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1 INTRODUCTION

The Facilities Design Methodology Document provides an overview of the facility planning processes employed to identify mainline facility requirements and new receipt and delivery meter stations and extension facilities. The overview will provide readers with the background to understand the purpose of and necessity for facilities requirements.

The Guidelines for New Facilities describe the new facilities that NGTL may construct. An electronic version of the Guidelines for New Facilities can be accessed at: http://www.tccustomerexpress.com/871.html

New facilities are divided into two categories:

- expansion facilities, which would include pipeline loop of the existing system, metering and associated connection piping and system compression; and
- extension facilities, which would include pipelines generally greater than 20 km (12.4 miles) in length, 305 mm (12 inches) or more in diameter, with volumes greater than 2.8 $10^6 m^3/d$ (100 MMcf/d), that are expected to meet the aggregate forecast of two or more facilities (gas plants/industrials).

The facilities design process, described in Section 4, contains two distinct facility planning sub-processes. The first sub-process relates to the facilities planning, design and construction of mainline expansion facilities. The second sub-process relates to the facilities planning, design and construction of new receipt and delivery facilities and connecting extensions. NGTL uses these processes to identify the necessary facility additions required to be placed in-service.

An important element of the facilities design process is the filing of specific facility applications. Facilities applications are filed with the regulator to facilitate proposed construction schedules, which must account for summer or winter construction constraints and the time required to procure major facility components such as pipe, compressors and valves.

The design flow determination used to determine the mainline expansion facility requirements is described in Section 3.5. Mainline facilities expansions are included in the Annual Plan Section 2 – Design Flow and Mainline Facilities.

Receipt and delivery facilities included in the Annual Plan Section 3 – Extension Facilities, Lateral Loops and Meter Stations, intended to meet Customers' firm transportation Service Agreements, are designed as part of the facility design process but are constructed independently of the construction of mainline expansion facilities. If these facilities are in place prior to the completion of mainline expansion facilities, Customers may be offered interruptible transportation pending the availability of sufficient mainline transportation capability.

2 THE NGTL SYSTEM

The physical characteristics of the NGTL System and the changing flow patterns on the system present significant design challenges. The NGTL System transports gas from many geographically diverse Receipt Points and moves it through pipelines that generally increase in size as they approach the major delivery points

The NGTL System is designed to meet the peak day design flow requirements of its Customers. NGTL's obligation under its firm transportation Service Agreements with each Customer is to:

- receive gas from the Customer at the Customer's Receipt Points including the transportation of gas; and
- deliver gas to the Customer at the Customer's Delivery Points including the transportation of gas.

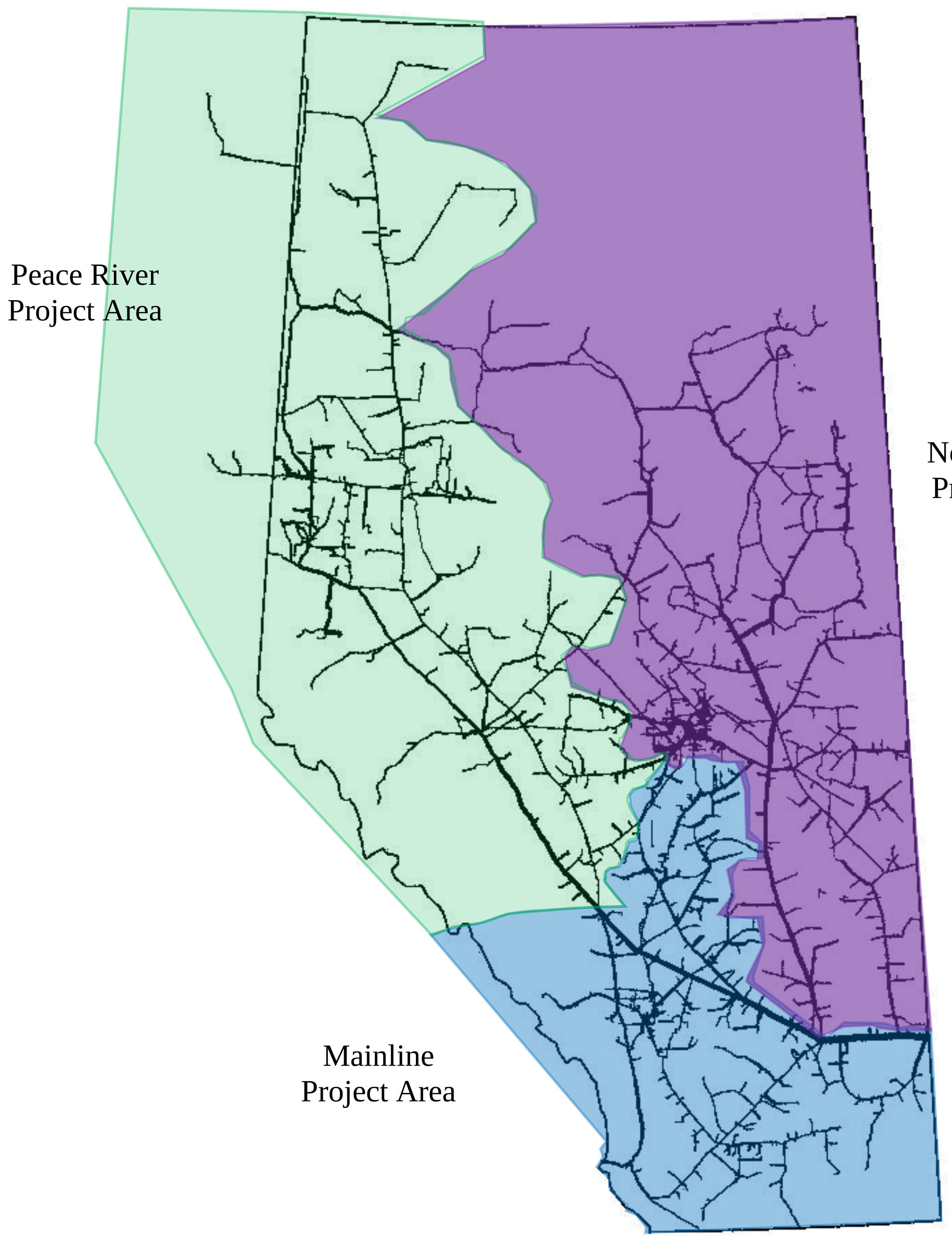
NGTL's facility design must ensure prudently sized facilities in order to meet flow requirements. The system design methodology developed to achieve this objective is described in the remainder of this document.

Firm transportation capability may exist from time to time at certain Export Delivery Points for Short Term Firm Transportation-Delivery service ("STFT"). This capability availability is either ambient temperature related capability or capability created by unsubscribed Firm Transportation Delivery ("FT-D1") transportation. Firm transportation capability may also exist in the winter season at certain Export Delivery Points for Firm Transportation-Delivery Winter service ("FT-DW") due to ambient temperature related capability. Interruptible transportation capability may exist from time to time on certain parts of the NGTL System based on unutilized or unsubscribed Firm Transportation

2.1 NGTL System Project and Design Areas

For design purposes, the NGTL System is divided into the three project areas shown in Figure 2.1, which are in turn divided into the design areas and design sub areas described in Sections 2.2 to 2.4. Dividing the pipeline system this way allows the system to be hydraulically modeled in a way that best reflects the pattern of flows in each specific area of the system, as described in Section 3.5. As the NGTL System evolves, changes to these divisions may be made as required, to ensure hydraulic modelling continues to reflect the pattern of flow. In addition, the NGTL System is divided into delivery design areas as described in Section 2.5.

