air filtration is rated at a minimum 50% dust spot efficiency and all requirements regarding exhaust/intake locations and other considerations outlined meet or exceed the C-2000 Program.

3.15 HVAC Delivery Systems

Building No. 8 utilizes a four-pipe heat/cool fan coil HVAC system with ventilation supply to each fan coil, a low temperature hydronic heating system, and chilled water cooling. Air supply to the space is constant volume through a conventional ceiling diffuser system.

The HVAC system is flexible enough to accommodate tenant layout requirements. It is also base-building zoned to accommodate three offices per zone in the perimeter and 100 m^2 open office space in the interior. Zoning resolution can be increased for tenant requirements down to one office per zone.

Refer to the following page for a schematic drawing of the HVAC system.

Air terminal noise control (NC) level is designed to NC 35 for general areas and NC 30 for conference rooms.

3.16 Power Systems

Transformers/Supply

Building No. 8 is fed from the existing outdoor substation initially designed for both Building No. 7 and No. 8, and is now energized as part of the Building No. 7 operation. Secondary cables within conduit rated at 600/347 volts are supplied from this transformer to the main electrical room in Building No. 8. Secondary distribution transformers are located in the main electrical room (total of 4) and each sub-electrical room on each floor and wing of the building. Tenant transformers are isolated from common area transformers to isolate electrical "noise". Tenant transformers also have a K-13 rating due to the proposed high computer loads of future tenants. The lighting systems are fed from the main 600/347 volt panels via various switching techniques.

Standby Power

As it is not a code requirement, no provisions were made for standby power.

Main Metering

A master B.C. Hydro meter is located on the outdoor unit substation, similar to the meter installed for Building No. 7. The advantage is that the meter can be read without accessing the building.

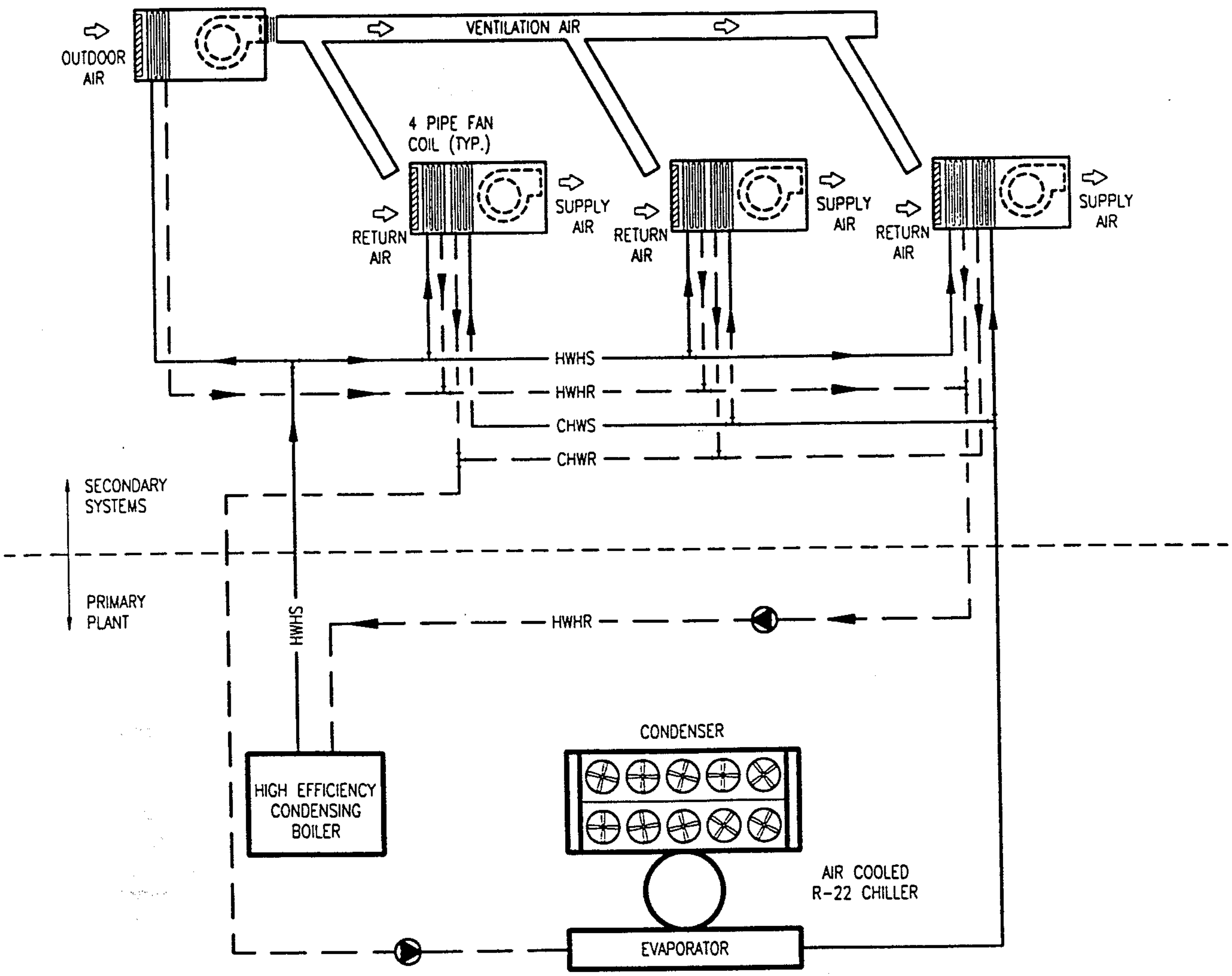
Sub Metering

A complete sub-metering system is provided to indicate usage for common areas and individual tenant areas. The metering within the tenant areas includes lighting and power. The metering system specified is approved by the Industry Canada Legal Metrology Branch for utility sub-metering.

Motor Control Centers

Due to the size of the building and the need to reduce costs the use of a Motor Control Centre (MCC) was not proposed. Building No. 8 does have a DDC controller

BUILDING No. 8 HVAC SYSTEM



- ELIMINATION OF REHEAT
- PRECISE ZONE TEMPERATURE CONTROL
- LOW FAN AND PUMP ENERGY
- PRECISE VENTILATION TAILORING
- HIGH VENTILATION EFFECTIVENESS
- SIMPLE VENTILATION HEAT RECOVERY
- LOWER COST THAN VAV REHEAT
- SMALLER CHILLER CAPACITY DUE TO ZONE SPECIFIC COOLING

C 2 0 0 0 : BUILDING No. 8

CRESTWOOD CORPORATE CENTRE

RICHMOND BRITISH COLUMBIA

VEL ENGINEERING
CONSULTING MECHANICAL ENGINEERS

DWT
D.W. THOMSON ENGINEERING LTD.

\DWGS\5560\SKM-1.DW

and each mechanical device has a magnetic starter adjacent to its location. Control wiring is provided to each magnetic device and back to the DDC. Also, space within the building was too limited to provide a MCC.

Vertical Risers

The building is distributed for power and telecommunications through conduit and wire from the main electrical room to each sub-electrical room. The feeds are located within the slab or just under the decking (depending on size) to the distribution points. As this building is only 3 floors a vertical buss duct riser was not practical or cost efficient.

Horizontal Distribution

Similar to above conduit and wire are distributed within or under the slab.

Lighting Control Panels

All lighting systems are controlled by a Douglas full 2-way lighting control package. This system has been utilized in Building No. 5, 6 & 7. With a computer smart controller the system can monitor each separate relay to a maximum of 280. Each relay can operate a number of lights or circuits. Also, the system is integrated with daylight and occupancy sensors and is compatible with the DDC System.

Motors

All motors were specified as high efficiency by Division 15 - Mechanical.

Plugs/Outlets

As a multi-tenant building the plug layout in Building No. 8 has been determined by tenant requirements. On a recent load test on Building No. 6 within the Crestwood Corporate Centre development, plug loads were determined at 0.43 watts per square foot. For design purposes Building No. 8 was modeled at 0.5 watts per square foot. For building design purposes a level of 0.75 watts per square foot was used to provide a margin for chiller sizing.

3.17 Lighting Systems

Ambient Lighting

Lighting for office areas was provided by a 3" deep cell parabolic luminaire using 2-T8 32 watt lamps. The lamps have a colour temperature of 3500K with a Colour Rendering Index (CRI) of 80 or greater. The lamps provide an ambient level of 60 footcandles.

The ballast that controls this luminaire is a Hybrid Electronic Start-Magnetic Run. The wattage could have been reduced using an electronic ballast but the costs were prohibitive and the possible interference with computers due to harmonics confirmed that a "standard" ballast was preferable.

Common area lighting is a combination of decorative lights in lobbies and recessed lights in washrooms and corridors that use energy efficient compact fluorescent lamps. Emergency lighting is built into the base building fluorescent fixtures and compact fluorescent recessed pot lights using a "Bodine" emergency lighting ballast. This ballast illuminates one lamp in various designated fixtures throughout to illuminate means of egress. Once normal power is returned this ballast recharges for the next usage.

Task Lighting

As this building is a multi-tenant oriented, task lighting on systems furniture was a possibility. This was not accounted for within the plug loads. However, Tenant Leasing Guidelines recommend that task lighting utilize the same energy efficient lamps and ballastry as specified for the base building.

3.18 Cabling & Building Automation Systems

Cabling

Each floor electrical room has access to telecommunications demarcation points. As a multi-tenant facility, each tenant will have different requirements for cabling. As cable systems vary from user to user a base building system could not be specified. Tenant Guidelines prepared in conjunction with the Building Owner indicate the suitable cabling to conform to C-2000 Guidelines.

Building Automation

The building systems are controlled from a fully integrated DDC System. The lighting controller is tied to this DDC System. Fire alarms, however, are a separate system.

3.19 Office Equipment

As a multi-tenant building, office equipment is an unknown within Building No. 8. As mentioned, plug loads have been assumed to be about .5 watts per sq. foot, including office equipment.

Tenant Guidelines encourage the use of energy efficient task lighting and office equipment.

3.20 Appliances

The use of tenant supplied refrigerators and coffee machines was anticipated. This was factored into plug load and is a minimal consumer due to the nature of the tenants. Again, Tenant Guidelines encourage the use of energy efficient appliances.

4.0 Introduction

This section contains the performance issues that make up the bulk of the C-2000 program. As previously noted, the technical requirements of the C-2000 program are designed to achieve advanced energy efficiency, reduced environmental impact and a superior indoor environment. As a result, the program has very specific performance criteria in a number of areas. These include:

- Energy Efficiency
- Environmental Impact
- Occupant Health and Comfort
- Functionality, Longevity and Adaptability
- Operations and Maintenance
- Economic Viability

This section will examine each of these criteria in depth while demonstrating how Building No. 8 of the Crestwood Corporate Centre achieved the ascribed performance goals.

4.1 Energy Efficiency Performance

4.1.1 Introduction

C-2000 Energy Performance Requirements

The key C-2000 program goals related to energy efficiency include the following:

- The Annual Purchased Energy Cost of a C-2000 building is 50% of ASHRAE/IES 90.1 for office buildings.
- The Annual Source Energy Consumption is 50% of ASHRAE/IES 90.1
- Compliance of C-2000 designs relative to ASHRAE/IES 90.1 requirements is determined through computerized energy simulations.

It should be noted that the C-2000 performance standard is a hybrid of three individual performance benchmarks. It uses the *Reference Shell* (same shape and orientation as the Design Building), *Prescriptive Envelope* (including envelope insulation values and fenestration areas and types as required by the Prescriptive method), and the HVAC and Electrical systems defined in the *Prototype Method.* In other words, the standard requires that the building achieve 50% of the energy use and cost of a ASHRAE/IES 90.1 Reference building shell with Prescriptive envelope characteristics and Prototype building systems. This combination of select parts of the three 90.1 benchmark methods is far more challenging than the commonly used Prototype method alone. This was done by the designers of the energy component of the C-2000 program specifically because the Prototype benchmark was considered too easy to beat. For example, the Prototype method is based on a simple rectangular shell in an exact east-west longitudinal orientation and huge gains can easily be realized through simple changes to the building shape and orientation.

Assumptions And Performance Targets

For Building No. 8 of the Crestwood Corporate Centre a preliminary energy efficiency plan was developed and submitted at the Concept Design phase of the project.

Although a number of modifications to specific strategies had to be made as the analyses continued through design development and construction, the initial premise and performance targets remained intact.

Simplicity, elegance, robustness, and cost-effectiveness were the key criteria for all strategies. Complex, highly exotic, specialized, or "fragile" technologies were steadfastly avoided. The introspective question continuously asked was whether or not a proposed approach or technology would be embraced and reproduced by the mainstream building industry. If not, it was abandoned as unsuitable.

Reflecting this premise, Building No. 8 was developed using entirely mainstream and readily reproducible technologies applied in an effective and integrated manner. The resulting building, a visual twin to the conventional Building No. 7 of the commercial park, achieves the original 50%-of-ASHRAE/IES 90.1 energy performance target with negligible projected net incremental capital cost compared to the baseline market building.

Computer Simulation Methodology

DOE 2.1e (integrated with LBL Window 4.1) was used for all energy analyses. In addition to the Building No. 8 ASHRAE/IES 90.1 Reference and C-2000 design models required by the program, two variations of a Building No. 8 "market" or baseline building were modeled for life-cycle costing purposes.

General Strategies

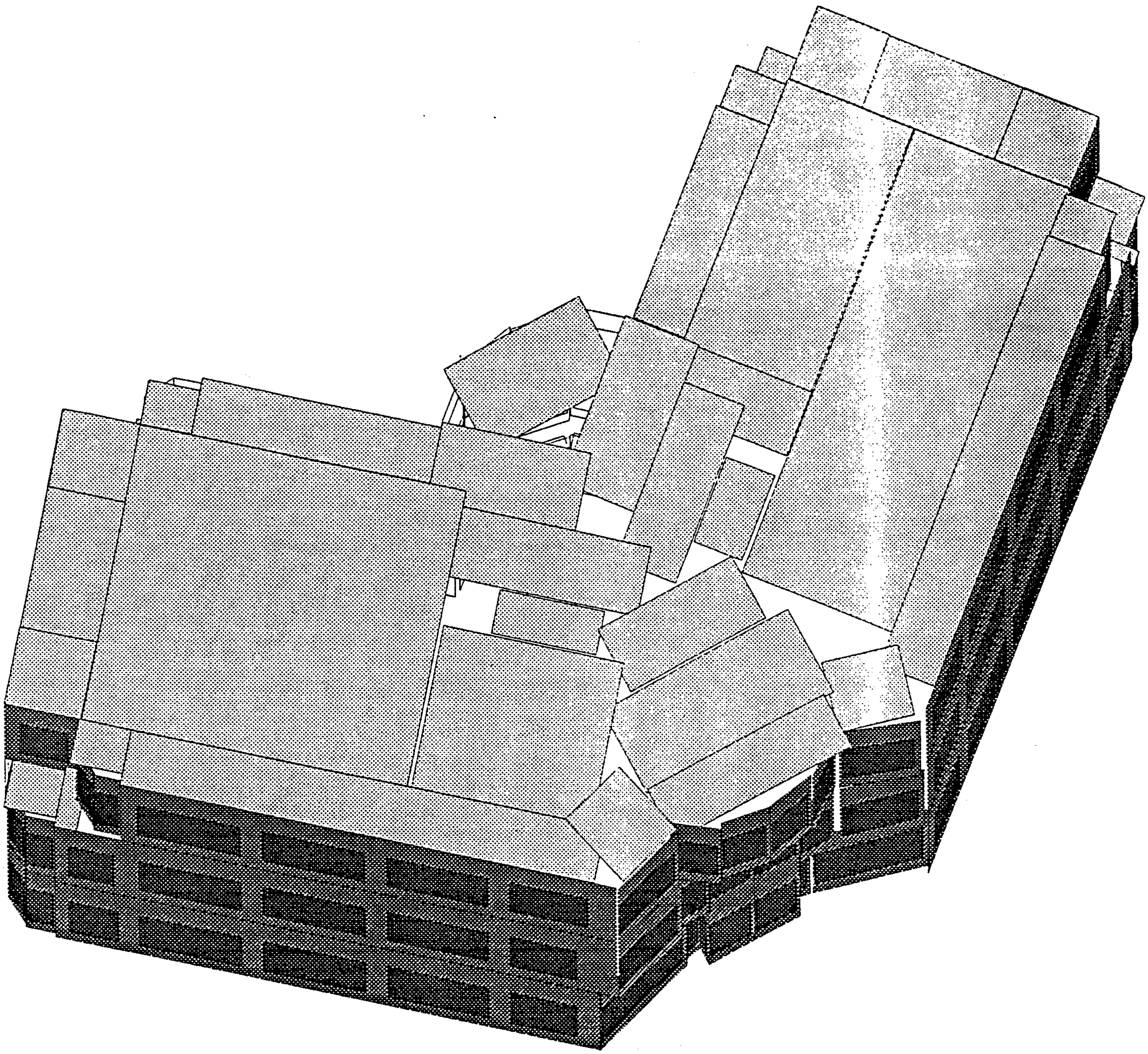
Conventional building design has evolved into a relatively linear process. The architectural team designs the building shell, and subsequently passes the design over to engineering teams who provide structural, mechanical, and electrical systems. Very little, if any, cross-discipline communication occurs. This results in building energy performance that is not optimized because the building systems have not been designed to work together in the most effective manner possible. Systems tend to be over sized or over designed, and even the simplest opportunities for synergistic benefits (e.g. optimizing glazing selection with a view towards minimizing HVAC capacity) are overlooked. The consequence is a building that is more expensive than it needs to be.

A further problem related to the non-integrated design approach is that the overall flow and use of energy in the building is left unmonitored. The limited perspective that each design discipline inevitably brings to the process results in the overall performance perspective being completely missed. Energy waste that may not be apparent at the level of individual disciplines is often patently obvious in the context of overall building energy use patterns. Consequently, the cornerstones of the energy efficiency strategy were a fully integrated approach to the design of Building No. 8 and the close scrutiny to areas of obvious energy waste in conventional building technology.

An integrated and synergistic approach to design was the key to success. Strategies focused on the energy waste of conventional building design practices

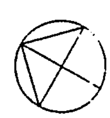
Design Evolution

The integrated design approach concentrated initially on the major energy users for an office building in a west coast climate: lighting system energy, heating energy and HVAC system electrical energy. As heating energy consumption is significantly



Doe 2.1e Visual Of Building No. 8 Of The Crestwood Corporate Centre.

Note: Although not an exact representation of the building it is an accurate mathematical model for simulation purposes.



influenced by the delivery system, or HVAC system used to maintain comfort conditions in the spaces, the selection of this system was a primary target for energy savings. In addition to the selection of the HVAC system, a major design strategy was the reduction of building loads with the intent to minimize HVAC system energy consumption and installed cost. The reduction of building loads was a combination of the lighting and envelope measures. The optimization of the lighting system promised the combined benefit of direct energy cost savings in electricity consumption and reduced building cooling loads.

4.1.2 HVAC

The response of the HVAC system to building loads is often the most significant factor in the building energy performance equation. In this regard popular central mixed-air VAV system do not perform well. Generally, they address multiple-zone load variations by supplying cooling air to meet the worst-zone cooling load and rely on VAV box shutdown combined with rehashing to control overcooling in less critical areas. Realistically, the minimum VAV box position is dictated by ventilation and/or air circulation requirements. Since this is often well above cooling load requirements, the zone operates in reheat mode for extended periods of time. In fact, most central VAV-reheat systems operate as Constant Volume Reheat systems most of the year. The wider the zone thermal variances, the more severe the effect.

Operating in reheat mode for extended periods, conventional VAV reheat systems incur substantial waste in reheat energy. One solution to this problem is to compartmentalize HVAC systems as much as possible, minimizing the number of zones served by any one system. In this respect the HVAC system for Building No. 8 extends the concept to its logical conclusion by meeting heating and cooling loads at the zone, or "terminal" level.

Major Strategies

A fully compartmentalized four-pipe fan coil system was used in Building No. 8. In computer building simulations, heating energy reductions, as compared to the ASHRAE/IES 90.1 Reference VAV Reheat system, ranged from 25-35% depending upon other interrelated building parameters at the time of the evaluation. By inference, these savings correspond to the reheat energy wasted in a typical VAV reheat system. Due to the local nature of the air system, fan system electrical energy requirements were also significantly reduced in comparison to the Reference VAV Reheat system.

The installed cost of the HVAC system was found to be lower and this was attributed to two key reasons:

- The size of the central cooling plant, which is based upon satisfying peak cooling loads, was reduced. This was due in a large part to the reduction in building loads (refer to Lighting and Envelope sections). A cooling load reduction at the plant level was also realized due to the compartmentalized air system. As central air systems must often cool the air supply to all zones based upon the worst case zone, compartmentalized systems are only required to satisfy the cooling requirements of their individual zone. As a result, the peak building cooling requirements at the plant level were reduced with the fan coil system.

- Reduced building loads resulted in lower air flow requirements to satisfy these loads and subsequently reduced equipment sizes.

Incremental Strategies

Strategies that were evaluated but rejected as either too complex or not cost-effective included a heat recovery chiller, ventilation heat recovery, and variable speed drives on hydronic system pumps. Successful incremental measures included pulse condensing boilers and optimization of the chiller configuration (screw type).

4.1.3 Lighting And Equipment

Major Strategies

The general design intent for optimizing the building energy consumption in regard to the lighting systems was to reduce lighting energy consumption and heat gain to spaces from lighting equipment. Critical owner initiated requirements that influenced lighting decisions included:

- a minimum lighting level of 60 footcandles,
- the same ceiling grid layout as Building No. 7. This was driven by aesthetic reasons and concerns over harmonic and 'RF' effects associated with electronic ballasts due to the high technology nature of the tenants.

The final lighting configuration was determined to be a two lamp T8 fluorescent recessed luminaires with hybrid high efficiency ballasts. The requirements of the owner were addressed with this configuration.

The reduction in lighting density was a significant part of the strategy to reduce building space cooling loads which led to a reduction in installed system capacities (refer to the HVAC section). The installed lighting density is 0.93 Watts/ft^2 for the gross building area.

The installation of an automatic lighting control system ensured that run hours for the lighting would be minimized.

Incremental Strategies

A number of incremental strategies were reviewed for Building No. 8. Two strategies that were implemented was the use of daylighting controls along the perimeter zones and the reduction of the equipment load or average tenant power density from the ASHRAE/IES 90.1 Standard of 0.75 Watts/ft^2 to 0.50 Watts/ft^2. This reduction was determined to be viable following the monitoring of an adjacent building in the commercial park. Strategies evaluated and rejected included lighting shelves, roof monitors and skylights in conjunction with expanded daylighting controls.

4.1.4 Envelope

The general design intent associated with the envelope was to optimize the building envelope so that building loads were minimized and the HVAC system was optimized. This direction was due in a large part to mild climate of Southwestern British Columbia and the minor impact on energy costs due to the envelope.

The starting point for the Building No. 8 envelope was the ASHRAE/IES 90.1 prescriptive requirements for the wall and roof insulating levels and glazing of the adjacent Building No. 7 constructed in 1994. This included wall insulation values of R-11, R-15.6 for the roof and perimeter insulation at the foundation. For aesthetic reasons the owner preferred the glazing colour and size to be the same as Building No. 7.

Some of the incremental strategies included the addition of another layer of roof insulation, improvements on the wall insulation levels and numerous glazing measures including the addition of a third pane of glazing, a second low-e coating, argon fill and combinations of these measures. Although incremental strategies were examined in depth results indicated that they were not cost effective based on energy savings. However, mid pane mullions were replaced with external cosmetic replicas. Ultimately, the envelope R-values were increased to R-15 for the walls to improve occupant comfort and R-20 for the roof to meet industry standards.

