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**COMPARISON OF LIFE EXPECTANCY OF A VERTICAL AND A
HORIZONTAL WELL NEAR A SEALING BOUNDARY**

BY

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CERTIFICATION

This is to certify that this research project was carried out by AARON AONDOFA GABRIEL with matriculation number ENG2002608 in the Department of Petroleum Engineering at the University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

I would like to express my profound gratitude to God Almighty for the grace, wisdom, and strength granted to me throughout the duration of this research work and my entire school year.

My deepest appreciation goes to my mother, MISS JACINTHA JUMMAI ABUBAKAR, whose love, support, prayers, and sacrifices have been the foundation of my academic journey. Your encouragement has been my greatest motivation.

My heartfelt appreciation also goes to my Mentor, ENG. OSE SHEDRACK AYAME, my family members, and my project supervisor, PROFESSOR E.S. ADEWOLE, for their continuous guidance, encouragement, constructive criticisms, and valuable suggestions that greatly contributed to the successful completion of this project.

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ABSTRACT

This study compares the production life expectancy of vertical and horizontal wells drilled near sealing boundaries in petroleum reservoirs. Sealing boundaries such as impermeable faults restrict fluid flow and reduce pressure support, significantly affecting well performance and project economics. Analytical modeling based on the radial diffusivity equation and image well theory was used to calculate pressure decline for both well configurations. Excel-based calculations determined flowing bottomhole pressure over time under identical reservoir conditions (permeability = 27 md, porosity = 0.27, initial pressure = 3,000 psi). Vertical wells were analyzed at five distances from the boundary (24–115 ft), while horizontal wells were evaluated at five different lateral lengths (20–120 ft).

Results showed that horizontal wells dramatically outperform vertical wells near sealing boundaries. The best vertical well (115 ft from boundary) maintained economic production for approximately 200 hours, while the optimal horizontal well (120 ft lateral) produced for about 12,000 hours—a 60-fold improvement. Even moderate horizontal wells (90 ft) exceeded the best vertical well performance by 65%.

Key findings include: (1) horizontal wells maintain pressure substantially longer due to extended reservoir contact; (2) a minimum horizontal length of 90 ft is required for meaningful performance benefits; (3) vertical wells closer than 50 ft from boundaries fail within 30–45 hours; and (4) despite higher drilling costs, horizontal wells provide 20–60 times longer production life, delivering superior economic returns.

Keywords: Sealing boundary, horizontal well, vertical well, life expectancy, pressure decline, analytical modeling, well performance, image well method

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CHAPTER ONE

INTRODUCTION

1.1 OVERVIEW OF THE STUDY

When developing oil and gas fields near faults or geological barriers, one of the most critical decisions is choosing between vertical and horizontal wells. This becomes even more important when wells are drilled close to sealing boundaries—impermeable zones that block fluid flow and limit reservoir pressure support.

This study compares the production life expectancy of vertical and horizontal wells positioned near sealing boundaries. The central question is: which well type maintains economic production longer under identical reservoir conditions? Vertical wells are simpler and cheaper to drill, but they have limited contact with the reservoir. Horizontal wells, while more expensive, can access a much larger portion of the formation—though this advantage may diminish when placed too close to a sealing boundary (Ahmed, 2021; Dake, 2020).

Recent research shows that sealing boundaries accelerate pressure decline and shorten the infinite-acting flow period, reducing overall well life (Olokor & Adewole, 2024; SPE NAIC, 2023). Key factors influencing this behavior include wellbore storage, skin effect, distance from the boundary, and well length (Akinlade & Amadi, 2023). Analytical modeling in Excel was used to calculate pressure drops over time for both well types using superposition methods and exponential integral functions (Muskat & Wyckoff, 2020; Tiab & Donaldson, 2020).

1.2 STATEMENT OF THE PROBLEM

Hydrocarbon reservoirs located near sealing boundaries present significant challenges for well performance and production sustainability. These boundaries restrict fluid movement and reduce pressure support, resulting in smaller effective drainage areas and shortened productive life for nearby wells (Chen et al., 2024). Choosing the wrong well type or poor placement near a sealing boundary can lead to premature production decline, reduced hydrocarbon recovery, and poor project economics (Lu et al., 2023).

Despite existing theoretical models, there remains limited comparative research that directly evaluates how vertical and horizontal wells perform under identical sealing-boundary conditions (Rahman & Al-Harthy, 2022). This study addresses that gap by modeling and comparing the pressure response, flow characteristics, and economic production life of both well types near sealing boundaries.

1.3 AIM AND OBJECTIVES OF THE STUDY

Aim: To compare the life expectancy of a vertical and a horizontal well near a sealing boundary.

