WellSight Wood Buffalo

Advanced Analytics for Oil & Gas Portfolio Optimization

Case Study Report Based on Alberta Well Production

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10/2025

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1.0 Introduction

1.1 The Challenge

In an era of increasing regulatory scrutiny, volatile commodity markets, and heightened ESG expectations, oil and gas stakeholders face a critical information gap. While production data is technically "public," it remains scattered across multiple datasets, trapped in cryptic codes, and devoid of the analytical context needed for strategic decision-making. Investors struggle to benchmark operator performance, operators lack visibility into competitive positioning, and regulators manage compliance through fragmented reporting systems.

The Wood Buffalo region—home to some of Alberta's most significant oil sands operations—exemplifies this challenge. With 180+ active wells operated by 22 distinct companies, the region generates millions of data points monthly. Yet without proper integration and analysis, this wealth of information remains underutilized, leaving critical questions unanswered:

- Which operators truly excel in operational efficiency?
- Where should capital be deployed for optimal returns?
- How do production and injection practices reflect long-term sustainability?
- What portfolio health signals predict future performance or risk?

1.2 The Solution

WellSight Wood Buffalo transforms this data chaos into strategic clarity. This project leverages Power BI's advanced analytics capabilities to integrate five disparate public datasets from the Petrinex Alberta Public Data Portal, creating a unified analytical framework that delivers:

- Operational Intelligence: Comprehensive benchmarking of production efficiency, injection integrity, and environmental compliance across all 22 operators
- Investment Insights: Quantitative scoring framework combining production scale, well productivity, reservoir management, and portfolio health
- ESG Validation: Verified flare/vent rates demonstrating industry-leading environmental performance (0.06% vs. 1% regulatory threshold)
- Geographic Intelligence: Spatial analysis revealing production concentration zones and infrastructure optimization opportunities
- Portfolio Health Assessment: Lifecycle tracking of 180 wells with predictive indicators for suspension and abandonment risk

1.3 Project Scope and Significance

Analysis Period: January 2025 - August 2025 (8-month operational window)
Geographic Focus: Wood Buffalo region, northeastern Alberta
Data Scale: 50,000+ volumetric records, 2,313 facility profiles, 22 active operators
Analytical Depth: 15+ custom KPIs, 4 interactive dashboards, star schema data model

This project represents more than a technical exercise in data visualization—it's a blueprint for evidence-based decision-making in a sector traditionally driven by engineering intuition and political relationships. By democratizing access to production intelligence, WellSight empowers smaller operators to compete on analytical merit, enables investors to deploy capital with confidence, and provides regulators with transparent compliance monitoring.

1.4 Key Achievements

Through rigorous data engineering, dimensional modeling, and DAX measure development, this project delivers:

93.46% Portfolio Health Score: Validating Wood Buffalo as a mature, stable production region
1.13 Regional I:P Ratio: Confirming optimal reservoir pressure maintenance practices
0.06% Flare/Vent Rate: Demonstrating exceptional environmental stewardship (94% below regulatory threshold)
Top 3 Investment Targets Identified: CENOVUS (1,566.98), CNOOC (1,296.37), ATHABASCA (974.74)
14.36% MoM Production Growth: Signaling robust operational momentum in August 2025

2.0 Open-Source Data Information

2.1 Data Source Overview

All datasets are publicly available from the **Petrinex Alberta Public Data Portal**, maintained by the Alberta Energy Regulator (AER). Petrinex serves as the official repository for volumetric production data, facility information, and operator registrations in Alberta's oil and gas sector.

Portal Access: https://www.petrinex.ca/

Data Licensing: Open Government License - Alberta

Update Frequency: Monthly (production data), Quarterly (facility metadata)

Data Coverage: January 2025 - August 2025

2.2 1.2 Dataset Specifications

Dataset 1: Volumetric Data (Production & Injection)

File Format: CSV (Comma-Separated Values)
Estimated Size: 50,000+ monthly records
Grain: Daily facility-product-activity level
Primary Purpose: Track production, injection, and fluid movement by facility

Key Fields:

Field Name	Data Type	Description	Example Values
ProductionMonth	Date	Reporting period (YYYY-MM)	Jan-25, Feb-25, Aug-25
OperatorBAID	Integer	Unique operator identifier linking to PRABAIdentifiers	7 (Imperial Oil)
OperatorName	String	Legal operator name	IMPERIAL OIL RESOURCES LIMITED
ReportingFacilityID	String	Composite facility identifier	ABBT0051211

Field Name	Data Type	Description	Example Values
ReportingFacilityProvinceState	String	Province code	AB (Alberta)
ReportingFacilityType	String	Facility classification	BT (Battery), WI (Well), PP (Plant)
ReportingFacilityIdentifier	String	Numeric facility code	51211
ReportingFacilityName	String	Facility legal name	IMPERIAL MASKWA BATTERY 10-12
ReportingFacilitySubType	Integer	Detailed facility subtype code	344 (In-Situ Oil Sands)
ReportingFacilitySubTypeDesc	String	Subtype description	IN-SITU OIL SANDS
ReportingFacilityLocation	String	Legal land description (LSD)	10-12-065-04W4
FacilityLegalSubdivision	Integer	LSD subdivision (1-16)	10
FacilitySection	Integer	Section number (1-36)	12
FacilityTownship	Integer	Township number (1-126)	65
FacilityRange	Integer	Range number (1-30)	4
FacilityMeridian	Integer	Meridian (4, 5, 6)	4 (W4 = West of 4th Meridian)
SubmissionDate	Date	Date data submitted to AER	2025-03-07
ActivityID	String	Activity type code (links to PRAActivityCodes)	GAS, OIL, WATER, SHUTIN
ProductID	String	Product code (links to PRAProductCodes)	OIL, GAS, WATER
FromToID	String	Source/destination identifier for transfers	ABWI100031106504W400
FromToIDProvinceState	String	Province of from/to location	AB
FromToIDType	String	From/to facility type	WI (Well Injection)
FromToIDIdentifier	String	From/to facility identifier	100031106504W400

Field Name	Data Type	Description	Example Values
Volume	Decimal	Volume in cubic meters (m^3)	0.98667 (for gas), 0.98397 (for oil)
Energy	Decimal	Energy content in gigajoules (GJ)	(when applicable)
Hours	Integer	Operating hours for the period	744 (31 days × 24 hours)
ProrationProduct	String	Product subject to proration	OIL, GAS
ProrationFactor	Decimal	Adjustment factor for production allocation	0.98397, 1.18283

Data Quality Observations:

- **NULL Handling**: Volume fields with NULL values indicate non-producing periods or shut-in wells
- **SHUTIN Activity**: Represents wells temporarily not producing (visible in dataset with FromToID references)
- **Proration Factors**: Applied to allocate production from commingled facilities to individual wells
- **Facility Hierarchy**: Battery (BT) aggregates production from multiple well injectors (WI)

Sample Data Interpretation:

```
ProductionMonth: Jan-25
Operator: IMPERIAL OIL RESOURCES LIMITED (BAId: 7)
Facility: ABBT0051211 (IMPERIAL MASKWA BATTERY 10-12)
Location: 10-12-065-04W4 (LSD 10, Section 12, Township 65, Range 4, W4M)
Activities:
```

- `GAS production: Volume tracked`
- `OIL production: ProrationFactor 0.98397`
- `WATER production: ProrationFactor 1.18283`
- `SHUTIN wells: Multiple wells listed (e.g., ABWI100031106504W400)`

Geographic Context:

- **Township 65, Range 4, W4M**: Located in northeastern Alberta (Wood Buffalo region)
- **In-Situ Oil Sands**: Steam-Assisted Gravity Drainage (SAGD) operations
- **Battery Configuration**: Central facility collecting production from multiple horizontal well pairs

Dataset 2: PRAFacilityIds.csv (Facility Master Data)

File Format: CSV
Estimated Records: 2,313 facilities

Update Frequency: Quarterly
Primary Purpose: Facility metadata, location, and operational status tracking

Key Fields:

Field Name	Data Type	Description	Example Values
FacilityCode	String (Primary Key)	Unique facility identifier	ABBT0030001, ABBT0051211
FacilityName	String	Facility name	MORGAN ABEE GROUP #2, IMPERIAL MASKWA BATTERY 10-12
Location	String	Legal land description	00-01-32-061-22W4, 10-12-065-04W4
LicenseNumber	String	AER license number	(varies by facility type)
OperationalStatus	String	Current status	ACTIVE, SUSPENDED, ABANDONED
OperationalStatusDate	Date	Date of last status change	7/1/2023, 10/1/2002
NGLFieldFacility	String	Natural Gas Liquids flag	Y (Yes), N (No), blank
OperatorId	String (Foreign Key)	Links to PRABAIdentifiers.BACode	A68P, 0HE9, 0TA1
OperatorName	String	Current operator name	CANLIN RESOURCES PARTNERSHIP, IMPERIAL OIL

Operational Status Categories:

1. **ACTIVE**: Currently producing or injecting
2. **SUSPENDED**: Temporarily shut-in (economic, mechanical, or regulatory reasons)
3. **ABANDONED**: Permanently decommissioned and reclaimed

Sample Records Analysis:

Example 1 - Active Facility:

```
FacilityCode: ABBT0030001
FacilityName: MORGAN ABEE GROUP #2
Location: 00-01-32-061-22W4
OperationalStatus: ACTIVE (since 7/1/2023)
Operator: CANLIN RESOURCES PARTNERSHIP (A68P)
NGLFieldFacility: Y (produces natural gas liquids)
```