An example that illustrates the lack of cost effectiveness of these strategies involved the simulation performed on a high performance aluminum window frame and super-performance glazing at an incremental level. In particular, the addition of an uncoated third pane, a low-e coated third pane, argon fill, or any combination of these measures resulted in negligible overall performance improvements. Close evaluation and parametric investigation revealed that this was a function of the following factors:

- U value and conduction losses with the double pane glass were already well into the realm of diminishing return. The addition of a third pane and/or argon fills offered little incremental conduction mitigation while compromising daylighting benefit, and to some degree beneficial passive solar gain, through reduced transmittance.
- A similar effect was evident with radiative losses. The addition of a second low-e coating on a third pane had marginal heating/cooling benefit while significantly penalizing daylighting and beneficial passive solar gain.
- These effects were further confirmed when an incremental test reduction of glazing area showed the same tradeoff between daylighting loss, heating/cooling, and beneficial passive solar gain.

This seemed to indicate that the design had arrived at an optimum balance between glazing area, thermal performance, and optical characteristics given the state of current available glazing technology.

4.1.5 Other Observations

An interesting dynamic presented for consideration by the C-2000 program administrators is the issue of relative magnitude of plug load in a mild versus severe climate. At the incremental level of performance improvement, ASHRAE/IES 90.1 specified plug load of 0.75 W per sq. ft. remained as a significant component of building energy use after weather-dependent energy end-uses had been cost-effectively reduced. Moreover, it presented a major obstacle to further improvement of the building energy performance since no proven or reliable technology could be identified for reducing this load. The disparity would not be as pronounced in a more severe climatic setting. The point is further illustrated by considering that if plug loads were dropped from consideration in both the reference and C-2000 design buildings, Building No. 8 would be performing at 45% of the ASHRAE/IES 90.1 reference building.

Including plug load in the C-2000 performance criteria places mild climate buildings at a disadvantage.

4.1.6 Final Energy Performance Results

Overall, the building achieved the energy performance requirements of the C-2000 program. The annual energy consumption is projected 51.7% less than the ASHRAE/IES Reference building while the annual energy costs will be 50.5% less. Energy performance projections are provided in tabular and graphical format in Appendix 1.

One contentious issued involves The Source Energy Adjustment Factor (SEAF) that was applied to the analysis. The SEAF of 3.0 specified by the C-2000 program is designed to penalize incremental electricity consumption in deference to the high proportion of thermal generation capacity in eastern Canada. This has been the source of some controversy during the course of this project since over 90% of electricity generated in B. C. is produced from hydro resources.

4.2 Environmental Impact Performance

According to the C-2000 Program for Advanced Commercial Buildings the environmental impact requirements were based on designing building systems to minimize the impact of building construction and operation on the external environment. Key elements of these criteria include:

- Site Ecosystem Protection
- Ozone Layer Protection
- Water Conservation
- Construction and Demolition Solid Waste
- Operational Solid Wastes

Detailed minimum basic C-2000 requirements and an explanation of how these were achieved for this particular project are addressed in the following sections

4.2.1 Site Ecosystem Protection

The minimum C-2000 requirements for site ecosystem protection included:

- ensuring that the replenishment of the water table was not interfered with and that the adjoining land was not damaged;
- continuity of access for wildlife to and from the site.

The design process for this project took advantage of the natural landscape features. For example, the natural watercourse was retained and protected from erosion. A jogging track was added with a bark-mulch surface to widen the bank and create a buffer zone to the parking areas.

The wildlife habitat was limited because of surrounding land uses and past disturbances of indigenous land forms. The natural watercourse is home to fish and blackbirds and other types of birds.

The site is extensively landscaped and treed. The natural watercourse was planted with a wildflower mix and berry bushes. All existing trees on the site were retained. Mature trees recycled from the 1986 Expo Worlds Fair were nurseried on the site. Besides providing a park-like atmosphere, the trees have a functional purpose by providing shade to the parking areas and the buildings.

4.2.2 Ozone Layer Protection

One of the goals of the C-2000 program was to reduce or eliminate the negative effects a building has on the ozone layer. To accomplish this, materials and systems that use CFC's in the manufacture, installation or operation were avoided.

Building Materials And Equipment

Best efforts were made to screen all materials and equipment specified to avoid ozone depleting substances during the construction of Building No. 8. An ODP 0.05 or less was targeted in all cases. Production of building materials and equipment was researched to meet these targets. Local suppliers were sourced for non-CFC expanded foamed products for roof insulation, fireproofing and rigid wall insulation.

Air Conditioning

Refrigerants used in air conditioning and refrigeration systems are the most pervasive sources of ozone depleting substances released into the atmosphere. The refrigerant, R22, selected for the building air conditioning systems has an ODP rating of 0.05.

In addition to the building systems, individual tenants may have small refrigerators in staff break rooms, or may require supplemental cooling for heat-producing electronic equipment. Individual tenant leases encourage approval of refrigerants and supplemental air conditioning systems by the Owner. The approval is based on energy efficiency and use of non-ozone depleting refrigerants with an ODP of 0.05 or less.

4.2.3 Water Conservation

The C-2000 target for building water consumption is 40% compared to the "base building" (exclusive of the site). This target was achieved by addressing both building water and site water conservation issues.

- Building water use was reduced by more than 50% from the "base building" (exclusive of the site) using low flow fixtures for toilets, urinals and sinks.
- The impact of building site water on the waste water infrastructure was reduced by:
    - Using low water species of perennials and tuff grass for landscaping;

- Drip irrigation for vegetation and landscaping;
- Air cooled chillers.

4.2.4 Construction and Demolition Waste Management Plan

The C-2000 guidelines call for a 50% reduction from base building assumptions in the amount of solid waste generated due to construction and demolition wastes. To achieve this a waste management plan was formed based on the *"Greater Vancouver Regional Solid Waste Management Plan"* (July 1995) and a *"Guide to Waste Audits and Reduction Workplans for Construction and Demolition Projects"* by the Ontario Ministry of Environment and Energy.

The following efforts were introduced during the construction to minimize waste and focus on recycled products:

- No demolition
- Existing vegetation was maintained
- Site base was filled with recycled crushed concrete
- Building materials with recycled elements were used including ceiling tile and gypsum board
- Forms for tilt-up panels used 12'-2x8's. 250 were salvaged and shipped to another site for reuse.
- 5/8" plywood forms were reused as sheathing for the parapet.
- All wood ends were kept and neatly stacked on site and reused for miscellaneous purposes such as backing, safety rails and ramps.
- Steel structural members were prefabricated off site and made to measure. Waste was removed by installer for recycling.
- There was minimal concrete waste. Any waste was made into piles and used as backfill on site.
- A large part of the waste was the result of interior work and glazing. Waste was separated and removed by independent recycling companies. The materials included; corrugated cardboard, plastic, drywall, acoustic ceiling tile, wood and paint.

To the general contractor the issue of reducing waste made sense in real economic terms. $500 was saved for each disposal container not required on the job site. The reuse of materials further reduced costs. The recycling companies paid for the cardboard, wood, and drywall.

4.2.5 Operational Solid Waste Management Plan

This plan is based on the "Greater Vancouver Regional Solid Waste Management Plan" (July 1995).

The target for Building No. 8 is to reduce solid waste by 50% compared to the "base building". Building management will participate in a recycling program that may include "product stewardship" requirements for supplies of materials and services. Tenants will be responsible for the majority of solid waste. Building Management will provide an infrastructure and set a leasing policy that promotes reduction, reuse and recycling. This will include:

- Provision of dedicated recyclables storage on site;

- Requirement for local recyclables storage in tenant space included in tenant improvement package;
- Designation of a member of the Operations and Management staff as a recycling coordinator for each building;
- Provision of a suggested solid waste management plan to all tenants.

An annual audit of solid waste is part of the monitoring program and will be performed to verify if actual results meet C-2000 Guidelines. The audit will be done by a third party agency and will include elements of "A Guide to Waste Audits and Reduction Workplans for Industrial, Commercial and Institutional Sectors," by the Ontario Ministry of Environment and Energy (1994).

4.3 Comfort and Productivity Performance

In general, the building related health, comfort and productivity of the building occupants is largely dependent on the indoor environment. This includes the quality of the indoor air as well as the lighting and acoustic quality. Integral to this is the degree to which the occupant has control over these issues.

The perceptions of the occupants to their surroundings are as important as the real numbers associated with these indoor environmental issues. Therefore, C-2000 requires that 90% of the building occupants are satisfied with their indoor environment. Building No. 8 will be monitored and the occupants surveyed for the first two years of the buildings operation to measure their satisfaction with their work environment.

4.3.1 Indoor Air Quality

The following are the indoor air quality targets as provided by the C-2000 guidelines:

Substance	*Concentration**
Carbon Dioxide	800 ppm (comfort)
Carbon Monoxide	9 ppm (alert)
	15-25 ppm (health)
Formaldehyde	0.2 ppm
Lead	15 micrograms/m^3
Nitrogen Dioxide	0.165 ppm (300 micrograms/m^3)
Respirable Particles	150 micrograms/m^3
Radon	4 pci/l
Sulphur Dioxide	0.1 ppm, (365 micrograms/m^3)
TVOC	3,000 micrograms/m^3

* All averaging times are 8 Hrs.

Regular monitoring for the first two years of occupancy will verify these targets and allow for remedial actions, if required. On going monitoring will test outside air quality to determine filtration rates.

Thermal Control

The C-2000 target is to maintain temperature set points at 21°C during heating design conditions and 24°C during cooling design conditions. ASHRAE Standard

55-1992 is the minimum design requirement. Based on mild climate conditions and monitoring of Building No. 7, humidity control was found to be unnecessary.

Ventilation

The maximum system capacity was designed at 30 CFM/person. Operational requirements range from 20 to 10 CFM/person. The actual operational ventilation rate will be determined after construction and building flush-out by monitoring indoor air quality parameters, including CO^2, CO, formaldehyde and VOC's. The system has the capacity to operate at 30 CFM/person during periods of flush-out, renovation and periodic maintenance including painting, waxing, and refinishing.

The locations of exhaust vents and outside air intakes were selected to avoid re-entry of exhaust air and infiltration of outdoor pollutants from adjacent sources. Ventilation has been complemented with a strategy of reducing off gassing materials.

Regular monitoring for the first two years of occupancy will verify these targets and allow for remedial action, if required.

Special Area Requirements

There are special use areas within Building No. 8 that have specific environmental and ventilation requirements. Ventilation duct chases for these areas are provided as part of the base building. Tenant connection to these for special area exhaust is part of the Tenant Improvement Package.

The special areas have been designed and constructed during tenancy fit up and include:

Copier Rooms/Reproduction Facilities	Local exhausts
Computer Areas	Adequate outside air supply and cooling for increased occupant density
Coffee Rooms/Lounges	Local exhaust, adequate outside air supply
Board Rooms	Adequate outside air supply and cooling for increased occupant density
Private Offices Used for Small Meetings	Adequate outside air supply and cooling
Libraries	Special filtration for dust control; maintain 50% humidity; use of sprinkler system other than water
Janitorial Closets	Storage areas for chemicals and maintenance products should be vented

Zoning

Building No. 8 was provided with sufficient zoning to ensure occupant comfort. For example, one HVAC zone is provided for each three private offices in the exterior zone. In the open plan office areas one HVAC zone is provided for every six work stations. The system can subzone down to one zone per office.

4.3.2 Architectural Systems

Envelope and Glazing

The composition of the building envelope was designed to avoid condensation and cold spots caused by thermal bridging through the use of rigid insulation placed between the concrete panels and the steel studs. The effective insulation value of the walls and roof are R-15 and R-20, respectively. The fenestration was composed of low-e glass to increase room Mean Radiant Temperatures during the heating season and reduce undesirable direct and diffuse solar gain during the cooling season.

Interior Planning

During tenancy fit up, the proposed partitioning arrangements will be reviewed with respect to daylighting and air distribution/circulation. The Worker's Compensation Board Proposed Workplace Ergonomics regulations have been made available to tenants to assist in design of tenant improvements.

Materials

Depending on availability, low off gassing materials were specified. The Contractor provided data sheets for selected materials and products to ensure low toxicity content.

Separation and Connections

The design of the building minimized the potential for transfer of contaminants, noise, and vibration from special use areas and from outdoors.

4.3.3 Illumination

C-2000 Requirements

The C-2000 Program requirements regarding lighting are extensive. The following are the key program requirements:

- Daylighting to be used to the maximum extent possible.
- Exterior lighting power to be installed is not greater than 80% of the ELPA based ASHRAE/IES 90.1.
- Interior lighting power to be installed is not greater than 75% of the ILPA based on ASHRAE/IES 90.1.
- Lighting level to conform to the Illuminating Engineering Society standards.
- Colour rendering index of light sources to be a minimum of 80 CRI.
- Glare control to be provided for all sources of daylighting. The brightness differential shall be less than ten to one in daylit areas.
- Perimeter areas to be controlled as a separate zone through the use of daylight sensing devices.

Performance

The lighting quality in the buildings is high. The use of deep two cell parabolic fixtures provide an overall ambient light level of 60 foot candles with an even distribution pattern. (A description of the lighting system is provided in Section 3.17) While task lights may be used depending on tenancy requirements the light system is not dependent on it. It is anticipated that task lighting will be limited to enhancing individual personal work spaces based on personal taste.

A number of daylighting enhancement strategies were examined including the use of light shelves and variable dimmers. It was determined that the only cost effective strategy was discrete photocell controls for the perimeter zones. Configurations of perimeter offices that consider daylight penetration into interior work areas have been recommended to tenants.

Building No. 8 was designed to meet all C-2000 program requirements. An on-going monitoring program will verify that the energy and quality standards have been achieved or provide areas that need remedial action.

4.3.4 Acoustics

The sound rating limit for building components, according to the C-2000 Program is:

Exterior wall	STC 55
Suite to suite partition	STC 65
Office Partitions	STC 60
Floor assembly	STC 60

To achieve these performance requirements the following measures were adopted:

- Acoustic T-bar and tile ceilings to provide for maximum attenuation of sound.
- Tenant installed carpeted floors.
- Additional insulation in the roof and walls to provide thermal and increased acoustic separation.
- Staggered stud walls in the stair shaft to prevent structure borne sound infiltrating the common and office areas.

A two year monitoring program will verify if these measures are successful in meeting the goals of the C-2000 program.

4.3.5 Occupant Control

The C-2000 program requires that there be control zones for HVAC systems, light control zones in office spaces and that these controls be accessible to the occupants.

The high resolution of the HVAC zoning system for Building No. 8 combined with the constant volume air delivery provides superior local temperature control.

All lighting systems are controlled by a Douglas full 2-way lighting control package. The system is integrated with daylight and occupancy sensors and is compatible with the installed DDC system.

4.4 Functionality, Longevity & Adaptability Performance

4.4.1 Functionality

The C-2000 Program required that the building design and building systems be functionally appropriate. The design, location, dimensional and environmental attributes of the facilities and spaces in the building are appropriate to the stated function of the building. The building systems complement this function.

The owners of Building No. 8 of the Crestwood Corporate Centre had two stated requirements for this building:

1. Create a suburban office park development that provided a first rate indoor and outdoor working environment.

2. Create a development providing an acceptable economic return for capital invested.

As this report indicates, the functional appropriateness of the building design was fundamental and attention was paid to it throughout the design development and construction phase of the building. The building was designed to be part of a suburban office park development. Building No. 8 is a visual twin of Building No. 7 and maintains the common architectural appearance of the rest of the park. The high lease rate of the building is indicative of the market's response to this initiative and the economic return of the investment.

4.4.2 Longevity

The C-2000 Program also puts emphasis on the assumed longevity of a building based on the notion that the longevity of the materials, components and systems has an obvious effect on the environment.

Building No. 8 was designed with a long life span in mind. The building construction was concrete and steel. Doors, windows and frames were all high quality. Interior finishes including washroom fixtures, wall tiles and balcony railings were all designed for long service.

All mechanical equipment and materials were selected and specified to reflect the cost-effective levels of quality and reliability. The simplicity of the systems of Building No. 8 contribute to the attainment of longevity and maintenance goals. The minimum standard of performance in all cases was in accordance with the most current ASHRAE/IES life-cycle guidelines. Supplier assurances and extended warranties were solicited whenever possible.

4.4.3 Adaptability

The ability to adapt a building to new requirements is a feature of the C-2000 program. The adaptability of a building can be directly linked to its life span. A building with components that possess a high degree of adaptability to changing requirements will have greater longevity.

Building No. 8 addressed the issue of adaptability on a number of fronts. The general building layout is designed to maximize multi-tenant lease opportunities. The location of elevator and stair cores were carefully considered in the context of future floor use areas. The tilt up wall construction was a modular system, making it conducive to modifications, if required. Building No. 8 can function as an office, warehouse, manufacturing, classroom, extended care or residential building with minor modifications in the future.

The fully compartmentalized mechanical systems resulted in an intrinsically high degree of adaptability. Their local operation is particularly well suited to mixed or highly variable occupancies. Cross-contamination of air systems was minimized and isolated extreme zone thermal load conditions were accommodated without compromising the operation of the rest of the building HVAC. Also, the HVAC system, with its autonomous operation of each zone, allowed for the shutdown of the fan systems throughout major portions of the building during weekends and evenings.

4.5 Envelope and Air Barrier Performance

4.5.1 Introduction

The C-2000 program placed major emphasis on the performance of the building envelope because of the effect it can have on the building as a whole. Excessive leakage through the envelope is a major factor in poor energy performance, deterioration of the envelope and poor indoor environment. For this reason the C-2000 program pays special attention to air leakage requirements, durability issues, and design and testing methods throughout the design and construction phases of the project.

The building envelope system for Building No. 8 was a tilt up concrete wall system to match the construction type of the park. Rather than using a rainscreen wall system, the decision was made to improve the detailing on the concrete wall construction by optimizing a common system to create a very transferable technology solution.

The wall construction for Building No. 7 and 8 are very similar in appearance but differ in the detailing. The tilt up wall panel system for prototypical Building No. 7, consisted of painted concrete panels on 3-5/8" steel stud batt insulated walls with a 4 mil polyethelin air and vapour barrier on 1/2" drywall. All panel joint and door and window openings were caulked and sealed. Building No. 8 was modified to increase the insulation value, decrease air and moisture penetration and reduce thermal bridging. The wall system was composed of 9" of painted concrete with 1-1/2" of rigid insulation rated at R-7.5 located between the concrete wall and steel studs to act as a thermal break. The steel studs were 3-5/8" at 16 o/c. with fibreglass batt insulation filling the void. The vapour barrier was 6 mil polyethelin film located on the warm side of the insulation and protected by 1/2" gypsum board.

4.5.2 Roles & Procedures

Attention to the envelope took place throughout the project. The consultant roles with respect to the design, construction and commissioning of the envelope and air barrier system are defined below.

Design Roles

During design, the envelope and air barrier system detailing was developed with the input of the energy engineer to prevent over or under design. Detailing paid particular attention to joints and connections and ensured that building science requirements were clearly communicated to the contractor.

The effects of wind load, stack effect and mechanical pressurization were also addressed during the design stage. The structural engineer was asked to provide the wind loads, while a building science consultant finalized the calculations prior to developing the test procedures for the wall assembly. A dew point analysis of the wall was done by a building technologist.

Testing procedures for the envelope were defined by a building science consultant during the final working drawing phase and included in the tender packages to meet specified standards and design requirements.

Construction

During the construction phase the architect inspected the as-built envelope details including that of concrete, window installation, roofing, vapour barrier installation and caulking. The contractor also prepared test wall sections on site and arranged for envelope testing as defined in the contract documents.

Strength Testing

The only elements of the envelope that required testing for strength were the windows and the panel joints. The panel joint was tested to 150 Pa and the windows to the appropriate C level based on wind load calculations.

Commissioning

At the time of commissioning, the architect communicated to the operations personnel the nature and extent of the envelope design features. Protection of membranes, performance of windows and fibreglass window frames and the importance of maintaining the continuity of insulation and seals were explained.

The contractor was asked to assemble important as-built details and product information. These were packaged and handed over to the operations personnel in a binder for future reference.

A system for the maintenance and protection of the panel joints was developed. Regular maintenance of the sealants and caulking will ensure the integrity of the building envelope.

4.5.3 Assumptions & Calculations

Stack Effect

A stack effect is the result of warmer inside air having a lower density than cooler outside air. The difference in density creates a slight outward positive pressure at the top of the building while exerting a slight inward negative pressure at the base. This tends to result in air infiltration at the lower levels of the building and exfiltration the upper levels. Generally this is a major concern for taller buildings. In the case of Building No. 8, it is less of a concern since the building is only 3 stories in height.

Wind Pressures

The calculation of the strength required for the caulked joints and the window frame seals were based on the design loads for wind as determined by the structural engineer. With the added strength of the concrete panel and the torch on membrane over the vertical joints, there is no anticipated concern with the wind acting on the air barrier.

Mechanical Pressurization

The air handling system was intended to be well balanced and maintained to avoid mechanical pressurization of the envelope.

Deflection & Dimensional Changes

The concrete wall panels will expand and contract with the heating and cooling of the building surfaces. There was a concern that the integrity of the air barrier at the panel joints might be affected, but the effect was mitigated by the peel and stick membrane applied behind the caulking at the panel joints.

The concrete panels are thick and rigid enough to avoid deflection due to structural or wind loading. The panel may exhibit some deflection due to construction methods, but the peel and stick membrane will conform to this shape.

4.5.4 Envelope & Air Barrier System Design

Many building performance problems can be traced to air leakage through the building envelope. The two most obvious problems are energy losses and deterioration of the building envelope. The transport of warm and moisture laden air through the envelope can cause condensation within the envelope, deteriorating the overall insulative performance of the envelope.

There are a number of mechanisms associated with air leakage. However, one thing is constant: for air leakage to occur there must be a hole in the envelope and a pressure difference at that point. Among the possible causes: stack effect, wind and fan pressurization.

The chief means of controlling air leakage is through the design and construction of an effective air barrier system. The principal function of the air barrier is to prevent both the infiltration of outdoor air into the building and exfiltration of indoor air to the outside. It should be noted that an air barrier is not necessarily a specific construction item. An air barrier may consist of a single material or of two or more materials that when assembled together make up an air impermeable, structurally adequate barrier.

There are four conditions that must be met for an assembly to be considered an air barrier.

1. Continuity - all materials must be connected together to ensure that there is no break in the airtightness of the envelope.
2. Structural Integrity - the system must be capable of resisting forces, like wind loads, or supported by one that can.
3. Air impermeability - the system must he highly resistive to air flow. This means that joints are joined into an airtight assembly.
4. Durability - the materials used must be long lasting. Often times the materials used are concealed within the envelope and inaccessible to on going maintenance. Therefore, the designer must verify the performance of the selected materials in terms of the planned life of the building.

The air barrier for Building No. 8 met these criteria.

Location of Air Barrier System

The air barrier was essentially comprised of the windows and window frames, the doors and door frames and the concrete panels with sealed joints. The line of the air barrier was, therefore, the inside face of the exterior wall.

Concrete is an effective air barrier system. In the case of Building No. 8, the concrete wall panels had vertical joints every 32 feet. These joints were approximately 1" wide and ran the full height of the building. The joints were caulked and sealed and, as an extra precaution against air leakage, a peel and stick membrane was applied to the inside face of the panels at the panel joints. It was assumed that there was no air leakage through the panels or the joints. A gap at grade level at the bottom of each caulked joint will drain any moisture accumulation and equalize pressure within the joint cavity. This system had the advantage of being easy to inspect during construction and simple to construct.

The relatively short life of caulking and sealants products was a concern. This problem was circumvented by minimizing the number of caulked joints required and by adding a peel and stick membrane to the inside surface. This not only extends the life of the caulking, but also improves its effectiveness.

The A-value for the window assembly corresponded with a 0.2 $L/s*m^2$ leakage rate and was based on the performance tests conducted on site. The expected temperature and pressure differentials were assessed and formed the basis for the design of the sealing at the joints. The frames were caulked, sealed and fitted tightly to the openings during construction.

The roof air barrier was the last layer of EPDM membrane torched on over a layer of drywall over the steel deck. This sat under two layers of membrane, protection board and insulation. The continuity of the air barrier was maintained at the roof by extending the membrane over the parapet.