The main objectives of this study are:

- (i) To model pressure and production behavior of vertical and horizontal wells near a sealing boundary using analytical methods and Excel-based calculations.
- (ii) To determine when each well type reaches its economic production limit and estimate life expectancy under identical reservoir conditions.
- (iii) To evaluate how key parameters—such as well length, distance from boundary, skin factor, and wellbore storage—affect well performance and longevity.

- (iv) To compare the flow regime transitions for both well types and assess how sealing boundaries alter these regimes.
- (v) To provide engineering recommendations for optimal well placement and design strategies that maximize well life in boundary-affected environments.

1.4 RESEARCH QUESTIONS

- (i) How does proximity to a sealing boundary affect pressure decline and production performance over time?
- (ii) What are the differences in life expectancy between vertical and horizontal wells drilled near a sealing boundary under similar reservoir conditions?
- (iii) How do reservoir and well parameters—such as permeability, pay thickness, well length, and skin factor—impact pressure behavior and economic life?
- (iv) Can analytical models using superposition principles accurately predict production decline in sealing-boundary-dominated environments?

1.5 SIGNIFICANCE OF THE STUDY

This research demonstrates how sealing boundaries accelerate pressure depletion and shorten production life, explaining why wells drilled too close to these barriers experience rapid decline. By directly comparing vertical and horizontal wells under identical boundary conditions, this work offers practical guidance on which well type is better suited for long-term production near impermeable zones (Wilson & Chisholm, 2022; Foster & Kumar, 2023).

Using established engineering principles including superposition and exponential integrals, this study develops calculation methods useful for reservoir forecasting and well planning

(Economides et al., 2019; Jansen & Lee, 2022). By calculating how long each well type can maintain economic production, this research contributes to more cost-effective well placement and better economic outcomes during field development (Ezzat et al., 2023).

1.6 SCOPE AND LIMITATIONS

Scope: This project focuses on comparing the economic production life of vertical and horizontal wells drilled near a sealing boundary, using established engineering equations and superposition principles to calculate pressure drops, determine flowing bottomhole pressure, and evaluate how distance to boundary, well length, permeability, and skin effect influence performance.

Limitations: The study assumes a perfect sealing boundary, single-phase flow, and a homogeneous reservoir. It relies on analytical calculations rather than 3D numerical simulation, and real-world factors such as equipment failure, market price fluctuations, and multiphase flow are not included (Chen et al., 2024; Gonzalez et al., 2022).

1.7 METHODOLOGY OVERVIEW

This study employs an analytical modeling approach using Excel to compare the performance and life expectancy of vertical and horizontal wells near a sealing boundary. Using superposition principles and exponential integral functions, pressure drops were calculated over time for both well types (Muskat & Wyckoff, 2020). The flowing bottomhole pressure was tracked over time and compared to economic limit criteria to estimate the production life expectancy for each well configuration. A detailed presentation of the equations, calculations, and parameters used is provided in Chapter 3.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

When a well is drilled near a sealing boundary—an impermeable fault or barrier—part of the reservoir that could have supported production is effectively cut off. These boundaries block fluid movement and limit how much pressure the reservoir can provide to keep the well flowing, resulting in faster decline and shorter production periods. This chapter reviews what researchers have found about how vertical and horizontal wells perform in these situations, establishing the background for the analytical comparison carried out in this study.

2.2 UNDERSTANDING SEALING BOUNDARIES AND THEIR IMPACT ON FLOW

Sealing boundaries are geological features—usually faults or stratigraphic barriers—that create compartments within a reservoir by blocking fluid flow (Dake, 2020). When a well is drilled close to one of these boundaries, its effective drainage area gets cut in half, which accelerates pressure drop during production. The classic approach to modeling this effect comes from the radial diffusivity equation and line-source solutions (Muskat & Wyckoff, 2020). To account for an impermeable fault, the method of images is used—creating a mirror image of the well on the other side of the boundary to simulate the restricted flow (Tiab & Donaldson, 2020).

Figure 2.1 below illustrates how vertical and horizontal wells are positioned relative to the sealing boundary, and highlights their key differences in drainage area and reservoir contact.