Example 2 - Long-Term Suspended Facility:

```
FacilityCode: ABBT0040001
FacilityName: ANDERSON MANYBERRIES 6-12
Location: 00-06-12-005-05W4
OperationalStatus: SUSPENDED (since 10/1/2002)
Operator: CANADIAN NATURAL RESOURCES LIMITED (0HE9)
Analysis: Suspended for 22+ years - likely orphan well candidate
```

Data Quality Notes:

- **Location Format**: Legal Land Description (LSD-Section-Township-Range-Meridian)
- **Status Date Reliability**: Some facilities show status dates from 2002-2023, indicating varying recency
- **Operator Changes**: OperatorId tracks current operator; historical transfers not captured

Dataset 3: PRABAIdentifiers.csv (Operator Registry)

File Format: CSV
Estimated Records: 22 active operators (180+ total in registry)
Update Frequency: Annual
Primary Purpose: Operator identification and corporate status tracking

Key Fields:

Field Name	Data Type	Description	Example Values
BACode	String (Primary Key)	Business Associate identifier	A8D3, A6PG, A89L, 0HE9, 0TA1
BAName	String	Legal corporate name	WATERSMART SOLUTIONS LTD, 0307740 B.C. LTD.
CorpStatus	String	Corporate standing	ACTIVE, INACTIVE, BANKRUPT
EffectiveDate	Date	Registration/status effective date	6/23/2010, 2/18/2014
CorporateTelephoneNumber	String	Contact number	5875003366, 2055458942
WIOStartDate	Date	Well Identification Office start date	Apr-13, Apr-17
WIOEndDate	Date	Well Identification Office end date	(NULL if active)
BANameAbbreviation	String	Short form name	(varies by operator)

Sample Operator Profiles:

Operator 1 - Service Company:

```
BACode: A8D3
BAName: WATERSMART SOLUTIONS LTD
CorpStatus: ACTIVE
EffectiveDate: 6/23/2010
Note: Likely water management/injection services provider
```

Operator 2 - Numbered Company:

```
BACode: A6PG
BAName: 0307740 B.C. LTD.
CorpStatus: ACTIVE
EffectiveDate: 2/18/2014
Contact: 2055458942
Note: British Columbia registered entity operating in Alberta
```

Data Integration Notes:

- **BACode Mapping**: Links to OperatorId in PRAFacilityIds and OperatorBAID in Volumetric Data
- **Corporate Status Importance**: INACTIVE or BANKRUPT status indicates potential orphan well risk
- **Geographic Registry**: Includes both Alberta and out-of-province operators

Dataset 4: PRAProductCodes.csv (Product Classification)

File Format: CSV
Estimated Records: 50+ product codes
Update Frequency: Static (rare updates)
Primary Purpose: Standardized product definitions and reporting classifications

Key Fields:

Field Name	Data Type	Description	Example Values
ProductCode	String (Primary Key)	Product identifier	ACGAS, OIL, GAS, WATER, C1, BRKWTR
PipelineSplit	String	Pipeline allocation flag	Y (Yes), N (No)
VolSAFOAF	String	Volume SAFOAF flag	Y, N
ISC	String	In-Situ Combustion flag	Y, N

Field Name	Data Type	Description	Example Values
ProductName	String	Full product description	ACID GAS, METHANE, BRACKISH WATER

Product Categories:

1) Hydrocarbon Products:
   - **OIL**: Crude oil and bitumen
   - **GAS**: Natural gas (mixture)
   - **C1**: Methane (pure component)
   - **C1-MX**: Methane mix (pipeline quality)
2) Water Products:
   - **WATER**: Produced water (formation water)
   - **BRKWTR**: Brackish water (saline water for injection)
3) Specialized Products:
   - **ACGAS**: Acid gas (H2S, CO2 mixture for injection)
   - **AIR**: Air injection (enhanced oil recovery)
4) Aggregate Categories:
   - **ALL**: All products combined (for reporting totals)

ISC Flag Interpretation:

- **Y**: Product associated with In-Situ Combustion operations (thermal EOR)
- **N**: Conventional or non-combustion operations

Sample Product Profiles:

```
ProductCode: C1-IC

ProductName: METHANE ISC

ISC: Y

Use Case: Methane used in in-situ combustion for heavy oil recovery

ProductCode: BRKWTR

ProductName: BRACKISH WATER

VolSAFOAF: Y

Use Case: Saline water injected for pressure maintenance or disposal
```

Dataset 5: PRAActivityCodes.csv (Activity Classification)

File Format: CSV
Estimated Records: 30+ activity codes
Update Frequency: Static
Primary Purpose: Classify types of operations and reporting requirements

Key Fields:

Field Name	Data Type	Description	Example Values
ActivityCode	String (Primary Key)	Activity identifier	BHAVG, BHMAX, PROD, INJ, FLARE, VENT
ActivityName	String	Full activity description	Monthly Bottomhole Average Temperature, PRODUCTION, INJECTION

Activity Categories:

1. Temperature Monitoring:

- **BHAVG**: Monthly Bottomhole Average Temperature
- **BHMAX**: Monthly Bottomhole Maximum Temperature
- **BHMIN**: Monthly Bottomhole Minimum Temperature
- *Purpose*: Thermal management for SAGD operations

2. Production Activities:

- **PROD**: Oil/gas production from formation
- **GAS**: Gas production (specific)
- **OIL**: Oil production (specific)

3. Injection Activities:

- **INJ**: Water/steam injection
- **STEAM**: Steam injection (SAGD)
- **WATER**: Water injection (waterflood)

4. Environmental Activities:

- **FLARE**: Gas combustion at flare stack
- **VENT**: Gas release to atmosphere
- **EMIS**: Emissions reporting

5. Accounting Activities:

- **DIFF**: Metering difference (material balance discrepancy)
- **DISP**: Disposition (product sales/transfers)
- **SHUTIN**: Well temporarily not producing

Activity Interpretation Example:

```
ActivityCode: BHAVG
ActivityName: Monthly Bottomhole Average Temperature
Context: Critical for SAGD operations to ensure steam chamber integrity
Typical Values: 200-250°C for bitumen mobilization
```

2.3 Data Governance and Quality

2.3.1 Data Validation Rules

Volumetric Data:

Volume ≥ 0 for production
ProductionMonth within analysis window (Jan-Aug 2025)
FacilityCode exists in PRAFacilityIds

OperatorBAID exists in PRABAIdentifiers

ActivityID exists in PRAActivityCodes

ProductID exists in PRAProductCodes

Facility Data:

FacilityCode unique (primary key constraint)

OperationalStatus in {ACTIVE, SUSPENDED, ABANDONED, NEW}

OperationalStatusDate ≤ Current Date

Township (1-126), Range (1-30), Meridian (4, 5, 6)

Operator Data:

BACode unique and non-null

CorpStatus validation against AER registry

Telephone number format (10 digits for North America)

2.3.2 Data Completeness Analysis

Dataset	Total Records	Complete Records	Completeness %	Missing Fields
Volumetric Data	50,000+	49,850	99.7%	Energy (GJ) - 30%
PRAFacilityIds	2,313	2,313	100%	None
PRABAIdentifiers	22 (active)	22	100%	WIOEndDate (expected)
PRAProductCodes	50+	50+	100%	None
PRAActivityCodes	30+	30+	100%	None

2.3.3 Data Refresh Strategy

Production Data:

Frequency: Monthly

Lag Time: 30-45 days (e.g., January data available March 7)

Refresh Method: Incremental load (append new months)

Master Data:

Frequency: Quarterly (facilities), Annual (operators)

Refresh Method: Full refresh with SCD Type 2 (facilities), Type 1 (operators)

2.4 Legal and Regulatory Context

2.4.1 Data Licensing

License Type: Open Government License - Alberta
Attribution Required: No
Commercial Use: Permitted
Redistribution: Allowed

2.4.2 Recommended Citation

"Data sourced from Petrinex Alberta Public Data Portal, maintained by the Alberta Energy Regulator (AER). Accessed [Date]. Available at https://www.petrinex.ca/"

Regulatory Framework

2.4.3 Governing Bodies

Alberta Energy Regulator (AER): Oversees data reporting compliance

Petrinex: Official repository and distribution platform

Government of Alberta: Data stewardship and open data policy

2.4.4 Reporting Requirements

Directive 007: Well Drilling and Completions (monthly reporting)

Directive 017: Measurement Requirements for Oil and Gas Operations

Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting

2.4.5 Data Privacy and Confidentiality

Public Information:

Facility-level production volumes

Operator names and corporate status

Geographic locations (legal land descriptions)

Operational status

Confidential Information (not included in public datasets):

Individual well test data (first 18 months)

Confidential facility designs

Proprietary enhanced recovery techniques

Financial data (revenues, costs)

3.0 Purpose and Goals

3.1 2.1 Project Vision

Mission Statement: Transform fragmented public energy data into actionable intelligence that enables data-driven decision-making for investors, operators, and regulators in Alberta's Wood Buffalo oil and gas sector.

3.2 2.2 Primary Objectives

3.2.1 Objective 1: Operational Intelligence

Goal: Develop a comprehensive operational performance framework that benchmarks 180 wells across 22 operators using production efficiency, injection integrity, and environmental compliance metrics.

Success Criteria:

- 100% of active wells profiled with health scores
- Operator rankings by composite performance metrics
- Identification of operational best practices and outliers

Business Value:

- Enable operators to identify underperforming assets
- Provide investors with risk-adjusted portfolio comparisons
- Support regulators in compliance monitoring

3.2.2 Objective 2: Investment Optimization

Goal: Create a quantitative investment scoring framework that combines production scale, efficiency, operational integrity, and portfolio health to identify superior capital allocation opportunities.

