DIALOG®

CANADIAN CONSULTING ENGINEERING AWARDS 2023

GRANDE PRAIRIE REGIONAL HOSPITAL

Connecting Patients, Care, and Community

The Grande Prairie Regional Hospital (GPRH) is a new 63,000 square metre acute care hospital and cancer centre in Grande Prairie, Alberta, Canada. The new hospital includes 243 single inpatient rooms, including medical, surgical, intensive care, cardiac care, obstetrics, neonatal intensive care, pediatric, and mental health beds. Rooms were purposely designed with the patient and family experience in mind, including a fold-down sleep space in each patient room to accommodate a family member or caregiver staying with the patient.

A state-of-the-art cancer centre features two radiation vaults, making Grande Prairie the fifth centre in Alberta — and the first in Alberta Health Services North Zone — to offer radiation and infusion therapy. GPRH also has eleven operating room suites (ORs), and a dedicated obstetrical OR in the maternity unit.

The facility design consists of a three-floor acute care centre plus one level below grade. A mechanical and electrical penthouse on the roof services the entire building. The facility also includes a 4000 square metre education program in partnership with Northwestern Polytechnic (formerly known as Grande Prairie Regional College), for the training of nurses and other healthcare professionals.

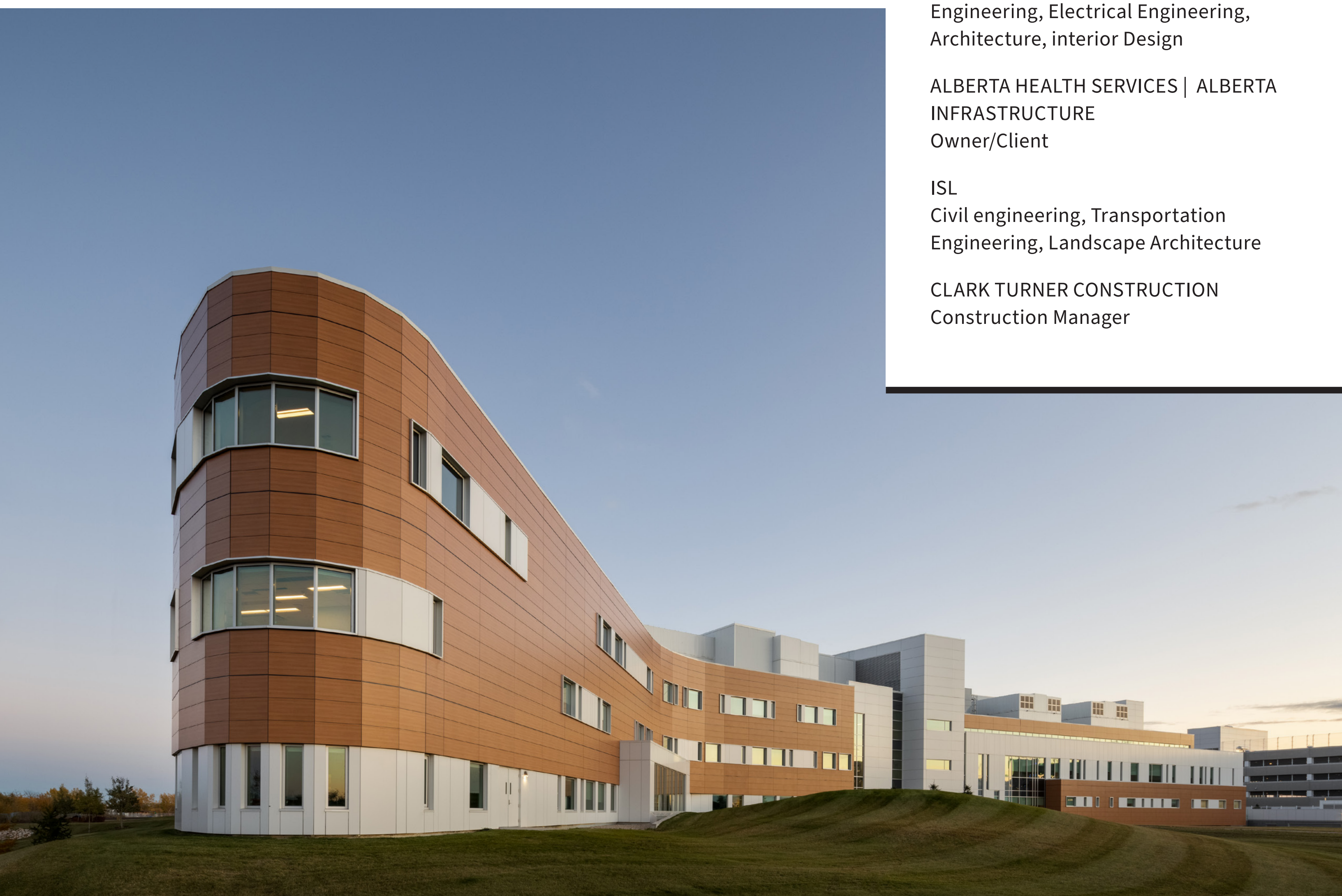
PROJECT TEAM

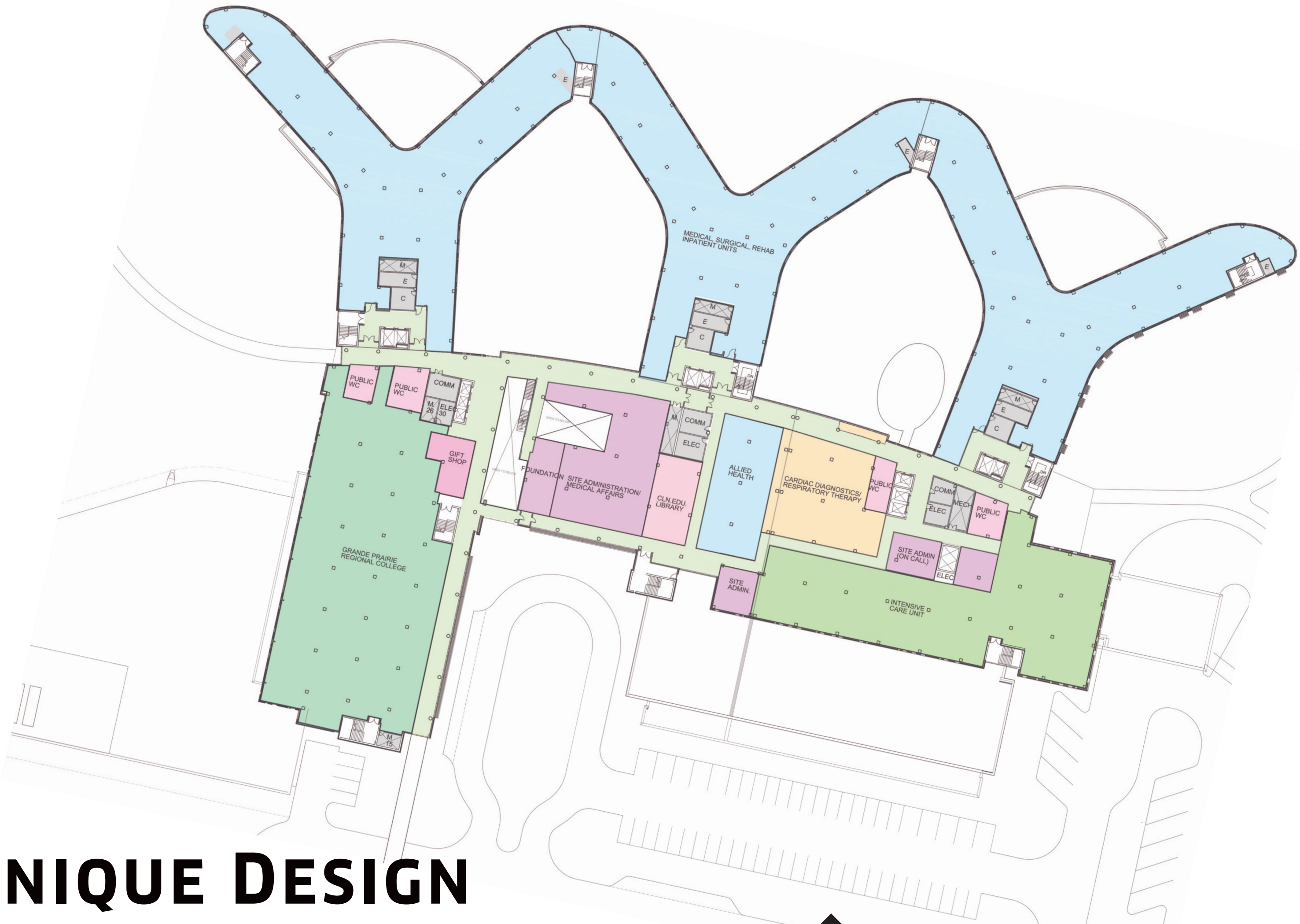
DIALOG
Structural Engineering, Mechanical Engineering, Electrical Engineering, Architecture, interior Design