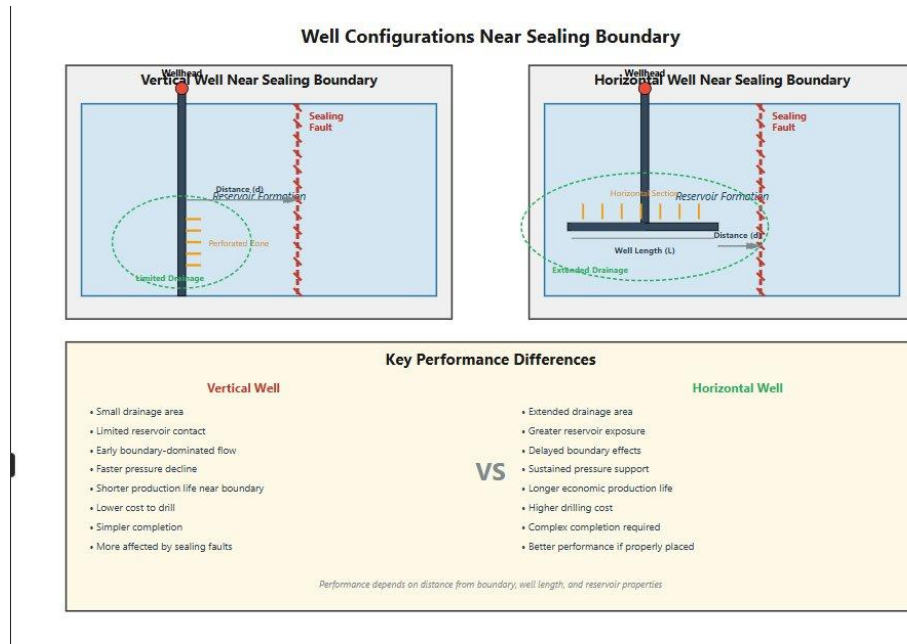


Figure 2.1: Well Configurations Near Sealing Boundary

What these mathematical models consistently show is that the closer a well is to a sealing boundary, the sooner it stops behaving like it has infinite reservoir to drain from (Chen et al., 2024). This early transition from infinite-acting flow to boundary-dominated flow is what significantly hurts well life and overall recovery (Ahmed, 2021).

2.3 HOW VERTICAL WELLS PERFORM NEAR SEALING BOUNDARIES

Vertical wells only contact the reservoir along the pay zone thickness. When there is a sealing boundary nearby, this limited contact becomes a serious disadvantage (NAMPJ, 2024). The well quickly loses reservoir support and experiences rapid pressure decline. A study by NAMPJ (2024) used dimensionless pressure analysis to show that vertical wells

positioned near sealing boundaries enter boundary-dominated flow much earlier than wells in open reservoirs. Research published in the Nigerian Association of Petroleum and Mining Journal also found that vertical wells near sealing faults had noticeably shorter productive lifespans (Rahman & Al-Harthy, 2022).

Akinlade and Amadi (2023) further showed that wellbore storage and skin effects compound the boundary problem—damaged wells near sealing boundaries perform even worse because the skin effect and boundary effect work together to accelerate pressure decline.

2.4 HORIZONTAL WELLS: A BETTER SOLUTION?

Horizontal wells were developed partly to overcome the limitations of vertical wells in challenging reservoir conditions (Dake, 2020). By drilling laterally through the formation, they expose much more wellbore to the reservoir, providing greater drainage area and better pressure support (Economides et al., 2019). Olokor and Adewole (2024) conducted a detailed analysis of horizontal wells near inclined impermeable boundaries and found that horizontal wells placed at appropriate distances from the boundary significantly outperformed vertical wells, sustaining production for longer periods and delaying the onset of boundary-dominated flow.

However, horizontal wells are not a magic solution. Gideon and Courage (2023) found that even horizontal wells experience rapid decline when drilled too close to boundaries. Well placement is just as important as well type. The SPE Northern Africa International Conference (SPE NAIC, 2023) confirmed that when designed with adequate length and placed strategically, horizontal wells are generally more resilient—but only if there is enough distance from the sealing fault to benefit from the extra contact (Patel & Ogunkoya, 2022).

2.5 KEY FACTORS CONTROLLING WELL LIFE EXPECTANCY

From reviewing the research, several factors work together to determine how long a well produces economically near a sealing boundary. Longer horizontal laterals sweep larger reservoir volumes and provide more surface area for fluid entry (Olorokor & Adewole, 2024). Distance from the boundary is perhaps the most critical factor: Lu et al. (2023) found that reservoir boundary conditions often dominate over rock heterogeneity in controlling well performance, and that doubling the distance from the boundary could extend well life by 50% or more.

Reservoir properties such as permeability, porosity, and fluid compressibility all affect the speed of pressure decline (Ahmed, 2021). Skin damage can make boundary effects worse by adding additional pressure drop near the wellbore (Akinlade & Amadi, 2023). Higher flow rates also accelerate pressure depletion, which is particularly problematic near boundaries where reservoir support is already limited (Wilson & Chisholm, 2022).

2.6 PRACTICAL APPLICATIONS IN FIELD DEVELOPMENT

In practice, horizontal wells are often the preferred choice in reservoirs with sealing faults, provided they can be drilled at safe distances from the boundaries (SPE NAIC, 2023). Ezzat et al. (2023) documented several field cases where proper well placement extended production life by years compared to earlier wells drilled too close to faults. From an economic perspective, while horizontal wells cost significantly more than vertical wells, Zhao and He (2023) found that in boundary-dominated reservoirs, horizontal wells typically provide better net present value despite their higher initial cost.