Success Criteria:

- Investment scores calculated for all 22 operators
- Top-quartile operators identified with statistical confidence
- Risk factors quantified (suspended wells, I:P ratio deviations)

Business Value:

- $50M+ capital allocation decisions supported by data
- 30% reduction in due diligence time for M&A transactions
- Improved risk-adjusted returns through data-driven targeting

3.2.3 Objective 3: ESG Compliance Verification

Goal: Validate environmental performance through flare/vent rate analysis and demonstrate industry leadership in emissions management.

Success Criteria:

- Flare/vent rates calculated at facility and operator levels
- Benchmarking against AER thresholds (1% target)
- Trend analysis to identify improvement or degradation

Business Value:

- ESG reporting for investor relations
- Regulatory compliance verification
- Identification of environmental liability risks

3.2.4 Objective 4: Geographic Intelligence

Goal: Map production density and efficiency by geographic clusters to inform infrastructure investment and land acquisition strategies.

Success Criteria:

- Heat maps visualizing production concentration
- Township-Range analysis identifying core zones
- Correlation of geography with operator performance

Business Value:

- Land acquisition targeting (mineral rights, surface leases)
- Infrastructure planning (pipelines, processing facilities)
- Regulatory planning (area-based closures, reclamation priorities)

3.2.5 Objective 5: Portfolio Health Assessment

Goal: Evaluate well lifecycle distribution to assess portfolio maturity, identify reclamation obligations, and forecast future production capacity.

Success Criteria:

- Operational status distribution (Active/Suspended/Abandoned)
- Time-series analysis of status transitions
- Forecasting of future suspension/abandonment rates

Business Value:

- Liability provisioning for abandoned well costs
- Production forecasting adjustments for aging portfolios
- Strategic planning for well reactivation vs. abandonment

3.3 Stakeholder Benefits

For Investment Firms & Analysts

- Due Diligence Acceleration: 30-day comprehensive portfolio assessment
- Comparative Benchmarking: Quantitative operator rankings
- Risk Identification: Suspended well exposure, integrity issues flagged
- Valuation Support: Production trends inform DCF models

For Operating Companies

- Competitive Intelligence: Anonymous benchmarking against peers
- Operational Optimization: Identify efficiency gaps vs. top performers
- ESG Reporting: Validated emissions data for sustainability reports
- Asset Management: Data-driven suspension/abandonment decisions

For Regulatory Bodies

- Compliance Monitoring: Automated flare/vent rate tracking

- Orphan Well Identification: Operators with high suspended well ratios
- Regional Planning: Production concentration analysis
- Public Transparency: Interactive dashboards for stakeholder access

For Service Providers

- Market Intelligence: Identify operators with high injection activity (water management opportunities)
- Target Marketing: Geographic concentration of potential clients
- Technology Adoption: Operators lagging in efficiency (automation opportunities)

3.4 Project Scope

In-Scope

- Wood Buffalo region (Townships 60-80, Ranges 1-15, W4M)
- January 2025 - August 2025 (8-month analysis window)
- 180 wells, 22 active operators
- Production, injection, flare/vent activities
- Oil, gas, water products

Out-of-Scope

- Other Alberta regions (Peace River, Cold Lake, Lloydminster)
- Individual well-level analysis (aggregated to facility level)
- Financial metrics (revenues, costs, profitability)
- Predictive modeling (future production forecasts)
- Real-time monitoring (monthly refresh only)

4.0 Key Questions on the Data

4.1 Question 1: Operator Excellence Analysis

Research Question

"Which operators maintain the healthiest and most productive well portfolios in Wood Buffalo, and what operational practices differentiate top performers from laggards?"

Sub-Questions

- What is the distribution of production volume across operators?
- Which operators achieve highest per-well productivity (efficiency)?
- How do operators compare on injection:production ratio (reservoir management)?
- What percentage of each operator's portfolio is active vs. suspended?
- Are there correlations between operator size and efficiency?

4.1.1 Analytical Approach

Step 1: Production Volume Distribution

```
dax
Total_Oil_Volume_By_Operator =
CALCULATE(
    SUM(Fact_Volume[Volume]),
```

```
    Dim_Product[ProductCategory] = "Oil",
    Dim_Activity[ActivityCategory] = "Production"
)
```

Visualization: Horizontal bar chart, operators ranked by total oil volume
Expected Insight: Pareto distribution (80/20 rule) - Top 5 operators likely account for 80% of production.

Step 2: Per-Well Productivity Analysis

```dax
Avg_Well_Productivity =
DIVIDE(
    [Total_Oil_Volume],
    DISTINCTCOUNT(Dim_Facility[FacilityCode]),
    BLANK()
)
```

Visualization: Scatter plot (X-axis: Total Wells, Y-axis: Avg Productivity, Bubble size: Total Volume)
Expected Insight: Identify operators with high efficiency (small footprint, high output)

Step 3: Injection Integrity Comparison

```dax
IP_Ratio =
DIVIDE(
    [Total_Injection_Volume],
    [Total_Production_Volume],
    BLANK()
)
```

Visualization: Gauge charts per operator with color coding:

Green: 0.8-1.2 (optimal)

Yellow: 0.5-0.8 or 1.2-1.5 (caution)

Red: < 0.5 or > 1.5 (concern)

Expected Insight: SAGD operators (e.g., Imperial, Suncor) should show I:P near 1.0-1.2

Step 4: Portfolio Health Scorecard

```dax
Portfolio_Health_Score =
VAR ActivePct = [Active_Wells_%]
VAR SuspendedPct = [Suspended_Wells_%]
RETURN
```

```
    (ActivePct * 1.0) - (SuspendedPct * 2.0)  // Penalty for suspended wells
```

Visualization: Matrix table with conditional formatting
Expected Insight: Mature operators (20+ years) may show 15-20% suspended wells; younger operators < 5%

Step 5: Composite Operator Ranking

```dax
Operator_Excellence_Score =
    ([Total_Oil_Volume] / 1000000) * 0.30 +  // Scale (30% weight)
    ([Avg_Well_Productivity] / 100000) * 0.25 +  // Efficiency (25%)
    (100 - ABS([IP_Ratio] - 1.0) * 100) * 0.25 +  // Integrity (25%)
    [Active_Wells_%] * 0.20  // Portfolio Health (20%)
```

Expected Outcome: Top 3 operators identified for investment targeting

4.2 Question 2: Well Health and Lifecycle Assessment

Research Question

"What is the current health profile and lifecycle distribution of wells in Wood Buffalo, and which operators face the highest reclamation obligations?"

Sub-Questions

- What percentage of wells are Active, Suspended, or Abandoned?
- How has operational status changed over the 8-month period?
- Which operators have the highest concentration of suspended wells?
- What is the average duration of well suspension before reactivation or abandonment?
- Are there geographic patterns in well status (e.g., clustering of abandoned wells)?

4.3 Analytical Approach

Step 1: Current Status Snapshot

```dax
Active_Wells_% =
VAR Active = CALCULATE(
    DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
    Dim_FacilityStatusCurrent[OperationalStatus] = "ACTIVE"
)
VAR Total = DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode])
RETURN DIVIDE(Active, Total, 0) * 100
```

Visualization: Donut chart with three segments (Active, Suspended, Abandoned)
Expected Result:

- Active: 90-95% (healthy mature basin)

  - Suspended: 5-10%
  - Abandoned: < 5%

Current Actual: 93.46% Active, 6.54% Suspended (excellent health)

Step 2: Temporal Trend Analysis

```dax
Status_Transitions =
CALCULATE(
    DISTINCTCOUNT(Status_By_Month[FacilityCode]),
    Status_By_Month[OperationalStatus] <>
        CALCULATE(
            SELECTEDVALUE(Status_By_Month[OperationalStatus]),
            DATEADD(Dim_Date[Date], -1, MONTH)
        )
)
```

Visualization: Area chart (stacked) showing Active/Suspended/New over Jan-Aug 2025
Expected Insight: Stable operations show flat lines; increasing suspensions indicate economic stress

Step 3: Operator Liability Exposure

```dax
Suspended_Well_Ratio =
DIVIDE(
    CALCULATE(
        DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
        Dim_FacilityStatusCurrent[OperationalStatus] = "SUSPENDED"
    ),
    DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
    0
)
```

Visualization: Matrix table sorted by Suspended_Well_Ratio (descending)
Expected Insight: Operators > 20% suspension ratio face significant reclamation costs

Step 4: Geographic Clustering Analysis

```dax
Abandoned_Wells_By_Township =
CALCULATE(
    DISTINCTCOUNT(Dim_Facility[FacilityCode]),
```

```
    Dim_Facility[OperationalStatus] = "ABANDONED"
)
```

Visualization: Heat map overlaying abandoned wells on Wood Buffalo map
Expected Insight: Older production areas (southern townships) show higher abandonment concentration

4.4 Question 3: Production and Injection Integrity Over Time

Research Question

"How do production and injection patterns reflect operational integrity, and which operators demonstrate consistent reservoir management practices?"

Sub-Questions

- What is the overall I:P ratio for the region, and how does it change month-to-month?
- Which months show unusual injection or production spikes (anomalies)?
- Do operators maintain consistent I:P ratios, or exhibit volatility?
- What is the correlation between injection volume and subsequent production (lagged effect)?
- How do flare/vent rates trend over time, and which operators show improvement or degradation?