Peel and Stick Membrane Detail at Panel Joints

The vapour barrier was located on the warm side of the insulation and was wrapped and sealed tight to the window frames to form a second level of defense against air infiltration. Any penetrations through the wall assembly and the vapour barrier were sealed. Also, the number of penetrations were kept to a minimum and ganged, where possible.

System Longevity

The components of the building envelope were designed in accordance with the system life span matrix as defined in the C-2000 Guidelines.

Envelope Components Lifespan

Vertical Structure	Concrete	100 years
Horizontal Structure	Steel	100 years
Roof	EPDM	35 years
Walls	torch on air barrier	35 years
	fiberglass insulation	35 years
	caulked joints	35 years
	interior drywall	35 years
Soffits	stucco	35 years
Exterior Shade	fabric	35 years
Foundation	concrete	100 years
Sealants	vary	15 years
Windows/Doors	glass,fibreglass	35 years

Air Permeance

The permeance of the components of the wall assembly was estimated to be:

Materials	*nq/Pa.s.m2*
paint	52-120
concrete 150mm	47
rigid insulation 37.5mm	61
batt insulation 90mm	1900
torch on membrane	zero
vapour barrier .05mm	8
gypsum 12.5mm	2000

The effective air barrier was the inside face of the concrete with the panel joints reinforced by the peel and stick membrane. The increase in permeance from inside to outside allows any moisture to leave the assembly through diffusion and at the same time forms a multiple barrier to air infiltration or exfiltration.

Material Compatibility

All materials were mechanically fastened with the exception of the peel and stick membrane. There were no issues of material incompatibility within the building envelope.

Continuity

Two methods assured the continuity of the air barrier system. First, the assembly was site tested and verified to meet the design limits as defined in the contract documents by the performance testing of the wall assembly. The test was performed during the construction of a typical wall assembly including a vertical panel joint and a window section. Further, a maintenance program for the protection of the panel joints was developed as there is typically a three year limit on the effectiveness of any sealant or caulking compound without regular maintenance.

4.5.5 Air Barrier System Testing And Verification

A component of the C-2000 program was the evaluation of the building envelope in terms of its rate of air leakage. When the envelope of Building No. 8 was completed, the air barrier system was field tested. The test was performed in accordance with the following Tests and Standards:

- *ASTM E283-91* - "Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, Doors Under Specified Pressure Differences across the Specimen".
- *ASTM E783-91* - "Standard Test Method for Measurements of Air Leakage Through Exterior Windows and Doors".
- *CAN/CGSB 149.10-M86* - "Determination of the Air Tightness of Building Envelopes by the Fan Depressurization Method."

The test section included a window, the concrete wall between the floor and the ceiling, and one joint in the tilt-up panel wall system. During the test, pressure was incrementally increased to a maximum of 75 Pa. At each increment, the pressure was maintained for at least one minute to ensure stability. To ensure the accuracy of the data, the test was performed twice.

The corrected combined leakage rate for the test section was 0.153 $l/s/m^2$ of area at 50 Pa. The allowable leakage rate for the test section where the window area makes up 56% of the total wall area was 0.155 $l/s/m^2$ This allowable rate was based on the percentage of window area and the allowable leakage rates of 0.1 $l/s/m^2$ for walls and 0.2 $l/s/m^2$for windows. The results show that design goals were met.

Refer to Appendix 2 for detailed test results.

4.5.6 Insulation Materials

Thermal Performance and Insulation

The wall system for Building No. 8 has an effective R value of 15. This was achieved by installing 1-1/2" of rigid insulation to the inside face of the concrete. This increased the overall insulation value of the wall from R10 to R15. No insulation or sealant that required the use of CFC's for its manufacture or installation was used. A pentane expanded polystyrene was specified as the rigid insulation. The effective insulation for the roof is R-20.

Thermal Bridging

The design strategy was to detail the walls so that the effects of thermal bridging were minimized. Thermal bridging can seriously interfere with the performance of the building envelope. One problem is the loss of moisture control due to temperature gradient differentials resulting in condensation forming within the wall cavity. Reduced insulation values result in heat loss and increased energy consumption. Adopting a strategy of minimizing thermal bridging can contribute to the overall occupant comfort within the building.

A number of strategies were adopted to avoid thermal bridges within the building envelope of Building No. 8 . The thermal bridging of the window frames was reduced through the use of a high performance aluminum window system. The thermal bridging effect of the interior steel stud wall was avoided with the use of a 1-1/2" application of rigid insulation between the concrete exterior wall and the interior steel studs. Metal clips were installed for strength and created only a minor thermal bridge. The structural steel deck was insulated where it met the wall. Only the steel imbed plates that carry the open web steel joists will provide an opportunity for thermal bridging. They are approximately 8 inches square and at 16' spacing along the outside wall, located underneath the structural steel deck flooring. The active surface of the plate cannot be tarred or effectively sprayed with a thermal insulation without compromising the structural integrity of the connection. However, the connection was sprayed after the structure was assembled to minimize the potential for condensation. Minimizing the exposed area of structural penetrations was the approach for all of this building.

4.5.7 Moisture Control

A major contributor to the failure of the building envelope is the accumulation of moisture within the wall assembly due to vapour diffusion and water penetration. Excessive and long term accumulation can result in the following:

- weaken or impair the insulation and structural materials by altering their chemical composition.
- repeated freezing and thawing can weaken or disfigure the concrete cladding.
- staining can occur on the inside surface of the wall.
- wet insulation can lose its insulative qualities.
- mold and mildew forming within the wall cavity can impact the indoor air quality

Moisture Migration

The building envelope was designed to prevent moisture migration that can lead to the deterioration of insulation and building materials. The exterior coats of paint will restrict the capillary action properties of the concrete and prevent the infiltration of external moisture into the concrete. The peel and stick membrane at the panel joint and caulking will prevent the direct infiltration of rain or moisture into the wall.

Vapour Diffusion Properties

The concrete wall and protected joints form the air barrier and have a significant resistance to vapour diffusion. The insulation layer behind the concrete is rigid polystyrene and is not subject to deterioration by moisture. The next layer of insulation is a fibreglass batt insulation that is subject to deterioration if it is allowed to stay wet. The vapour barrier is located on the warm side of the insulation to avoid this problem.

Dew Point Analysis

Refer to the diagrams 4.1 and 4.2 in the appendix.

At ambient conditions (25% Relative Humidity) the Dew Point for Vancouver is 3°C. At 35% R.H., the Dew Point is at 7°C. Since any condensation that may occur requires a condensing plane to be absorbed, the insulation with zero absorption capacity will stay dry. Theoretically, moisture through condensation could occur on the concrete plane if the evaporation rate is lower than the condensation rate.

EMPTIED Analysis

Calculations have been done on the EMPTIED software package to determine the potential for condensation due to vapour diffusion. The vapour barrier is located on the warm side of the insulation to prevent the potentially damaging effects of moisture migration due to air leakage and vapour diffusion. Results are tabulated in Tables 4.3, 4.4,4.5 located in the Appendix 3.

The data in Table 4.3 is for an air leakage of 0.1 $L/s{\cdot}m^2$ (equivalent to .07 cm^2/m^2 @ n=0.7), 0 pressure differential, Vancouver ambient relative humidity levels (no moisture added upon heating of outside air). For a worst case example, the bottom table shows condensation due to air leakage and diffusion to be .0081 kg/m^2 for the month of November. The top table shows an evaporation rate of .0620 kg/m^2. For this worst case condition, the potential for evaporation exceeds the condensation and no moisture will accumulate.

In table 4.4 the relative humidity has been increased to 35% and in table 4.5 a positive pressure of 20 pascals has been added. The results show that the majority of condensation is due to air leakage which is exaggerated further by the added pressure. The vapour diffusion rates remain low due to the 6 mil poly vapour barrier. Even in this extreme case condensation rates are kept well below the evaporation rates and in doing so prevents the concrete from absorbing moisture. Moisture in the concrete could be detrimental since freezing could occur (Hours Below Freezing - Nov [11], Dec [3], Jan [87]).

Although no problems are foreseen during normal conditions, the results do underline the importance of controlling air leakage, continuity of the vapour barrier, balanced operation of the heating/cooling equipment, and control of humidity levels.

4.5.8 Penetrations Of The Building Envelope

Balconies

Building No. 8 has balconies that break the continuity of the main walls in a few locations. These balconies have be detailed in a similar way to the roof and parapet to ensure the continuity of the thermal and moisture protection.

Penetrations

All operable dampers, passive exhaust/ intake openings and service penetrations have been detailed to provide continuous thermal and moisture protection.

4.6 Quality Assurance and Commissioning

4.6.1 Quality Assurance Strategy

The process to be followed for building commissioning, or Quality Assurance, began with the Concept Design Phase of the project and followed the typical phases of project delivery: Design, Construction, Acceptance and Post-Acceptance. The following section outlines the general work that was performed during each phase of the process and the roles and responsibilities of each member of the quality assurance team.

Program Phase

The front-end of the process was the most important. This established the ground rules and it was critical that the lines of communication were open and all parties understood the decisions that were made and why.

During this phase the owner's requirements and budget were identified. From this, the design team prepared a concept design brief as an outline of the design requirements and defined, in specific language, the design intent. A number of important documents resulted from the process.

In the case of Building No. 8, the owner defined a program of requirements and from this program, a design intent document was prepared. The concept design brief clearly defined items and criteria important to the owner, to all members of the design team and to future tenants. For example, these criteria included:

- The facilities functional use.
- Occupancy requirements.
- Quality of materials and construction.
- Environmental and energy management goals and requirements.

Based on the Concept Design Brief, the design team then prepared a Design Development Report. The Design Development Report defined how the owners intent would be achieved.

Design Phase

During the Design Development Phase the design of the building, including all components and systems, was finalized. The design was reviewed in accordance with the Design Development Report. Specifications and contract documents were then prepared. In addition to typical documents, a complete description of design assumptions and criteria was prepared and integrated into the specifications.

This Quality Assurance and Commissioning Strategy was used by the designers to develop Quality Assurance and Commissioning Specifications that became part of the contract documents. The Quality Assurance and Commissioning Specifications detailed the Quality Assurance and Commissioning process, identified responsibilities and requirements, detailed the scope of work for all participants including contractors, vendors and project managers. The specifications also identified the skills and qualifications of all members of the commissioning team. The Quality Assurance specifications did not form a separate document, but were integrated, section by section, into a typical building specification for ease of tender.

The documents delivered at this phase were the Design Development Report including the Quality Assurance and Commissioning Strategy and a detailed description of all building components and systems.

Construction Phase

During the Construction Phase, all systems and components were installed, tested and put into operation. The Quality Assurance and Commissioning Plan was modified to reflect all changes made during construction to the equipment and components as well as the parties responsible for these changes. During this phase responsibilities and schedules for functional performance testing were determined. Operation and Maintenance information and warranties were obtained for all components and equipment. Field inspections were undertaken regularly to ensure that construction complied with the documentation.

The documentation of the Construction Phase included:

- Updated descriptions of all building components, equipment and systems.
- Field inspection reports.

Acceptance Phase

During the Acceptance Phase, a substantially complete building was turned over to the owner. During this Phase, it was important to determine that all components, equipment and systems were installed correctly, tested and adjusted.

Total Building Performance is a function of the integrated performance of all components, equipment and systems. Functional performance testing was undertaken to verify total integrated systems performance. Testing documented the completion and performance of all components, equipment and systems including the building envelope and air barrier. In addition to a complete and functioning building, all documentation was assembled and turned over to the owner.

The documents completed during the Acceptance Phase included:

- As-built drawings.
- Functional performance test results.
- Architectural warranty and maintenance manuals
- Electrical warranty and maintenance manuals
- Mechanical warranty and maintenance manuals

Post Acceptance

A building is dynamic, performance is seasonal and use changes over time. Post Acceptance Phase Actions will be undertaken to respond to changes that occur over time through the normal use and operation of a building. As an extension of the acceptance phase, functional performance tests will be continued to verify the seasonal operation of all components, equipment and systems. Furthermore, procedures will be set in place to document changes in use, equipment and occupancy over time and also to record user feedback. This will be complemented by a program of periodic indoor environmental and energy performance testing and monitoring.

Documents produced during the Post Acceptance Phase, which may span the useful life of the building will include:

- Periodic updates of as-built drawings.
- Periodic updates of Operations and maintenance manuals.
- Log of user feedback.
- Record of environmental and energy performance over time.

4.6.2 The Quality Assurance Management Team

The quality assurance management team included the building owner/developer, designers (architects, engineers), co-ordinating design professional, contractors and operations and maintenance personnel. Each one of these team members had a specific set of responsibilities to assure that the process was complete.

Building Owner/Developer

The responsibilities of the Building Owner and Developer were:

- Define overall vision and use of the building.
- Set operating requirements and agree to quality assurance objectives.
- Engage quality assurance team.
- Set building construction budget.
- Determine the role of operations and maintenance staff in the quality assurance process.
- Retain a quality assurance manager.

Co-ordinating Design Professional

The role of the coordinator was:

- Receive and distribute information for review by quality assurance team.
- Set co-ordinating time table.
- Facilitate communication between members of the quality assurance team.
- Receive and issue all final letters of acceptance.
- Recommend acceptance or non-acceptance to owner.
- Co-ordinate submission distribution and hand over of shop drawings, operation and maintenance manuals.
- Co-ordinate the quality assurance team.
- Review all quality assurance related submittals.
- Review quality assurance specifications.
- Attend pre-functional performance tests.
- Co-ordinate acceptance of reviewed training, materials and procedures.
- Co-ordinate acceptance of reviewed operations and maintenance manuals.
- Co-ordinate acceptance of reviewed record drawings and documentation.

Design Team

The responsibilities of the Design Team were:

- Document the design intent.
- Oversee construction activities.
- Ensure that quality assurance training is included in the design specifications.
- Review and approve shop drawings, mock ups, and operation and maintenance manuals.
- Review record drawings, control strategies and documentation.
- Attend pre-functional performance tests.
- Review pre-functional performance test reports.
- Review training materials and procedures.
- Recommend acceptance or non-acceptance to the owner.

Contractor

The responsibilities of the contractor were:

- Perform work and supply equipment and systems as stated in the contracts.
- Co-ordinate quality assurance work schedules.
- Provide documentation per contract.
- Perform pre-functional performance tests and checks per contract.
- Perform functional performance tests, and fine tune and adjust equipment and systems per contract.
- Provide operations and maintenance manuals and staff training per contract.

Building Manager

The responsibilities of the Building Manager were:

- Participate in the Design Phase to define operations and maintenance requirements of the building.
- Participate in Design Phase for selection of systems and controls.
- Participate in Design Phase to develop maintenance manual, record drawing and documentation requirements.
- Participate in Design Phase to define training program requirements.
- Assist with functional performance tests as required.
- Attend contractor and vendor training sessions.

4.7 Building Operations & Maintenance

4.7.1 General Building Operations Policies

The Owner's Operations and Maintenance (O&M) personnel was included as one of the owner's representatives on the design team. The O&M personnel assisted in the development of a number of documents that form the basis of the O&M policies and training program. These included:

- Specification sheets for all materials, equipment and controls
- Operations Manuals
- Maintenance Manuals

- Manufacturer Training Manuals
- As-built Records

The O&M manuals and policies to be followed were finalized upon building acceptance. O&M manuals were a complete collection of all manufacturer's operation and maintenance literature supplemented by information specific to the facility for each material, piece of equipment, control and system. The manuals were organized into permanently labeled binders.

Manuals include the following data:

- Detailed description of each system and each of its components with diagrams and illustrations where applicable.
- Wiring and control diagrams with data to explain detailed operation and control of each component.
- Control sequence describing start up, all modes of operation and shut down.
- Installation instructions.
- Procedures for starting, operation and shut down for every system, including all required emergency instructions and safety precautions.
- Maintenance and overhaul instructions.
- Product information identifying all performance curves, rating data, features, options, etc. on all installed equipment.
- Copies of approved certifications and laboratory test reports (where applicable).
- Copies of warranties.
- Test procedures.
- Parts lists, including source of supply and recommended spare parts. Name, address, and 24 hour telephone number of each subcontractor who installed equipment and systems, and local representative for each type of equipment of each system.
- Other pertinent data applicable to the operation and maintenance of particular systems or equipment and/or other data specified in technical sections of the specification.

4.7.2 Training Of Building Operations And Maintenance

The objective of the training program was for the O&M personnel to take over the building and all systems upon project acceptance, and have the knowledge to operate it in accordance with the design intent and operating procedures as contained in the system manual. The intent of the training program was to train O&M staff on specific equipment operation, systems and the design intent. The identification of the O&M personnel was undertaken in the design phase. The program was detailed so that it could be repeated for new and replacement personnel. Thorough documentation was supplied for future training activities.

The O&M personnel working with the commissioning authority were responsible for planning and coordinating the training program. The training was performed by parties with specific expertise that relates to each component of the building's HVAC systems. The commissioning authority, design professional, mechanical contractor, automatic controls contractor, manufacturers and specialized training consultants participated in the training sessions.

The training program furnished a thorough understanding of all materials, equipment, components, systems and their operation including appropriate how-to skills. Training included the following topics:

Use of the System Manual with an emphasis on:

- Design intent
- Systems description, capabilities and limitations
- System operational procedures for all modes of operation, including warm-up, cool down, occupied, unoccupied, etc.
- Acceptable tolerances for system adjustments in all operating modes
- Procedures for dealing with abnormal conditions and emergency situations for which there is a specified systems response
- Documentation available in the final O&M manuals
- How to use the O&M manuals
- Recommended procedures for collecting and interpreting specific performance data
- Specialized manufacturers training programs

Upon completion of the training, each participant, using appropriate documentation and with guidance, was able to perform basic system operations and describe the general theory of the operation of the system. This level of understanding includes:

1. The Theory of Operations includes:
   - Basic Concept
   - Energy efficiency
   - Indoor air quality
   - Comfort
   - Occupied vs. unoccupied or partial occupancy
   - Seasonal modes of operation
   - Emergency conditions and procedures
2. Types of systems
3. Systems operations
4. Operating parameters
5. Use of control systems, including:
   - Sequence of operation
   - Problem indicators
   - Diagnostics
   - Corrective actions
6. Use of reports and logs
7. Service, maintenance, diagnostics and repair

The training program included classroom activities, hands on experience, and on-site building system familiarization.

4.7.3 Strategy For Involving Tenants In Building Operations And Maintenance

Tenants play a major role in ensuring that the building maintains both energy, environmental and comfort goal during ongoing operation. The tenant role includes:

- Operation of the windows, illumination, shading and lighting in a manner that will conform to the building design intent.
- Notification to the building O&M staff of any changes they are intending to make to their space, this includes modification to the interior layout, changes to floor, wall and ceiling finishes and materials, the addition of office equipment, and modifications to the HVAC or illumination systems.
- Report comfort or health problems that they believe are associated with the building to the O&M staff.

Requirements for tenant involvement in training in O&M activities was included in the lease documents.

5.0 Cost Analysis

Funding for the incremental design costs and construction costs was provided by CANMET and BC Hydro, BC Gas, Bentall Properties Ltd. and Westminster Management Corporation.

The final tendering and construction costs were evaluated after construction. The construction cost of Building No. 8 was $5,150,000 including the cost of additional insulation, mechanical and electrical systems, improved glazing and other energy saving measures valued at $264,000. The construction value also included envelope testing during construction for $10,750. Additional monitoring costs of $100,000 over 2 years have been set aside for the project. The additional research, design and reporting relating to the C-2000 program totaled $122,204.

At this time, the incremental capital expenditure for energy and environmental measures is estimated at 5.13% of the total construction cost of Building No. 8. This analysis indicates a simple payback of 5.1 years based on energy savings.

The following is a spreadsheet based on input from property management for the existing Building No. 7 and the projected energy costs for Building No. 8:

C-2000 Cost Benefit Analysis

Project Final Construction Cost $5,150,000

Value of Upgrades (and Funding):

	C-2000 Building Upgrades				*Monitoring*		
	Envelope Testing	Consultant Fees	Construction Costs	Subtotal	Monitoring Fees	Construction Costs	Total
C-2000*	10,750	122,204	74,806	207,560			207,560
C-2000 Monitoring BPL/CANMET					54,813	50,687	105,500
BC Hydro			159,667	159,667			159,667
BC Gas*			30,000	30,000			30,000
C-2000 Monitoring BPL/CANMET					100,000		100,000
Totals	**10,750**	**122,204**	**264,273**	**397,227**	**154,813**	**50,687**	**602,727**

*Value shown is partially funded by Owners

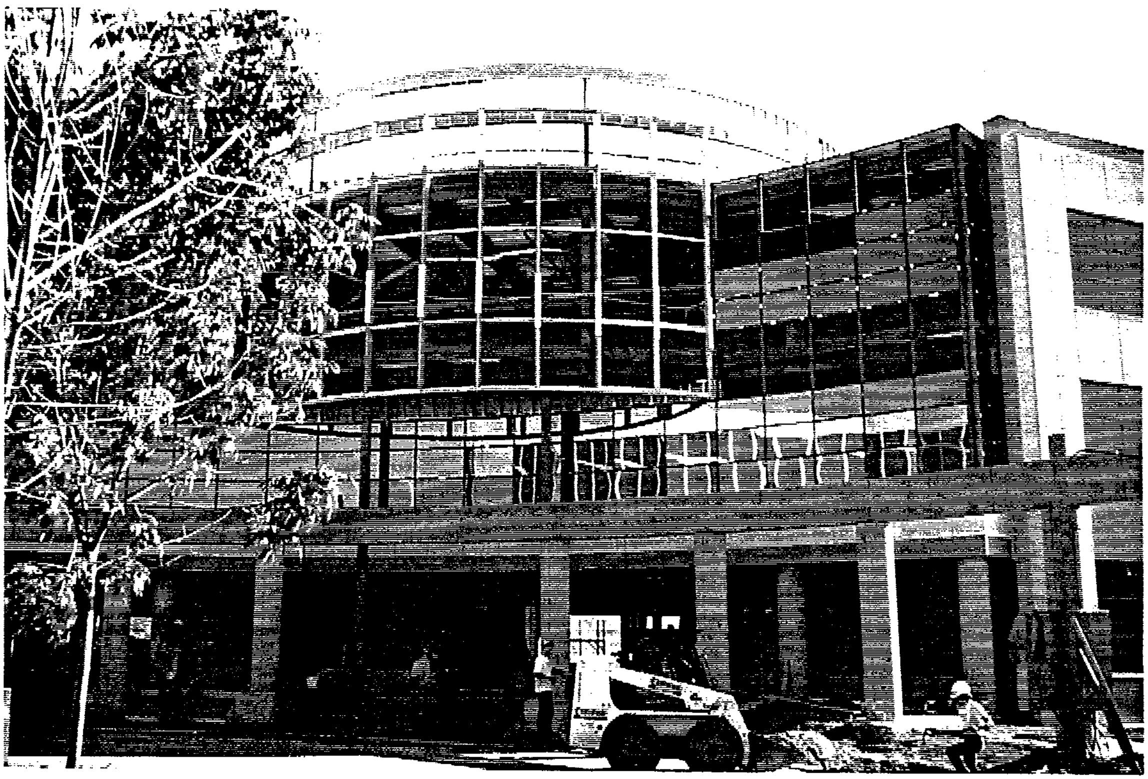
Construction Cost Upgrades Expressed as percentage of Total Construction Cost is:

$$\frac{264,273}{5,150,000} = 5.13\%$$

	Electrical	Natural Gas	Total
Average Building No. 7 Energy Costs Per Annum (Actual)	108,000	8,000	118,000
Average Building No. 8 Energy Costs Per Annum (Projected)	41,000	11,000	52,000
Savings	**67,000**	**(3,000)**	**64,000**

Simple Payback of Premium Construction Costs Only:	
Actual Discount Rate	7.00%
Construction Cost Premium	$266,000
Annual Savings	$64,000
Based on Above Payback Period is:	5.1 years

It should be noted that the monetary basis of evaluations is not entirely valid as none of the environmental benefits can be costed. Nevertheless, the improvements show a break-even value after 5.1 years, regardless of the intangible benefits.