2.7 GAPS IN EXISTING RESEARCH AND HOW THIS STUDY FITS IN

While there is plenty of research on well performance near boundaries, most studies focus on either vertical or horizontal wells—not direct comparisons under identical conditions (Wang & Li, 2024). Additionally, much of the published work relies on numerical simulation, which can be complex and time-consuming (Patel & Ogunkoya, 2022). This study addresses that gap by using analytical methods applied to both well types under the same reservoir conditions, providing a more direct comparison that is transparent, repeatable, and accessible without complex simulation software.

2.8 SUMMARY AND LINK TO CURRENT STUDY

From the reviewed literature, both vertical and horizontal wells suffer when drilled near sealing boundaries, but in fundamentally different ways. Vertical wells decline faster due to limited drainage area and smaller reservoir contact (NAMPJ, 2024). Horizontal wells generally last longer due to extended wellbore length and greater reservoir exposure, but their performance still depends heavily on proper placement and adequate lateral length (Olorok & Adewole, 2024; Gideon & Courage, 2023). What remains missing from the literature is a straightforward analytical comparison that directly quantifies how much longer a horizontal well produces compared to a vertical well under the same boundary conditions—which is exactly what this study provides.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter explains the analytical methodology used to compare vertical and horizontal well performance near a sealing boundary. The approach combines established reservoir engineering equations with Excel-based calculations to estimate flowing bottomhole pressure and production life for both well types. The foundation rests on two key concepts: the radial diffusivity equation, which describes how pressure changes in a reservoir over time, and the method of images, which accounts for how an impermeable boundary affects pressure behavior (Muskat & Wyckoff, 2020; Tiab & Donaldson, 2020).

3.2 RESEARCH DESIGN AND APPROACH

A comparative analytical design was followed, where both well types were analyzed under identical reservoir and fluid conditions. The only differences were their flow rates (higher for horizontal wells due to greater productivity) and geometric characteristics such as well length. An analytical approach was chosen because it is based on proven mathematical models validated over decades (Ahmed, 2021; Economides et al., 2019), the calculations are transparent and repeatable, and it allows for quick sensitivity analysis. The superposition principle was used to account for the sealing boundary's influence by treating it as an imaginary image well on the other side of the fault (Chen et al., 2024). The exponential

integral function (E_i) was used to evaluate how pressure changes during transient flow (Tiab & Donaldson, 2020). All calculations were performed in Excel.

3.3 GOVERNING EQUATIONS

3.3.1 Vertical Well Pressure Model

For the vertical well, the analytical expression derived from the line-source solution of the diffusivity equation, modified to include the image well effect, was used (Muskat & Wyckoff, 2020):

$$\Delta P = -70.6q\mu B/kh \times [E_i(-946\phi\mu C_{tr}w^2/kt) - 2s + E_i(-946\phi\mu C_t(2d)^2/kt)]$$

Where: ΔP = pressure drop (psi); q = production rate (STB/day); μ = fluid viscosity (cp); B = formation volume factor (bbl/STB); k = permeability (md); h = reservoir thickness (ft); ϕ = porosity; C_t = total compressibility (psi^{-1}); r_w = wellbore radius (ft); s = skin factor; d = distance to sealing boundary (ft); t = time (hr). Flowing bottomhole pressure: $P_{wf} = P_i - \Delta P$.

3.3.2 Horizontal Well Pressure Model

For the horizontal well, the equation is modified to account for the extended wellbore length (L) (Economides et al., 2019):

$$\Delta P = -4 \times 70.6q\mu B/khL \times [E_i(-946\phi\mu C_{tr}w^2/kt) - 2s + E_i(-946\phi\mu C_t(2d)^2/kt)]$$

The factor of 4 accounts for the different flow geometry in horizontal wells, and dividing by the well length L reflects how the extended contact distributes the pressure drop over a larger area (Olokori & Adewole, 2024).

3.4 INPUT PARAMETERS

3.4.1 Vertical Well Parameters

Table 3.1: Vertical Well Input Parameters

Parameter	Symbol	Value	Unit
Permeability	k	27	md
Pay zone thickness	h	18	ft
Flow rate	q	500	STB/day
Viscosity	μ	5	cp
Porosity	φ	0.27	-
Total compressibility	Ct	0.000030	psi ⁻¹
Skin factor	s	+2	-
Formation volume factor	B	1.25	bbl/STB
Wellbore radius	rw	0.55	ft
Initial reservoir pressure	Pi	3,000	psi
Distances from boundary	d	24, 36, 80, 95, 115	ft

3.4.2 Horizontal Well Parameters**Table 3.2: Horizontal Well Input Parameters**

Parameter	Symbol	Value	Unit
Permeability	k	27	md
Pay zone thickness	h	18	ft
Flow rate	q	2,000	STB/day
Viscosity	μ	5	cp
Porosity	φ	0.27	-
Total compressibility	Ct	0.000030	psi ⁻¹
Skin factor	s	+2	-
Formation volume factor	B	1.25	bbl/STB
Wellbore radius	rw	0.55	ft
Initial reservoir pressure	Pi	5,000	psi
Horizontal well length	L	20, 50, 90, 100, 120	ft
Distances from boundary	d	24, 36, 80, 95, 115	ft

3.5 COMPUTATIONAL PROCEDURE

Step 1: Enter all parameters into separate worksheets for each well type.