4.4.1 Analytical Approach

Step 1: Regional I:P Ratio Trends

```
dax
IP_Ratio_Regional =
VAR TotalInjection =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"INJ", "INJECTION", "WATER"}
    )
VAR TotalProduction =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"PROD", "OIL", "WATER"},
        Dim_Product[ProductCategory] IN {"Oil", "Water"}
    )
RETURN DIVIDE(TotalInjection, TotalProduction, BLANK())
```

Visualization: Line chart with reference line at 1.0 (optimal), confidence bands at 0.8-1.2
Expected Pattern:

- SAGD operations should maintain 1.0-1.2 consistently
- Deviations indicate operational issues (equipment failures, steam breakthrough)

Current Result: 1.13 (within optimal range, indicating healthy voidage replacement)

Step 2: Anomaly Detection

```dax
Production_Volatility =
VAR CurrentMonth = [Total_Oil_Volume]
VAR MovingAvg3M =
    CALCULATE(
        AVERAGE([Total_Oil_Volume]),
        DATESINPERIOD(Dim_Date[Date], LASTDATE(Dim_Date[Date]), -3, MONTH)
    )
VAR StdDev3M =
    CALCULATE(
        STDEV.P([Total_Oil_Volume]),
        DATESINPERIOD(Dim_Date[Date], LASTDATE(Dim_Date[Date]), -3, MONTH)
    )
RETURN
    ABS((CurrentMonth - MovingAvg3M) / StdDev3M)  // Z-score
```

Visualization: Control chart with ±2 standard deviation bands
Anomaly Threshold: Z-score > 2.0 (statistically significant deviation)
Expected Insight: June 2025 production spike visible in dashboard (efficiency peak)

Step 3: Operator I:P Consistency Score

```dax
IP_Ratio_Consistency =
VAR IP_StdDev =
    CALCULATE(
        STDEV.P([IP_Ratio]),
        ALLEXCEPT(Dim_Operator, Dim_Operator[BAName])
    )
VAR IP_Mean =
    CALCULATE(
        AVERAGE([IP_Ratio]),
        ALLEXCEPT(Dim_Operator, Dim_Operator[BAName])
    )
RETURN
    1 - (IP_StdDev / IP_Mean)  // Higher = more consistent
```

Visualization: Bar chart ranking operators by consistency score
Interpretation:

- Score > 0.90: Excellent reservoir management
- Score 0.80-0.90: Good operational control
- Score < 0.80: Volatile operations (potential integrity issues)

Step 4: Lagged Correlation Analysis

dax

```
Production_Response_To_Injection =
VAR InjectionLastMonth =
    CALCULATE(
        [Total_Injection_Volume],
        DATEADD(Dim_Date[Date], -1, MONTH)
    )
VAR ProductionThisMonth = [Total_Oil_Volume]
RETURN
    DIVIDE(ProductionThisMonth, InjectionLastMonth, BLANK())
```

Visualization: Scatter plot (X: Injection Month N, Y: Production Month N+1)
Expected Pattern: Positive correlation ($R^2 > 0.6$) for SAGD operations
Interpretation: Steam injection effectiveness (1-2 month lag typical for bitumen response)

Step 5: Environmental Compliance Trends

dax

```
FlareVent_Trend =
VAR FlareVentVol =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"FLARE", "VENT"}
    )
VAR TotalGasVol =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Product[ProductCategory] = "Gas"
    )
RETURN DIVIDE(FlareVentVol, TotalGasVol, 0) * 100
```

Visualization: Area chart showing flare/vent % trend over 8 months
Regulatory Context:

- AER Target: < 1.0%

- Industry Average: ~0.5%
- Wood Buffalo Actual: 0.06% (exceptional)

Expected Insight: Stable low rates indicate mature gas conservation infrastructure

4.5 Analytical Findings Summary

Regional Performance:

- I:P Ratio 1.13: Optimal pressure maintenance
- Production Volatility: Low (CV < 0.15)
- Flare/Vent Rate: 0.06% (94% below threshold)

Operator Excellence:

- Top I:P Consistency: SUNCOR (1.12 ± 0.05), CENOVUS (1.70 ± 0.10)
- Highest Production Response: CNOOC (1.5x injection-to-production multiplier)

Anomalies Identified:

- June 2025: 200% production spike (likely turnaround completion)
- ATHABASCA: I:P 1.77 (slight over-injection, monitor for integrity)

5.0 Metrics and KPIs

5.1 KPI Framework Overview

The WellSight Wood Buffalo analytics framework employs 15 core KPIs organized into five strategic categories. Each metric is purpose-built to answer specific business questions and follows a standardized development methodology:

5) **Business Definition**: Stakeholder-validated purpose
6) **Mathematical Formulation**: DAX measure specification
7) **Validation**: Cross-reference with manual calculations
8) **Benchmarking**: Industry standard comparison
9) **Interpretation Guidelines**: Decision thresholds and context

5.2 Production Performance Metrics

5.2.1 KPI 1: Total Oil Volume

Business Definition: Cumulative oil production (crude + bitumen) across all facilities and reporting periods.

DAX Formula:

```
dax
Total_Oil_Volume =
CALCULATE(
    SUM(Fact_Volume[Volume]),
    Dim_Product[ProductCode] IN {"OIL", "BITUMEN", "CRUDE"},
    Dim_Activity[ActivityName] IN {"PROD", "PRODUCTION"}
)
```

Current Value: 42.85M m^3 (January-August 2025)
August MTD: 5.38M m^3

Interpretation Guidelines:

- **Trend Analysis**: Compare month-over-month for operational momentum
- **Operator Benchmarking**: Top quartile operators produce 10M+ m^3 over 8 months
- **Investment Signal**: Consistent growth = stable cash flow

Industry Context: Wood Buffalo accounts for ~15% of Alberta's total oil production

5.2.2 KPI 2: Total Gas Volume

Business Definition: Cumulative natural gas production (solution gas + associated gas).

DAX Formula:

```
dax

Total_Gas_Volume =

CALCULATE(

    SUM(Fact_Volume[Volume]),

    Dim_Product[ProductCategory] = "Gas",

    Dim_Activity[ActivityName] IN {"PROD", "GAS"}

)
```

Current Value: 11.68M m^3 (January-August 2025)

Gas-Oil Ratio (GOR):

```
dax

GOR = DIVIDE([Total_Gas_Volume], [Total_Oil_Volume], BLANK())

Current GOR: 0.27 m³/m³ (typical for heavy oil/bitumen: 0.2-0.5)
```

Interpretation:

- Low GOR confirms heavy oil/bitumen production (versus light oil: 50-200 GOR)
- Stable GOR indicates consistent reservoir conditions

5.2.3 KPI 3: Average Well Productivity (Oil)

Business Definition: Mean oil production per well; normalized efficiency metric independent of operator scale.

DAX Formula:

```
dax

Avg_Well_Productivity_Oil =

VAR TotalOilVol = [Total_Oil_Volume]

VAR TotalWells =

    DISTINCTCOUNT(Dim_Facility[FacilityCode])

RETURN
```

```
    IF(
        TotalWells > 0,
        DIVIDE(TotalOilVol, TotalWells, 0),
        BLANK()
    )
```

Current Regional Average: 237,700 m^3/well (180 wells, 42.85M m^3)

Operator Performance Tiers:

Tier	Productivity (m^3/well)	Classification	Example Operators
Elite	> 1,000,000	Exceptional efficiency	CNOOC (10.41M/well)
High	500,000 - 1,000,000	Above average	SUNCOR (8.76M/well)
Average	200,000 - 500,000	Standard performance	CENOVUS (2.55M/well)
Below Average	< 200,000	Optimization opportunity	Small operators

Critical Factors Influencing Productivity:

- Reservoir quality (permeability, porosity)
- Well design (horizontal length, completion quality)
- Artificial lift efficiency (ESP, PCP, gas lift)
- Operating practices (downtime management)

5.2.4 KPI 4: Oil Volume Month-over-Month %

Business Definition: Sequential monthly growth rate; momentum indicator.

DAX Formula:

```
dax
Oil_Vol_MoM_Percent =
VAR CurrentMonth = [Total_Oil_Volume]
VAR PreviousMonth =
    CALCULATE(
        [Total_Oil_Volume],
        DATEADD(Dim_Date[Date], -1, MONTH)
    )
RETURN
    IF(
        NOT(ISBLANK(PreviousMonth)) && PreviousMonth <> 0,
        DIVIDE(CurrentMonth - PreviousMonth, PreviousMonth, BLANK()) * 100,
        BLANK()
```

```
    )
```

Current Value: 14.36% (August 2025)

Interpretation Thresholds:

- **> 10%**: Strong growth (new wells online, operational improvements)
- **0-10%**: Stable operations
- **-5% to 0%**: Natural decline
- **< -5%**: Operational issues or planned maintenance

August 2025 Context: 14.36% growth likely reflects:

- Completion of spring turnaround activities
- Seasonal optimization (warmer weather = higher efficiency)
- New well tie-ins

5.3 Operational Integrity Metrics

5.3.1 KPI 5: Injection:Production Ratio (I:P)

Business Definition: Ratio of injected fluid volume to produced fluid volume; primary reservoir pressure maintenance indicator.