South Elevation of Crestwood Corporate Centre Building No. 8
Under Construction - Summer 1996

6.0 Conclusions

The following sections are a summary of the results achieved during the design and construction of Crestwood Corporate Centre Building No. 8

Energy Performance

Crestwood Corporate Centre, Building No. 8 achieved the main goals of the C-2000 Program for Advanced Commercial Buildings. Through the adoption of an integrated design team, the building will consume 50% less energy than an ASHRAE/IES 90.1 reference building. With the use of computer modeling, optimum levels of lighting, ventilation and envelope performance were integrated into the design of the building.

Environmental Impact / Occupant Comfort

The C-2000 Program also succeeded in reducing the impact of the building on the environment. The adopted strategies of water conservation, recycled materials and materials with low embodied energy, and reducing construction waste, all contributed to the sustainability of the project. The ventilation strategy of small individual zones combined with reducing sources of indoor air contamination will contribute to a high standard of air quality and occupant comfort.

Integrated Design Process

Initially, the biggest challenge faced by the team was to simplify and incorporate all of the potential research into the project. The first real result of the program was the development of the Eight Step Integrated Design Process. This process was so successful it was developed into a Quality Assurance Program for the local Utility, B.C. Hydro, and used as a model for provincial programs through the B.C. Building Corporation. Development of this process is ongoing. It appears to be transferable to commercial projects ranging in size from $1M to $100M.

Simulation Experience

The next major discovery was the actual level of simulation work required for the results to be of value to the Architects in determining the shape of the building. Through this process, it became evident that the gap between Architect and Engineer must be breached before any real progress in building efficiency is made. Under the special circumstances of the C-2000 Program this was achievable, but real work needs to be done to ensure other groups can achieve the same results. Obstacles include time constraints imposed on design teams and budget allowances for simulation work.

Daylighting and Lighting

The availability of the Seattle Lighting Design Laboratory stimulated interest and was used to select glass colors and lamp types. The team planned to develop some full scale mock-ups of daylighting and lighting set-ups in the Seattle lab. This did not occur because the time and expense was not warranted. It probably would have been reasonable to do a mock-up if indirect lighting was used. The team felt the mock-up would have given a better level of comfort to the owner but with real time and budget constraints, even within the C-2000 Program, no mock-up was done. This is an area where local facilities could be of tremendous assistance to ensure progressive lighting design is incorporated into commercial buildings in Vancouver.

Showcase Products

Many suppliers were approached for special discounts on showcase products, but in the end, no real incentives were offered. The project was tendered through general contractors. As a result, the owner and the designers did not have influence on the bids and could not select products with a particular supplier. This was probably the most reasonable method in a fair market.

Site Design Features

Grass paving was considered, but even though the single source supplier did offer a discount, it was not enough to off set the premium and the concerns regarding maintenance. An interesting side note to the grass paving issue is that, although it was not used on Building No. 8, the owner was intrigued by the product and is now considering it for future areas of the development. Other developers in Vancouver have also been influenced by members of the design team and a couple of new installations are underway.

One big disappointment for the team was the decision not to go with operable windows. In a life cycle cost analysis there is simply no way to make them "pay-back" and tenants and their leasing agents do not yet seem to value them enough to create a demand. Installation would have revised the cost of the building to non-competitive levels.

Indoor Air Quality / Ventilation

A valuable lesson was learned in regard to the integration of the structural and mechanical systems. The structural system for Building No. 8 was a replication of Building No. 7. The structural system for Building No. 7 was designed to accommodate a heat pump system and not the fan coil system that was used in Building No. 8. As a result, ductwork for the mechanical system had to be snaked around and under structural members and many of the fan coils have been placed in less than optimal locations in deference to structural restrictions. The fan coil system was important in achieving the energy results of Building No. 8 but in future the team will be aware of the need to integrate the structural elements with mechanical requirements.

Costing

As a result of the tender process with a general contractor the assessment of the true value of the "incremental" capital costs was extremely difficult to evaluate. Baseline prices from Building No. 7 built two years earlier helped, but it was very difficult to assess the line items. It was also difficult to assess what the competitively bid cost of items and systems "would have been" had they been bid on a non-C-2000 basis. Many items did not have an energy saving's payback, and were difficult to support under a life cycle payback analysis. For example, the use of Environ by Phenix Biocomposites was withdrawn at the last minute as a replacement for the plastic laminate in the elevators because it cost significantly more, with no perceived owner/tenant benefit.

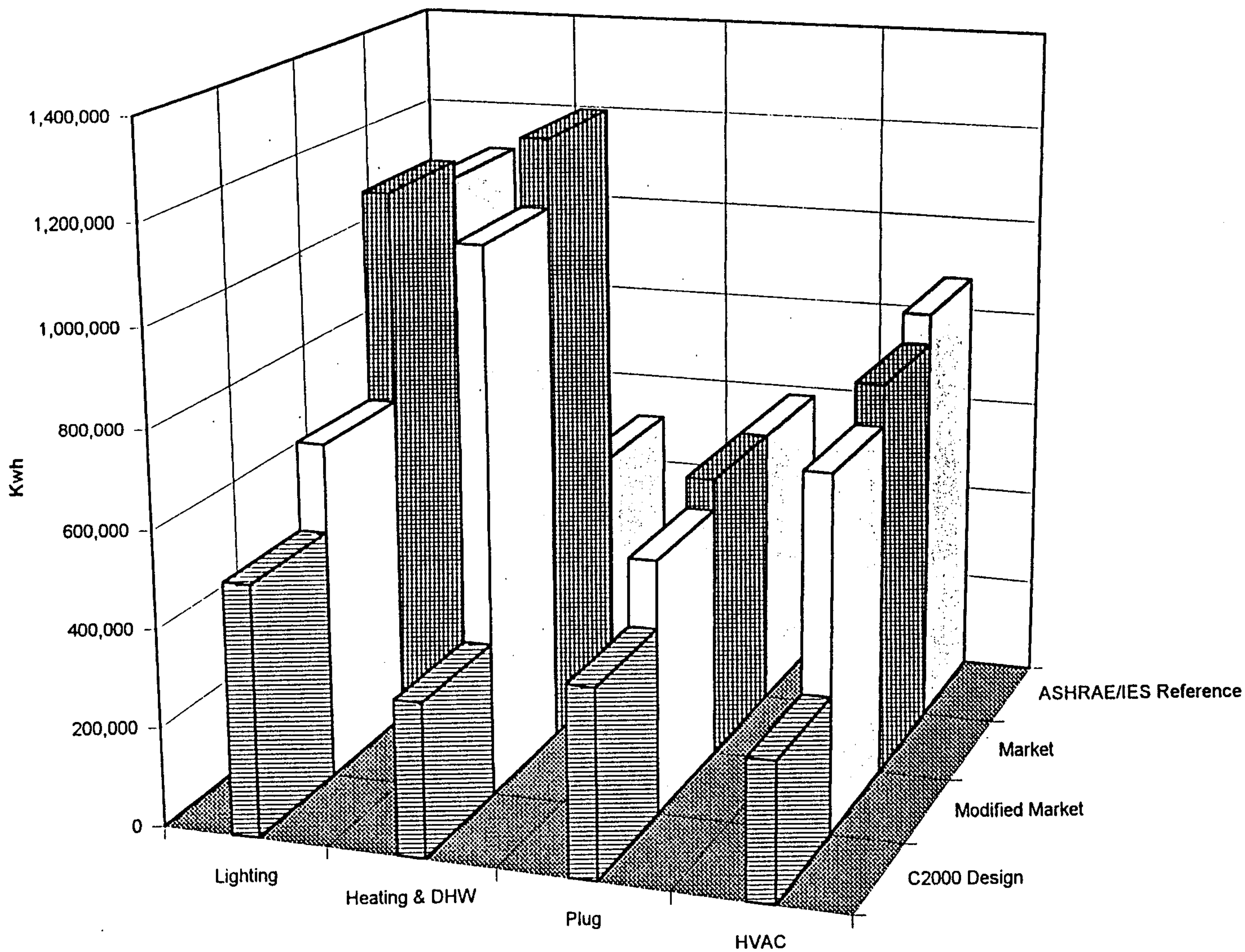
Much of what was learned is unseen. The peel and stick membrane in the panel joints was an excellent solution, but the first installation did not adhere and was rejected, and had to be redone. The underspray was eliminated in most areas to maintain indoor air quality, but where it was done, it was done very quickly and poorly and had to be rejected. Rigid insulation was installed throughout to reduce thermal bridging, but overnight a sub-contractor installed steel brackets to support the steel studs through the insulation, inadvertently compromising the break. Low VOC points were specified and used, but occasional touch-ups would occur with very volatile compounds unless the General Contractor was vigilant. However, the dust control and recycling programs were a great success and the General Contractor intends to repeat them on the next job site.

The Crestwood Corporate Centre Building No. 8 C-2000 project highlights technologies and products that did make it through a "real" process in a market driven environment and on many levels, it is considered an outstanding success.

Appendix 1

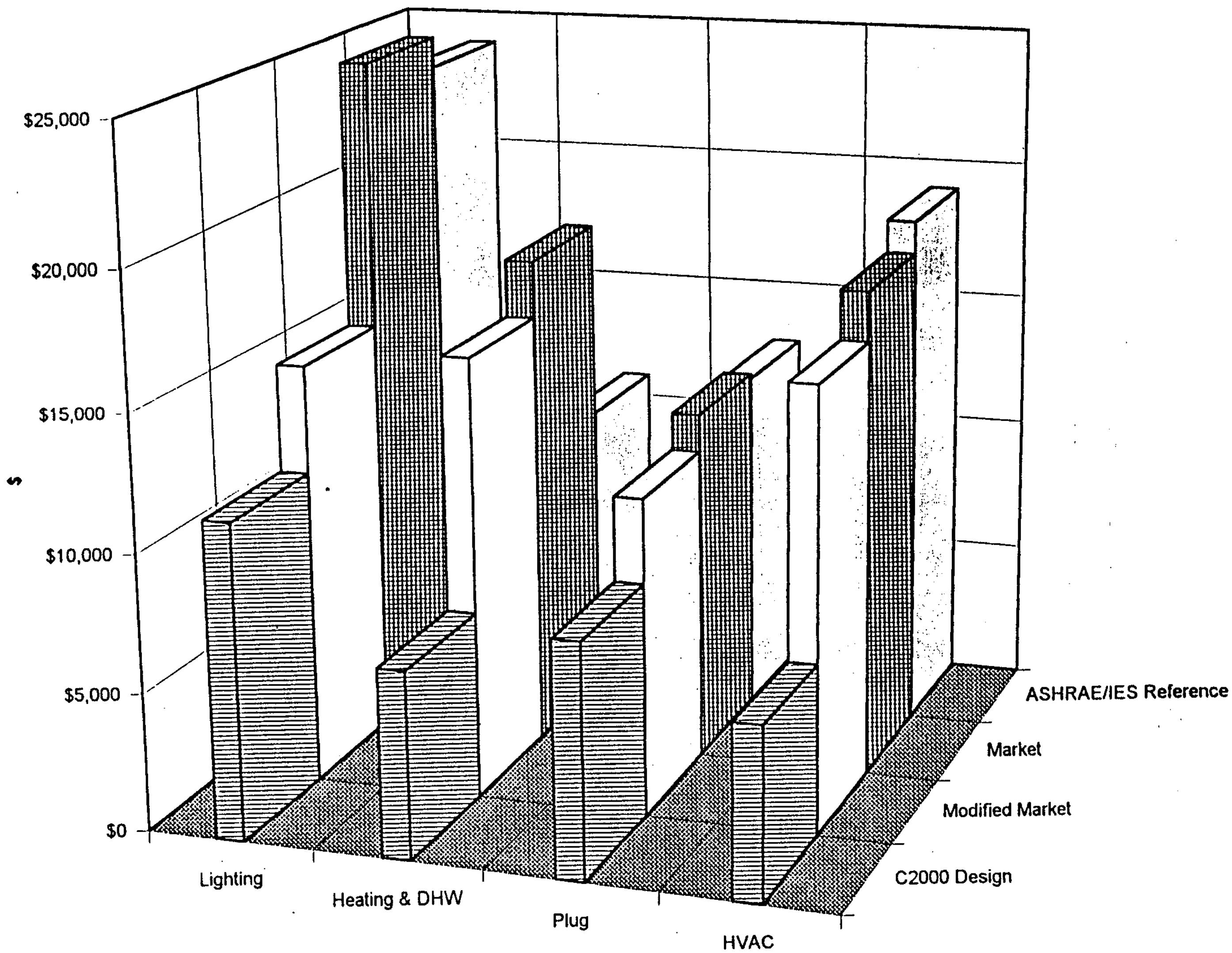
Energy Performance Projections

Crestwood Building No. 8 End Use Breakdown



Note: **Lighting graph refers exclusively to lighting**
Heating & DHW includes all heating (gas & electric) and DHW
Plugs include equipment and elevators
HVAC includes fans, pumps, cooling and misc.

Crestwood Building No. 8 Annual Cost Breakdown



Note: **Lighting graph refers exclusively to lighting**
Heating & DHW includes all heating (gas & electric) and DHW
Plugs include equipment and elevators
HVAC includes fans, pumps, cooling and misc.

CRESTWOOD C2000 BUILDING 8 ENERGY PERFORMANCE

	ASHRAE / IES 90.1 REFERENCE		MARKET		MODIFIED MARKET		C2000 DESIGN	
	Annual Energy Consumption SEAF = 3.0 kWh	Annual Cost $	Annual Energy Consumption SEAF = 3.0 kWh	Annual Cost $	Annual Energy Consumption SEAF = 3.0 kWh	Annual Cost $	Annual Energy Consumption SEAF = 3.0 kWh	Annual Cost $
Lights	1,093,828	$23,829	1,128,988	$24,924	691,773	$15,357	509,117	$11,404
Pumps & Misc	34,721	$756	268,007	$5,917	247,439	$5,493	32,347	$725
Equipment	418,782	$9,123	418,782	$9,245	418,281	$9,286	279,135	$6,253
Elevators	161,358	$3,515	161,358	$3,562	96,813	$2,149	96,813	$2,169
Gas Heating	478,791	$10,294	359,511	$7,909	309,174	$6,811	288,429	$6,345
Electric Heating	0	$0	873,023	$9,637	782,662	$8,688	0	$0
DHW	25,403	$544	25,403	$554	25,403	$559	20,862	$451
Cooling	189,688	$4,132	348,875	$7,702	295,608	$6,562	100,733	$2,256
Fans	643,868	$14,027	187,930	$4,149	175,800	$3,909	143,101	$3,205
Gas Total	504,194	$10,838	384,914	$8,463	2,708,375	$51,444	288,429	$6,345
Electricity Total	2,542,244	$55,384	3,386,963	$65,136	334,577	$7,370	1,182,109	$26,463
Total	3,046,438	$66,221	3,771,877	$73,599	3,042,952	$58,814	1,470,538	$32,808
% Relative to ASHRAE / IES Reference :			123.8%	111.1%	99.9%	88.8%	48.3%	49.5%

Appendix 1

DOE2.1E Modeling Results for Building Options

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

NUMBER OF SPACES 76 EXTERIOR 58 INTERIOR 18

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	AZIMUTH	LIGHTING (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	AIR CHANGES PER HOUR	AREA (SQFT)	VOLUME (CUFT)
GNW	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
GN1	1.0	EXT	0.0	1.57	1.7	0.75	AIR-CHANGE	0.25	479.00	4311.00
116COR	1.0	EXT	0.0	0.70	0.0	0.00	AIR-CHANGE	0.01	151.00	1359.00
GN2	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	301.00	2709.00
GNE1	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
GNE2	1.0	EXT	0.0	1.57	3.6	0.75	AIR-CHANGE	0.25	978.00	8802.00
GIN2	1.0	INT	0.0	1.57	14.2	0.75	NO-INFILT.	0.00	3918.00	35262.00
GIN2C	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
GW	1.0	EXT	0.0	1.57	5.8	0.75	AIR-CHANGE	0.25	1608.00	14472.00
GS	1.0	EXT	0.0	1.57	6.1	0.75	AIR-CHANGE	0.25	1678.00	15102.00
GISE	1.0	INT	0.0	1.57	14.3	0.75	NO-INFILT.	0.00	3940.00	35460.00
GE5	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
GE4	1.0	EXT	0.0	1.57	1.7	0.75	AIR-CHANGE	0.25	461.00	4149.00
118COR	1.0	EXT	0.0	0.70	0.0	0.00	AIR-CHANGE	0.01	150.00	1350.00
GE2	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
GE3	1.0	EXT	0.0	1.57	1.0	0.75	AIR-CHANGE	0.25	279.00	2511.00
GINE	1.0	INT	0.0	1.57	6.6	0.75	NO-INFILT.	0.00	1820.00	16380.00
GIN1	1.0	INT	0.0	1.57	6.0	0.75	NO-INFILT.	0.00	1663.00	14967.00
GN3	1.0	EXT	0.0	1.57	3.6	0.75	AIR-CHANGE	0.25	978.00	8802.00
GE1	1.0	EXT	0.0	1.57	2.0	0.75	AIR-CHANGE	0.25	538.00	4842.00
101L	1.0	EXT	0.0	0.70	9.4	0.00	AIR-CHANGE	0.11	2589.00	23301.00
GIE1	1.0	INT	0.0	1.57	4.8	0.75	NO-INFILT.	0.00	1320.00	11880.00
GIE2	1.0	INT	0.0	1.57	4.8	0.75	NO-INFILT.	0.00	1307.00	11763.00
GSW1	1.0	EXT	0.0	1.57	1.7	0.75	AIR-CHANGE	0.25	473.00	4257.00
GSW2	1.0	EXT	0.0	1.57	1.7	0.75	AIR-CHANGE	0.25	478.00	4302.00
108MEN	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	396.00	3564.00
112WOM	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	417.00	3753.00
2NW	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
2N1	1.0	EXT	0.0	1.57	2.9	0.75	AIR-CHANGE	0.25	807.00	7263.00
2NE1	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
2NE2	1.0	EXT	0.0	1.57	3.3	0.75	AIR-CHANGE	0.25	916.00	8244.00
2W	1.0	EXT	0.0	1.57	6.0	0.75	AIR-CHANGE	0.25	1663.00	14967.00
2IN	1.0	INT	0.0	1.57	22.7	0.75	NO-INFILT.	0.00	6250.00	56250.00
2INC	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
2N2	1.0	EXT	0.0	1.57	3.3	0.75	AIR-CHANGE	0.25	916.00	8244.00
2INE	1.0	INT	0.0	1.57	8.1	0.75	NO-INFILT.	0.00	2234.00	20106.00
2ISE	1.0	INT	0.0	1.57	14.1	0.75	NO-INFILT.	0.00	3890.00	35010.00
2EE2	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
2EE3	1.0	EXT	0.0	1.57	2.8	0.75	AIR-CHANGE	0.25	775.00	6975.00
2EE4	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.25	140.00	1260.00
2S	1.0	EXT	0.0	1.57	6.1	0.75	AIR-CHANGE	0.25	1678.00	15102.00
2EE1	1.0	EXT	0.0	1.57	2.6	0.75	AIR-CHANGE	0.25	725.00	6525.00
2SW1	1.0	EXT	0.0	1.57	1.2	0.75	AIR-CHANGE	0.25	341.00	3069.00
2SW2	1.0	EXT	0.0	1.57	1.7	0.75	AIR-CHANGE	0.25	459.00	4131.00
2IE1	1.0	INT	0.0	1.57	4.8	0.75	NO-INFILT.	0.00	1317.00	11853.00
2IE2	1.0	INT	0.0	1.57	4.9	0.75	NO-INFILT.	0.00	1344.00	12096.00
205MEN	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00

Crestwood Building 8 C2000 REFEERENCE BUILDING DOE-2.1E-003 10/17/1994 12:34: 5 LDL RUN 1
LOADS
REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

(CONTINUED)

207WOM	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
3NW	1.0	EXT	0.0	1.57	0.4	0.75	AIR-CHANGE	0.25	118.00	1062.00
3NE1	1.0	EXT	0.0	1.57	0.4	0.75	AIR-CHANGE	0.25	117.00	1053.00
3N3	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	308.00	2772.00
3N1	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	308.00	2772.00
3N2	1.0	EXT	0.0	1.57	2.0	0.75	AIR-CHANGE	0.25	557.00	5013.00
3NE2	1.0	EXT	0.0	1.57	2.4	0.75	AIR-CHANGE	0.25	661.00	5949.00
3W	1.0	EXT	0.0	1.57	4.9	0.75	AIR-CHANGE	0.25	1356.00	12204.00
3IN	1.0	EXT	0.0	1.57	21.9	0.75	NO-INFILT.	0.00	6017.00	54153.00
3INC	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
3IE1	1.0	EXT	0.0	1.57	4.8	0.75	NO-INFILT.	0.00	1307.00	11763.00
3IE2	1.0	EXT	0.0	1.57	4.9	0.75	NO-INFILT.	0.00	1335.00	12015.00
3EE1	1.0	EXT	0.0	1.57	2.6	0.75	AIR-CHANGE	0.25	725.00	6525.00
3SW1	1.0	EXT	0.0	1.57	1.2	0.75	AIR-CHANGE	0.25	324.00	2916.00
3SW3	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	290.00	2610.00
3SW2	1.0	EXT	0.0	1.57	2.1	0.75	AIR-CHANGE	0.25	580.00	5220.00
3ISW	1.0	EXT	0.0	1.57	3.6	0.75	NO-INFILT.	0.00	993.00	8937.00
3L	1.0	EXT	0.0	0.80	2.0	0.00	NO-INFILT.	0.00	545.00	4905.00
3S	1.0	EXT	0.0	1.57	5.0	0.75	AIR-CHANGE	0.25	1386.00	12474.00
3N4	1.0	EXT	0.0	1.57	2.4	0.75	AIR-CHANGE	0.25	657.00	5913.00
3NE3	1.0	EXT	0.0	1.57	0.4	0.75	AIR-CHANGE	0.25	119.00	1071.00
3INE	1.0	EXT	0.0	1.57	8.0	0.75	NO-INFILT.	0.00	2190.00	19710.00
3EE2	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	308.00	2772.00
3EE3	1.0	EXT	0.0	1.57	2.0	0.75	AIR-CHANGE	0.25	559.00	5031.00
3EE4	1.0	EXT	0.0	1.57	1.1	0.75	AIR-CHANGE	0.25	308.00	2772.00
3SE	1.0	EXT	0.0	1.57	0.4	0.75	AIR-CHANGE	0.25	119.00	1071.00
3ISE	1.0	EXT	0.0	1.57	14.2	0.75	NO-INFILT.	0.00	3912.00	35208.00
306MEN	1.0	EXT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
311WOM	1.0	EXT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
BUILDING TOTALS					307.8				77156.00	694404.00

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.672	0.089	0.230	1890.92	5929.79	7820.71
NORTH-EAST	0.674	0.089	0.229	1503.82	4759.44	6263.26
EAST	0.637	0.089	0.212	77.06	264.78	341.84
SOUTH-EAST	0.679	0.089	0.237	1275.60	3790.58	5066.18
SOUTH	0.673	0.089	0.263	595.77	1401.73	1997.51
SOUTH-WEST	0.679	0.089	0.240	1530.15	4452.39	5982.54
WEST	0.637	0.089	0.211	76.16	265.06	341.22
FLOOR	0.000	0.063	0.063	0.00	405.20	405.20
ROOF	0.000	0.063	0.063	0.00	27275.87	27275.87
ALL WALLS	0.674	0.089	0.235	6949.47	20863.79	27813.26
WALLS+ROOFS	0.674	0.074	0.150	6949.47	48139.66	55089.13
UNDERGRND	0.000	0.065	0.065	0.00	795.34	795.34
BUILDING	0.674	0.074	0.148	6949.47	49340.19	56289.66