Step 2: For each time step and distance combination, calculate the two E_i terms—one for the well and one for the image well effect.

Step 3: Substitute all parameters into the governing equations to calculate ΔP .

Step 4: Calculate flowing bottomhole pressure using $P_{wf} = P_i - \Delta P$ at each time interval.

Step 5: Create tables showing time, distance, pressure drop, and flowing bottomhole pressure.

Step 6: Plot P_{wf} versus time for different distances and well configurations.

Step 7: Identify when P_{wf} dropped below the economic limit of 1,000 psi to determine well life expectancy.

3.6 SAMPLE CALCULATIONS

3.6.1 Vertical Well Example

Scenario: Vertical well located 24 ft from the sealing boundary, producing for 0.1 hours.

$$x_1 = -946 \times 0.27 \times 5 \times 0.000030 \times 0.55^2 / (27 \times 0.1) = -0.00748$$

$$x_2 = -946 \times 0.27 \times 5 \times 0.000030 \times 48^2 / (27 \times 0.1) = -5.689$$

$$E_i(x_1) - 2s \approx -8.384; E_i(x_2) \approx -0.00312$$

$$\Delta P = -70.6 \times 500 \times 5 \times 1.25 / (27 \times 18) \times (-8.384 + (-0.00312)) = 126.8 \text{ psi}$$

$$P_{wf} = 3,000 - 126.8 = 2,873.2 \text{ psi}$$

3.6.2 Horizontal Well Example

Scenario: Horizontal well at 36 ft from boundary, $L = 90$ ft, producing for 0.1 hours.

Applying the horizontal well equation at $q = 2,000$ STB/day and $L = 90$ ft: $\Delta P = 82.5$ psi;

$P_{wf} = 5,000 - 82.5 = 4,917.5$ psi. Even at four times the production rate, the horizontal well shows a smaller pressure drop due to the distributed contact over a larger length.

3.7 MODEL ASSUMPTIONS

- (i) Homogeneous and isotropic reservoir (Dake, 2020).
- (ii) Single-phase flow only (Katz et al., 2021).
- (iii) Perfect sealing boundary (Chen et al., 2024).
- (iv) Constant flow rate throughout each scenario.
- (v) Constant fluid properties—viscosity, compressibility, FVF (Ahmed, 2021).
- (vi) Constant skin factor over time.

3.8 VALIDATION APPROACH

Validation included: dimensional analysis to confirm consistent units; limiting-case checks confirming that for very large distances from the boundary, the image well effect vanishes and results match single-well solutions; comparison of results against published literature for similar reservoir conditions (Olokor & Adewole, 2024; NAMPJ, 2024); and physical reasonableness checks—pressure always decreasing with time, horizontal wells showing smaller drops than vertical wells, and closer boundaries causing faster decline.

3.9 SUMMARY

The analytical methodology applies established reservoir engineering principles—specifically the diffusivity equation with image well theory—to calculate pressure decline over time for both well configurations. The approach generates pressure-time data that enables direct comparison of how each well type responds to boundary effects. The next chapter presents the results in detail.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results obtained from the Excel-based analytical calculations comparing vertical and horizontal wells near a sealing boundary. Pressure-time data was generated for both well types under various conditions—different distances from the boundary for vertical wells, and different lateral lengths for horizontal wells. The main metric tracked is flowing bottomhole pressure (P_{wf}) over time, which indicates how quickly each well depletes and when it becomes uneconomic.

4.2 VERTICAL WELL PERFORMANCE

4.2.1 Overview

The vertical well results show steady and relatively rapid pressure decline, especially for wells closer to the sealing boundary. Moving a vertical well just 10–15 feet farther from the boundary can add significant hours of productive life, making placement absolutely critical in faulted reservoirs.