DAX Formula:

```dax
IP_Ratio =
VAR InjectionVol =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"INJ", "INJECTION", "STEAM", "WATER"}
    )
VAR ProductionVol =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"PROD", "PRODUCTION"},
        Dim_Product[ProductCategory] IN {"Oil", "Water"}
    )
RETURN
    DIVIDE(InjectionVol, ProductionVol, BLANK())
```

Current Regional I:P: 1.13

Engineering Interpretation:

I:P Range	Status	Reservoir Implication	Recommended Action
0.95 - 1.05	Optimal	Perfect voidage replacement	Maintain

I:P Range	Status	Reservoir Implication	Recommended Action
1.05 - 1.20	Good	Slight reservoir pressure increase	Monitor
1.20 - 1.50	Caution	Over-injection; potential water breakthrough	Reduce injection
> 1.50	Concern	Significant over-injection; integrity risk	Immediate review
0.80 - 0.95	Caution	Under-injection; pressure depletion	Increase injection
< 0.80	Critical	Severe under-injection; production decline risk	Urgent intervention

Current Assessment: 1.13 = Excellent reservoir management (slight positive pressure maintenance)

Operator-Specific I:P Analysis:

- **SUNCOR**: 1.12 (optimal)
- **CNOOC**: 0.72 (under-injection, but may reflect different recovery mechanism)
- **CENOVUS**: 1.70 (over-injection, requires monitoring)
- **ATHABASCA**: 1.77 (highest in region, investigate for integrity)

SAGD-Specific Context:

- Target I:P: 1.0-1.2 (accounts for steam condensate return)
- Higher ratios acceptable during steam chamber development
- Lower ratios during mature production phase

5.3.2 KPI 6: Flare/Vent Rate (%)

Business Definition: Percentage of produced gas lost to flaring or venting; environmental compliance metric.

DAX Formula:

```
dax
FlareVent_Rate_Percent =
VAR FlareVentVol =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Activity[ActivityName] IN {"FLARE", "VENT"}
    )
VAR TotalGasProduced =
    CALCULATE(
        SUM(Fact_Volume[Volume]),
        Dim_Product[ProductCategory] = "Gas",
        Dim_Activity[ActivityName] = "PROD"
    )
```

```
RETURN
    IF(
        TotalGasProduced > 0,
        DIVIDE(FlareVentVol, TotalGasProduced, 0) * 100,
        BLANK()
    )
```

Current Regional Rate: 0.06%

Regulatory Framework (Alberta):

- **AER Target**: < 1.0% flare intensity
- **Industry Average**: 0.4-0.6%
- **Penalties**: Progressive enforcement above 5%
- **Best Practice**: < 0.1%

Performance Assessment:

Rate Range	Classification	Environmental Impact	Compliance Status
< 0.1%	Excellent	Minimal emissions	Leading practice
0.1 - 0.5%	Good	Low emissions	Compliant
0.5 - 1.0%	Acceptable	Moderate emissions	Compliant
1.0 - 5.0%	Concerning	High emissions	Action required
> 5.0%	Critical	Excessive emissions	Non-compliant

Wood Buffalo Achievement: 0.06% = Exceptional environmental performance

- 94% below regulatory threshold
- 85% better than industry average
- Indicates mature gas conservation infrastructure

Economic Context:

- At $2.50/GJ natural gas price, 0.06% flare rate represents minimal revenue loss
- Gas conservation infrastructure (compression, pipelines) fully operational

5.3.3 KPI 7: Volume Imbalance (DIFF)

Business Definition: Material balance discrepancy; production minus injection minus losses.

DAX Formula:

dax

```
Volume_Imbalance =
VAR TotalInjection =
    CALCULATE(SUM(Fact_Volume[Volume]), Dim_Activity[ActivityName] = "INJ")
VAR TotalProduction =
```

```
    CALCULATE(SUM(Fact_Volume[Volume]), Dim_Activity[ActivityName] = "PROD")
VAR TotalLoss =
    CALCULATE(SUM(Fact_Volume[Volume]), Dim_Activity[ActivityName] IN
{"FLARE", "VENT", "LOSS"})
RETURN
    (TotalInjection - TotalProduction - TotalLoss)
```

Interpretation:

- **≈ 0**: Perfect material balance (expected with measurement accuracy ±2%)
- **Positive**: Reservoir inventory build (injecting more than producing)
- **Negative**: Unaccounted losses or measurement errors

Acceptable Variance: ±5% (accounting for meter uncertainty and unmeasured losses)

5.4 Portfolio Health Metrics

5.4.1 KPI 8: Active Wells Percentage

Business Definition: Proportion of wells currently producing or injecting; portfolio vitality indicator.

DAX Formula:

dax

```
Active_Wells_Percent =
VAR ActiveCount =
    CALCULATE(
        DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
        Dim_FacilityStatusCurrent[OperationalStatus] = "ACTIVE"
    )
VAR TotalCount =
    DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode])
RETURN
    DIVIDE(ActiveCount, TotalCount, 0) * 100
```

Current Value: 93.46% (143 of 153 wells)

Industry Benchmarks:

Basin Maturity	Expected Active %	Wood Buffalo Actual
Emerging (< 5 years)	95-100%	—
Growth (5-15 years)	85-95%	93.46%
Mature (15-30 years)	70-85%	—

Basin Maturity	Expected Active %	Wood Buffalo Actual
Declining (> 30 years)	< 70%	—

Assessment: 93.46% indicates healthy, well-maintained portfolio

Risk Indicators:

- < 80%: Portfolio under stress (economic, technical, or regulatory issues)
- Declining trend: Potential abandonment wave approaching

5.4.2 KPI 9: Suspended Wells Percentage

Business Definition: Proportion of wells temporarily shut-in; operational challenge indicator.

DAX Formula:

```
dax
Suspended_Wells_Percent =
VAR SuspendedCount =
    CALCULATE(
        DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
        Dim_FacilityStatusCurrent[OperationalStatus] = "SUSPENDED"
    )
VAR TotalCount =
    DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode])
RETURN
    DIVIDE(SuspendedCount, TotalCount, 0) * 100
```

Current Value: 6.54% (10 of 153 wells)

Suspension Reasons:

- **Economic**: Low oil prices making production uneconomical
- **Mechanical**: Equipment failure requiring repair
- **Regulatory**: Compliance issues or temporary license suspension
- **Strategic**: Planned maintenance or awaiting facility upgrades

Liability Context:

- Each suspended well represents future reclamation obligation (~$100K-500K/well)
- Extended suspension (> 2 years) increases orphan well risk

5.4.3 KPI 10: Abandoned Wells Percentage

Business Definition: Proportion of permanently decommissioned wells; reclamation completion indicator.

DAX Formula:

```
dax
```

```
Abandoned_Wells_Percent =
VAR AbandonedCount =
    CALCULATE(
        DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode]),
        Dim_FacilityStatusCurrent[OperationalStatus] IN {"ABANDONED",
"RECLAIMED"}
    )
VAR TotalCount =
    DISTINCTCOUNT(Dim_FacilityStatusCurrent[FacilityCode])
RETURN
    DIVIDE(AbandonedCount, TotalCount, 0) * 100
```

Note: Dashboard shows 0% abandoned (all wells either active or suspended)

Expected Range: 5-15% in mature basins (Wood Buffalo's 0% suggests young/active portfolio)

5.5 Investment & Strategic Metrics

5.5.1 KPI 11: Investment Score

Business Definition: Composite risk-adjusted performance metric combining production scale, efficiency, integrity, and portfolio health.

DAX Formula:

```dax
Investment_Score =
VAR ScaleScore = ([Total_Oil_Volume] / 1000000) * 0.01  // Normalized to 0-
400 range
VAR EfficiencyScore = ([Avg_Well_Productivity_Oil] / 1000000) * 10  //
Normalized to 0-100 range
VAR IntegrityScore =
    1000 * (1 - MIN(ABS([IP_Ratio] - 1.2), 0.5))  // Penalty for deviation
from optimal 1.2
VAR HealthScore = [Active_Wells_Percent] * 5  // 0-500 range
RETURN
    ScaleScore + EfficiencyScore + IntegrityScore + HealthScore
```

Component Weighting:

- **Production Scale** (30%): Total oil volume
- **Efficiency** (25%): Per-well productivity
- **Integrity** (25%): I:P ratio optimality
- **Portfolio Health** (20%): Active well percentage

Current Top 5 Operators:

- CENOVUS ENERGY INC: 1,566.98
- CNOOC PETROLEUM NORTH AMERICA: 1,296.37
- ATHABASCA OIL CORPORATION: 974.74
- SUNCOR ENERGY INC: 385.22
- BOUNTY DEVELOPMENTS LTD: 402.72

Interpretation:

- **> 1,000**: Premier investment targets (scale + efficiency + integrity)
- **500-1,000**: Solid mid-tier opportunities
- **< 500**: Small operators or operational challenges

Investment Decision Framework:

- Scores > 1,000 + Active Wells > 90% + I:P 0.9-1.3 = **BUY SIGNAL**
- Scores < 500 + Suspended Wells > 20% = **AVOID**

5.5.2 KPI 12: Operator Health Score

Business Definition: Simplified operational performance index for quick screening.

DAX Formula:

```
dax

Operator_Health_Score =

VAR ProductivityComponent = MIN(([Avg_Well_Productivity_Oil] / 500000), 1) * 30

VAR IntegrityComponent = (1 / (1 + ABS([IP_Ratio] - 1.0))) * 40

VAR PortfolioComponent = ([Active_Wells_Percent] / 100) * 30

RETURN

    ProductivityComponent + IntegrityComponent + PortfolioComponent
```

Scoring Scale (0-100):

- **80-100**: Excellent (top-tier operator)
- **60-79**: Good (above-average performance)
- **40-59**: Average (meets baseline expectations)
- **< 40**: Underperforming (operational issues)

5.6 KPI Summary Dashboard

Category	KPI	Current Value	Target/Benchmark	Status
Production	Total Oil Volume (8M)	42.85M m³	–	✅
	Oil Volume MTD (Aug)	5.38M m³	–	✅
	MoM Growth %	14.36%	> 0%	✅ Excellent

Category	KPI	Current Value	Target/Benchmark	Status
	Avg Well Productivity	237.7K m^3/well	> 200K	✅
Integrity	I:P Ratio	1.13	0.95-1.20	✅ Optimal
	Flare/Vent Rate	0.06%	< 1.0%	✅ Exceptional
	Volume Imbalance	±3%	±5%	✅
Portfolio	Active Wells %	93.46%	> 80%	✅ Healthy
	Suspended Wells %	6.54%	< 10%	✅
	Abandoned Wells %	0%	< 15%	✅
Strategic	Top Investment Score	1,566.98	> 1,000	✅ CENOVUS
	Operator Count	22	—	✅ Diversified
	Total Wells	180	—	✅

Overall Assessment: Wood Buffalo demonstrates exceptional operational performance across all metric categories.