NUMBER OF CONSTRUCTIONS 7 DELAYED 7 QUICK 0

CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
FLATROOF	0.064	0.50	2	DELAYED	11
FLOORSLAB	0.157	0.70	3	DELAYED	15
INTERNALWALL	1.479	0.70	3	DELAYED	3
INTERNALGB	0.132	0.70	3	DELAYED	4
INTERNALCONC	0.395	0.70	3	DELAYED	7
BASEFLOOR	0.065	0.70	3	DELAYED	12
LIGHTWALL	0.092	0.65	3	DELAYED	7

*** BUILDING ***

FLOOR AREA	77156	SQFT	7168	SQMT
VOLUME	694404	CUFT	19666	CUMT

	COOLING LOAD				HEATING LOAD	
TIME	AUG 11 5PM				DEC 4 6AM	
DRY-BULB TEMP	77F	25C			16F	-9C
WET-BULB TEMP	66F	19C			13F	-11C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	41.595	12.187	0.000	0.000	-106.222	-31.123
ROOF CONDUCTION	30.006	8.792	0.000	0.000	-91.039	-26.674
WINDOW GLASS+FRM COND	102.348	29.988	0.000	0.000	-245.491	-71.929
WINDOW GLASS SOLAR	122.998	36.038	0.000	0.000	6.259	1.834
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-0.868	-0.254	0.000	0.000	-1.319	-0.387
OCCUPANTS TO SPACE	62.469	18.304	57.364	16.808	0.420	0.123
LIGHT TO SPACE	316.942	92.864	0.000	0.000	33.052	9.684
EQUIPMENT TO SPACE	150.979	44.237	0.000	0.000	1.168	0.342
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-62.951	-18.445
TOTAL	826.470	242.156	57.364	16.808	-466.123	-136.574

	COOLING		HEATING	
TOTAL LOAD	883.833 KBTU/H	258.963 KW	-466.123 KBTU/H	-136.574 KW
TOTAL LOAD / AREA	11.46BTU/H.SQFT	36.128 W /SQMT	6.041BTU/H.SQFT	19.053 W /SQMT

NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

REPORT- SV-A SYSTEM DESIGN PARAMETERS OFFICESYS WEATHER FILE- VANCOUVER TMY

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
OFFICESYS	VAVS	1.000	75092.0	308.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
60940.	52.019	2.6	58008.	22.695	1.2	0.330	2628.604	0.645	-877.391	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
GW	2080.	0.	0.000	0.520	686.	0.00	0.00	44.93	-40.88	-23.36	1.0
GNW	280.	0.	0.000	0.610	92.	0.00	0.00	6.05	-6.46	-3.69	1.0
GN1	350.	0.	0.000	1.000	116.	0.00	0.00	7.56	-13.23	-7.56	1.0
GN2	190.	0.	0.000	1.000	63.	0.00	0.00	4.10	-7.18	-4.10	1.0
GNE1	170.	0.	0.000	1.000	56.	0.00	0.00	3.67	-6.43	-3.67	1.0
GNE2	1090.	0.	0.000	0.580	360.	0.00	0.00	23.54	-23.90	-13.66	1.0
GE1	480.	0.	0.000	1.000	158.	0.00	0.00	10.37	-18.14	-10.37	1.0
GN3	630.	0.	0.000	1.000	208.	0.00	0.00	13.61	-23.81	-13.61	1.0
GE2	190.	0.	0.000	0.900	63.	0.00	0.00	4.10	-6.46	-3.69	1.0
GE3	350.	0.	0.000	0.520	116.	0.00	0.00	7.56	-6.88	-3.93	1.0
GE4	650.	0.	0.000	0.540	215.	0.00	0.00	14.04	-13.27	-7.58	1.0
GE5	280.	0.	0.000	0.570	92.	0.00	0.00	6.05	-6.03	-3.45	1.0
GS	2250.	0.	0.000	0.460	743.	0.00	0.00	48.60	-39.12	-22.36	1.0
GSW2	560.	0.	0.000	0.520	185.	0.00	0.00	12.10	-11.01	-6.29	1.0
101L	1560.	0.	0.000	1.000	515.	0.00	0.00	33.70	-58.97	-33.70	1.0
GSW1	550.	0.	0.000	0.520	182.	0.00	0.00	11.88	-10.81	-6.18	1.0
GIN1	1000.	157.	0.025	1.000	330.	0.00	0.00	21.60	-37.80	-21.60	1.0
GIN2	2360.	470.	0.074	1.000	779.	0.00	0.00	50.98	-89.21	-50.98	1.0
GIE1	800.	0.	0.000	1.000	264.	0.00	0.00	17.28	-30.24	-17.28	1.0
GIE2	790.	0.	0.000	1.000	261.	0.00	0.00	17.06	-29.86	-17.06	1.0
GINE	1100.	149.	0.023	1.000	363.	0.00	0.00	23.76	-41.58	-23.76	1.0
GISE	2370.	446.	0.070	1.000	782.	0.00	0.00	51.19	-89.59	-51.19	1.0

(CONTINUED)

2W	2000.	0.	0.000	0.530	660.	0.00	0.00	43.20	-40.07	-22.90
2NW	270.	0.	0.000	0.680	89.	0.00	0.00	5.83	-6.94	-3.97
2N1	550.	0.	0.000	1.000	182.	0.00	0.00	11.88	-20.79	-11.88
2NE1	190.	0.	0.000	1.000	63.	0.00	0.00	4.10	-7.18	-4.10
2NE2	1010.	0.	0.000	0.570	333.	0.00	0.00	21.82	-21.76	-12.44
2EE1	510.	0.	0.000	1.000	168.	0.00	0.00	11.02	-19.28	-11.02
2N2	580.	0.	0.000	1.000	191.	0.00	0.00	12.53	-21.92	-12.53
2EE2	190.	0.	0.000	1.000	63.	0.00	0.00	4.10	-7.18	-4.10
2EE3	930.	0.	0.000	0.620	307.	0.00	0.00	20.09	-21.80	-12.45
2EE4	260.	0.	0.000	0.690	86.	0.00	0.00	5.62	-6.78	-3.88
2S	2150.	0.	0.000	0.470	710.	0.00	0.00	46.44	-38.20	-21.83
2SW2	440.	0.	0.000	0.630	145.	0.00	0.00	9.50	-10.48	-5.99
2SW1	400.	0.	0.000	0.520	132.	0.00	0.00	8.64	-7.86	-4.49
2IN	3750.	441.	0.069	1.000	1238.	0.00	0.00	81.00	-141.75	-81.00
2IE1	790.	0.	0.000	1.000	261.	0.00	0.00	17.06	-29.86	-17.06
2IE2	810.	0.	0.000	1.000	267.	0.00	0.00	17.50	-30.62	-17.50
2INE	1340.	0.	0.000	1.000	442.	0.00	0.00	28.94	-50.65	-28.94
2ISE	2340.	414.	0.065	1.000	772.	0.00	0.00	50.54	-88.45	-50.54
3W	1880.	0.	0.000	0.610	620.	0.00	0.00	40.61	-43.35	-24.77
3NW	240.	0.	0.000	0.700	79.	0.00	0.00	5.18	-6.35	-3.63
3N1	410.	0.	0.000	0.800	135.	0.00	0.00	8.86	-12.40	-7.08
3N2	370.	0.	0.000	1.000	122.	0.00	0.00	7.99	-13.99	-7.99
3N3	340.	0.	0.000	1.000	112.	0.00	0.00	7.34	-12.85	-7.34
3NE1	170.	0.	0.000	1.000	56.	0.00	0.00	3.67	-6.43	-3.67
3NE2	720.	0.	0.000	0.770	238.	0.00	0.00	15.55	-20.96	-11.98
3EE1	620.	0.	0.000	1.000	205.	0.00	0.00	13.39	-23.44	-13.39
3N4	550.	0.	0.000	1.000	182.	0.00	0.00	11.88	-20.79	-11.88
3NE3	170.	0.	0.000	1.000	56.	0.00	0.00	3.67	-6.43	-3.67
3EE2	340.	0.	0.000	1.000	112.	0.00	0.00	7.34	-12.85	-7.34
3EE3	590.	0.	0.000	0.680	195.	0.00	0.00	12.74	-15.17	-8.67

(CONTINUED)

3EE4	330.	0.	0.000	0.930	109.	0.00	0.00	7.13	-11.60	-6.63	1.0
3SE	230.	0.	0.000	0.700	76.	0.00	0.00	4.97	-6.09	-3.48	1.0
3S	1850.	0.	0.000	0.600	611.	0.00	0.00	39.96	-41.96	-23.98	1.0
3SW3	360.	0.	0.000	0.620	119.	0.00	0.00	7.78	-8.44	-4.82	1.0
3SW2	750.	0.	0.000	0.660	248.	0.00	0.00	16.20	-18.71	-10.69	1.0
3SW1	380.	0.	0.000	0.610	125.	0.00	0.00	8.21	-8.76	-5.01	1.0
3IN	3610.	441.	0.069	1.000	1191.	0.00	0.00	77.98	-136.46	-77.98	1.0
3IE1	790.	0.	0.000	1.000	261.	0.00	0.00	17.06	-29.86	-17.06	1.0
3IE2	800.	0.	0.000	1.000	264.	0.00	0.00	17.28	-30.24	-17.28	1.0
3L	330.	0.	0.000	1.000	109.	0.00	0.00	7.13	-12.47	-7.13	1.0
3ISW	600.	0.	0.000	1.000	198.	0.00	0.00	12.96	-22.68	-12.96	1.0
3INE	1320.	0.	0.000	1.000	436.	0.00	0.00	28.51	-49.90	-28.51	1.0
3ISE	2350.	414.	0.065	1.000	776.	0.00	0.00	50.76	-88.83	-50.76	1.0
GIN2C	750.	0.	0.000	0.480	248.	0.00	0.00	16.20	-13.61	-7.78	1.0
2INC	750.	0.	0.000	0.480	248.	0.00	0.00	16.20	-13.61	-7.78	1.0
3INC	750.	0.	0.000	0.480	248.	0.00	0.00	16.20	-13.61	-7.78	1.0

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	1.794	1	1															
HERM-CENT-CHLR	1.632	1	1															
COOLING-TWR	2.044	1	1															

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	AVAIL	SIZE (MBTU/H)	NUMBER INSTD	AVAIL	SIZE (MBTU/H)	NUMBER INSTD	AVAIL	SIZE (MBTU/H)	NUMBER INSTD	AVAIL	SIZE (MBTU/H)	NUMBER INSTD	AVAIL	SIZE (MBTU/H)	NUMBER INSTD	AVAIL
HW-BOILER	1.794	1	1															
HERM-CENT-CHLR	1.632	1	1															
COOLING-TWR	2.044	1	1															

	PART LOAD RATIOS			
EQUIPMENT	MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	0.2500	1.2000	1.0000	0.0000
HERM-CENT-CHLR	0.1000	1.0000	0.8000	0.2380
COOLING-TWR	0.3300	2.0000	0.0000	0.0000

REPORT- PS-C EQUIPMENT PART LOAD OPERATION WEATHER FILE- VANCOUVER TMY

EQUIPMENT	HOURS AT PERCENT PART LOAD RATIO 0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110+	TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (KWH)	THERMAL USED (MBTU)
HW-BOILER	2384	919	495	276	162	87	36	17	6	3	1	4386	1059.5	0.0	0.	1634.1
	2384	919	495	276	162	87	36	17	6	3	1					
HERM-CENT-CHLR	144	157	178	170	182	119	84	73	24	10	0	1141	708.2	0.0	52050.	0.0
	144	157	178	170	182	119	84	73	24	10	0					
COOLING-TWR	413	384	205	114	23	2	0	0	0	0	0	1141	912.8	0.0	11199.	0.0
	413	384	205	114	23	2	0	0	0	0	0					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 4970. KWH
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 6603. KWH
CONDENSER WATER PUMP ELECTRICAL USE = 8764. KWH
TOWER OR CONDENSER FAN ELECTRICAL USE = 2435. KWH

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	1059.5	1059.5	0.000	0.000	0
COOLING LOADS	708.2	708.2	0.000	0.000	0
ELECTRICAL LOADS	2892.4	2892.4	0.000	0.000	0

REPORT- PS-H EQUIPMENT USE STATISTICS WEATHER FILE- VANCOUVER TMY

E Q U I P M E N T	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	0.135	1.794	12	12	8	1.794	4386								
HERM-CENT-CHLR	0.380	1.632	7	22	17	1.632	1141								
COOLING-TWR	0.391	2.035	7	22	17	2.044	1141								

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	1244.4	0.0
MISC EQUIPMT	660.0	0.0
SPACE HEAT	0.0	1634.1
SPACE COOL	177.6	0.0
HEAT REJECT	38.2	0.0
PUMPS & MISC	39.5	0.0
VENT FANS	732.5	0.0
DOMHOT WATER	0.0	86.7
TOTAL	2892.4	1720.9

TOTAL SITE ENERGY	4613.22 MBTU	59.8 KBTU/SQFT-YR GROSS-AREA	59.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY	10398.80 MBTU	134.8 KBTU/SQFT-YR GROSS-AREA	134.8 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.3
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELECCOST	ELECTRICITY	1 2 3 4 5	847464. KWH	55384.	0.0654	YES
NGASCOST	NATURAL-GAS	1 2 3 4 5	1816. GJ	10841.	5.9712	YES
				==========		
				66225.		

ENERGY COST/GROSS BLDG AREA: 0.86
ENERGY COST/NET BLDG AREA: 0.86

NUMBER OF SPACES 76 EXTERIOR 58 INTERIOR 18

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	AZIMUTH	LIGHTING (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	AIR CHANGES PER HOUR	AREA (SQFT)	VOLUME (CUFT)
GNW	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
GN1	1.0	EXT	0.0	0.86	1.7	0.50	AIR-CHANGE	0.13	479.00	4311.00
116COR	1.0	EXT	0.0	0.33	0.0	0.00	AIR-CHANGE	0.05	151.00	1359.00
GN2	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	301.00	2709.00
GNE1	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
GNE2	1.0	EXT	0.0	0.86	3.6	0.50	AIR-CHANGE	0.13	978.00	8802.00
GIN2	1.0	INT	0.0	0.86	14.2	0.50	NO-INFILT.	0.00	3918.00	35262.00
GIN2C	1.0	INT	0.0	0.86	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
GW	1.0	EXT	0.0	0.86	5.8	0.50	AIR-CHANGE	0.13	1608.00	14472.00
GS	1.0	EXT	0.0	0.86	6.1	0.50	AIR-CHANGE	0.13	1678.00	15102.00
GISE	1.0	INT	0.0	0.86	14.3	0.50	NO-INFILT.	0.00	3940.00	35460.00
GE5	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
GE4	1.0	EXT	0.0	0.86	1.7	0.50	AIR-CHANGE	0.13	461.00	4149.00
118COR	1.0	EXT	0.0	0.33	0.0	0.00	AIR-CHANGE	0.05	150.00	1350.00
GE2	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
GE3	1.0	EXT	0.0	0.86	1.0	0.50	AIR-CHANGE	0.13	279.00	2511.00
GINE	1.0	INT	0.0	0.86	6.6	0.50	NO-INFILT.	0.00	1820.00	16380.00
GIN1	1.0	INT	0.0	0.86	6.0	0.50	NO-INFILT.	0.00	1663.00	14967.00
GN3	1.0	EXT	0.0	0.86	3.6	0.50	AIR-CHANGE	0.13	978.00	8802.00
GE1	1.0	EXT	0.0	0.86	2.0	0.50	AIR-CHANGE	0.13	538.00	4842.00
101L	1.0	EXT	0.0	0.60	9.4	0.00	AIR-CHANGE	0.06	2589.00	23301.00
GIE1	1.0	INT	0.0	0.86	4.8	0.50	NO-INFILT.	0.00	1320.00	11880.00
GIE2	1.0	INT	0.0	0.86	4.8	0.50	NO-INFILT.	0.00	1307.00	11763.00
GSW1	1.0	EXT	0.0	0.86	1.7	0.50	AIR-CHANGE	0.13	473.00	4257.00
GSW2	1.0	EXT	0.0	0.86	1.7	0.50	AIR-CHANGE	0.13	478.00	4302.00
108MEN	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	396.00	3564.00
112WOM	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	417.00	3753.00
2NW	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
2N1	1.0	EXT	0.0	0.86	2.9	0.50	AIR-CHANGE	0.13	807.00	7263.00
2NE1	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
2NE2	1.0	EXT	0.0	0.86	3.3	0.50	AIR-CHANGE	0.13	916.00	8244.00
2W	1.0	EXT	0.0	0.86	6.0	0.50	AIR-CHANGE	0.13	1663.00	14967.00
2IN	1.0	INT	0.0	0.86	22.7	0.50	NO-INFILT.	0.00	6250.00	56250.00
2INC	1.0	INT	0.0	0.86	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
2N2	1.0	EXT	0.0	0.86	3.3	0.50	AIR-CHANGE	0.13	916.00	8244.00
2INE	1.0	INT	0.0	0.86	8.1	0.50	NO-INFILT.	0.00	2234.00	20106.00
2ISE	1.0	INT	0.0	0.86	14.1	0.50	NO-INFILT.	0.00	3890.00	35010.00
2EE2	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
2EE3	1.0	EXT	0.0	0.86	2.8	0.50	AIR-CHANGE	0.13	775.00	6975.00
2EE4	1.0	EXT	0.0	0.86	0.5	0.50	AIR-CHANGE	0.13	140.00	1260.00
2S	1.0	EXT	0.0	0.86	6.1	0.50	AIR-CHANGE	0.13	1678.00	15102.00
2EE1	1.0	EXT	0.0	0.86	2.6	0.50	AIR-CHANGE	0.13	725.00	6525.00
2SW1	1.0	EXT	0.0	0.86	1.2	0.50	AIR-CHANGE	0.13	341.00	3069.00
2SW2	1.0	EXT	0.0	0.86	1.7	0.50	AIR-CHANGE	0.13	459.00	4131.00
2IE1	1.0	INT	0.0	0.86	4.8	0.50	NO-INFILT.	0.00	1317.00	11853.00
2IE2	1.0	INT	0.0	0.86	4.9	0.50	NO-INFILT.	0.00	1344.00	12096.00
205MEN	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

(CONTINUED)

207WOM	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
3NW	1.0	EXT	0.0	0.86	0.4	0.50	AIR-CHANGE	0.13	118.00	1062.00
3NE1	1.0	EXT	0.0	0.86	0.4	0.50	AIR-CHANGE	0.13	117.00	1053.00
3N3	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	308.00	2772.00
3N1	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	308.00	2772.00
3N2	1.0	EXT	0.0	0.86	2.0	0.50	AIR-CHANGE	0.13	557.00	5013.00
3NE2	1.0	EXT	0.0	0.86	2.4	0.50	AIR-CHANGE	0.13	661.00	5949.00
3W	1.0	EXT	0.0	0.86	4.9	0.50	AIR-CHANGE	0.13	1356.00	12204.00
3IN	1.0	EXT	0.0	0.86	21.9	0.50	NO-INFILT.	0.00	6017.00	54153.00
3INC	1.0	INT	0.0	0.86	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
3IE1	1.0	EXT	0.0	0.86	4.8	0.50	NO-INFILT.	0.00	1307.00	11763.00
3IE2	1.0	EXT	0.0	0.86	4.9	0.50	NO-INFILT.	0.00	1335.00	12015.00
3EE1	1.0	EXT	0.0	0.86	2.6	0.50	AIR-CHANGE	0.13	725.00	6525.00
3SW1	1.0	EXT	0.0	0.86	1.2	0.50	AIR-CHANGE	0.13	324.00	2916.00
3SW3	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	290.00	2610.00
3SW2	1.0	EXT	0.0	0.86	2.1	0.50	AIR-CHANGE	0.13	580.00	5220.00
3ISW	1.0	EXT	0.0	0.86	3.6	0.50	NO-INFILT.	0.00	993.00	8937.00
3L	1.0	EXT	0.0	0.60	2.0	0.00	NO-INFILT.	0.00	545.00	4905.00
3S	1.0	EXT	0.0	0.86	5.0	0.50	AIR-CHANGE	0.13	1386.00	12474.00
3N4	1.0	EXT	0.0	0.86	2.4	0.50	AIR-CHANGE	0.13	657.00	5913.00
3NE3	1.0	EXT	0.0	0.86	0.4	0.50	AIR-CHANGE	0.13	119.00	1071.00
3INE	1.0	EXT	0.0	0.86	8.0	0.50	NO-INFILT.	0.00	2190.00	19710.00
3EE2	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	308.00	2772.00
3EE3	1.0	EXT	0.0	0.86	2.0	0.50	AIR-CHANGE	0.13	559.00	5031.00
3EE4	1.0	EXT	0.0	0.86	1.1	0.50	AIR-CHANGE	0.13	308.00	2772.00
3SE	1.0	EXT	0.0	0.86	0.4	0.50	AIR-CHANGE	0.13	119.00	1071.00
3ISE	1.0	EXT	0.0	0.86	14.2	0.50	NO-INFILT.	0.00	3912.00	35208.00
306MEN	1.0	EXT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
311WOM	1.0	EXT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
					-------				---------	----------
BUILDING TOTALS					307.8				77156.00	694404.00

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.346	0.066	0.203	3816.39	4004.32	7820.71
NORTH-EAST	0.334	0.066	0.194	2981.53	3281.74	6263.26
EAST	0.440	0.066	0.251	168.92	172.92	341.84
SOUTH-EAST	0.322	0.066	0.189	2426.53	2639.66	5066.18
SOUTH	0.339	0.066	0.219	1114.02	879.23	1993.26
SOUTH-WEST	0.320	0.066	0.189	2895.18	3087.35	5982.54
WEST	0.440	0.066	0.251	168.83	172.39	341.22
FLOOR	0.000	0.122	0.122	0.00	405.20	405.20
ROOF	0.000	0.047	0.047	0.00	27275.87	27275.87
ALL WALLS	0.335	0.066	0.197	13571.40	14237.61	27809.01
WALLS+ROOFS	0.335	0.054	0.123	13571.40	41513.48	55084.88
UNDERGRND	0.000	0.079	0.079	0.00	747.54	747.54
BUILDING	0.335	0.055	0.122	13571.40	42666.22	56237.62

REPORT- LV-I DETAILS OF CONSTRUCTIONS OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

NUMBER OF CONSTRUCTIONS 9 DELAYED 9 QUICK 0

CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
FLATROOF	0.046	0.50	2	DELAYED	12
FLOORSLAB	0.157	0.70	3	DELAYED	15
INTERNALWALL	1.479	0.70	3	DELAYED	3
INTERNALGB	0.132	0.70	3	DELAYED	4
INTERNALCONC	0.395	0.70	3	DELAYED	7
SOFFITCON	0.129	0.65	5	DELAYED	7
TERRACEROOF	0.104	0.65	3	DELAYED	5
BASEFLOOR	0.079	0.70	3	DELAYED	12
CONCWALL	0.068	0.65	3	DELAYED	7

*** BUILDING ***

FLOOR AREA	77156	SQFT	7168	SQMT
VOLUME	694404	CUFT	19666	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 15	4PM	DEC 4	6AM
DRY-BULB TEMP	73F	23C	16F	-9C
WET-BULB TEMP	62F	17C	13F	-11C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (KW)	COOLING LATENT (KBTU/H)	COOLING LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	5.746	1.683	0.000	0.000	-52.327	-15.332
ROOF CONDUCTION	11.221	3.288	0.000	0.000	-67.420	-19.754
WINDOW GLASS+FRM COND	202.520	59.338	0.000	0.000	-244.991	-71.782
WINDOW GLASS SOLAR	118.289	34.659	0.000	0.000	5.938	1.740
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-0.987	-0.289	0.000	0.000	-1.502	-0.440
OCCUPANTS TO SPACE	60.139	17.621	57.364	16.808	0.420	0.123
LIGHT TO SPACE	114.347	33.504	0.000	0.000	19.763	5.791
EQUIPMENT TO SPACE	97.448	28.552	0.000	0.000	0.779	0.228
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-33.239	-9.739
TOTAL	608.722	178.356	57.364	16.808	-372.580	-109.166