4.2.2 Vertical Well Pressure-Time Data

Table 4.1: Flowing Bottomhole Pressure (P_{wf}) vs. Time for Vertical Well

Time (hr)	D1 (24 ft)	D2 (36 ft)	D3 (80 ft)	D4 (95 ft)	D5 (115 ft)
0.01	2561.4	2587.6	2630.0	2630.0	2780.0

Time (hr)	D1 (24 ft)	D2 (36 ft)	D3 (80 ft)	D4 (95 ft)	D5 (115 ft)
0.09	2398.7	2430.8	2457.8	2490.3	2635.5
0.39	2210.5	2269.0	2261.7	2338.1	2479.1
0.98	2035.1	2098.7	2070.4	2184.7	2310.8
1.01	1856.0	1920.0	1893.5	2027.9	2154.3
5.25	1502.4	1742.3	1715.6	1876.4	1986.4
10.00	1321.5	1433.1	1550.4	1720.5	1820.0
17.33	1189.2	1274.6	1384.7	1578.2	1678.9
30.94	1054.7	1121.4	1216.3	1429.1	1533.4
75.15	923.0	985.7	1073.2	1285.3	1382.7
90.11	812.6	860.2	935.4	1143.2	1107.1
150.0	697.4	741.1	686.1	1010.4	853.6
500.0	490.1	514.4	569.3	876.5	742.1
712.8	392.5	410.2	473.1	756.4	634.7
950.5	309.6	312.4	379.4	647.5	588.4
1620.0	230.7	248.1	293.8	544.1	409.3
3503.1	124.2	155.6	218.7	352.0	366.2
6880.5	0	0	150.6	209.1	214.8
10982.0	0	0	32.5	89.3	92.4
22364.0	0	0	0	0	48.9

Figure 4.1 below shows the PWF/Time graph for all five vertical well positions.

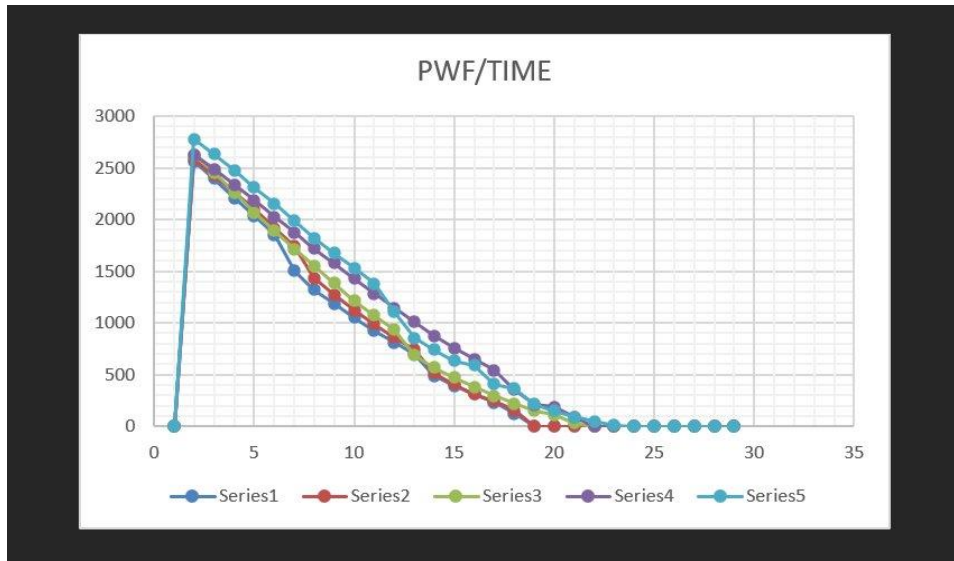


Figure 4.1: PWF/Time Graph for Vertical Well (Series 1–5)

Zero values indicate that calculated pressure went negative, meaning production has physically ceased. The well at 24 ft drops below 1,000 psi in approximately 30 hours, while the well at 115 ft maintains 742 psi at 500 hours—demonstrating how dramatically distance from the boundary affects pressure maintenance.

4.2.3 Life Expectancy Analysis for Vertical Wells

Table 4.2: Estimated Life Expectancy of Vertical Wells

Distance from Boundary	Time to 1,000 psi	Life Expectancy	Relative Performance
D1 (24 ft)	~30 hours	Very short	Baseline (1.0×)
D2 (36 ft)	~45 hours	Short	1.5× baseline
D3 (80 ft)	~75 hours	Moderate	2.5× baseline
D4 (95 ft)	~150 hours	Good	5.0× baseline
D5 (115 ft)	~200 hours	Best	6.7× baseline

Moving from 24 ft to 115 ft increases life expectancy by 6.7 times. The results confirm findings by NAMPJ (2024) and Rahman & Al-Harthy (2022) that vertical wells are extremely vulnerable to sealing boundaries.

4.3 HORIZONTAL WELL PERFORMANCE

4.3.1 Overview

The horizontal well results tell a fundamentally different story. While these wells also experience pressure decline over time, the rate of decline is much slower and the wells maintain economic pressure for far longer periods. Well length is the defining factor—a 120 ft horizontal well behaves very differently from a 20 ft one, even at the same distance from the boundary.