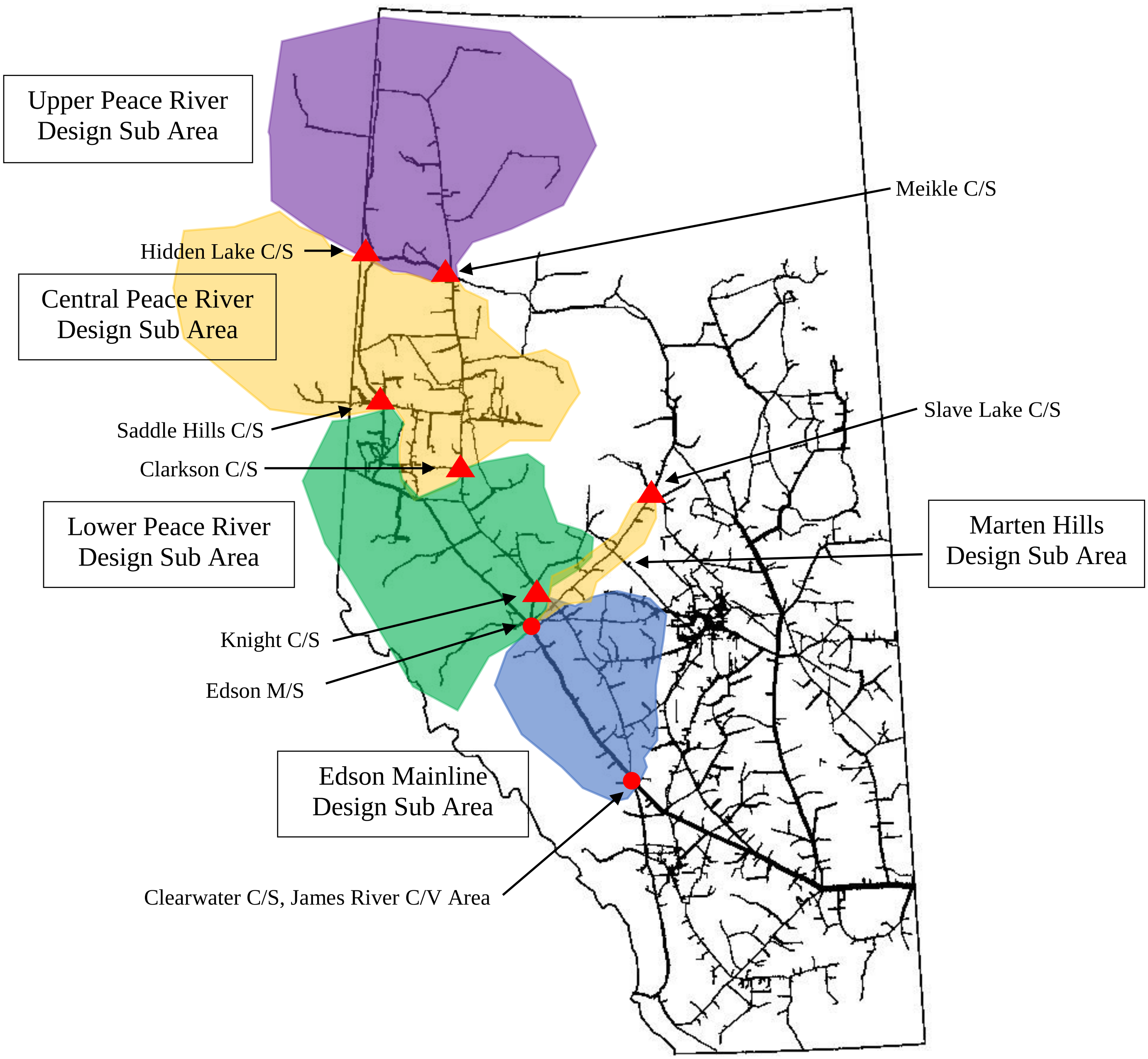
Figure 2.1
NGTL System Project Areas



2.2 Peace River Project Area

The Peace River Project Area comprises the Peace River, Marten Hills, and Edson Mainline Design Areas (Figure 2.2).

Figure 2.2
Peace River Project Area



Peace River Design Area

The Peace River Design Area comprises three design sub areas: the Upper Peace River Design Sub Area; the Central Peace River Design Sub Area; and the Lower Peace River Design Sub Area.

Upper Peace River Design Sub Area

The Upper Peace River Design Sub Area comprises facilities north of the Meikle River and Hidden Lake Compressor Stations.

Central Peace River Design Sub Area

The Central Peace River Design Sub Area comprises facilities north of the Clarkson and Saddle Hills Compressor Stations up to the Meikle River and Hidden Lake Compressor Stations.

Lower Peace River Design Sub Area

The Lower Peace River Design Sub Area comprises facilities north of the Edson Meter Station up to the Clarkson and Saddle Hills Compressor Stations.

Marten Hills Design Area

The Marten Hills Design Area comprises facilities from the Slave Lake Compressor Station to the Edson Meter Station.