	COOLING		HEATING	
TOTAL LOAD	666.086 KBTU/H	195.163 KW	-372.580 KBTU/H	-109.166 KW
TOTAL LOAD / AREA	8.63BTU/H.SQFT	27.227 W /SQMT	4.829BTU/H.SQFT	15.230 W /SQMT

NOTE
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1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

Crestwood Bldg 8V-7'6/3 Windows C2000 DESIGN FANCOIL 20 DOE-2.1E-003 12/ 1/1994 23:34:34 SDL RUN 1
R22/R15/Bldg 7 Fibre/Daylight
REPORT- SV-A SYSTEM DESIGN PARAMETERS CREST WEATHER FILE- VANCOUVER TMY

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
CREST	FPFC	1.000	75092.0	308.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
60350.	0.000	0.2	0.	0.000	0.0	0.205	0.000	0.000	0.000	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
GW	2200.	0.	0.396	1.000	250.	72.35	0.71	47.11	-62.22	-48.00	1.0
GNW	450.	0.	0.081	1.000	22.	14.68	0.72	9.63	-10.92	-9.75	1.0
GN1	350.	0.	0.063	1.000	75.	11.58	0.71	7.50	-12.07	-7.72	1.0
GN2	250.	0.	0.045	1.000	47.	8.26	0.71	5.36	-8.22	-5.50	1.0
GNE1	250.	0.	0.045	1.000	22.	8.19	0.71	5.35	-6.66	-5.44	1.0
GNE2	1200.	0.	0.216	1.000	152.	39.79	0.71	25.70	-34.91	-26.22	1.0
GE1	400.	0.	0.072	1.000	84.	13.23	0.71	8.57	-13.70	-8.81	1.0
GN3	450.	0.	0.081	1.000	152.	15.27	0.70	9.65	-19.12	-10.05	1.0
GE2	300.	0.	0.054	1.000	22.	9.87	0.71	6.42	-7.72	-6.52	1.0
GE3	450.	0.	0.081	1.000	43.	14.86	0.71	9.64	-12.25	-9.80	1.0
GE4	700.	0.	0.126	1.000	72.	23.13	0.71	14.99	-19.31	-15.26	1.0
GE5	450.	0.	0.081	1.000	22.	14.70	0.72	9.63	-10.92	-9.75	1.0
GS	2200.	82.	0.409	1.000	261.	72.49	0.71	47.11	-62.89	-48.03	1.0
GSW2	600.	0.	0.108	1.000	74.	19.89	0.71	12.85	-17.35	-13.11	1.0
101L	1100.	161.	0.223	1.000	403.	37.30	0.70	23.58	-48.73	-24.64	1.0
GSW1	550.	0.	0.099	1.000	74.	18.26	0.71	11.78	-16.24	-12.03	1.0
GIN1	1000.	103.	0.196	1.000	259.	33.63	0.70	21.43	-37.38	-22.15	1.0
GIN2	2400.	244.	0.470	1.000	609.	80.68	0.70	51.42	-88.99	-53.13	1.0
GIN2C	350.	111.	0.080	1.000	278.	12.06	0.70	7.52	-25.72	-8.21	1.0
GIE1	800.	82.	0.157	1.000	205.	26.90	0.70	17.14	-29.80	-17.72	1.0
GIE2	800.	81.	0.157	1.000	203.	26.90	0.70	17.14	-29.67	-17.71	1.0
GINE	1100.	113.	0.216	1.000	283.	36.99	0.70	23.57	-41.03	-24.36	1.0

GISE	2400.	245.	0.470	1.000	613.	80.69	0.70	51.42	-89.21	-53.14	1
2W	2100.	0.	0.378	1.000	259.	69.13	0.71	44.97	-60.62	-45.86	1
2NW	450.	0.	0.081	1.000	22.	14.68	0.72	9.63	-10.92	-9.75	1
2N1	500.	0.	0.090	1.000	126.	16.59	0.71	10.71	-18.45	-11.07	1
2NE1	250.	0.	0.045	1.000	22.	8.24	0.71	5.35	-6.66	-5.44	1
2NE2	1000.	0.	0.180	1.000	142.	33.23	0.71	21.42	-30.07	-21.88	1
2EE1	450.	0.	0.081	1.000	113.	14.96	0.71	9.64	-16.59	-9.96	1
2N2	550.	0.	0.099	1.000	142.	18.32	0.71	11.78	-20.57	-12.18	1
2EE2	250.	0.	0.045	1.000	22.	8.19	0.71	5.35	-6.66	-5.44	1
2EE3	900.	0.	0.162	1.000	121.	29.88	0.71	19.27	-26.58	-19.68	1
2EE4	400.	0.	0.072	1.000	22.	13.07	0.72	8.56	-9.86	-8.67	1
2S	2100.	0.	0.378	1.000	261.	69.25	0.71	44.97	-60.76	-45.87	1
2SW2	300.	0.	0.054	1.000	71.	10.09	0.70	6.43	-10.82	-6.63	1
2SW1	250.	0.	0.045	1.000	53.	8.38	0.71	5.36	-8.61	-5.51	1
2IN	3800.	389.	0.745	1.000	972.	127.77	0.70	81.42	-141.36	-84.15	1
2INC	350.	111.	0.080	1.000	278.	12.06	0.70	7.52	-25.72	-8.21	1
2IE1	800.	0.	0.144	1.000	205.	26.94	0.70	17.14	-29.77	-17.72	1
2IE2	800.	0.	0.144	1.000	209.	26.96	0.70	17.14	-30.04	-17.73	1
2INE	1400.	113.	0.270	1.000	348.	47.05	0.70	30.00	-51.40	-30.98	1
2ISE	2400.	242.	0.470	1.000	605.	80.67	0.70	51.42	-88.71	-53.12	1
3W	2000.	0.	0.360	1.000	211.	65.72	0.71	42.83	-55.54	-43.60	1
3NW	350.	0.	0.063	1.000	18.	11.44	0.72	7.49	-8.58	-7.59	1
3N1	400.	0.	0.072	1.000	48.	13.16	0.71	8.57	-11.46	-8.73	1
3N2	350.	0.	0.063	1.000	87.	11.65	0.71	7.50	-12.84	-7.74	1
3N3	250.	0.	0.045	1.000	48.	8.36	0.71	5.36	-8.28	-5.50	1
3NE1	200.	0.	0.036	1.000	18.	6.56	0.71	4.28	-5.38	-4.35	1
3NE2	800.	0.	0.144	1.000	103.	26.54	0.71	17.13	-23.36	-17.48	1
3EE1	600.	0.	0.108	1.000	113.	19.84	0.71	12.85	-19.74	-13.19	1
3N4	400.	0.	0.072	1.000	102.	13.32	0.71	8.57	-14.87	-8.86	1
3NE3	200.	0.	0.036	1.000	19.	6.56	0.71	4.28	-5.40	-4.35	1

---(CONTINUED)--------

3EE2	300.	0.	0.054	1.000	48.	9.99	0.71	6.43	-9.34	-6.58	1.0
3EE3	600.	0.	0.108	1.000	87.	19.95	0.71	12.85	-18.13	-13.13	1.0
3EE4	350.	0.	0.063	1.000	48.	11.54	0.71	7.50	-10.40	-7.65	1.0
3SE	350.	0.	0.063	1.000	19.	11.44	0.72	7.49	-8.59	-7.59	1.0
3S	1900.	0.	0.342	1.000	216.	62.89	0.71	40.69	-53.70	-41.46	1.0
3SW3	250.	0.	0.045	1.000	45.	8.35	0.71	5.36	-8.11	-5.49	1.0
3SW2	700.	0.	0.126	1.000	90.	23.22	0.71	14.99	-20.45	-15.30	1.0
3SW1	250.	0.	0.045	1.000	50.	8.37	0.71	5.36	-8.44	-5.50	1.0
3IN	3600.	374.	0.707	1.000	936.	121.09	0.70	77.14	-134.87	-79.75	1.0
3INC	350.	111.	0.080	1.000	278.	12.06	0.70	7.52	-25.72	-8.21	1.0
3IE1	800.	0.	0.144	1.000	203.	26.94	0.70	17.14	-29.67	-17.71	1.0
3IE2	800.	0.	0.144	1.000	208.	26.95	0.70	17.14	-29.95	-17.72	1.0
3L	350.	0.	0.063	1.000	85.	11.77	0.70	7.50	-12.72	-7.74	1.0
3ISW	600.	0.	0.108	1.000	154.	20.21	0.70	12.86	-22.38	-13.29	1.0
3INE	1400.	127.	0.272	1.000	341.	47.02	0.70	30.00	-50.97	-30.96	1.0
3ISE	2400.	243.	0.470	1.000	609.	80.68	0.70	51.42	-88.93	-53.13	1.0

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	0.905	1	1	0.905	1	1												
HERM-CENT-CHLR	1.368	1	1															

EQUIPMENT	PART LOAD RATIOS MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	0.2500	1.0000	1.0000	0.0000
HERM-CENT-CHLR	0.1000	1.0000	0.8000	0.2840

EQUIPMENT	HOURS AT PERCENT PART LOAD RATIO 0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110+	TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (KWH)	THERMAL USED (MBTU)
HW-BOILER	1497	330	469	701	470	202	24	8	5	0	0	3706	957.7	0.0	0.	984.4
	1827	704	619	315	139	65	24	8	5	0	0					
HERM-CENT-CHLR	1448	445	306	110	41	5	1	0	0	0	0	2356	363.1	0.0	33375.	0.0
	1448	445	306	110	41	5	1	0	0	0	0					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 3342. KWH
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 7450. KWH
CONDENSER WATER PUMP ELECTRICAL USE = 0. KWH
TOWER OR CONDENSER FAN ELECTRICAL USE = 13635. KWH

NOTES TO TABLE

1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	957.7	957.7	0.000	0.000	0
COOLING LOADS	363.1	363.1	0.000	0.000	0
ELECTRICAL LOADS	1321.1	1321.1	0.000	0.000	0

E Q U I P M E N T	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	0.240	1.629	12	12	7	0.905	3706	0.905	707						
HERM-CENT-CHLR	0.113	0.989	7	5	7	1.368	2356								

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	579.2	0.0
MISC EQUIPMT	427.7	0.0
SPACE HEAT	0.0	984.4
SPACE COOL	68.1	0.0
HEAT REJECT	46.5	0.0
PUMPS & MISC	36.8	0.0
VENT FANS	162.8	0.0
DOMHOT WATER	0.0	71.2
TOTAL	1321.1	1055.5

TOTAL SITE ENERGY	2376.65 MBTU	30.8 KBTU/SQFT-YR GROSS-AREA	30.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY	5019.26 MBTU	65.1 KBTU/SQFT-YR GROSS-AREA	65.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.2
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELECCOST	ELECTRICITY	1 2 3 4 5	387094. KWH	26014.	0.0672	YES
NGASCOST	NATURAL-GAS	1 2 3 4 5	1114. GJ	6794.	6.1008	YES
				==========		
				32808.		

ENERGY COST/GROSS BLDG AREA: 0.43
ENERGY COST/NET BLDG AREA: 0.43

Crestwood Building 2 C2000 REFEERENCE BUILDING DOE-2.1E-W53 11/30/1994 1:55:15 LDL RUN 1

LOADS

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

NUMBER OF SPACES 57 EXTERIOR 40 INTERIOR 17

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	AZIMUTH	LIGHTING (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	AIR CHANGES PER HOUR	AREA (SQFT)	VOLUME (CUFT)
GE1	1.0	EXT	0.0	0.70	11.5	0.00	AIR-CHANGE	0.06	3162.00	44500.00
GIE	1.0	INT	0.0	1.57	5.8	0.75	NO-INFILT.	0.00	1592.00	14328.00
GSW	1.0	EXT	0.0	1.57	2.8	0.75	AIR-CHANGE	0.22	779.00	8278.00
GW	1.0	EXT	0.0	1.57	5.6	0.75	AIR-CHANGE	0.26	1552.00	13968.00
GNW	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
GN1	1.0	EXT	0.0	1.57	3.1	0.75	AIR-CHANGE	0.26	848.00	7632.00
GNE1	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
GNE2	1.0	EXT	0.0	1.57	5.1	0.75	AIR-CHANGE	0.26	1392.00	12528.00
GN3	1.0	EXT	0.0	1.57	5.0	0.75	AIR-CHANGE	0.26	1388.00	12492.00
GE2	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
GE4	1.0	EXT	0.0	1.57	2.9	0.75	AIR-CHANGE	0.26	804.00	7236.00
GE5	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
GS	1.0	EXT	0.0	1.57	6.0	0.75	AIR-CHANGE	0.26	1640.00	14760.00
GIN1	1.0	INT	0.0	1.57	11.4	0.75	NO-INFILT.	0.00	3145.00	28305.00
GIN2	1.0	INT	0.0	1.57	10.4	0.75	NO-INFILT.	0.00	2857.00	25713.00
GIN2C	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
GISE	1.0	INT	0.0	1.57	12.3	0.75	NO-INFILT.	0.00	3389.00	30501.00
GINE	1.0	INT	0.0	1.57	10.9	0.75	NO-INFILT.	0.00	2987.00	26883.00
108MEN	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	396.00	3564.00
112WOM	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	417.00	3753.00
2SW	1.0	EXT	0.0	1.57	2.8	0.75	AIR-CHANGE	0.26	779.00	7011.00
2W	1.0	EXT	0.0	1.57	5.6	0.75	AIR-CHANGE	0.26	1552.00	13968.00
2NW	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
2N1	1.0	EXT	0.0	1.57	3.1	0.75	AIR-CHANGE	0.26	848.00	7632.00
2NE1	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
2NE2	1.0	EXT	0.0	1.57	5.2	0.75	AIR-CHANGE	0.26	1419.00	12771.00
2N2	1.0	EXT	0.0	1.57	5.2	0.75	AIR-CHANGE	0.26	1433.00	12987.00
2EE2	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
2EE3	1.0	EXT	0.0	1.57	2.9	0.75	AIR-CHANGE	0.26	804.00	7236.00
2EE4	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
2S	1.0	EXT	0.0	1.57	6.0	0.75	AIR-CHANGE	0.26	1640.00	14760.00
2IN	1.0	INT	0.0	1.57	25.7	0.75	NO-INFILT.	0.00	7070.00	63630.00
2INC	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
2IW	1.0	INT	0.0	1.57	3.7	0.75	NO-INFILT.	0.00	1017.00	9153.00
2ISE	1.0	INT	0.0	1.57	26.6	0.75	NO-INFILT.	0.00	7320.00	65880.00
205MEN	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
207WOM	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
3SW	1.0	EXT	0.0	1.57	2.8	0.75	AIR-CHANGE	0.22	779.00	8278.00
3W	1.0	EXT	0.0	1.57	5.6	0.75	AIR-CHANGE	0.26	1552.00	13968.00
3NW	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
3N1	1.0	EXT	0.0	1.57	3.1	0.75	AIR-CHANGE	0.26	848.00	7632.00
3NE1	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
3NE2	1.0	EXT	0.0	1.57	5.1	0.75	AIR-CHANGE	0.26	1392.00	12528.00
3EE	1.0	EXT	0.0	1.57	1.3	0.75	AIR-CHANGE	0.26	362.00	3258.00
3N4	1.0	EXT	0.0	1.57	5.0	0.75	AIR-CHANGE	0.26	1388.00	12492.00
3EE2	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
3EE3	1.0	EXT	0.0	1.57	2.9	0.75	AIR-CHANGE	0.26	804.00	7236.00

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY

(CONTINUED)

3EE4	1.0	EXT	0.0	1.57	0.5	0.75	AIR-CHANGE	0.26	140.00	1260.00
3S	1.0	EXT	0.0	1.57	6.0	0.75	AIR-CHANGE	0.26	1640.00	14760.00
3IN	1.0	EXT	0.0	1.57	23.2	0.75	NO-INFILT.	0.00	6379.00	57411.00
3INC	1.0	INT	0.0	1.57	12.5	0.75	NO-INFILT.	0.00	250.00	2250.00
3IE3	1.0	EXT	0.0	1.57	3.6	0.75	NO-INFILT.	0.00	997.00	8973.00
3IW	1.0	EXT	0.0	1.57	5.2	0.75	NO-INFILT.	0.00	1438.00	12942.00
3INE	1.0	EXT	0.0	1.57	9.5	0.75	NO-INFILT.	0.00	2609.00	23481.00
3ISE	1.0	EXT	0.0	1.57	13.0	0.75	NO-INFILT.	0.00	3584.00	32256.00
306MEN	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
311WOM	1.0	INT	0.0	0.80	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
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BUILDING TOTALS					309.8				77382.00	715104.00

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.668	0.086	0.225	2467.77	7886.66	10354.43
NORTH-EAST	0.669	0.089	0.229	713.52	2245.93	2959.45
EAST	0.676	0.089	0.239	118.05	342.66	460.71
SOUTH-EAST	0.667	0.089	0.240	1466.71	4153.25	5619.96
SOUTH	0.667	0.089	0.244	1541.22	4195.52	5736.74
SOUTH-WEST	0.676	0.089	0.268	118.05	267.66	385.71
WEST	0.669	0.089	0.225	713.52	2325.00	3038.52
NORTH-WEST	0.679	0.089	0.233	95.05	292.78	387.83
FLOOR	0.000	0.089	0.089	0.00	257.00	257.00
ROOF	0.000	0.068	0.068	0.00	25547.44	25547.44
ALL WALLS	0.668	0.088	0.233	7233.91	21709.44	28943.35
WALLS+ROOFS	0.668	0.077	0.156	7233.91	47256.89	54490.79
UNDERGRND	0.000	0.065	0.065	0.00	673.70	673.70
BUILDING	0.668	0.077	0.154	7233.91	48187.58	55421.48

NUMBER OF CONSTRUCTIONS 7 DELAYED 7 QUICK 0

CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
FLATROOF	0.064	0.50	2	DELAYED	11
FLOORSLAB	0.157	0.70	3	DELAYED	15
INTERNALWALL	1.479	0.70	3	DELAYED	3
INTERNALGB	0.132	0.70	3	DELAYED	4
INTERNALCONC	0.395	0.70	3	DELAYED	7
BASEFLOOR	0.065	0.70	3	DELAYED	12
LIGHTWALL	0.092	0.65	3	DELAYED	7

*** BUILDING ***

FLOOR AREA	77382	SQFT	7189	SQMT
VOLUME	715104	CUFT	20252	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 15 4PM		DEC 4 6AM	
DRY-BULB TEMP	73F	23C	16F	-9C
WET-BULB TEMP	62F	17C	13F	-11C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	41.549	12.174	0.000	0.000	-106.257	-31.133
ROOF CONDUCTION	23.358	6.844	0.000	0.000	-95.396	-27.951
WINDOW GLASS+FRM COND	130.109	38.122	0.000	0.000	-256.645	-75.197
WINDOW GLASS SOLAR	139.877	40.984	0.000	0.000	9.467	2.774
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-0.735	-0.215	0.000	0.000	-1.118	-0.327
OCCUPANTS TO SPACE	60.519	17.732	57.728	16.914	0.422	0.124
LIGHT TO SPACE	305.152	89.410	0.000	0.000	32.146	9.419
EQUIPMENT TO SPACE	147.187	43.126	0.000	0.000	1.171	0.343
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-66.829	-19.581
TOTAL	847.016	248.176	57.728	16.914	-483.038	-141.530

	Cooling		Heating	
TOTAL LOAD	904.744 KBTU/H	265.090 KW	-483.038 KBTU/H	-141.530 KW
TOTAL LOAD / AREA	11.69BTU/H.SQFT	36.874 W /SQMT	6.242BTU/H.SQFT	19.687 W SQMT

NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

REPORT- SV-A SYSTEM DESIGN PARAMETERS OFFICESYS WEATHER FILE- VANCOUVER TMY

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
OFFICESYS	VAVS	1.000	75619.0	310.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
59530.	50.815	2.6	56894.	22.259	1.2	0.340	2424.280	0.659	-894.532	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
GW	2010.	0.	0.000	0.460	683.	0.00	0.00	43.42	-34.95	-19.97	1.
GNW	230.	0.	0.000	0.640	78.	0.00	0.00	4.97	-5.56	-3.18	1.
GN1	940.	0.	0.000	0.540	320.	0.00	0.00	20.30	-19.19	-10.96	1.
GNE1	180.	0.	0.000	0.890	61.	0.00	0.00	3.89	-6.06	-3.46	1.
GNE2	860.	0.	0.000	1.000	292.	0.00	0.00	18.58	-32.51	-18.58	1.
GE1	1900.	0.	0.000	1.000	646.	0.00	0.00	41.04	-71.82	-41.04	1.
GN3	860.	0.	0.000	1.000	292.	0.00	0.00	18.58	-32.51	-18.58	1.
GE2	160.	0.	0.000	1.000	54.	0.00	0.00	3.46	-6.05	-3.46	1.
GE4	930.	0.	0.000	0.530	316.	0.00	0.00	20.09	-18.63	-10.65	1.
GE5	220.	0.	0.000	0.690	75.	0.00	0.00	4.75	-5.74	-3.28	1.
GS	2020.	0.	0.000	0.490	687.	0.00	0.00	43.63	-37.41	-21.38	1.
GSW	1000.	0.	0.000	0.470	340.	0.00	0.00	21.60	-17.77	-10.15	1.
GIN1	1890.	333.	0.052	1.000	643.	0.00	0.00	40.82	-71.44	-40.82	1.
GIN2	1720.	333.	0.052	1.000	585.	0.00	0.00	37.15	-65.02	-37.15	1.
GIN2C	750.	0.	0.000	0.480	255.	0.00	0.00	16.20	-13.61	-7.78	1.
GIE	960.	0.	0.000	1.000	326.	0.00	0.00	20.74	-36.29	-20.74	1.
GINE	1800.	317.	0.050	1.000	612.	0.00	0.00	38.88	-68.04	-38.88	1.
GISE	2040.	317.	0.050	1.000	694.	0.00	0.00	44.06	-77.11	-44.06	1.
2W	1880.	0.	0.000	0.500	639.	0.00	0.00	40.61	-35.53	-20.30	1.
2NW	230.	0.	0.000	0.640	78.	0.00	0.00	4.97	-5.56	-3.18	1.
2N1	990.	0.	0.000	0.520	337.	0.00	0.00	21.38	-19.46	-11.12	1.
2NE1	180.	0.	0.000	0.870	61.	0.00	0.00	3.89	-5.92	-3.38	1.