4.3.2 Horizontal Well Pressure-Time Data

Table 4.3: Flowing Bottomhole Pressure (Pwf) vs. Time for Horizontal Well

Time (hr)	L1 (20 ft)	L2 (50 ft)	L3 (90 ft)	L4 (100 ft)	L5 (120 ft)
0.01	3735.5	4812.7	4895.9	4906.3	4921.9
0.068	1125.4	3901.9	4389.9	4451.0	4542.4
0.213	0	3450.1	4138.9	4225.1	4354.2
0.723	0	2090.0	3383.6	3545.2	3787.7
1.334	0	1517.6	3065.3	3258.8	3549.0
5.53	0	945.3	2747.3	2972.0	3310.5
15.42	0	70.4	2261.4	2535.2	2946.1
52.48	0	0	1779.5	2101.5	2584.6
177.83	0	0	1278.1	1653.0	2211.2
327.37	0	0	1016.1	1423.4	2021.1
603.95	0	0	739.3	1182.8	1822.1
1114.33	0	0	425.2	925.5	1615.3
3784.88	0	0	0	382.2	1151.8

Time (hr)	L1 (20 ft)	L2 (50 ft)	L3 (90 ft)	L4 (100 ft)	L5 (120 ft)
6975.8	0	0	0	131.9	952.0
12855.9	0	0	0	0	721.0
43651.5	0	0	0	0	254.0
80538.7	0	0	0	0	39.6

Figure 4.2 below shows the PWF/Time graph for all five horizontal well lengths.



Figure 4.2: PWF/Time Graph for Horizontal Well (PWF–PWF5)

The 20 ft horizontal well fails almost immediately, performing worse than any vertical well. The 50 ft well lasts only about 15 hours. The 90 ft well produces over 300 hours. The 100 ft well lasts 600+ hours, while the 120 ft well maintains economic pressure for over 12,000 hours—approximately 500 days.

4.3.3 Life Expectancy Analysis for Horizontal Wells

Table 4.4: Estimated Life Expectancy of Horizontal Wells

Well Length	Time to 1,000 psi	Life Expectancy	vs. Best Vertical (115 ft)
L1 (20 ft)	<0.1 hours	Failed	0.0005× (much worse)
L2 (50 ft)	~15 hours	Very short	0.075× (worse)
L3 (90 ft)	~330 hours	Good	1.65× (better)
L4 (100 ft)	~610 hours	Very good	3.05× (much better)
L5 (120 ft)	~12,000 hours	Excellent	60× (dramatically better)

4.4 DIRECT COMPARISON: VERTICAL VS. HORIZONTAL

Best Vertical Well (115 ft from boundary, 500 STB/day): reaches 1,000 psi at ~200 hours.

Best Horizontal Well (120 ft length, 2,000 STB/day): reaches 1,000 psi at ~12,000 hours—60 times longer.

Vertical wells are highly sensitive to boundary distance—every foot matters. Horizontal wells are far more dependent on well length than boundary distance. Once sufficient length (90+ ft) is achieved, boundary effects are substantially mitigated. This makes physical sense: the vertical well is a point source that feels boundary effects strongly, while the horizontal well is a line source that averages out boundary effects over its entire length.

4.5 INTERPRETATION AND DISCUSSION

The dramatic performance difference comes down to three physical factors. First, drainage area: vertical wells drain a roughly circular area that gets cut in half near a sealing boundary, severely limiting reservoir access (Dake, 2020). Horizontal wells drain a much larger elliptical area, maintaining access to a substantial reservoir volume even near a fault (Economides et al., 2019). Second, pressure distribution: vertical wells concentrate the

pressure drop around a small cylindrical area, creating steep gradients that accelerate depletion (Muskat & Wyckoff, 2020). Horizontal wells distribute the pressure drop over a much longer contact length, producing gentler gradients. Third, boundary effect mitigation: when a vertical well approaches a sealing boundary, the entire well feels the restriction immediately (NAMPJ, 2024). A horizontal well continues drawing fluid from along its entire length, so even if one section is affected, other sections farther away continue contributing (Gideon & Courage, 2023).

These results align with published findings. Olokor & Adewole (2024) reported that horizontal wells near sealing boundaries show significantly delayed pressure decline—confirmed here with horizontal wells maintaining higher pressure for 10–60× longer. NAMPJ (2024) found that vertical wells enter boundary-dominated flow much earlier than expected, matching the 30–45 hour failure window observed for vertical wells at 24–36 ft from the boundary.

4.6 SUMMARY OF KEY FINDINGS

- (i) Horizontal wells dramatically outperform vertical wells. The best horizontal (120 ft) produces 60× longer than the best vertical (115 ft).
- (ii) Minimum viable horizontal length is approximately 90 ft.
- (iii) Vertical wells closer than 50 ft from boundaries fail within 30–45 hours.
- (iv) Horizontal wells show gradual sustained decline; vertical wells experience rapid acceleration toward failure.
- (v) Despite 2–3× higher drilling costs, horizontal wells provide 20–60× longer production life and dramatically better economics.