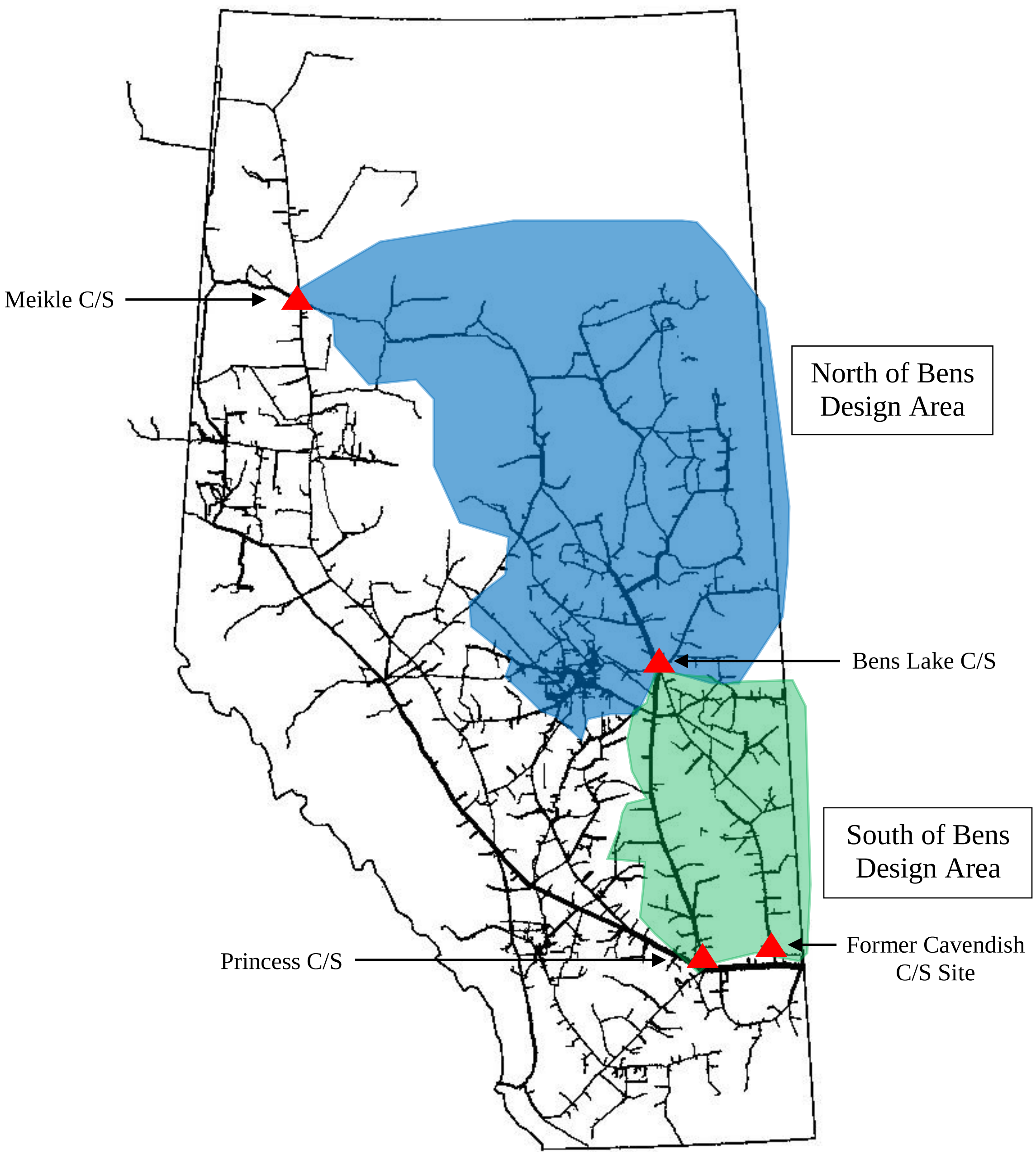
Edson Mainline Design Sub Area

The Edson Mainline Design Sub Area comprises facilities from the Edson Meter Station and Knight Compressor Station to the Clearwater Compressor Station/James River Control Valve area.

2.3 North and East Project Area

The North and East Project Area (Figure 2.3) comprise the North of Bens Lake and South of Bens Lake Design Areas.

Figure 2.3
North and East Project Area



North of Bens Lake Design Area

The North of Bens Lake Design Area comprises facilities north of the Bens Lake Compressor Station up to the Meikle River Compressor Station.

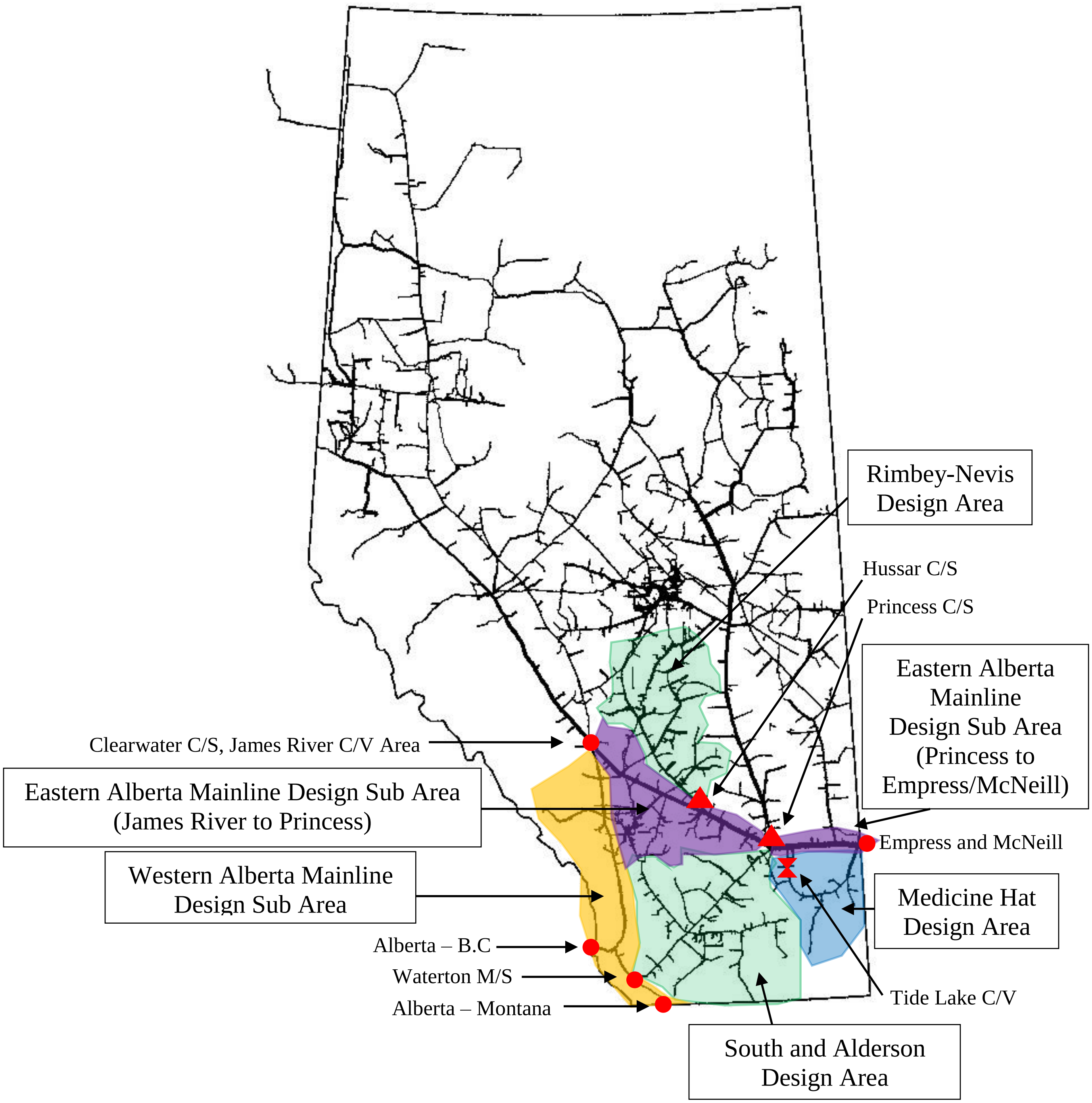
South of Bens Lake Design Area

The South of Bens Lake Design Area comprises facilities north of the Princess Compressor Station and former Cavendish Compressor Station site up to the Bens Lake Compressor Station.

2.4 Mainline Project Area

The Mainline Project Area (Figure 2.4) comprises the Mainline Design Area, the Rimbey-Nevis Design Area, the South and Alderson Design Area and the Medicine Hat Design Area.

Figure 2.4
Mainline Project Area



Mainline Design Area

The Mainline Design Area comprises three design sub areas: the Eastern Alberta Mainline Design Sub Area (James River to Princess); the Eastern Alberta Mainline Design Sub Area (Princess to Empress/McNeill); and the Western Alberta Mainline Design Sub Area.

Eastern Alberta Mainline Design Sub Areas

The Eastern Alberta Mainline Design Area comprises two sections, James River to Princess and Princess to Empress/McNeill. The James River to Princess section comprises facilities from the James River Control Valve to the Princess Compressor Station. The Princess to Empress/McNeill section comprises facilities from the Princess Compressor Station to the Empress and McNeill Export Delivery Points.