(CONTINUED)

2NE2	860.	0.	0.000	1.000	292.	0.00	0.00	18.58	-32.51	-18.58	1.0
2N2	860.	0.	0.000	1.000	292.	0.00	0.00	18.58	-32.51	-18.58	1.0
2EE2	150.	0.	0.000	1.000	51.	0.00	0.00	3.24	-5.67	-3.24	1.0
2EE3	970.	0.	0.000	0.520	330.	0.00	0.00	20.95	-19.07	-10.90	1.0
2EE4	220.	0.	0.000	0.680	75.	0.00	0.00	4.75	-5.65	-3.23	1.0
2S	1890.	0.	0.000	0.520	643.	0.00	0.00	40.82	-37.15	-21.23	1.0
2SW	1000.	0.	0.000	0.470	340.	0.00	0.00	21.60	-17.77	-10.15	1.0
2IN	4250.	392.	0.061	1.000	1445.	0.00	0.00	91.80	-160.65	-91.80	1.0
2INC	750.	0.	0.000	0.480	255.	0.00	0.00	16.20	-13.61	-7.78	1.0
2IW	610.	0.	0.000	1.000	207.	0.00	0.00	13.18	-23.06	-13.18	1.0
2ISE	4400.	184.	0.029	1.000	1496.	0.00	0.00	95.04	-166.32	-95.04	1.0
3W	1840.	0.	0.000	0.590	626.	0.00	0.00	39.74	-41.04	-23.45	1.0
3NW	240.	0.	0.000	0.710	82.	0.00	0.00	5.18	-6.44	-3.68	1.0
3N1	1130.	0.	0.000	0.590	384.	0.00	0.00	24.41	-25.20	-14.40	1.0
3NE1	190.	0.	0.000	0.950	65.	0.00	0.00	4.10	-6.82	-3.90	1.0
3NE2	1020.	0.	0.000	1.000	347.	0.00	0.00	22.03	-38.56	-22.03	1.0
3EE	420.	0.	0.000	1.000	143.	0.00	0.00	9.07	-15.88	-9.07	1.0
3N4	1020.	0.	0.000	1.000	347.	0.00	0.00	22.03	-38.56	-22.03	1.0
3EE2	180.	0.	0.000	1.000	61.	0.00	0.00	3.89	-6.80	-3.89	1.0
3EE3	1000.	0.	0.000	0.650	340.	0.00	0.00	21.60	-24.57	-14.04	1.0
3EE4	210.	0.	0.000	0.800	71.	0.00	0.00	4.54	-6.35	-3.63	1.0
3S	1830.	0.	0.000	0.790	622.	0.00	0.00	39.53	-54.65	-31.23	1.0
3SW	970.	0.	0.000	0.560	330.	0.00	0.00	20.95	-20.53	-11.73	1.0
3IN	3830.	392.	0.061	1.000	1302.	0.00	0.00	82.73	-144.77	-82.73	1.0
3INC	750.	0.	0.000	0.480	255.	0.00	0.00	16.20	-13.61	-7.78	1.0
3IE3	600.	0.	0.000	1.000	204.	0.00	0.00	12.96	-22.68	-12.96	1.0
3IW	870.	0.	0.000	1.000	296.	0.00	0.00	18.79	-32.89	-18.79	1.0
3INE	1570.	184.	0.029	1.000	534.	0.00	0.00	33.91	-59.35	-33.91	1.0
3ISE	2150.	184.	0.029	1.000	731.	0.00	0.00	46.44	-81.27	-46.44	1.0

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	1.785	1	1															
HERM-CENT-CHLR	1.609	1	1															
COOLING-TWR	2.015	1	1															

EQUIPMENT	PART LOAD RATIOS MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	0.2500	1.2000	1.0000	0.0000
HERM-CENT-CHLR	0.1000	1.0000	0.8000	0.2380
COOLING-TWR	0.3300	2.0000	0.0000	0.0000

REPORT- PS-C EQUIPMENT PART LOAD OPERATION WEATHER FILE- VANCOUVER TMY

EQUIPMENT	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110+	TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (KWH)	THERMAL USED (MBTU)
HW-BOILER	2364	921	524	291	161	93	38	18	6	3	1	4420	1092.0	0.0	0.	1682.8
	2364	921	524	291	161	93	38	18	6	3	1					
HERM-CENT-CHLR	144	162	174	190	179	120	89	71	37	12	0	1178	731.0	0.0	53590.	0.0
	144	162	174	190	179	120	89	71	37	12	0					
COOLING-TWR	396	424	212	114	28	4	0	0	0	0	0	1178	941.3	0.0	11413.	0.0
	396	424	212	114	28	4	0	0	0	0	0					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 4976. KWH
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 6720. KWH
CONDENSER WATER PUMP ELECTRICAL USE = 8921. KWH
TOWER OR CONDENSER FAN ELECTRICAL USE = 2492. KWH

NOTES TO TABLE

1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	1092.0	1092.0	0.000	0.000	0
COOLING LOADS	731.0	731.0	0.000	0.000	0
ELECTRICAL LOADS	2887.6	2887.6	0.000	0.000	0

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	0.138	1.785	12	12	8	1.785	4420								
HERM-CENT-CHLR	0.386	1.609	8	22	17	1.609	1178								
COOLING-TWR	0.397	2.003	8	22	17	2.015	1178								

REPORT- BEPS BUILDING ENERGY PERFORMANCE SUMMARY WEATHER FILE- VANCOUVER TMY

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	1245.1	0.0
MISC EQUIPMT	663.3	0.0
SPACE HEAT	0.0	1682.8
SPACE COOL	182.9	0.0
HEAT REJECT	39.0	0.0
PUMPS & MISC	39.9	0.0
VENT FANS	717.3	0.0
DOMHOT WATER	0.0	86.7
TOTAL	2887.6	1769.6

TOTAL SITE ENERGY 4657.16 MBTU 60.2 KBTU/SQFT-YR GROSS-AREA 60.2 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 10433.16 MBTU 134.8 KBTU/SQFT-YR GROSS-AREA 134.8 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.8
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELECCOST	ELECTRICITY	1 2 3 4 5	846059. KWH	55562.	0.0657	YES
NGASCOST	NATURAL-GAS	1 2 3 4 5	1867. GJ	11141.	5.9673	YES
				==========		
				66703.		

ENERGY COST/GROSS BLDG AREA: 0.86
ENERGY COST/NET BLDG AREA: 0.86

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT C2000 DESIGN WEATHER FILE- VANCOUVER TMY

NUMBER OF SPACES 57 EXTERIOR 40 INTERIOR 17

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	AZIMUTH	LIGHTING (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	AIR CHANGES PER HOUR	AREA (SQFT)	VOLUME (CUFT)
GE1	1.0	EXT	0.0	0.50	11.5	0.00	AIR-CHANGE	0.03	3162.00	44500.00
GIE	1.0	INT	0.0	0.70	5.8	0.50	NO-INFILT.	0.00	1592.00	14328.00
GSW	1.0	EXT	0.0	0.70	2.8	0.50	AIR-CHANGE	0.11	779.00	8278.00
GW	1.0	EXT	0.0	0.70	5.6	0.50	AIR-CHANGE	0.12	1552.00	13968.00
GNW	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
GN1	1.0	EXT	0.0	0.70	3.1	0.50	AIR-CHANGE	0.18	848.00	7632.00
GNE1	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
GNE2	1.0	EXT	0.0	0.70	5.1	0.50	AIR-CHANGE	0.12	1392.00	12528.00
GN3	1.0	EXT	0.0	0.70	5.0	0.50	AIR-CHANGE	0.12	1388.00	12492.00
GE2	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
GE4	1.0	EXT	0.0	0.70	2.9	0.50	AIR-CHANGE	0.18	804.00	7236.00
GE5	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
GS	1.0	EXT	0.0	0.70	6.0	0.50	AIR-CHANGE	0.12	1640.00	14760.00
GIN1	1.0	INT	0.0	0.70	11.4	0.50	NO-INFILT.	0.00	3145.00	28305.00
GIN2	1.0	INT	0.0	0.70	10.4	0.50	NO-INFILT.	0.00	2857.00	25713.00
GIN2C	1.0	INT	0.0	0.70	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
GISE	1.0	INT	0.0	0.70	12.3	0.50	NO-INFILT.	0.00	3389.00	30501.00
GINE	1.0	INT	0.0	0.70	10.9	0.50	NO-INFILT.	0.00	2987.00	26883.00
108MEN	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	396.00	3564.00
112WOM	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	417.00	3753.00
2SW	1.0	EXT	0.0	0.70	2.8	0.50	AIR-CHANGE	0.12	779.00	7011.00
2W	1.0	EXT	0.0	0.70	5.6	0.50	AIR-CHANGE	0.12	1552.00	13968.00
2NW	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
2N1	1.0	EXT	0.0	0.70	3.1	0.50	AIR-CHANGE	0.18	848.00	7632.00
2NE1	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
2NE2	1.0	EXT	0.0	0.70	5.2	0.50	AIR-CHANGE	0.12	1419.00	12771.00
2N2	1.0	EXT	0.0	0.70	5.2	0.50	AIR-CHANGE	0.12	1433.00	12987.00
2EE2	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
2EE3	1.0	EXT	0.0	0.70	2.9	0.50	AIR-CHANGE	0.18	804.00	7236.00
2EE4	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
2S	1.0	EXT	0.0	0.70	6.0	0.50	AIR-CHANGE	0.12	1640.00	14760.00
2IN	1.0	INT	0.0	0.70	25.7	0.50	NO-INFILT.	0.00	7070.00	63630.00
2INC	1.0	INT	0.0	0.70	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
2IW	1.0	INT	0.0	0.70	3.7	0.50	NO-INFILT.	0.00	1017.00	9153.00
2ISE	1.0	INT	0.0	0.70	26.6	0.50	NO-INFILT.	0.00	7320.00	65880.00
205MEN	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
207WOM	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
3SW	1.0	EXT	0.0	0.70	2.8	0.50	AIR-CHANGE	0.11	779.00	8278.00
3W	1.0	EXT	0.0	0.70	5.6	0.50	AIR-CHANGE	0.12	1552.00	13968.00
3NW	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
3N1	1.0	EXT	0.0	0.70	3.1	0.50	AIR-CHANGE	0.18	848.00	7632.00
3NE1	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
3NE2	1.0	EXT	0.0	0.70	5.1	0.50	AIR-CHANGE	0.12	1392.00	12528.00
3EE	1.0	EXT	0.0	0.70	1.3	0.50	AIR-CHANGE	0.18	362.00	3258.00
3N4	1.0	EXT	0.0	0.70	5.0	0.50	AIR-CHANGE	0.12	1388.00	12492.00
3EE2	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
3EE3	1.0	EXT	0.0	0.70	2.9	0.50	AIR-CHANGE	0.18	804.00	7236.00

LOADS
REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT WEATHER FILE- VANCOUVER TMY
(CONTINUED)

3EE4	1.0	EXT	0.0	0.70	0.5	0.50	AIR-CHANGE	0.18	140.00	1260.00
3S	1.0	EXT	0.0	0.70	6.0	0.50	AIR-CHANGE	0.12	1640.00	14760.00
3IN	1.0	EXT	0.0	0.70	23.2	0.50	NO-INFILT.	0.00	6379.00	57411.00
3INC	1.0	INT	0.0	0.70	12.5	0.50	NO-INFILT.	0.00	250.00	2250.00
3IE3	1.0	EXT	0.0	0.70	3.6	0.50	NO-INFILT.	0.00	997.00	8973.00
3IW	1.0	EXT	0.0	0.70	5.2	0.50	NO-INFILT.	0.00	1438.00	12942.00
3INE	1.0	EXT	0.0	0.70	9.5	0.50	NO-INFILT.	0.00	2609.00	23481.00
3ISE	1.0	EXT	0.0	0.70	13.0	0.50	NO-INFILT.	0.00	3584.00	32256.00
306MEN	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	230.00	2070.00
311WOM	1.0	INT	0.0	0.33	0.0	0.00	NO-INFILT.	0.00	245.00	2205.00
					-------				---------	----------
BUILDING TOTALS					309.8				77382.00	715104.00

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.333	0.063	0.190	4869.09	5485.34	10354.43
NORTH-EAST	0.325	0.066	0.185	1361.02	1598.43	2959.45
EAST	0.359	0.066	0.174	169.93	290.78	460.71
SOUTH-EAST	0.328	0.066	0.196	2785.92	2834.04	5619.96
SOUTH	0.327	0.066	0.199	2920.36	2816.38	5736.74
SOUTH-WEST	0.359	0.066	0.192	166.25	219.46	385.71
WEST	0.325	0.066	0.182	1361.02	1677.50	3038.52
NORTH-WEST	0.383	0.066	0.218	185.68	202.15	387.83
FLOOR	0.000	0.122	0.122	0.00	257.00	257.00
ROOF	0.000	0.052	0.052	0.00	25547.44	25547.44
ALL WALLS	0.331	0.065	0.192	13819.26	15124.09	28943.35
WALLS+ROOFS	0.331	0.057	0.126	13819.26	40671.54	54490.79
UNDERGRND	0.000	0.032	0.032	0.00	1723.70	1723.70
BUILDING	0.331	0.056	0.123	13819.26	42652.23	56471.48

NUMBER OF CONSTRUCTIONS 10 DELAYED 10 QUICK 0

CONSTRUCTION NAME	U-VALUE (BTU/HR-SQFT-F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
LOBBYFLOOR	0.004	0.70	3	DELAYED	10
FLATROOF	0.046	0.50	2	DELAYED	12
FLOORSLAB	0.157	0.70	3	DELAYED	15
INTERNALWALL	1.479	0.70	3	DELAYED	3
INTERNALGB	0.132	0.70	3	DELAYED	4
INTERNALCONC	0.395	0.70	3	DELAYED	7
SOFFITCON	0.129	0.65	5	DELAYED	7
TERRACEROOF	0.104	0.65	3	DELAYED	5
BASEFLOOR	0.079	0.70	3	DELAYED	12
CONCWALL	0.068	0.65	3	DELAYED	7

REPORT- LS-C BUILDING PEAK LOAD COMPONENTS WEATHER FILE- VANCOUVER TMY

*** BUILDING ***

FLOOR AREA	77382	SQFT	7189	SQMT
VOLUME	715104	CUFT	20252	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 15 4PM		DEC 8 5AM	
DRY-BULB TEMP	73F	23C	16F	-9C
WET-BULB TEMP	62F	17C	13F	-11C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	5.016	1.470	0.000	0.000	-58.373	-17.103
ROOF CONDUCTION	14.949	4.380	0.000	0.000	-85.090	-24.931
WINDOW GLASS+FRM COND	142.882	41.864	0.000	0.000	-240.742	-70.537
WINDOW GLASS SOLAR	63.787	18.690	0.000	0.000	9.604	2.814
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-0.919	-0.269	0.000	0.000	-1.397	-0.409
OCCUPANTS TO SPACE	60.519	17.732	57.728	16.914	2.491	0.730
LIGHT TO SPACE	94.506	27.690	0.000	0.000	21.921	6.423
EQUIPMENT TO SPACE	98.125	28.751	0.000	0.000	4.816	1.411
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-35.831	-10.499
TOTAL	478.866	140.308	57.728	16.914	-382.601	-112.102

TOTAL LOAD	536.594 KBTU/H	157.222 KW	-382.601 KBTU/H	-112.102 KW
TOTAL LOAD / AREA	6.93BTU/H.SQFT	21.870 W /SQMT	4.944BTU/H.SQFT	15.594 W SQMT

NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

Crestwood Bldg 2H   C2000 DESIGN FANCOIL 20   DOE-2.1E-W53 12/ 1/1994 14: 3:55 SDL RUN 1
R20/R12/Bldg 7 Glass/Daylight
REPORT- SV-A SYSTEM DESIGN PARAMETERS   CREST   WEATHER FILE- VANCOUVER TMY

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
CREST	FPFC	1.000	75619.0	310.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
56500.	0.000	0.2	0.	0.000	0.0	0.221	0.000	0.000	0.000	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIE
GW	1900.	0.	0.171	1.000	241.	63.01	0.71	40.69	-55.30	-41.51	1.
GNW	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.
GN1	1000.	0.	0.090	1.000	132.	32.95	0.71	21.42	-29.41	-21.86	1.
GNE1	150.	0.	0.014	1.000	22.	4.95	0.71	3.21	-4.53	-3.28	1.
GNE2	850.	0.	0.077	1.000	217.	28.62	0.70	18.21	-31.56	-18.82	1.
GE1	1900.	0.	0.171	1.000	492.	64.01	0.70	40.71	-71.05	-42.09	1.
GN3	900.	0.	0.081	1.000	216.	29.84	0.71	19.28	-32.57	-19.90	1.
GE2	150.	0.	0.014	1.000	22.	4.95	0.71	3.21	-4.53	-3.28	1.
GE4	900.	0.	0.081	1.000	125.	29.90	0.71	19.27	-26.86	-19.69	1.
GE5	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.
GS	2000.	0.	0.180	1.000	255.	65.97	0.71	42.83	-58.28	-43.70	1.
GSW	850.	0.	0.077	1.000	121.	28.25	0.71	18.20	-25.56	-18.60	1.
GIN1	1900.	333.	0.223	1.000	489.	63.82	0.70	40.71	-70.88	-42.08	1.
GIN2	1800.	333.	0.214	1.000	444.	60.39	0.71	38.57	-65.93	-39.82	1.
GIN2C	300.	0.	0.027	1.000	278.	10.32	0.70	6.45	-24.92	-7.14	1.
GIE	1000.	0.	0.090	1.000	248.	33.65	0.70	21.43	-36.68	-22.12	1.
GINE	1800.	317.	0.212	1.000	465.	60.47	0.70	38.57	-67.22	-39.87	1.
GISE	2100.	317.	0.239	1.000	527.	70.52	0.70	45.00	-77.48	-46.48	1.
2W	1500.	0.	0.135	1.000	241.	49.97	0.71	32.13	-46.82	-32.89	1.
2NW	200.	0.	0.018	1.000	22.	6.62	0.71	4.28	-5.60	-4.36	1.
2N1	1200.	0.	0.108	1.000	132.	39.45	0.71	25.70	-33.66	-26.17	1.
2NE1	150.	0.	0.014	1.000	22.	4.95	0.71	3.21	-4.53	-3.28	1.

(CONTINUED)

2NE2	850.	0.	0.077	1.000	221.	28.64	0.70	18.21	-31.83	-18.83	1.0
2N2	900.	0.	0.081	1.000	223.	29.96	0.71	19.28	-33.01	-19.91	1.0
2EE2	150.	0.	0.014	1.000	22.	4.95	0.71	3.21	-4.53	-3.28	1.0
2EE3	1100.	0.	0.099	1.000	125.	36.14	0.71	23.56	-31.11	-24.00	1.0
2EE4	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.0
2S	1400.	0.	0.126	1.000	255.	46.44	0.71	29.99	-45.57	-30.76	1.0
2SW	750.	0.	0.068	1.000	121.	24.99	0.71	16.06	-23.44	-16.45	1.0
2IN	4300.	392.	0.448	1.000	1100.	144.61	0.70	92.14	-159.93	-95.22	1.0
2INC	300.	0.	0.027	1.000	278.	10.32	0.70	6.45	-24.92	-7.14	1.0
2IW	650.	0.	0.059	1.000	158.	21.86	0.70	13.93	-23.66	-14.37	1.0
2ISE	4400.	184.	0.425	1.000	1139.	148.13	0.70	94.28	-164.50	-97.46	1.0
3W	1400.	0.	0.126	1.000	241.	46.71	0.71	29.99	-44.71	-30.73	1.0
3NW	200.	0.	0.018	1.000	22.	6.62	0.71	4.28	-5.60	-4.36	1.0
3N1	1300.	0.	0.117	1.000	132.	42.70	0.71	27.84	-35.78	-28.33	1.0
3NE1	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.0
3NE2	850.	0.	0.077	1.000	217.	28.62	0.70	18.21	-31.56	-18.82	1.0
3EE	500.	0.	0.045	1.000	56.	16.44	0.71	10.71	-14.11	-10.91	1.0
3N4	850.	0.	0.077	1.000	216.	28.31	0.71	18.21	-31.52	-18.82	1.0
3EE2	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.0
3EE3	1200.	0.	0.108	1.000	125.	39.66	0.71	25.70	-33.23	-26.16	1.0
3EE4	200.	0.	0.018	1.000	22.	6.57	0.71	4.28	-5.60	-4.36	1.0
3S	1400.	0.	0.126	1.000	255.	46.77	0.71	29.99	-45.57	-30.76	1.0
3SW	750.	0.	0.068	1.000	121.	24.99	0.71	16.06	-23.44	-16.45	1.0
3IN	3900.	392.	0.412	1.000	992.	131.12	0.70	83.56	-144.73	-86.35	1.0
3INC	300.	0.	0.027	1.000	278.	10.32	0.70	6.45	-24.92	-7.14	1.0
3IE3	600.	0.	0.054	1.000	155.	20.21	0.70	12.86	-22.42	-13.29	1.0
3IW	900.	0.	0.081	1.000	224.	30.29	0.70	19.28	-33.06	-19.91	1.0
3INE	1600.	184.	0.173	1.000	406.	53.78	0.70	34.28	-59.30	-35.42	1.0
3ISE	2200.	184.	0.227	1.000	558.	73.98	0.70	47.14	-81.50	-48.70	1.0

EQUIPMENT	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU/H)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	1.500	1	1															
ELEC-HW-BOILER	0.566	1	1															
HERM-REC-CHLR	0.605	1	1															

EQUIPMENT	PART LOAD RATIOS MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	0.2500	1.0000	1.0000	0.0000
ELEC-HW-BOILER	0.0100	1.0000	1.0000	0.2220
HERM-REC-CHLR	0.2500	1.0000	1.0000	0.1250

EQUIPMENT	HOURS AT PERCENT PART LOAD RATIO 0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110+	TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (KWH)	THERMAL USED (MBTU)
HW-BOILER	0	0	546	36	19	7	3	0	0	0	0	611	245.6	0.0	0.	288.9
	0	0	546	36	19	7	3	0	0	0	0					
ELEC-HW-BOILER	950	198	169	278	315	341	335	286	251	219	103	3445	835.3	0.0	56867.	0.0
	950	198	169	278	315	341	335	286	251	219	103					
HERM-REC-CHLR	947	253	172	149	93	73	39	33	10	4	2	1775	189.2	0.0	6093.	0.0
	947	253	172	149	93	73	39	33	10	4	2					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 2974. KWH
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 3526. KWH
CONDENSER WATER PUMP ELECTRICAL USE = 0. KWH
TOWER OR CONDENSER FAN ELECTRICAL USE = 0. KWH

NOTES TO TABLE

1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	1080.9	1080.9	0.000	0.000	0
COOLING LOADS	189.2	189.2	0.017	0.017	2
ELECTRICAL LOADS	1226.7	1226.7	0.000	0.000	0

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	0.268	0.985	12	12	3	1.500	611								
ELEC-HW-BOILER	0.428	0.566	12	27	10	0.566	3445								
HERM-REC-CHLR	0.176	0.605	8	11	17	0.605	1775								

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	480.4	0.0
MISC EQUIPMT	429.9	0.0
SPACE HEAT	194.1	288.9
SPACE COOL	20.8	0.0
PUMPS & MISC	22.2	0.0
VENT FANS	79.4	0.0
DOMHOT WATER	0.0	71.2
TOTAL	1226.7	360.0

TOTAL SITE ENERGY	1586.76 MBTU	20.5 KBTU/SQFT-YR GROSS-AREA	20.5 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY	4040.56 MBTU	52.2 KBTU/SQFT-YR GROSS-AREA	52.2 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.8
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

YEAR 1
Wall type = T-UP .1LKG,0PA, RH=35

	Plane 1 - kg/m»				Plane 2 - kg/m»			
MON	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
Sep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0000	0.0000	0.0000	0.0000	0.0045	0.0877	0.0000	0.0000
Nov	0.0000	0.0000	0.0000	0.0000	0.0259	0.0385	0.0000	0.0000
Dec	0.0000	0.0000	0.0000	0.0000	0.0445	0.0172	0.0000	0.0273
Jan	0.0000	0.0000	0.0000	0.0000	0.0257	0.0274	0.0000	0.0256
Feb	0.0000	0.0000	0.0000	0.0000	0.0161	0.0267	0.0000	0.0150
Mar	0.0000	0.0000	0.0000	0.0000	0.0106	0.0401	0.0000	0.0000
Apr	0.0000	0.0000	0.0000	0.0000	0.0062	0.0749	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0001	0.1335	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for VANCOUVER, B.C.
interior temp = Latest Input
interior dewpoint = Latest Input
leakage area = 0.07000 cm»/m»

Plane1 = MINERAL WOOL 90 MM
Plane2 = CONCRETE 100MM
Max absorb plane1 = 0.00
Max absorb plane2 = 22.00

CONDENSATION BREAKDOWN - AIR LEAKAGE vs VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = T-UP .1LKG,0PA, RH=35

	Plane 1 - kg/m»					Plane 2 - kg/m»				
MON	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	720	0
Oct	0.0000	0.0000	0.0000	744	0	0.0040	0.0005	0.0045	744	0
Nov	0.0000	0.0000	0.0000	720	0	0.0240	0.0019	0.0259	709	11
Dec	0.0000	0.0000	0.0000	744	0	0.0411	0.0034	0.0445	741	3
Jan	0.0000	0.0000	0.0000	744	0	0.0253	0.0003	0.0257	657	87
Feb	0.0000	0.0000	0.0000	672	0	0.0119	0.0041	0.0161	672	0
Mar	0.0000	0.0000	0.0000	744	0	0.0095	0.0011	0.0106	744	0
Apr	0.0000	0.0000	0.0000	720	0	0.0055	0.0007	0.0062	720	0
May	0.0000	0.0000	0.0000	744	0	0.0001	0.0000	0.0001	744	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	720	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	744	0
Aug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	744	0