6.0 Data Model

6.1 Data Modeling Philosophy

The WellSight Wood Buffalo data model follows **Kimball dimensional modeling methodology**, implementing a classic star schema optimized for:

- **Query Performance**: Minimized joins through denormalization
- **Business Logic Clarity**: Fact/dimension separation mirrors operational concepts
- **Analytical Flexibility**: Drill-down/roll-up capabilities across all hierarchies
- **Scalability**: Supports incremental data loads and temporal analysis

Design Principles:

- **Single Fact Table**: Atomic-level volumetric transactions
- **Conformed Dimensions**: Consistent definitions across all analyses
- **Slowly Changing Dimensions**: Historical tracking where business-critical
- **Date Intelligence**: Full calendar table with fiscal period support
- **Bridge Tables**: Handle many-to-many relationships (status history)

6.2 Star Schema Architecture

The model consists of a single central fact table surrounded by nine dimension tables, creating the characteristic "star" pattern that gives this architecture its name.

The star schema design delivers several critical advantages for this analytical use case. First, it minimizes the number of table joins required for most queries, directly improving dashboard load times and interactive filtering responsiveness. Second, the separation of facts (measurements) from dimensions (descriptive attributes) mirrors how business users naturally conceptualize operational data—they think about "oil production" (fact) "by operator" (dimension) "in January" (dimension). Third, the denormalized structure of dimension tables eliminates the need for complex multi-table joins that would be required in a normalized transactional database, trading some storage efficiency for dramatic improvements in analytical query speed.

6.2.1 Central Fact Table: Fact_Volume

At the heart of the data model sits the Fact_Volume table, which stores every volumetric activity transaction reported to the Alberta Energy Regulator during the analysis period. The grain—or level of detail—of this fact table is critical to understand: each row represents a single combination of facility, product, activity, and date. This atomic-level granularity provides maximum analytical flexibility, allowing users to aggregate data at any desired level (monthly totals, operator summaries, regional rollups) while maintaining the ability to drill down to daily facility-product-activity detail when investigating anomalies or operational patterns.

The fact table contains approximately 50,000 records covering the eight-month analysis window from January through August 2025. Despite this substantial row count, the table consumes only 45 megabytes of storage after Power BI's VertiPaq compression algorithm is applied, representing a 90% reduction from the raw CSV file size. This compression efficiency is achieved through columnar storage optimization, where Power BI stores each column independently and applies encoding techniques tailored to each data type and distribution pattern.

Each record in Fact_Volume contains five foreign key columns that link to dimension tables, establishing the star schema relationships. The FacilityCode foreign key connects to the Dim_Facility dimension, enabling users to filter or slice data by facility name, location, or operational status. The OperatorBAID foreign key links to Dim_Operator, supporting operator-level analysis and benchmarking. ProductID and ActivityID foreign keys connect to their respective dimensions, allowing filtering by product type (oil, gas, water) and activity category (production, injection, flaring). Finally, the DateKey foreign key establishes the temporal relationship to Dim_Date, enabling all time-based analysis and trend calculations.

Beyond the foreign keys, Fact_Volume stores four measure columns containing the actual quantitative data. The Volume column records the measured quantity in cubic meters, representing either produced fluids, injected fluids, or lost volumes depending on the associated activity code. Energy content in gigajoules is captured when applicable, particularly for natural gas volumes where heating value varies by composition. The Hours column tracks operating time, enabling calculation of utilization rates and downtime analysis. Finally, ProrationFactor stores the allocation coefficient used to distribute commingled facility production to individual wells, a common requirement in fields where multiple wells flow through a single battery or processing facility.

6.2.2 Dim_Facility: The Geographic and Operational Context

The Dim_Facility dimension provides all descriptive attributes related to production facilities and wells. With 2,313 rows, this dimension catalogs every facility that has reported production data to the Alberta Energy Regulator in the Wood Buffalo region, including currently active facilities, temporarily suspended wells, and recently abandoned sites. The primary key, FacilityCode, is a composite identifier created by concatenating the province code (AB for Alberta), facility type (BT for battery, WI for well injector, PP for plant), and a unique numeric identifier assigned by the regulator.

This dimension implements a Slowly Changing Dimension Type 2 (SCD Type 2) pattern to preserve historical operational status changes. In practical terms, when a facility's operational status transitions from ACTIVE to SUSPENDED, the model doesn't overwrite the existing record. Instead, it expires the current record by setting its ExpiryDate field and creates a new record with the updated status and a new EffectiveDate. This approach maintains a complete audit trail of status changes, enabling analysis of questions like "how many facilities were suspended during the January-March period?" or "what was the average duration between suspension and reactivation?"

The geographic attributes embedded in Dim_Facility deserve special attention, as they enable the spatial analysis that underpins the project's investment targeting capabilities. Every facility record includes Township, Range, and Meridian fields that specify its location using Alberta's legal land description system. This grid-based coordinate system divides the province into townships (six-mile squares) numbered from south to north, and ranges (six-mile strips) numbered from east to west relative to specific meridian lines. The full Location field combines these elements with section and legal subdivision identifiers to pinpoint facilities within approximately 100-meter precision—sufficient for regional analysis while protecting operational security.

6.2.3 Dim_Operator: Corporate Identity and Status

The Dim_Operator dimension maintains the registry of all companies and partnerships authorized to operate oil and gas facilities in Alberta. Unlike the facility dimension, this table implements Slowly Changing Dimension Type 1, meaning updates to operator information overwrite previous values rather than creating new historical records. This design choice reflects the business reality that operator corporate name changes, telephone number updates, and similar modifications are not analytically significant for this project's objectives. The 22 active operators currently conducting operations in Wood Buffalo represent a subset of the broader operator registry maintained by the regulator.

Each operator record is identified by a BACode (Business Associate Code), an alphanumeric identifier assigned by the Alberta Energy Regulator's Well Identification Office. The BAName field stores the legal corporate name, which can range from major integrated producers like Imperial Oil Resources Limited to smaller numbered companies like "0307740 B.C. LTD." The CorpStatus field tracks whether the company remains an active operator in good standing or has transitioned to inactive, bankrupt, or receivership status—a critical data point for identifying potential orphan well liabilities.

The relationship between Dim_Operator and Dim_Facility creates a snowflake pattern extending from the central star schema. While Fact_Volume links directly to both dimensions, Dim_Facility also contains an OperatorId foreign key pointing to Dim_Operator. This dual relationship enables both direct operator-level queries against the fact table and facility-to-operator navigation, supporting analytical patterns like "show me all facilities operated by CENOVUS" without requiring a join through the fact table.

6.2.4 Dim_Product: Standardized Commodity Classification

The Dim_Product dimension establishes a controlled vocabulary for the diverse array of substances produced, injected, and managed in oil and gas operations. With over 50 distinct product codes, this dimension goes far beyond the simple oil-gas-water trichotomy that dominates public discourse about petroleum production. Product codes include specialized entries for methane components (C1, C1-MX), brackish water suitable for injection (BRKWTR), acid gas containing hydrogen sulfide and carbon dioxide (ACGAS), and even air used in enhanced oil recovery combustion processes.

Each product record includes a ProductCategory field that rolls up detailed product codes into high-level groupings used throughout the dashboard visualizations. This hierarchy allows technical users to filter by specific product codes when needed while providing executive audiences with simplified Oil/Gas/Water/Other categories. The ISC flag (In-Situ Combustion) identifies products associated with thermal enhanced oil recovery techniques, enabling specialized analysis of these advanced production methods. The PipelineSplit flag indicates whether the product requires special allocation logic when transported through commingled pipeline systems.

This dimension remains static—product definitions are established by regulatory standard and rarely change. This stability eliminates the need for slowly changing dimension logic and ensures that historical comparisons remain valid over time. When the regulator does occasionally introduce new product codes to accommodate emerging technologies or reporting requirements, they are added as new rows rather than modifications to existing codes.

6.2.5 Dim_Activity: Operational Classification Framework

The Dim_Activity dimension categorizes the dozens of distinct operational activities that facilities report to the regulator. Beyond the obvious production and injection activities that drive economic value, this dimension captures environmental compliance activities (flaring, venting, emissions), operational monitoring (bottomhole temperature measurements), accounting adjustments (metering differences), and facility status changes (shut-ins, dispositions). The ActivityCategory field groups these granular codes into Production, Injection, Loss, and Flare categories that align with the KPI framework developed for this analysis.

Like Dim_Product, this dimension remains static across reporting periods. The stability of activity classifications is essential for regulatory compliance and year-over-year trend analysis. When users filter dashboards to show only "production activities" or calculate flare/vent rates, they rely on consistent activity categorization that doesn't shift meanings between reporting periods.

6.2.6 Dim_Date: Enabling Time Intelligence

The Dim_Date dimension implements a standard date table spanning from January 2020 through December 2030, providing 3,653 rows of calendar attributes that power all temporal analysis in the model. While this may seem like excessive coverage for an eight-month analysis project, the extended range supports both historical context (prior period comparisons if earlier data becomes available) and forward-looking scenario planning (production forecasts, abandonment schedules).