Western Alberta Mainline Design Sub Area

The Western Alberta Mainline Design Sub Area comprises facilities from the James River Control Valve to the Alberta-British Columbia Export and the Alberta-Montana Delivery Points.

Rimbey-Nevis Design Area

The Rimbey-Nevis Design Area comprises facilities north of the Hussar Compressor Station up to the city of Edmonton.

South and Alderson Design Area

The South and Alderson Design Area comprises facilities from the Princess Compressor Station to the Waterton Meter Stations.

Medicine Hat Design Area

The Medicine Hat Design Area comprises facilities south the Tide Lake Control Valve and south (upstream) of the Empress and McNeill Export Delivery Point.

2.5 Delivery Design Area (DDA)

The NGTL System is also divided into five delivery design areas (Figure 2.5). The delivery design areas have special significance to the transfer of FT-D service as described in Rate Schedule FT-D Firm Transportation - Delivery of NGTL's Gas Transportation Tariff.

(i) the Northwest Alberta and Northeast B.C. Area;

(ii) the Northeast Alberta Area;

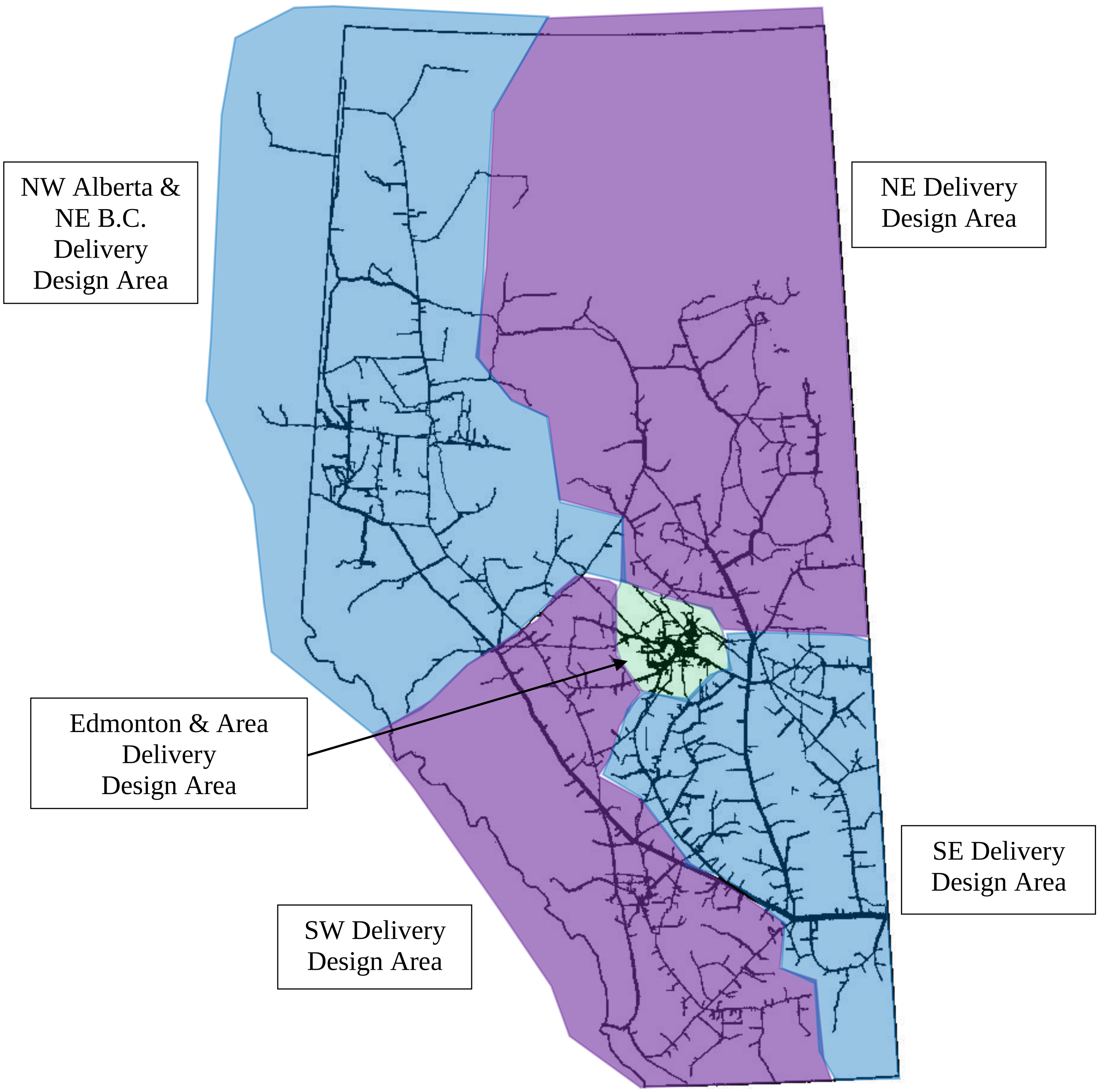
(iii) the Southwest Alberta Area;

(iv) the Southeast Alberta Area; and

(v) Edmonton and Area.

Figure 2.5

Delivery Design Areas



3 BASIS FOR DESIGN FLOW DETERMINATION

The following sections describe the design flow methodology used throughout the NGTL System to size various facilities to meet Customer requirements.

3.1 Receipt Meter Station Design Methodology

The design of new receipt meter stations is based on the methodology that the highest possible flow through the receipt meter station will be the lesser of the aggregate Receipt Contract Demand under firm transportation Service Agreements for all Customers at the meter station or the capability of upstream producer facilities.

3.2 Receipt Extension Facilities Design Methodology

Extension facilities for receipts are designed to transport peak expected flow (Section 4.4. 2 taking into consideration Receipt Contract Demand under firm transportation Service Agreements and the extension facilities criteria as described in the Guidelines for New Facilities shown in Table 3.2.

Table 3.2
Extension Facilities Criteria

NGTL Builds (Owns/Operates)
Facilities to serve aggregate forecast as per Annual Plan process
Facilities greater than or equal to 305 mm (12 inches) in diameter
Facilities greater than 20 kilometers (12.4 miles) in length
Volumes greater than 2.8 $10^6 m^3/d$ (100 MMcf/d)

Peak expected flow at specific receipt points (field deliverability) is based on an assessment of reserves, flow capability, future supply development and the capability of upstream gathering and processing facilities at each receipt meter station on the extension facility.

This design methodology recognizes and accommodates the potential for Customers to maximize peak expected flow from a small area of the NGTL System. In NGTL's assessment of facility alternatives to accommodate peak expected flow, a number of facility configurations are considered which may include future facilities. The assessment of facility alternatives includes both NGTL and third party costs to ensure the most orderly, economic and efficient construction of combined facilities. NGTL typically selects the proposed facilities and optimal tie-in point on the basis of overall (NGTL and third party) lowest cumulative present value cost of service ("CPVCOS").

3.3 Delivery Meter Station Design Methodology

The design of new delivery meter stations is based on the methodology that the highest possible flow through the delivery meter station will be the lesser of the aggregate Delivery Contract Demand under firm transportation Service Agreements for all Customers at the meter station or the capability of facilities downstream of the meter station.