ALBERTA HEALTH SERVICES | ALBERTA INFRASTRUCTURE
Owner/Client

ISL
Civil engineering, Transportation Engineering, Landscape Architecture

CLARK TURNER CONSTRUCTION
Construction Manager





Overall building floor plan displaying the inpatient wings and diagnostic and imaging blocks.

Unique Design Aspects and Innovation

SITE AND BUILDING FORM

The location of the hospital is on land donated by the Grande Prairie Regional College (GPRC) and forms part of the GPRC master plan for future development. Attracted by the presence of Bear Creek flowing north of the site, DIALOG designed the facility's inpatient units to be adjacent to this beautiful body of water, giving patients direct views to it from their hospital beds. GPRH is designed with two neighborhoods that reflect its two distinct healthcare functions. The diagnostic and treatment component is rectilinear in form to accommodate effective flow through its exam and procedure rooms, while the residential inpatient units are more curvilinear and fluid reflecting their private accommodations of patients.

The inpatient units look like Y shaped wings that are inspired by the meandering form of the creek. A main street corridor bathed by natural light links the two neighborhoods together to provide intuitive access and wayfinding for patients, visitors, and staff.

To realize this unique design, a cast in place structural concrete slab superstructure was selected to avoid the dust and debris required for fireproofing of a structural steel design, while providing superior flexibility and vibration control for a hospital facility with strict medical equipment and loading requirements. The concrete slabs are designed with segmented slab edges that support the segmented cladding system to express the curvilinear form of the inpatient wings.

The site's proximity to Bear Creek and Muskoseepi Park inspires its landscape design. The park is integrated into the very heart of Grande Prairie, featuring over 1100 acres of parkland with six distinct areas offering their own special opportunities. GPRH's landscape design provides therapeutic walkways meandering through trees and shrubs while connecting into Muskoseepi Trail. The result is a building and landscape design that reflects the beauty, character, and energy of beautiful Grande Prairie.

RADIATION VAULTS

The radiation vaults are located below grade to utilize the ground cover as part of its radiation containment. This strategy also allows the vaults to be blended into the landscape by berming landscape vegetation over the vaults. Natural light is brought into the vault entry through clerestory windows.

The radiation vault concrete walls and slabs act as the primary shielding members against radiation transmission; wall thicknesses are determined by AHS Medical Physicists in consultation with the Canadian Nuclear Safety Commission (CNSC). Wall thickness is impacted by the density of the concrete mix, which is critical to the overall shielding performance of the vaults. After discussion with local concrete suppliers and trial batch testing, a dry (cured) density of 2330kg/m3 was determined to be most feasible. The logistical challenges associated with procurement of high-density aggregate precluded its use in the vaults. To ensure that the intended in-situ density of the local concrete supply was achieved, multiple test batches were completed, and a correlating wet density value was determined. Relying on this wet density benchmark, every concrete truck delivering material for the vault pours was tested prior to placement to ensure the required values were achieved.

Due to the thickness of the radiation vault walls and roof slabs which ranged up to 2.4m thick, continuous pours in excess of 12 hours were required to limit the number of construction joints. To control the heat of hydration of the concrete and limit any potential shrinkage cracking, the concrete pours began early morning and ice substituted for water in the concrete mix to slow the hydration reaction and allow for a more uniform cure.

The result was a concrete vault that met AHS and CNSC's requirements.

Collaborative coordination between the installation and design teams achieved the required service penetrations for M&E services through the concrete vault walls. Penetrations for imaging equipment cooling, ventilation, plumbing, medical gas, and electrical distribution serving the medical linear accelerator (LINAC) were fully dimensioned and located in a 3D virtual construction model prior to installation. Careful consideration of size, quantity and position of each penetration was taken to ensure the adequate shielding of the concrete structure was maintained.