Each date record includes comprehensive calendar attributes: Year, Month name, MonthNum (1-12), Quarter designation, and a composite YearMonth field used extensively in visualization axis labels. The FiscalYear and FiscalQuarter fields implement Alberta's April-to-March fiscal year, aligning analysis with government reporting cycles and budget periods. Calculated flags like IsCurrentMonth and IsLastMonth support dynamic filtering that automatically adjusts as new data loads each month.

The relationship between Fact_Volume and Dim_Date deserves special attention because it employs bidirectional filtering, a departure from the standard star schema pattern of unidirectional dimension-to-fact filtering. This bidirectional relationship is required for DAX time intelligence functions like TOTALYTD, SAMEPERIODLASTYEAR, and DATEADD to work correctly. These functions need to evaluate which dates are "in scope" based on user filter selections, then modify that date scope according to the function's logic (e.g., "all dates in the same year-to-date period"). While bidirectional relationships can occasionally create ambiguous filter paths in complex models, the WellSight schema's simple star structure avoids these pitfalls.

6.2.7 Dim_Region: Strategic Geographic Aggregation

The Dim_Region dimension provides high-level geographic groupings that roll up the granular township-range coordinates into meaningful strategic zones. These regional definitions are custom-created for this analysis based on production density patterns, infrastructure clusters, and operational characteristics observed in the Wood Buffalo basin. Each region is defined by minimum and maximum township and range boundaries, creating rectangular zones that can contain anywhere from a few dozen to several hundred facilities.

This dimension enables executive-level dashboards to show regional production trends without overwhelming users with township-by-township detail. An investor evaluating market entry might first review region-level production concentration before drilling into specific township opportunities. The relationship between Dim_Region and Dim_Facility is calculated rather than physically stored—Power BI evaluates each facility's township and range coordinates against the region boundary definitions to determine regional membership.

6.2.8 Dim_TRM: Precise Geospatial Reference

Where Dim_Region provides strategic zones, Dim_TRM (Township-Range-Meridian) delivers precision geospatial coordinates for every facility in the dataset. This dimension stores the complete legal land description decomposed into its constituent elements: FacilitySection (1-36), Township (1-126), Range (1-30), and Meridian (W4M, W5M, W6M). Additionally, Lat_Approx and Lon_Approx fields contain decimal degree coordinates calculated from the legal land description, enabling integration with mapping platforms and GIS systems.

The 2,313 rows in this dimension exactly match the facility count, creating a one-to-one relationship between facilities and their geographic coordinates. This dimensional separation—rather than embedding coordinates directly in Dim_Facility—follows Kimball methodology for attributes that might be reused across multiple fact tables or queried independently of facility operations. The FacilityLocation_Key combines all elements into a single string identifier (e.g., "10-12-065-04W4") used for map labeling and drill-through filtering.

6.2.9 Dim_FacilityStatusCurrent: Performance-Optimized Snapshot

The Dim_FacilityStatusCurrent dimension addresses a specific performance challenge: most dashboard queries only care about current operational status, yet retrieving current status from the SCD Type 2 Dim_Facility table requires filtering for IsCurrent = 'Y' on every query. This seemingly minor filter adds computational overhead that accumulates across dozens of visuals rendering simultaneously when a dashboard loads.

By maintaining a separate current-status snapshot with only 153 rows (the current well inventory, excluding abandoned facilities), queries against this dimension execute in a fraction of the time required for full SCD table scans. The dimension includes calculated fields like

Wells_Current_Percent that pre-aggregate status distributions, further accelerating KPI card rendering. This table refreshes with each monthly data load, ensuring synchronization with the master Dim_Facility table while optimizing the 95% of queries that only need current state.

6.2.10 Status_By_Month: Temporal Bridge for Lifecycle Analysis

The Status_By_Month table implements a bridge table pattern to support time-series analysis of facility status changes without the query complexity of joining through SCD Type 2 effective date ranges. Each row represents a facility's status during a specific month, with 1,224 rows covering 153 facilities across 8 months. The NextStartDate field enables forward-looking calculations (e.g., "how many months until likely reactivation?"), while StatusEndDate_Filled provides a calculated expiry date that handles NULL values for currently ongoing statuses.

This bridge table particularly shines in the Well Health & Lifecycle dashboard page, where area charts display status distribution trends over time. Rather than complex DAX logic to determine which SCD Type 2 version was active on each date, queries simply filter Status_By_Month to the desired date range and count facilities by OperationalStatus—a straightforward aggregation that executes in milliseconds even as data volumes grow.

6.3 Relationship Summary

The complete WellSight Wood Buffalo data model comprises eight active relationships connecting the fact table to dimensions and linking dimensions to each other. Five relationships radiate from Fact_Volume to the primary dimensions (Facility, Operator, Product, Activity, Date), forming the classic star pattern. Two snowflake relationships extend from Dim_Facility to Dim_Operator and Dim_Region, creating limited denormalization where operational efficiency demands it. Finally, the Status_By_Month bridge connects to Dim_Facility to support temporal status analysis.

All relationships except Fact_Volume-to-Dim_Date flow unidirectionally from dimension to fact, ensuring that filters applied at the dimension level (e.g., selecting specific operators) propagate downward to constrain fact table queries. This unidirectional flow prevents circular filter paths that could create ambiguous query results or performance degradation. The single bidirectional relationship to Dim_Date is carefully controlled and monitored to ensure it doesn't introduce unexpected cross-filtering behavior as the model evolves.

7.0 Conclusions

7.1 Executive Summary of Findings

The WellSight Wood Buffalo analysis delivers unambiguous evidence of a mature, well-managed oil and gas production region operating at exceptional performance levels across all measured dimensions. The eight-month analysis period from January through August 2025 reveals 180 wells operated by 22 distinct companies generating 42.85 million cubic meters of oil production while maintaining industry-leading environmental compliance and operational integrity metrics. These are not merely abstract data points—they represent a region that has achieved the operational excellence that regulators demand, investors seek, and communities expect from responsible energy development.

The 93.46% active well rate stands as the most compelling single indicator of portfolio health. In mature petroleum basins worldwide, operators struggle to maintain 70-80% active well ratios as reservoirs deplete, economics deteriorate, and mechanical failures accumulate. Wood Buffalo's performance surpasses these benchmarks by 15-20 percentage points, signaling that operators in this region have mastered the technical and economic challenges of heavy oil and oil sands production. The corresponding 6.54% suspended well rate—representing only 10 wells out of 153—indicates minimal operational stress and suggests that temporary suspensions are likely driven by planned maintenance rather than economic distress or mechanical failure.

The regional injection-to-production ratio of 1.13 confirms sophisticated reservoir management practices that balance production maximization with long-term reservoir sustainability. This metric reveals that operators collectively inject 13% more fluid volume than they produce, creating slight net pressure increase that supports continued production from these heavy oil and bitumen reservoirs. The ratio's proximity to the theoretical optimal value of 1.0-1.2 for steam-assisted gravity drainage operations indicates that Wood Buffalo operators have achieved the delicate equilibrium between under-injection (which causes reservoir pressure depletion and production decline) and over-injection (which risks reservoir integrity, water breakthrough, and steam chamber collapse).

Perhaps most remarkably, the region's 0.06% flare and vent rate demonstrates environmental performance that exceeds regulatory expectations by an order of magnitude. Alberta's regulatory threshold stands at 1.0%, yet Wood Buffalo operators collectively achieve 94% better performance. This metric validates that the region has successfully deployed gas conservation infrastructure—compression facilities, gas gathering pipelines, and processing plants—that captures nearly all produced natural gas for sale or beneficial use rather than flaring or venting to atmosphere. For context, this represents approximately 11.68 million cubic meters of natural gas conserved over the eight-month period, translating to both environmental stewardship and revenue optimization.

7.2 Operator Performance Differentiation

The comparative analysis across 22 operators reveals substantial performance heterogeneity that carries significant implications for investment allocation, regulatory oversight, and operational best practice dissemination. Three operators emerge as clear performance leaders based on the composite investment scoring framework: CENOVUS Energy Inc. (score: 1,566.98), CNOOC Petroleum North America ULC (1,296.37), and Athabasca Oil Corporation (974.74). These scores reflect superior performance across multiple dimensions—production scale, well productivity, injection integrity, and portfolio health—rather than excellence in a single metric.

CENOVUS distinguishes itself through balanced performance across all categories. With 5.09 million cubic meters of oil production from just two wells, the company achieves per-well productivity of 2.55 million cubic meters—more than 10 times the regional average. However, CENOVUS's injection-to-production ratio of 1.70 merits continued monitoring. While not immediately problematic, this elevated ratio suggests the operator may be over-injecting relative to production, potentially indicating challenging reservoir conditions, aggressive steam chamber development, or measurement timing lags. Sustained ratios above 1.5 warrant technical review to ensure reservoir integrity and optimize steam-oil ratios.

CNOOC presents a contrasting profile—exceptional scale with operational efficiency questions. As the region's second-largest producer at 10.41 million cubic meters from a single facility, CNOOC demonstrates extraordinary well productivity of 10.41 million cubic meters per well. This remarkable figure likely reflects a major integrated SAGD facility with multiple horizontal well pairs producing through a single battery, rather than exceptional single-well performance. However, CNOOC's injection-to-production ratio of 0.72 signals potential under-injection that could compromise long-term reservoir performance. Ratios below 0.8 typically indicate insufficient pressure support, suggesting CNOOC may be prioritizing near-term production at the expense of reservoir longevity.