3.4 Delivery Extension Facilities Design Methodology

Delivery extension facilities are designed to transport maximum day delivery taking into consideration the extension facilities criteria as described in the Guidelines for New Facilities as shown in Table 3.2. In NGTL's assessment of facility alternatives to accommodate maximum day delivery, a number of facility configurations are considered which may include future facilities. NGTL's assessment of facility alternatives includes both NGTL and third party costs to ensure the most orderly, economic and efficient construction of combined facilities. NGTL typically selects the proposed facilities and optimal tie-in point on the basis of overall (NGTL and third party) lowest CPVCOS.

3.5 Mainline Facilities Flow Determination

The Mainline facilities flow determination is based on the receipt and delivery forecasts as described in section 4.4.

In each periodic design review, the facilities necessary to provide the capability to meet future design flow requirements are identified. To ensure the facilities identified are the most economic, a minimum five-year forecast of facilities requirements is considered.

While the design of the NGTL System is affected by many interrelated factors, the following major design methodologies are currently included in determination of design flows:

- supply-demand balancing methodology;
- design area delivery methodology;
- downstream capability methodology;
- storage methodology;
- productive capability methodology; and
- maximum delivery methodology.

These methodologies are briefly described in Sections 3.5.1 to 3.5.6.

3.5.1 Supply-Demand Balancing Methodology

The NGTL System is designed to transport gas from many Receipt Points to multiple Delivery Points (Section 2). The pipeline system is designed to meet deliveries based on the general methodology that gas will be drawn on an equally prorated basis from each Receipt Point on the pipeline system. If gas is nominated in a manner that differs from the pattern assumed in the system design, delivery shortfalls may occur.

The supply-demand balancing methodology is applied to situations where the total system peak day supply exceeds the total system peak day delivery requirements and results in a system design that reduces the take from all system receipt points to align with the overall system demands.

3.5.2 Design Area Delivery Methodology

In identifying facilities to transport gas within or through a design area, NGTL takes the approach that the facilities must be capable of transporting the highest required flow into or out of that area. This is accomplished using the design area delivery methodology, which considers the following key factors:

- delivery requirements within the design area;
- delivery requirements outside the design area; and
- delivery requirements at the major Export Delivery Points.

This methodology is periodically reviewed to ensure load conditions that are likely to occur under system operations are reflected in the system design.

The design area delivery methodologies relied upon for the design review process for each design area are described in Table 3.5.2.

Table 3.5.2

Design Area Delivery Methodologies

Design Area	Prevailing Design Season	Winter[1]	Summer[1]
• Peace River (including Upper, Central & Lower Design Sub Areas)			
• Flow Through	Winter	Min u/s James[2]/Max/Max	Min u/s James[2]/Max/Max
• Flow Within	Winter[4]	Max/Max/Min	Max/Max/Min
• Marten Hills	Summer	Min u/s James[2]/Avg/Max	Min u/s James[2]/Max/Max
• North and East Project Area (North and South of Bens Lake Design Areas)			
• Flow Through	Summer	Min[3]/Avg/Max	Min[3]/Max/Max
• Flow Within	Winter[4]	Max Area Delivery	Max Area Delivery
• Mainline	Summer	Min u/s James[2]/Avg/Max	Min u/s James[2]/Max/Max
• Rimbey Nevis			
• Flow Through	Summer	Min/Avg/Max	Min/Max/Max
• Flow Within	Winter[4]	Max Area Delivery	Max Area Delivery
• South and Alderson	Summer	Min/Avg/Max	Min/Max/Max
• Medicine Hat			
• Flow Through	Summer	Min/Avg/Max	Min/Max/Max
• Flow Within	Winter[4]	Max Area Delivery	Max Area Delivery

NOTES:

1 Demand within design area/Intra-basin demand outside design area /Export Delivery Points.
2 u/s James = upstream James River Interchange.
3 Total North and East Project Area.
4 Seasonally Adjusted Receipt Flow Conditions.

Min = minimum Avg = average Max = maximum

Certain Design Areas have two distinct flow conditions that are examined in assessing facilities requirements. First, there is the "flow through" condition. The "flow through" design condition occurs when the receipts are at the peak expected volume and the deliveries are at a seasonal minimum volume. Second, there is the "flow within" condition that is governed by the maximum day delivery and seasonal available supply within the area. The "flow within" design condition occurs when the receipts are at a seasonal low volume and the deliveries are at a seasonal maximum volume.

For example, in the Peace River Design Area, the "flow through" condition in the winter season currently governs facility requirements. A Min upstream James/Max/Max design flow methodology is applied to generate design flow requirements. The Min upstream James/Max/Max design flow condition assumes that the Delivery Points upstream of the James River Interchange are at their minimum day delivery values, while the Delivery Points elsewhere on the system and the major Export Delivery Points are at their maximum day delivery values.

By contrast, the "flow within" condition in the winter season currently governs facility requirements in the North and East Project Area. Seasonally adjusted minimum receipts and maximum area deliveries are the most appropriate conditions to describe the constraining design.

NGTL reviews delivery patterns for each design area. These reviews show that while individual Delivery Points will require maximum day delivery, the probability that all Delivery Points will require maximum day delivery simultaneously is extremely low. To account for this, a factor, called the demand coincidence factor, was applied to decrease the forecast maximum day delivery for the aggregate of all the Delivery Points within each design area to a value more indicative of the forecast peak day deliveries. Similarly, demand coincidence factors were determined and applied to increase the aggregate minimum day delivery values at Delivery Points within each design area to be more indicative of the expected minimum day delivery.

3.5.3 Downstream Capability Methodology

The system design is based on the methodology that the maximum day delivery at the Delivery Points will not exceed the lesser of the capability of the downstream pipeline or the aggregate of the firm transportation Service Agreements associated with those Delivery Points. Downstream capability is determined through ongoing dialogue with downstream pipeline operators.

3.5.4 Storage Methodology

The Storage Facilities connected to the NGTL System at the AECO ‘C’, Big Eddy, Carbon, Chancellor, Crossfield East, January Creek, Rat Creek West, Severn Creek, and Warwick Southeast Storage Meter Stations are shown in Figure 3.5.4. Maximum receipt meter capabilities for Storage Facilities are presented in the Annual Plan Section 1.6.