All electrical systems within the Vaults were similarly coordinated early in the design process. Many services are brought to the vault in concrete encased conduits which terminate at carefully selected locations within the vaults.

All raceways within the vaults were coordinated with selected equipment datasheets and validated by vendor. All electrical systems cabling, and raceways were kept at preset distances from the imaging equipment. The imaging equipment is interlocked with multiple sensors in the entryway into the vault to safely operate the equipment once the personnel entry has been validated in accordance with CNSC requirements. In case of a breach of entry into the vaults, the imaging equipment immediately shuts down to ensure people safety.

MAIN ENTRANCE LOBBY AND FEATURE STAIR

The Hospital welcomes visitors through a vast three-storey open volume atrium with includes a feature wall supporting a structural steel feature stair, and atrium bridges connecting each side of the atrium at each of the floor levels. The stair structure cantilevers off the feature wall to give the effect of the stair floating at each level. Strict deflection and vibration criteria were followed for the design of the stairs to prevent damage to tile floor finishes and to ensure user conform for visitors, staff, and patients.

The heating, ventilation and air-conditioning (HVAC) system is integrated into the three-storey open atrium to allow for an unobstructed view of the feature stair and exterior glazing while promoting occupant comfort as they first enter the facility.

Perimeter heating radiant panels are incorporated into the atrium bridge along the perimeter to address heat loss through the envelope and manage moisture accumulation at the glazing ensuring the view through the glazing remains clear. Displacement diffusers located at each open storey level provide fresh air that washes occupants in a low velocity air stream as they move through the atrium. Contaminants and thermal loads are directed upwards to the top level and collected through an exhaust air inlet grilles. Waste energy is recovered from the exhaust air stream and utilized to pre-condition the fresh air discharged into the atrium.

Electrical systems in the three-story atrium are seamlessly integrated and provide an unobstructed view of the feature stairwell. Light fixtures are carefully coordinated in the hallway ceilings at every level and further supplemented with surface mounted luminaires that define seating areas for staff and patients to enjoy. Fire alarm system in the atrium space uses VESDA systems which samples the air from the atrium space and detects any smoke content. Smoke detectors are located away from the atrium in service rooms in order to ensure clean aesthetics of the space.

Visitors are welcomed to the hospital with a feature entrance stair and three-storey open space atrium.

SURGICAL SUITES

The hospital has eleven operating room suites (ORs), including a dedicated obstetrical OR in the maternity unit. Most of the operating rooms having windows to the exterior to provide daylight and views for surgical staff. Critical diagnostic and treatment components such as Operating Rooms, ICU, and Emergency/Trauma have fully redundant Air Handling units to minimize service disruption in the event of equipment failure or planned maintenance.

One isolation operating room was designed and built at GPRH to facilitate invasive surgery of infectious patients. Similar to the design of all other Isolation rooms in the facility, the Isolation OR includes an anteroom, is lined with an air vapor barrier, and has interlocking doors. The theatre will continue to be positively pressured compared to the ante room and corridor.

▲ *Surgical suite with windows to bring in natural light.*

The ventilation system at GPRH is critical to occupant safety, comfort, and wellbeing throughout the facility, especially within the surgical suites. As mentioned above, the surgical suites are supported by a fully dedicated N+1 redundant air handling units, which provide fresh 100% outside air that is conditioned and filtered to meet the stringent requirements critical to the operation of these suites.

More specifically, large volumes of fresh air (20 air changes per hour) are provided to each operating room and strategically discharged overtop of the operating table within the surgical zone. Laminar flow diffusers supply the air at low velocity and is collected by low level exhaust grilles located at each corner of the room.

The design effectively creates a “washing” effect across the surgical zone intended to create a barrier of clean air that directs harmful pathogens away from the vulnerable patient. The low velocity air provides the “washing” effect without disrupting a protective thermal plume created by body heat radiating from the surgical site on the patient. The intent is to reduce the potential of inducing particles from surfaces (such as the surgeons mask or arms) into the surgical site.