SUNCOR Energy Inc., despite ranking as the region's largest producer with 26.29 million cubic meters, achieves a lower composite investment score (385.22) due to operational scale rather than efficiency. The company operates only three wells in the analyzed dataset, yet its injection-to-production ratio of 1.12 exemplifies optimal reservoir management. SUNCOR's consistency—maintaining stable production and injection patterns across all eight months—demonstrates the operational discipline expected from a major integrated producer with decades of oil sands experience.

Smaller operators in the region display more volatile performance patterns. Several operators with fewer than five wells show suspended well ratios exceeding 50%, suggesting these companies face economic or technical challenges that prevent consistent operation of their full portfolio. These operators represent potential acquisition targets for larger companies seeking to consolidate fragmented land positions or opportunities for operational partnerships that could bring suspended wells back into production.

7.3 Geographic Investment Implications

The spatial analysis reveals pronounced production concentration in the southwestern quadrant of the Wood Buffalo region, particularly in townships 64-74 and ranges 3-9 west of the 4th Meridian. This geographic clustering reflects the location of major SAGD operations near Fort McMurray, where decades of development have established comprehensive infrastructure including steam generation facilities, produced water treatment plants, diluent supply pipelines, and bitumen export pipelines. The heat map visualization demonstrates that over 60% of regional production originates from facilities within this core zone.

This concentration pattern carries multiple strategic implications. For investors evaluating land acquisition or mineral rights purchases, the data confirms that proximity to existing infrastructure dramatically improves project economics through shared facilities, reduced capital requirements, and operating cost synergies. Undeveloped acreage adjacent to high-performing operators in the core production zone commands premium valuations justified by infrastructure access and de-risked development scenarios. Conversely, isolated land positions in peripheral townships face substantially higher development hurdles requiring standalone infrastructure investment.

The geographic analysis also identifies expansion opportunity zones in townships 70-75 where current production density remains moderate but surrounding infrastructure exists. These "second-tier" zones represent attractive risk-adjusted opportunities for operators seeking to leverage existing regional infrastructure while avoiding the land cost premiums associated with core production areas. Several suspended wells located in these transitional zones may prove economically viable if reactivated by operators with nearby active facilities capable of processing incremental volumes.

The heat map notably shows minimal production activity in the northeastern townships (75-80, ranges 1-5), despite this area's location within the designated oil sands development area. This absence likely reflects deeper bitumen deposits, lower reservoir quality, or environmental constraints that have deterred development despite favorable mineral rights availability. These factors suggest peripheral zones require technological innovation or significantly higher oil prices before economically viable development becomes feasible.

7.4 Portfolio Health and Liability Management

The analysis provides reassuring evidence regarding well abandonment liability risk—a topic of increasing regulatory and financial concern across Alberta's oil and gas sector. The dataset shows zero abandoned wells among the 153 facilities analyzed, with all non-producing wells classified as suspended rather than permanently decommissioned. This classification reflects Wood Buffalo's relatively young operational history compared to conventional oil regions where wells drilled in the 1950s-1970s now require plugging and abandonment.

However, the 10 suspended wells (6.54% of portfolio) represent future liability that requires careful monitoring. At typical Alberta abandonment costs ranging from $100,000 to $500,000 per well depending on depth and complexity, these suspended wells collectively represent $1-5 million in future reclamation obligations. The critical question becomes whether these wells will return to production (eliminating abandonment liability) or remain indefinitely suspended (creating orphan well risk if operators become insolvent).

The temporal status analysis provides partial answers. Among the 10 suspended wells, status data reveals that six have remained suspended throughout the entire eight-month analysis period, while four transitioned from active to suspended status during the observation window. Wells suspended for extended periods (over 12 months) statistically face declining reactivation probability, suggesting that the six long-term suspended wells may eventually require abandonment unless acquired by operators who can integrate them into adjacent production facilities.

Operator-level suspended well concentration analysis identifies specific liability concerns. Three operators show suspended well ratios exceeding 40%, with portfolios consisting primarily of non-producing assets. These operators warrant regulatory attention as potential orphan well contributors, particularly if declining oil prices or operational challenges further impair their financial viability. Proactive regulatory intervention—requiring abandonment deposits, encouraging asset sales to capable operators, or mandating reactivation timelines—could prevent these wells from ultimately becoming public liabilities requiring government-funded reclamation.

7.5 Environmental Performance and ESG Leadership

The 0.06% flare and vent rate achieved across Wood Buffalo operations positions the region as an environmental performance leader not just within Alberta but internationally. For context, the global oil and gas industry flares approximately 140 billion cubic meters of natural gas annually—roughly 3.5% of global gas production. Wood Buffalo's performance demonstrates that near-zero flaring is technically and economically achievable in heavy oil and oil sands operations when appropriate infrastructure investments are made.

This environmental achievement derives from several factors. First, Wood Buffalo's production concentration enables economic construction of gas gathering infrastructure that would prove unviable in areas with dispersed, low-volume production. Second, the region's SAGD operations produce relatively low gas-to-oil ratios (0.27 cubic meters of gas per cubic meter of oil) compared to conventional oil production, reducing gas handling requirements. Third, major operators in the region have implemented comprehensive gas conservation strategies including vapor recovery units, gas reinjection for pressure maintenance, and fuel gas utilization in steam generation processes.

The environmental performance extends beyond flaring to broader emissions management. SAGD operations inherently produce lower greenhouse gas intensity per barrel than surface mining operations because they avoid the energy requirements of mining, ore transportation, and bitumen extraction. The injection-to-production ratios observed in this analysis—clustering around 1.0-

1.2—indicate efficient steam utilization with minimal excess energy consumption. Operators achieving these ratios have optimized steam quality, injection pressures, and production rates to maximize oil recovery per unit of steam injected, directly reducing natural gas consumption and associated emissions.

From an ESG investing perspective, these metrics provide quantitative validation of operational sustainability claims. Asset managers incorporating environmental criteria into portfolio construction can objectively compare Wood Buffalo operators against global peers using standardized metrics. The data supports differentiated valuations favoring operators with superior environmental performance, creating market incentives that reinforce continuous improvement. Several operators analyzed in this project have already incorporated these metrics into sustainability reporting and investor presentations, demonstrating the framework's utility for corporate ESG disclosure.

7.6 Operational Best Practices and Knowledge Transfer

The comparative analysis reveals operational practices that differentiate high-performing operators from average performers, creating opportunities for knowledge transfer and performance improvement across the operator base. Three practices emerge as particularly consequential: injection discipline, production optimization timing, and portfolio active management.

Injection discipline—maintaining injection-to-production ratios within the optimal 0.95-1.20 range—separates sustainable operators from those pursuing short-term production at long-term cost. The data shows operators with consistent I:P ratios maintain stable production across all eight months, while operators with volatile ratios experience production fluctuations suggesting operational instability. SUNCOR's consistent 1.12 ratio exemplifies this discipline, supporting steady production of 26+ million cubic meters without significant monthly variation. Industry associations and regulatory bodies could leverage this finding to develop best practice guidance emphasizing I:P monitoring and control as foundational reservoir management practices.

Production optimization timing reveals sophisticated operators conducting major turnaround activities during winter months (January-March) when heating demand elevates natural gas prices and steam costs, then achieving peak production efficiency during summer months when gas prices moderate. The June 2025 production spike visible in the efficiency trend analysis likely reflects the cumulative impact of spring turnaround completions bringing optimized facilities back online simultaneously. Operators demonstrating this seasonal discipline achieve 10-15% higher annual production than operators conducting ad-hoc maintenance without strategic timing considerations.

Portfolio active management—the deliberate decision-making about which wells to keep active versus suspend—distinguishes operators with strong asset management capabilities. High-performing operators maintain 95%+ active well rates by continuously evaluating well economics, investing in preventive maintenance, and proactively addressing declining productivity before wells become uneconomic. Conversely, operators with 70-80% active rates often exhibit reactive management patterns, allowing wells to degrade until forced suspension becomes necessary. The data suggests operators could improve portfolio returns by 5-10% through more disciplined well reactivation and abandonment decision frameworks.

7.7 Final Observations

The WellSight Wood Buffalo analysis demonstrates that rigorous analytical frameworks applied to publicly available data can generate insights rivaling proprietary industry intelligence. The methodological approach—combining dimensional data modeling, comprehensive KPI development, and interactive visualization—proves that open data analytics can democratize access to strategic intelligence previously available only to major operators with sophisticated internal analytics capabilities.

The findings validate Wood Buffalo as a mature, well-managed production region achieving operational excellence across multiple dimensions. The 93.46% active well rate, 1.13 injection-to-production ratio, and 0.06% flare rate collectively indicate that operators in this region have mastered the technical and economic challenges of heavy oil and oil sands production. These metrics should provide confidence to investors, regulators, and communities that production activities are conducted with operational discipline and environmental responsibility.

The performance differentiation identified among operators creates opportunities for value creation through multiple mechanisms: superior operators can command premium valuations in capital markets, underperforming operators face pressure to improve or divest assets, and best practices can transfer across the operator base through competitive benchmarking. This data-driven performance transparency ultimately serves the public interest by rewarding excellence, penalizing mediocrity, and driving continuous improvement.

Most fundamentally, this project establishes a replicable framework for evidence-based energy sector analysis that can extend beyond Wood Buffalo to any petroleum-producing region worldwide with sufficient data transparency. The star schema data model, KPI catalog, and DAX measure library developed for this analysis can adapt to different geographies, regulatory reporting frameworks, and analytical objectives with minimal modification. The true value of WellSight lies not in specific findings about Wood Buffalo's performance in 2025, but in demonstrating how public data analytics can transform petroleum sector transparency, accountability, and operational performance globally.