For facility planning purposes it is assumed that:

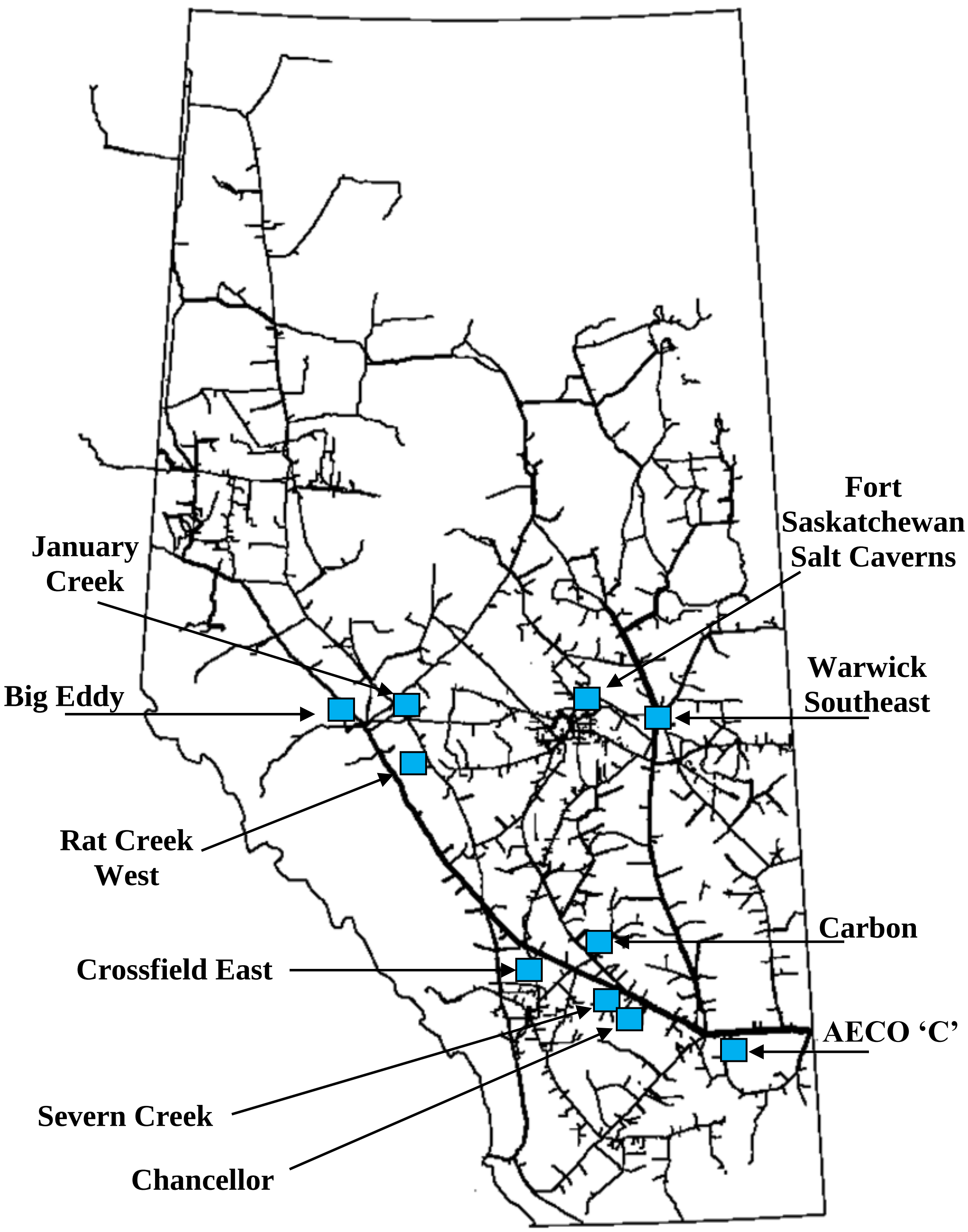
- For the winter period, system design flow requirements will include receipt volumes from selected Storage Facilities onto the NGTL System at approximately average historical withdrawal levels.

  This methodology recognizes the supply contribution from Storage Facilities to meet peak day winter delivery requirements and provide for a better correlation between forecast design flow requirements and historical actual flows for the winter period. Volumes withdrawn from the Storage Facilities will be considered as interruptible flows, but will be incorporated into the flow analysis within all design areas where it may lead to a reduction in the design flow requirements and a potential reduction in additional mainline facilities.

- For the summer period, system design flow requirements will not include delivery volumes from the NGTL System into Storage Facilities. Consequently, for the purpose of calculating design flow requirements, volumes injected into the Storage Facilities will be considered to be interruptible flows and will therefore not be reflected in the design of mainline facilities.

Figure 3.5.4

Location of Storage Facilities on the NGTL System



3.5.5 Productive Capability Methodology

In areas where gas is drawn from a small collection of Receipt Points, there is a greater likelihood that the peak expected flow will be required simultaneously from all such Receipt Points than is the case when gas is drawn from an area having a large number of Receipt Points. As a result, the system design for those areas with a small collection of Receipt Points, usually at the extremities of the system, is based on the methodology that the system must be capable of simultaneously receiving the aggregate of the peak expected flow from each Receipt Point. However, when the productive capability methodology is applied to any collection of Receipt Points, the flows from the other areas upstream of a common point are reduced such that the supply-demand balancing methodology (Section 3.5.1) is maintained through that common point. This results in the system upstream of the common point being designed to match the capability of the system downstream of the common point.

3.5.6 Maximum Delivery Methodology

In areas where gas is supplied to a small collection of Delivery Points, there is a greater likelihood that the maximum delivery flow will be required simultaneously at all such Delivery Points than is the case when gas is supplied to an area having a large number of Delivery Points. Areas dominated by temperature-sensitive demand also have a greater likelihood of simultaneous maximum delivery flow to their Delivery Points. As a result, the system design for those areas is based on the methodology that the system must be capable of simultaneously delivering the aggregate maximum delivery flow to each Delivery Point.

3.6 Maintaining Required Flow Levels

The design of the NGTL System is based on the methodology that facilities comprising the system are in-service and operating. However, facilities are not 100 percent reliable and are not always available for service. Facilities will experience scheduled down-time for regular maintenance and will also experience occasional unscheduled down-time. This may impact the ability to maintain required flow levels.

3.7 System Optimization

System optimization has been and will continue to be an integral part of the overall system design process. The NGTL System is optimized to reduce operating and maintenance costs without adversely affecting throughput. The intent is to maximize volumes on the system in order to minimize rates. Accordingly, cost reduction initiatives are not intended to reduce system volumes. The identification of compressor units and/or pipe that should be removed from service or replaced continues to be an integral part of the overall system design.