4.5 *EMPTIED* Analysis of Condensation as a Resultof Air Leakage

YEAR 1
Wall type = T-UP .1LKG,20PA, RH=35

MON	Plane 1 - kg/m» Conden	Evap	Drain	Absorb	Plane 2 - kg/m» Conden	Evap	Drain	Absorb
Sep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0000	0.0000	0.0000	0.0000	0.0289	0.3650	0.0000	0.0000
Nov	0.0000	0.0000	0.0000	0.0000	0.1663	0.1301	0.0000	0.0362
Dec	0.0000	0.0000	0.0000	0.0000	0.1443	0.0460	0.0000	0.1345
Jan	0.0000	0.0000	0.0000	0.0000	0.1672	0.0609	0.0000	0.2407
Feb	0.0000	0.0000	0.0000	0.0000	0.0877	0.0572	0.0000	0.2712
Mar	0.0000	0.0000	0.0000	0.0000	0.0679	0.1025	0.0000	0.2366
Apr	0.0000	0.0000	0.0000	0.0000	0.0203	0.2574	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0010	0.5275	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for VANCOUVER, B.C.
interior temp = Latest Input
interior dewpoint = Latest Input
leakage area = 0.07000 cm»/m»

Plane1 = MINERAL WOOL 90 MM
Plane2 = CONCRETE 100MM
Max absorb plane1 = 0.00
Max absorb plane2 = 22.00

CONDENSATION BREAKDOWN - AIR LEAKAGE vs VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = T-UP .1LKG,20PA, RH=35

MON	Plane 1 - kg/m» Air Lkge	Diffusion	Total	HAFZ	HBFZ	Plane 2 - kg/m» Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	720	0
Oct	0.0000	0.0000	0.0000	744	0	0.0285	0.0005	0.0289	744	0
Nov	0.0000	0.0000	0.0000	720	0	0.1644	0.0019	0.1663	709	11
Dec	0.0000	0.0000	0.0000	744	0	0.1409	0.0034	0.1443	741	3
Jan	0.0000	0.0000	0.0000	744	0	0.1669	0.0003	0.1672	657	87
Feb	0.0000	0.0000	0.0000	672	0	0.0836	0.0041	0.0877	672	0
Mar	0.0000	0.0000	0.0000	744	0	0.0667	0.0011	0.0679	744	0
Apr	0.0000	0.0000	0.0000	720	0	0.0196	0.0007	0.0203	720	0
May	0.0000	0.0000	0.0000	744	0	0.0010	0.0000	0.0010	744	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	720	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	744	0
Aug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	744	0

4.4 *EMPTIED* Analysis of Condensation as a Resultof Air Leakage

YEAR 1
Wall type = T-UP .1LKG,0 PA,VAN RH

	Plane 1 - kg/m»				Plane 2 - kg/m»			
MON	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
Sep	0.0000	0.0000	0.0000	0.0000	0.0014	0.0986	0.0000	0.0000
Oct	0.0000	0.0000	0.0000	0.0000	0.0059	0.0782	0.0000	0.0000
Nov	0.0000	0.0000	0.0000	0.0000	0.0081	0.0620	0.0000	0.0000
Dec	0.0000	0.0000	0.0000	0.0000	0.0044	0.0498	0.0000	0.0000
Jan	0.0000	0.0000	0.0000	0.0000	0.0039	0.0769	0.0000	0.0000
Feb	0.0000	0.0000	0.0000	0.0000	0.0005	0.0642	0.0000	0.0000
Mar	0.0000	0.0000	0.0000	0.0000	0.0014	0.0821	0.0000	0.0000
Apr	0.0000	0.0000	0.0000	0.0000	0.0013	0.1034	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0002	0.1286	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0006	0.1454	0.0000	0.0000
Aug	0.0000	0.0000	0.0000	0.0000	0.0005	0.1272	0.0000	0.0000

Output for VANCOUVER, B.C.
interior temp = VANHO.DYR
interior dewpoint = VANHO.DYR
leakage area = 0.07000 cm»/m»

Plane1 = MINERAL WOOL 90 MM
Plane2 = CONCRETE 100MM
Max absorb plane1 = 0.00
Max absorb plane2 = 22.00

CONDENSATION BREAKDOWN - AIR LEAKAGE vs VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = T-UP .1LKG,0 PA,VAN RH

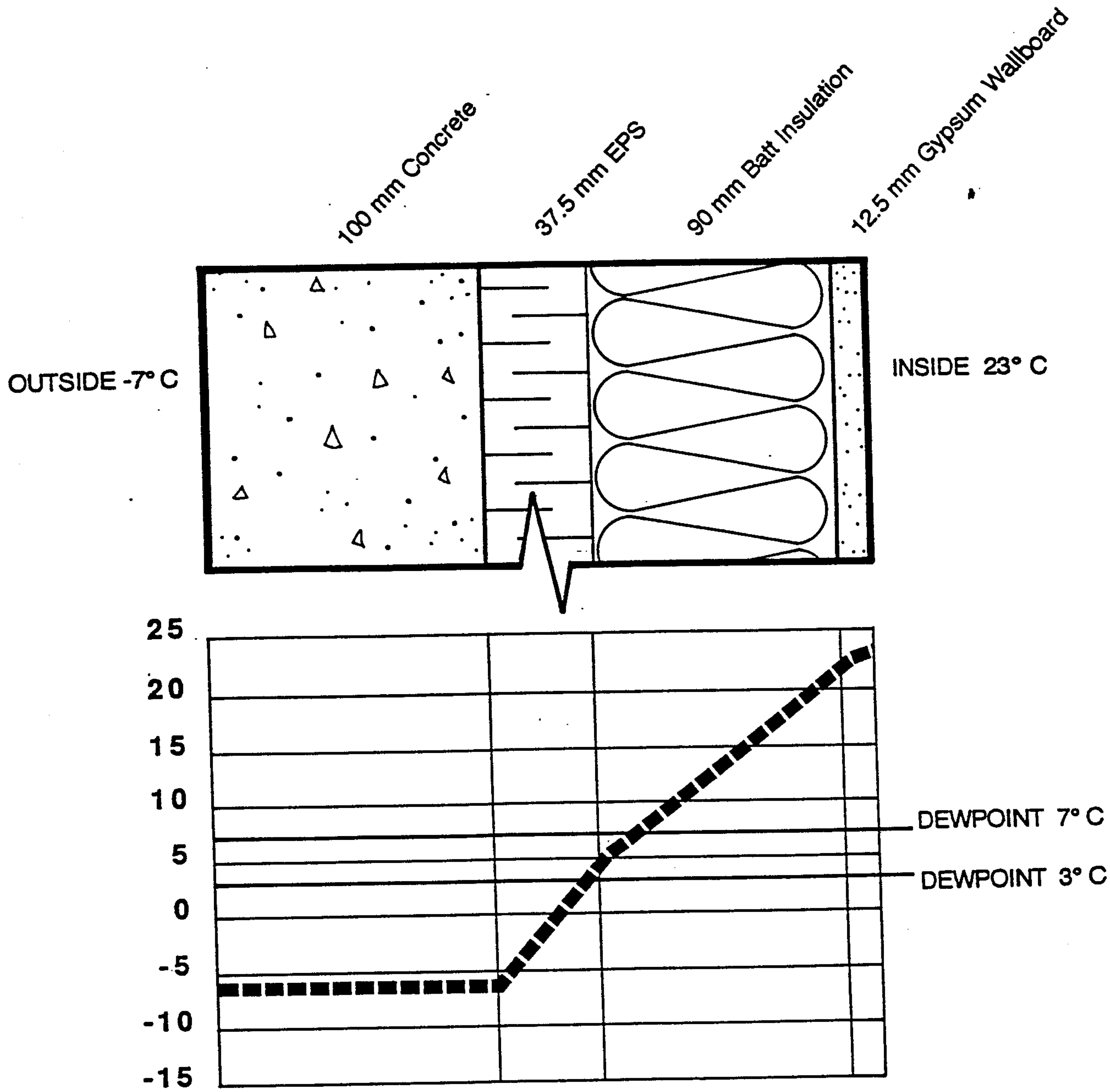
	Plane 1 - kg/m»					Plane 2 - kg/m»				
MON	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0000	0.0000	0.0000	720	0	0.0012	0.0002	0.0014	720	0
Oct	0.0000	0.0000	0.0000	744	0	0.0053	0.0006	0.0059	744	0
Nov	0.0000	0.0000	0.0000	720	0	0.0081	0.0000	0.0081	709	11
Dec	0.0000	0.0000	0.0000	744	0	0.0044	0.0000	0.0044	741	3
Jan	0.0000	0.0000	0.0000	744	0	0.0039	0.0000	0.0039	657	87
Feb	0.0000	0.0000	0.0000	672	0	0.0005	0.0000	0.0005	672	0
Mar	0.0000	0.0000	0.0000	744	0	0.0014	0.0000	0.0014	744	0
Apr	0.0000	0.0000	0.0000	720	0	0.0010	0.0002	0.0013	720	0
May	0.0000	0.0000	0.0000	744	0	0.0002	0.0000	0.0002	744	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	720	0
Jul	0.0000	0.0000	0.0000	744	0	0.0006	0.0000	0.0006	744	0
Aug	0.0000	0.0000	0.0000	744	0	0.0004	0.0001	0.0005	744	0

4.3 *EMPTIED* Analysis of Condensation as a Resultof Air Leakage

	Conductance w/(m2•k)	Rsistance (m2.k/w)	Temperature Difference K	Temperature °C
				-7
Outside Surface, paint	34	0.029	0.2	
				-6.8
Concrete 100mm	18.2	0.055	0.5	
				-6.3
EPS, 37.5mm	0.773	1.293	11.1	
				4.8
Batt Insulation, 90mm	0.52	1.92	16.5	
				21.3
Gypsum, 125mm	12.5	0.08	0.7	
				22
Inside Surface, fi	8.3	0.12	1	
		3.5	30	

Vancouver 2 1/2% Temp = -7°C
Inside Temp. (assumed) = 23°C
Dewpoint temp. for 23°C, 35°R.H. = 7°C
Dewpoint temp. for 23°C, 25°R.H. = 3°C

4.2 Heat Transmission Analysis of Wall



4.1 Dew Point Analysis Chart

Appendix 3

Envelope Analysis

Air Leakage Test - Data Sheet:

Test Time: Start:	2:00 pm	Test Date:	June 21, 1996
Finish:	3:00 pm	Project No.:	**996-465**

Ambient Conditions: **Temperature -- F**

Interior: 70 Exterior: 70

Wind Direction: SW

Speed: 7 mph Gusts: 0 mph

Barometric Pressure: Initial: 29.96 " Hg Final: 29.96 " Hg

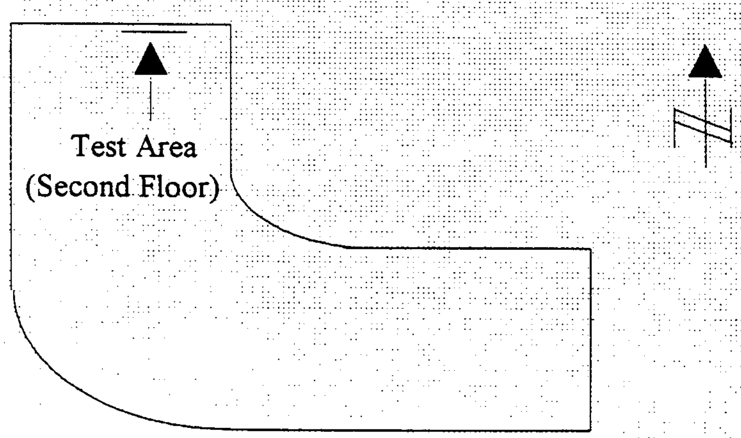
Relative Humidity: Initial: 45 % Final: 45 %

Pressure Differential Data:

Wall Section:	Start		Finish	
North:	0	Inches Water	0	Inches Water
East:	0	Inches Water	0	Inches Water
South:	0	Inches Water	0	Inches Water
West:	0	Inches Water	0	Inches Water
Test Section:	0	Inches Water	0	Inches Water

Pressure Inches of Water	Flow 1 SCFM	Flow 2 SCFM	Intake Air Temperature F
0.00	0.00	0.00	70
0.05	1.25	1.40	70
0.10	2.40	2.40	70
0.15	3.30	3.15	70
0.20	3.75	3.70	70
0.25	4.50	4.20	70
0.30	4.90	5.00	70

Floor Area Sketch:



DIMENSIONS

	Length	Height	
Test Area:	17.25	9.33	Ft.
Windows	12	7.33	Ft.
Joints	9		Ft.
Building	225	36	Ft.
	465	36	Ft.
			Ft.
			Ft.

Design Window Area: 56 %

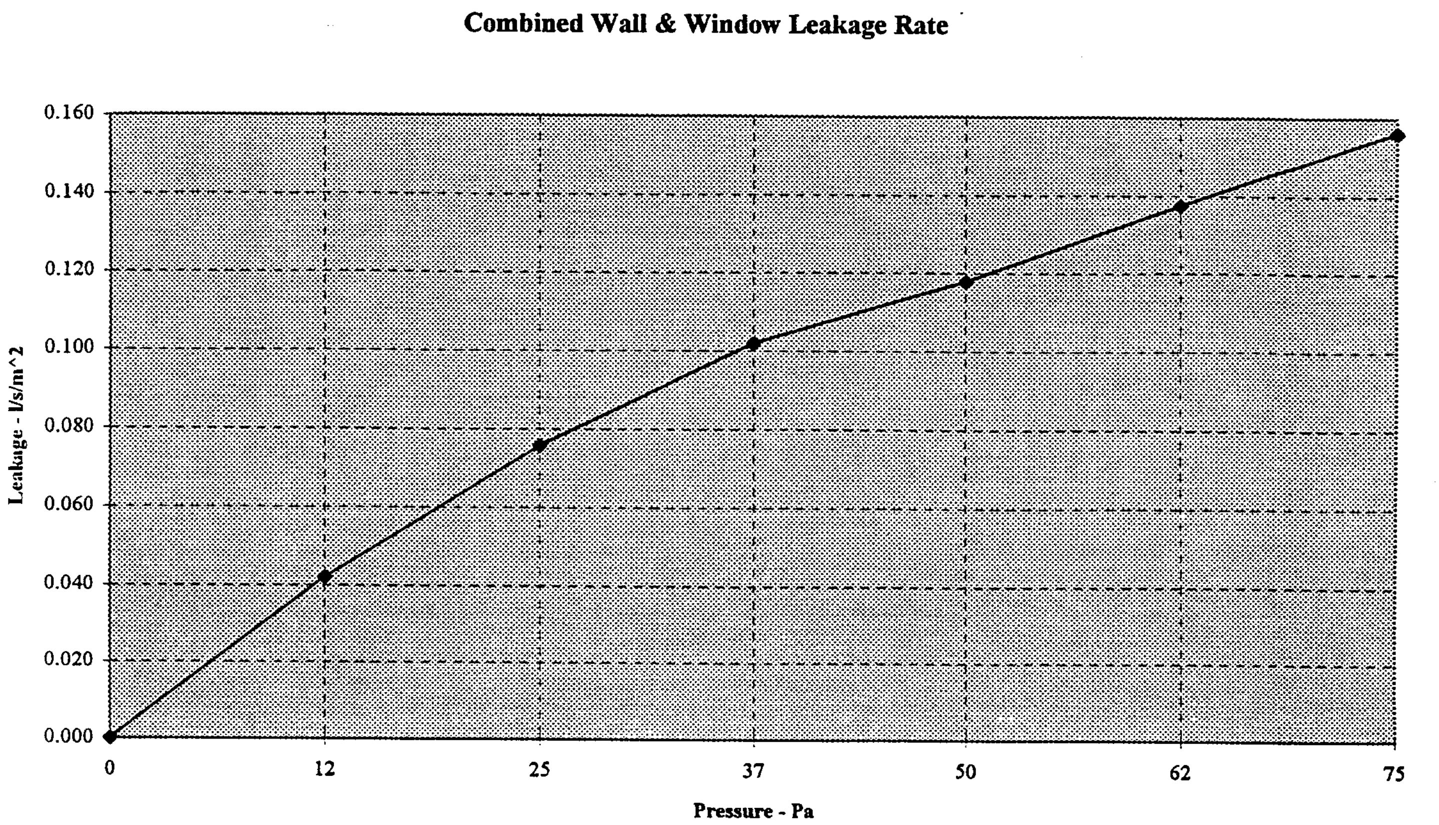
Test Results:

Static Pressure Across Envelope: Initial = 0 Inches of Water

Final = 0 Inches of Water

Imperial Data					Metric Data				
Pressure	Flow -- SCFM			Flow[1]	Pressure	Flow -- L/s			Flow[1]
In H2O	Average	/Ft^2	Corrected	/Ft^2	Pa	Average	/m^2	Corrected	/m^2
0.00	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000
0.05	1.33	0.008	1.470	0.009	12.45	0.625	0.042	0.694	0.045
0.10	2.40	0.015	2.353	0.014	24.90	1.133	0.076	1.111	0.072
0.15	3.23	0.020	3.098	0.019	37.35	1.522	0.102	1.462	0.095
0.20	3.73	0.023	3.767	0.023	49.80	1.758	0.118	1.778	0.116
0.25	4.35	0.027	4.383	0.027	62.25	2.053	0.137	2.069	0.135
0.30	4.95	0.031	4.960	0.030	74.70	2.336	0.156	2.341	0.153

Flow[1] = Air Flow per unit area pro-rated to 56% window area.



Data Verification:

	Test Results:	Data Limits:	Rating:
Relative Standard Air Flow Error @ 10Pa =	0.051	<0.07	Pass
Correlation Coefficient r =	0.996	> 0.990	Pass
Regression Coeficient n =	0.679	0.50 < n < 1.00	Pass
Maximum Flow Data Relative Error =	0.039	< 0.06	Pass
Normalized Leakage Area NLA =	n.a.	cm^2/m^2	
Equivalent Leakage Area ELA =	n.a.	m^2	

NORSON CONSTRUCTION LIMITED

Crestwood Corporate Center

Building Envelope Air Leakage Testing

File Number: 996-465

Test Date: June 21, 1996 **Report Date:** July 5, 1996

Tested By: **B. H. LEVELTON ASSOCIATES** **Technician:** **Don Empey, P.Eng**

Test Area Description: North Wall, second level, grid lines 1-C-D. See sketch on the attached test data sheet.

Ambient Conditions:

Wind Speed:	11.2	KPH	Relative Humidity:	45	%
Wind Gusts:	0	KPH	Temperature:	21.11	C
Wind Direction:	0		Barometric Pressure:	101.50	KPa

Building Envelope Description:

Precast concrete wall section with a "punched" window. The test area on the second level included the window, wall from floor to ceiling, and one wall joint. The wall joint was sealed with Peel-n-Stick membrane. The window was sealed into the concrete opening with exterior caulking and interior foam insulation.

Test Section Parameters:

Test Section Area:	161	Ft^2		14.96	M^2
Window in Test Area:	88	Ft^2		8.18	M^2
Wall Joint in Test Area:	9	Ft		2.74	M
Building Envelope Wall Area:	24840	Ft^2	(estimated)	7571.23	M
Allowable Wall Leakage:	0.0044	SCFM/Ft^2		0.100	L/s/m^^2
Allowable Window Leakage:	0.0088	SCFM/Ft^2		0.200	L/s/m^^2
Combined Allowable Leakage:	0.0068	SCFM/Ft^2		0.155	L/s/m^^2

Deviations from the CAN/CGSB-149.10-M86 Standard:

1. The load was increased in 0.05 " of water head increments from zero to 3.0 ". (0 to 75 Pa.)
2. The loading cycle was repeated.
3. The interior and exterior temperatures and pressures were equal; the building envelope was not complete.
4. The test did not evaluate the joint between the wall and the floor slab or roof.
5. The chamber walls were 6 mil polyethlene sheet sealed to the concrete with a Peel-n-Stick membrane.
6. Pressure sensing taps were not placed around the building perimeter as the windows had not been installed.

Cont'd on Page 2.

The project specifications indicated that a wood chamber would be fabricated for the air leakage test. As an alternate to construction of the wooden chamber, a sheet of 6 mil thick polyethylene supported on a wood frame was sealed to the concrete panel with a 'peel-n-stick' membrane. The chamber prepared for a test conducted June 18th was not adequately sealed to the concrete walls, and chamber leakage influenced the overall leakage results.

The polyethylene chamber was re-sealed to the concrete with peel-n-stick membrane and the wall section was retested June 21, 1996.

For these tests, the test pressure was incrementally increased to a maximum of 75 Pa. (In accordance with CGSB Standard 149.10-M86, all calculations were based upon the defined pressure -- 50 Pa.) At each increment the pressure was maintained for at least one minute to ensure stability. To ensure the data, the test was conducted twice. Field data collected in the June 21, 1996 test are attached along with the data report analyzing the results.

The corrected combined leakage rate for the test section is 0.153 litres per second per square meter of area at 50 Pa. The allowable leakage rate for the test section where the window area is 56% of the total wall area is 0.155 $L/s/m^2$. This allowable rate is based upon the percentage of window area and the allowable leakage rates of 0.1 $L/s/m^2$ for walls and 0.2 $L/s/m^2$ for windows. The section was marginally better than the allowable rate.

We trust that this report meets your present requirements for this project. If you have any questions or comments, please contact us at your convenience.

Yours very truly,
Levelton Associates

PROFESSIONAL PROVINCE OF D. P. EMPEY BRITISH COLUMBIA ENGINEER

8/7/96

Don Empey, P.Eng.

reviewed by:
Marcus Dell, P.Eng.
Manager, Building Science Division.

/DE August 7, 1996, 2:30 pm

LEVELTON ASSOCIATES CONSULTING ENGINEERS

RICHMOND VICTORIA NANAIMO COURTENAY SURREY ABBOTSFORD PRINCE RUPERT CALGARY

RECEIVED AUG 8 1996 NORSON CONSTRUCTION LTD.

FILE 9551.01

BUNTING COADY ARCHITECTS

7 August 1996

File No.: 996-465

Norson Construction Ltd.
105-267 West Esplanade
North Vancouver, B.C.
V7M 1A5

Attention: Mr. Rod Fors

PROJECT: Building No. 8 -- Crestwood Corporate Center
SUBJECT: Wall Section Air Leakage Study

Dear Mr. Fors:

A test program was initiated to evaluate the air leakage of a window wall section at the site referenced above. The test program is part of an energy conservation program defined by the Canada C2000 program which in essence evaluates the building envelope at the completion of construction and after one year of occupancy.

As discussed at a site meeting May 14, 1996, the wall section to be tested included the precast wall with a window installed in standard fashion. The test section included a window, the concrete wall between the floor and the ceiling, and one joint in the precast wall system. The wall section for evaluation was jointly selected by Norson Construction and Bunting Coady Architects.

Air leakage tests were conducted June 18 and June 21, 1996 on a second level wall section defined by Grid Lines 1-C-D. The test program was defined by the following section of the project specifications:

Division 1 -- Section h -- Tests and Standards:

- ASTM E283-91 entitled "Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, Doors Under Specified Pressure Differences across the Specimen".
- ASTM E783-91 entitled "Standard Test Method for Measurements of Air Leakage Through Exterior Windows and Doors".
- CAN/CGSB 149.10-M86 entitled "Determination of the Air-Tightness of Building Envelopes by the Fan Depressurization Method".

Celebrating 30 Years

Appendix 2

Air Barrier Test Results

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELECCOST	ELECTRICITY	1 2 3 4 5	359424. KWH	24789.	0.0690	YES
NGASCOST	NATURAL-GAS	1 2 3 4 5	380. GJ	2430.	6.3965	YES
				==========		
				27219.		

ENERGY COST/GROSS BLDG AREA: 0.35
ENERGY COST/NET BLDG AREA: 0.35