In addition, the suites are positively pressurized to prevent potentially harmful pathogens entering the operating room from the adjacent corridors. The is especially critical for the Isolation OR, where room pressurization between the ante room, adjacent corridor and operation suite is actively monitored and controlled to maintain pressurization and ensure the safety of patients and staff.

Due to the quantity of mechanical and electrical services required to meet the function of the hospital, close coordination between all disciplines within the design team was required. All above ceiling services were coordinated 3D BIM environment both during design and construction. The installation trades collaborated with the design team to determine the optimal route and “sandwich” of the services within the ceiling plenum to minimize material and labor costs without compromising serviceability and maintainability of services.

The electrical systems within the Surgical Suites were carefully coordinated with the users and equipment vendors. All equipment and end devices within the suites are located to suit user needs and program requirements. All critical equipment within the suits is backed up by Uninterrupted Power Supply (UPS) which, in turn is backed up by emergency generator power.

Lighting fixtures within the suite were coordinated with other ceiling components, such as diffusers, grilles, sprinklers, and overhead service equipment arms. Lighting systems are connected to UPS + emergency generator power to ensure continuous lighting system during a power outage. All power outlets within each individual surgical suite are fed from a dedicated panel to facilitate maintenance of the suite without impacting other suites. All HVAC equipment serving the surgical suites is powered from dual ended emergency power switchgear to ensure concurrent maintainability of all systems.

After building occupancy, DIALOG assisted Alberta Health Services in obtaining an alternate solution deleting the audible alarms from the surgical suites in a fire alarm condition to minimize disruption to the surgical team. This alternative solution was incorporated into the fire safety plan developed for the surgical suites in collaboration with the City of Grande Prairie Safety Codes Officer and Fire Marshall.

Environmentally responsible

The Grande Prairie Regional Hospital includes a s state-of-the-art cancer centre features two radiation vaults, making Grande Prairie the fifth centre in Alberta — and the first in Alberta Health Services North Zone — to offer radiation and infusion therapy. GPRH also has eleven operating room suites (ORs), and a dedicated obstetrical OR in the maternity unit.

The facility design consists of a three-floor acute care centre plus one level below grade. A mechanical and electrical penthouse on the roof services the entire building. The facility also includes a 4000 square metre education program in partnership with Northwestern Polytechnic (formerly known as Grande Prairie Regional College), for the training of nurses and other healthcare professionals.

During the early stages of design, an online tool originally developed to screen projects for the former Commercial Building Incentive Program (CBIP) was used to evaluate the energy performances of the facility with an ASHRAE Reference Building. While not a comprehensive hourly energy-modeling tool, it provided valuable feedback when testing basic building design scenarios against an equivalent reference building to quickly confirm the initial design decisions on massing.

Grande Prairie weather data was used for the evaluation. Miscellaneous and equipment energy densities, anticipated lighting densities, and outdoor air loads were included in the analysis of both the reference and proposed building models.

Energy Rates are variable and volatile, so reasonable assumptions are required to predict building energy costs. Energy rates were obtained from local energy retailers and distributors.

Space heating consumes approximately 55% of the total energy and is followed by auxiliary (fans and pumps), lighting, plug load, and domestic hot water heating, at 19%, 12%, 7%, and 6% respectively. Space cooling's consumption is negligible, at 2%.

The cost of electricity is considerably higher than natural gas; the cost of auxiliary equipment is the highest at 39%, followed by lighting, space heating, and plug load, at 25%, 20%, and 12%.

A parametric analysis was undertaken on the four major parameters of the envelope design, namely, wall, window, and, roof thermal performance, and window to wall ratio.

For each parameter, operating cost savings were expressed relative to the ASHRAE reference building. For this project, the ASHRAE reference building was taken to be a building complying with the requirements outlined in ASHRAE 90.1 – 2007. The analysis revealed that optimal performance to energy cost was achieved with the roof at R-35, walls at R-20 and triple glazing for windows. The window to wall ratio was targeted at 20%, yet as the photographs reveal, the facility is bright and airy with generous penetration of natural light to patient and staff areas throughout the facility.

The GPRH landscape includes natural vegetation and stormwater retention pond.