4 TRANSPORTATION DESIGN PROCESS

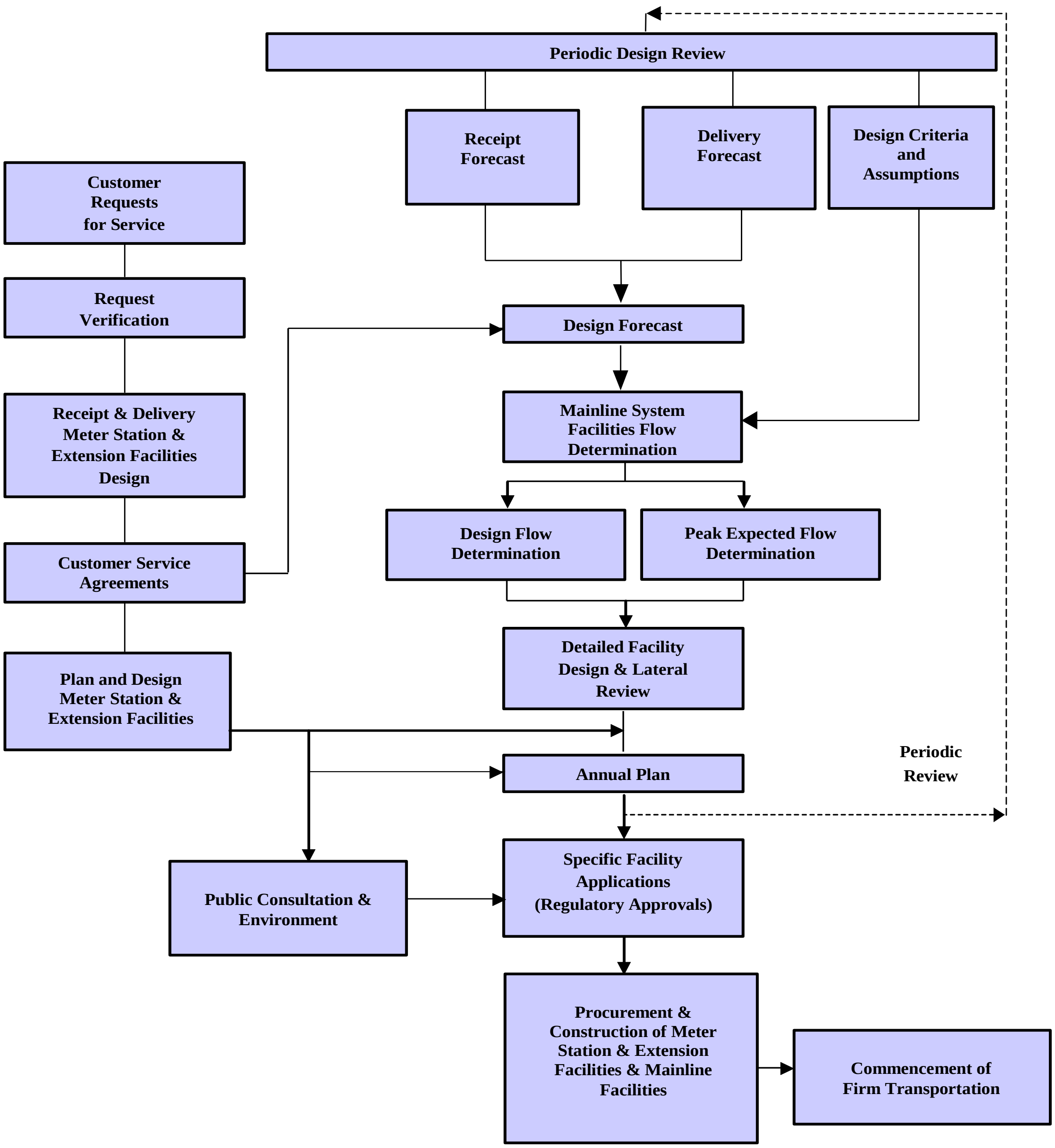
Periodic design reviews are conducted throughout the year to closely monitor industry activity and respond to Customer requirements for firm transportation on a timely basis.

The following is a brief overview of the significant activities involved in the facility design process. While Receipt Points, Delivery Points and extension facilities are designed as part of the transportation design process, the construction of these facilities may take place independently of the construction of mainline facilities.

The activities relating to the transportation design process are described below and are shown in the process flow chart included as Figure 4. Although activities have been grouped in distinct phases, some of the activities occur concurrently.

Figure 4

Facility Design Process



4.1 Customer Request Phase

Requests for firm transportation are received by NGTL and included in the transportation design process.

Requests for firm transportation are reviewed through this process and categorized as requiring new facilities, requiring expansion of existing facilities, or not requiring either new facilities or expansion of existing facilities. Each category of receipt and delivery facility is treated somewhat differently in the following phases of the design process.

4.2 New Meter Station and Extension Facilities Design

NGTL proceeds with the design of new meter stations and extension facilities to meet Customers' requirements for those requests for firm transportation that remain after the initial review process and are consistent with the Guidelines for New Facilities.

NGTL, with significant input from Customers, has established economic criteria that must be met prior to receipt meter stations being constructed. The criteria are described in Appendix E of NGTL's Gas Transportation Tariff entitled *Criteria for Determining Primary Term*.

For delivery meter stations, the term of service is described in Rate Schedule FT-D Firm Transportation - Delivery of NGTL's Gas Transportation Tariff.

In the design of new extension facilities, the receipt or delivery volume and location of each new facility is identified. In the case of receipt facilities, a review is undertaken of the reserves that are identified as supporting each new extension facility to ensure the Receipt Point peak expected flow for the area can be accommodated. In the case of delivery facilities, a review is undertaken to establish the forecast demand levels that are identified for each new extension facility to ensure the maximum day delivery for the area can be accommodated. Hydraulic and economic analyses are also conducted, using the design methodologies for new meter station and extension facilities described in Section 3.1 through Section 3.4.

Once the design is completed and construction costs estimated, Project and Expenditure Authorizations for new receipt and delivery meter stations and related Service Agreements are prepared and forwarded to Customers for authorization.

4.3 Existing Meter Station Design

Concurrent with the design of new meter stations and extension facilities (Section 4.2), NGTL proceeds with the identification of new metering requirements and lateral capacity constraints associated with incremental firm transportation requests at existing Receipt and Delivery Points. If no new facilities are required, Customers requesting Service are asked to execute firm transportation Service Agreements. Where additional metering is identified as being required, construction costs are estimated, and Project and Expenditure Authorizations and related Service Agreements are prepared and forwarded to Customers for authorization. When a lateral capacity constraint is identified, a review of the area peak expected flow is undertaken to determine potential looping requirements. Lateral loops are designed in conjunction with the design of mainline facilities.

4.4 Design Forecast Methodology

As shown in Figure 4, the transportation design process involves the preparation of a design forecast. The design forecast is a projection of anticipated peak expected flow, average receipts, and delivery requirements on the NGTL System, and plays an essential role in the determination of future facility requirements and planning capital expenditures.

The design forecast comprises the forecast of peak expected flow at each Receipt Point, the average receipt forecast and the gas delivery forecast. The following sections describe these forecasts and the methods by which they are developed.

4.4.1 Average Receipt Forecast

Average receipt is the forecast of the annual average volume expected to be received onto the pipeline system at each Receipt Point. The Annual Plan Section 1.4 presents the forecast of average receipts within the three main Project Areas on the NGTL System.

NGTL forecasts average expected flow through an assessment of reserves, flow capability and future supply development. NGTL determines this information based on data gathered from government sources, Canadian Gas Potential Committee studies, and through interaction with producers and Customers active in the area.

4.4.2 Peak Expected Flow Forecast

In order to predict peak expected flows a peaking factor is applied to the average receipt forecast to yield a more realistic design condition. The peaking factor is derived from an analysis of historical coincidental peak to average flow observed within the design areas over a number of gas years. In areas with new receipt production, existing and requested firm service contracts are also taken into consideration.

4.4.3 Gas Delivery Forecast

Delivery forecasts for each Delivery Point and each Export Delivery Point are developed. Each forecast includes average annual delivery as well as average, maximum and minimum delivery for both the winter and summer seasons. These seasonal conditions are used in the transportation design process to meet firm transportation delivery requirements over a broad range of operating conditions. The gas delivery forecast is reported in detail in the Annual Plan Section 1.3.

The development of the gas delivery forecast draws upon historical data and a wide variety of information sources, including general economic indicators and growth trends. These gas forecasts are augmented by analysis of each end use market.