Electrical engineering

The electrical systems within this facility are designed for an acute healthcare facility. The electrical system includes two incoming services and dual ended switchgears which provides concurrent maintainability of critical electrical distribution for the entire facility. The backup power system in the facility includes three (3) 2,000KW Diesel generators and dual ended switchgear arrangement throughout the facility. The three-generator arrangement provides N+1 redundancy as mandated by CSA Z32 for a Healthcare Facility.

Backup power is provided to all life safety and essential systems throughout the facility. 2x300KW UPS units provide central UPS power system to support Communication Systems as well as critical medical equipment throughout the facility. Two UPS units provide 2N redundancy.
The fire alarm system supports emergency paging from within the facility as well as remote authorized locations.
LED light fixtures are used throughout the facility, and the lighting control system is integrated with the Building Automation System and Security System.

The electronic security system includes access control, intrusion alarm, and CCTV surveillance systems. All elements of the electronic security system were designed with close coordination with the users and AHS security team and sends notifications to a central control center to integrate with the other AHS facilities. The nurse call system is integrated with wireless communication system, patient wandering systems and infant protection system and provides seamless patient care system throughout the facility.

MECHANICAL ENGINEERING

Within built environments, the mechanical systems are intended to support the architectural design by providing critical life safety elements and promote occupant comfort and wellbeing through conditioning the indoor environment. This is especially critical within a health care facility where occupant safety, wellbeing and health are the core function of the program.

At GPRH, a key design strategy for promoting occupant health and wellbeing was the effective use of fresh air. Large volumes of fresh outdoor air are brought into the facility via dedicated air handling unit systems and discharged in strategic locations. The outdoor air mixes with room air and is exhausted from the space. To control the direction of airflow, zones of high pressure (+) are created in "clean" areas intended to protect occupants and processes (ex. immunocompromised patients); and zones of negative pressure are created in "dirty" areas to discharge it safely out of the building or filter the air of harmful particles.

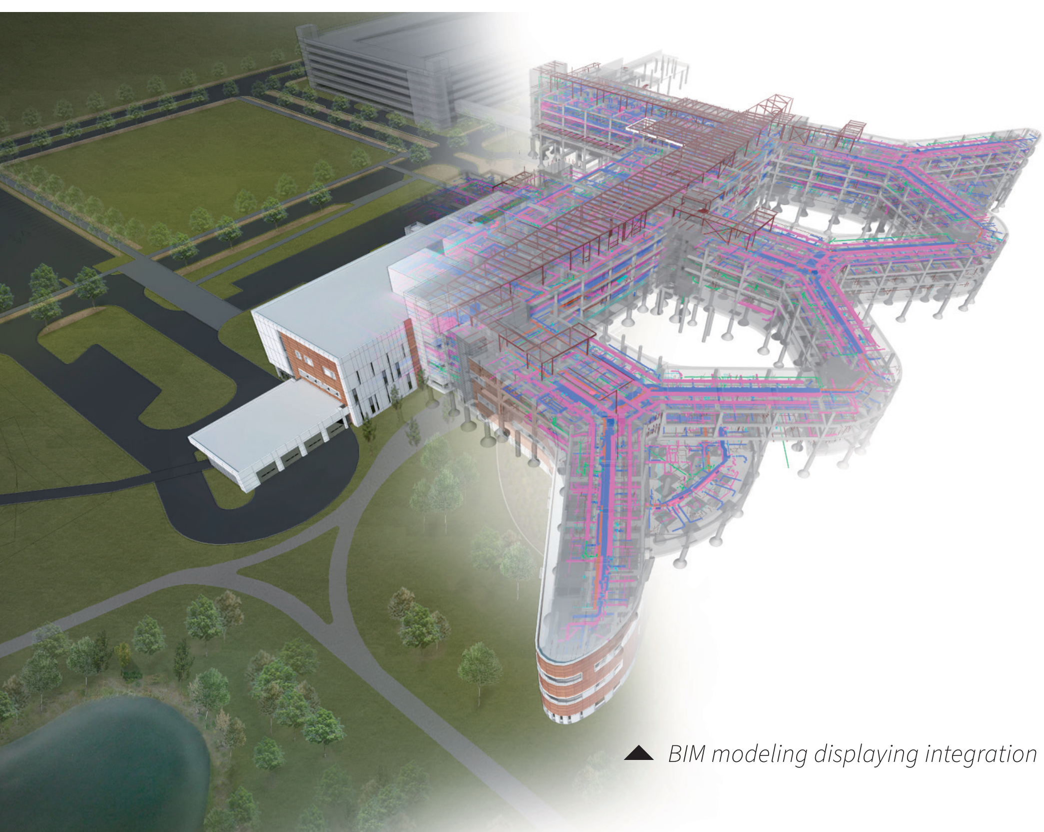
The air movement creates a path of travel to move dirty airborne particles to areas where they can be contained, or exhausted from the building.

The large volumes of air are introduced via air handling systems that were strategically dedicated to each major department to simplify the smoke control strategy and provide safe air supply to critical zones during a life safety event. Each unit provides fresh outside air via variable speed high-efficiency plenum fans. The supply air stream is preconditioned by glycol heating coils, chilled water-cooling coils and an enthalpy recovery wheel that captures waste heat energy and moisture from the exhaust air stream. Humidity levels within the facility are constantly monitored and controlled via a combination of the chilled water-cooling coil to remove moisture from the air during humid shoulder seasons, and high-efficiency steam dispersion humidifiers to provide moisture to the air during the dry winter season. To ensure a high quality of fresh air and protect the air handling unit components from debris multiple stages of filtration are included in the construction of the units.

The air handling units are incorporated into the facility through the main service and circulation spine. The spine acts as a backbone for the facility containing the main curved public circulation corridor, all public and service elevators, and the primary mechanical and electrical systems distribution. The standalone air handling units are placed along the spine, which at the roof level forms a mechanical penthouse. This is intended to facilitate air distribution to vertical shafts as well as staff access for maintenance. The in-patient units and diagnostic and treatment block plug into this service and circulation spine on all four levels.

The penthouse contains the central heating and cooling plant equipment serving the facility. Heating water and low-pressure steam for humidification is produced by a series of dual fuel heating boilers. Waste heat energy is recovered from the boiler flue stacks for preheating domestic hot water and pre-conditioning boiler room combustion air. The central cooling plant consists of variable speed magnetic bearing centrifugal chillers paired with induced draft cooling towers to provide cooling for air-conditioning, and process cooling for imaging equipment, electrical rooms, and network rooms. A closed-circuit cooling tower is utilized during the winter months to provide essentially free-cooling when the outdoor wet bulb temperature drops below a defined setpoint. Heating and cooling water are circulated via variable speed pumping systems, and critical components are provided with N+1 redundancy to ensure adequate standby capacity is provided for maintainability and reliability of the systems.

The outcome is a system that is fully integrated with the architectural design and program of the hospital while at its core fostering safety, wellbeing and health of patients and staff.



▲ *BIM modeling displaying integration of mechanical and electrical systems*

Structural Engineering

The structure of the GPRH primarily consists of reinforced cast in place concrete, with structural steel utilized for the roof mechanical penthouse, entry and social stair feature and medical supports. The structure has been designed to meet the strict loading and vibration criteria required for an acute care hospital, with special attention considered for diagnostics and imaging equipment and surgical suite medical supports.

A two-way flat slab with drop panels floor system was utilized for diagnostics and imaging areas, and surgical floors due to their ability to support heavy loads efficiently and cost-effectively from the medical equipment and associated medical support services.
The in-patient unit floor system was comprised of a beam and girder systems due their longer spans (typically 10.55m) to allow for column free spaces within the patient rooms. A portion of the facility also accommodates space for the Northwestern Polytechnic, this space includes a two-storey open atrium with concrete floors cantilevering up to 4.5 meters.

The overhanging structure forms an important part of the functional program for the polytechnic.

For the in-patient beams and girder floors, horizontal block-outs were incorporated into the webs of the beams to allow for services to be run tight to the underside of the slab, allowing for greater headroom clearance within the ceiling space.

Coordination with the mechanical and electrical design teams were integral to the success of the project. Slab recesses, sleeves and beam penetrations were accommodated within the structure to allow for integration of shower depressions, medical equipment, and mechanical and electrical services.

The architectural design of the hospital showcases exposed concrete surfaces, with exposed circular concrete columns present along the common curved main street corridor and architectural exposed concrete stair and elevator cores throughout.

Reinforcing steel for 1200mm thick radiation vault roof

Radiation vault roof, prior to concrete placement