A consideration in developing the maximum day gas delivery forecast for Export Delivery Points is the forecast of new firm transportation Service Agreements. Firm transportation Service Agreements (new Service Agreements or renewals of expiring Service Agreements) are assumed to be authorized at each major Export Delivery Point to a level based on the average annual delivery forecast and historical data. The average annual delivery forecast is developed through consideration of Customer requests for firm transportation and from NGTL's market analysis. NGTL's market analysis considers market growth, the competitiveness of Western Canada Sedimentary Basin gas within the various markets and a general assessment of the North American gas supply and demand outlook (Annual Plan Section 1.2).

The key component to the development of the delivery forecast is the assessment of economic development by market sectors within the province. The potential for additional electrical, industrial and petrochemical plants, oil sands, heavy oil exploitation, miscible flood projects, new natural gas liquids extraction facilities and residential/commercial space heating is evaluated. Each year, NGTL also surveys large industrial and local distribution customers who receive gas from the NGTL System regarding their forecast of gas requirements for the next several years.

5 MAINLINE DESIGN PHASE

The detailed mainline hydraulic design is completed using the Design Forecast and the mainline facilities design methodologies described in Section 3.5 as well as system optimization described in Section 3.7. Computer simulations of the pipeline system are performed to identify the facilities that would be required to meet firm and peak transportation expectations.

The following guidelines are used in assessing and determining the facilities requirements in the Annual Plan.

5.1 Flow Equation

The input parameters for the flow equation used for hydraulic simulations are based on the characteristics of the NGTL System. These parameters include friction and efficiency factors.

Friction factors are determined using the Smooth Pipe/Rough Pipe friction factor calculation method. In high-pressure gas transmission lines, such as the NGTL System, two types of flow regimes can be observed: fully turbulent flow or Rough Pipe Flow and partially turbulent flow or Smooth Pipe Flow. The flow regime is determined by the Reynolds Number which is a function of gas density, velocity, viscosity and pipe diameter. The Smooth Pipe/Rough Pipe calculation method makes friction factor dependent on Reynolds Number in Smooth Pipe Flow and surface roughness dependent in Rough Pipe Flow. The assumption used for pipe surface roughness is generally 19.05 micro meters or 750 micro inches for internally uncoated pipes and 6.35 micro meters or 250 micro inches for internally coated pipes.

The reduced friction resulting from internally coating pipes can improve their performance. Studies have shown that on pipes larger than 914 mm (30 inches) in diameter, the cost benefit provided by internal coating outweighs the added cost of its application. A guideline of applying internal coating to new NGTL pipelines greater than 914 mm (30 inches) inches in diameter is used.

Efficiency factors for all pipes are set at 100% unless measured data indicates differently. In these cases, studies are conducted to tune the efficiency factors of these pipe segments to better match measured data.

5.2 Maximum Operating Pressure

A higher maximum operating pressure ("MOP") results in a more efficient system. It is possible to consider more than one MOP when reviewing the long term expansion of the pipeline system. If the expansion is such that a complete looping of an existing pipeline is likely within a few years, then it may be appropriate to consider developing a high-pressure line that will eventually be isolated from the existing system.

5.3 Temperature Parameters

Pipeline design requires that reasonable estimates be made for ambient air and ground temperatures. These parameters influence the design in the following areas:

- power requirements for compressors;
- cooling requirements at compressor stations; and
- pressure drop calculations in pipes.

Winter and summer design ambient temperatures are determined using historical daily temperatures from Environment Canada at a number of representative locations. An interpolation/extrapolation method was used to calculate the peak day ambient temperature for pipeline sections within each design area.

5.4 Pipe Size and Compression Requirements

A combination of pipe and compression facilities is reviewed to meet the design flow requirements. The possible combinations are almost unlimited so guidelines have been developed based upon experience and engineering judgment to assist in determining pipe size and compression requirements.

Experience has shown that the pressure drop along the mainline system should be within a range of approximately 15 to 35 kPa/km (3.5 to 8.0 psi/mile) of pipe. Above this range, compressor power requirements become excessive because of high friction losses, and pipeline loop usually becomes more economical than adding compression.

In addition, experience has also shown that generally it is advantageous to provide for a loop with a diameter at least as large as the largest existing line being looped. As a guide to selecting loop length, the loop should extend between two existing block valves where possible, thus minimizing system outages and impact from failures. In cases where design flow requirements are projected to increase, it is usually cost effective to add loop in a manner that will ensure that no additional loop will be required in the same area in the near future.

There is some flexibility in the location of compressor stations when new compression is required. Shifting the location changes the pressure at the inlet to the station and, hence, the compression ratio (i.e., the ratio of outlet pressure to inlet pressure). Capital costs, fuel costs, and environmental and public concerns are also key factors in selecting compressor station location.

5.5 Selection of Proposed and Alternative Facilities

Various alternatives are identified when combinations of the facility configurations and optimization parameters are considered. This process requires a careful evaluation of alternative designs to select those appropriate for further study.

Facilities that are most likely to meet future gas flows and minimize the long term cost of service are considered. As well, when appropriate, Transportation By Others (TBO) or purchase of existing other party facilities, are considered as an alternative to constructing facilities.

The process to identify the potential for facilities requirements begins with the generation of design flow and peak expected flow requirements (Annual Plan Section 2). Then, design capabilities on the system are determined to identify where capability restrictions will occur. Pipe sizes, MOP and routings, as well as compressor station sizes and locations are evaluated as part of alternative solutions to eliminate these capability restrictions.

The capital cost of each reasonable alternative is then estimated. Rule of thumb costing guidelines are established at the beginning of the process. These guidelines take the form of cost per kilometer of pipeline and cost per unit type of compression and are based on the latest actual construction costs experienced by NGTL. Adjustments may be made for exceptions (i.e., winter/summer construction, location, and river crossings) that significantly impact these rule of thumb costing guidelines.

The results of the preliminary hydraulics and rule of thumb costs are compared and the best alternatives are given further study.

Simulations of gas flows on the NGTL System are performed for future years to determine when each new compressor station or section of loop should be installed and to establish the incremental power required at each station. Additional hydraulic flow simulations beyond the design period are performed for each remaining alternative to further define the location and size of compressor stations and loops.

Once the requirement for facilities in each year is determined, hydraulic flow simulations are performed based on seasonal average flows for each of the future years to determine compressor fuel usage, annual fuel, and operating and maintenance costs for each facility.

Next, detailed capital cost estimates for new facilities are determined to further improve upon the assessment of alternatives. Where appropriate, the alternatives include the use of standard compressor station designs which are incorporated into the cost estimates. These capital cost estimates reflect the best available information regarding the cost of labour and materials based on the preliminary project scope and also consider land and environmental constraints that may affect project timing and costs.

In reviewing capital, fuel, operating and maintenance costs, it is possible that some alternatives will have higher costs in all of these categories than other alternatives. The higher cost alternatives are eliminated from further consideration.

The annual cost of service, based on capital and operating cost estimates, is determined for each remaining alternative. This calculation includes annual fuel costs, capital costs escalated to the in-service date, annual operating costs, municipal and income taxes, return on investment and depreciation. The present value of each of the annual cost of service calculations are determined and then summed to calculate the CPVCOS for each alternative.

The proposed facilities are usually selected on the basis of lowest CPVCOS and lowest first year capital cost. However, a number of alternatives may be comparable when these costs are considered. For practical purposes, when these alternatives are essentially equal based on financial analyses, other relevant factors including operability of the facilities, environmental considerations and land access may more heavily influence alternative selections.