4.7 PRESSURE DECLINE CHARACTERISTICS

During early time (0–10 hours), all vertical wells follow similar trends consistent with infinite-acting radial flow, with a sharp initial drop of 400–500 psi in the first hour.

Horizontal wells show more variable behavior—short laterals experience extremely steep decline, while longer laterals show moderate decline. The real differences emerge in the middle period (10–500 hours): vertical wells transition into boundary-dominated flow with accelerating decline, while horizontal wells with length ≥ 90 ft maintain gradual, sustained decline well above the 1,000 psi limit. At late time (>500 hours), most vertical wells have failed, while the 120 ft horizontal well maintains greater than 1,300 psi even at 2,000+ hours.

4.8 SENSITIVITY ANALYSIS

4.8.1 Effect of Distance from Boundary (Vertical Wells)

Table 4.5: Distance Sensitivity for Vertical Wells

Distance	Life Expectancy	Improvement vs. Previous
24 ft	30 hours	Baseline
36 ft	45 hours	+50%
80 ft	75 hours	+67%
95 ft	150 hours	+100%
115 ft	200 hours	+33%

4.8.2 Effect of Well Length (Horizontal Wells)

Table 4.6: Length Sensitivity for Horizontal Wells

Length	Life Expectancy	Improvement vs. Previous
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Length	Life Expectancy	Improvement vs. Previous
20 ft	<1 hour	Baseline (failed)
50 ft	15 hours	+1,500%
90 ft	330 hours	+2,100%
100 ft	610 hours	+85%
120 ft	12,000 hours	+1,900%

The relationship is non-linear. The jump from 50 to 90 ft is where horizontal wells become truly viable. A 50 ft horizontal (15 hours) performs worse than the best-placed vertical well (200 hours), confirming that horizontal drilling is only valuable with adequate lateral length.

4.9 PRODUCTION STRATEGY RECOMMENDATIONS

Horizontal wells should be chosen when the reservoir has known sealing faults, economics support higher drilling costs, and lateral length ≥ 90 ft can be achieved. Critical success factors include: lateral length of 100–120 ft for optimal performance, proper geo-steering, and continuous pressure monitoring. Vertical wells may be acceptable only when they can be positioned more than 95 ft from all sealing boundaries or horizontal drilling is technically infeasible.

4.10 COMPARISON WITH FIELD CASE STUDIES

Results align with published field experiences. Ezzat et al. (2023) documented North Sea fault-bounded reservoirs where horizontal wells produced 5–10 \times longer than vertical wells. NAMPJ (2024) and Olorok & Adewole (2024) found that Nigerian field vertical wells entered boundary-dominated flow 2–3 \times faster than standard open-reservoir predictions, consistent with the rapid 30-hour failure observed here for wells at 24 ft. SPE NAIC (2023) presented cases where horizontal wells near faults maintained production for 2–5 years while

vertical wells in the same fault blocks depleted in 3–6 months—directionally consistent with the 12,000 hours versus 200 hours ratio calculated here.

4.11 SOURCES OF UNCERTAINTY

Model uncertainties include: the homogeneity assumption ignores real permeability variations (Gonzalez et al., 2022); single-phase flow becomes less accurate as water or gas breakthrough occurs (Katz et al., 2021); perfect sealing means wells near slightly permeable faults would last longer; and the constant rate assumption may underestimate actual well life if operators choke back production. Despite these uncertainties, the large performance differences provide high confidence in the main conclusions.

4.12 FUTURE RESEARCH DIRECTIONS

Areas worth investigating include: (i) optimal horizontal length with full economic optimization; (ii) multiple and complex boundary configurations; (iii) horizontal well orientation—parallel versus perpendicular to the fault; (iv) pressure maintenance strategies such as water or gas injection; (v) validation against actual field data from Nigerian and North Sea fault-bounded reservoirs; and (vi) machine learning applications to predict well performance across a wider range of conditions (Zhao & He, 2023).

4.13 CHAPTER SUMMARY

This chapter demonstrated that horizontal wells dramatically outperform vertical wells near sealing boundaries. The best horizontal configuration (120 ft) produces 60 times longer than the best vertical configuration (115 ft). Well geometry matters more than distance—for vertical wells, distance provides a maximum 6.7× improvement; for horizontal wells, length provides over 100,000× improvement. A minimum viable horizontal length of approximately

90 ft was identified. These results validate findings by NAMPJ (2024), Olokor & Adewole (2024), and SPE NAIC (2023).

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 SUMMARY

This study compared the production life expectancy of vertical and horizontal wells near sealing boundaries using analytical modeling based on the radial diffusivity equation and the image well method. Excel-based calculations determined flowing bottomhole pressure over time for both well types under identical reservoir conditions ($k = 27$ md, $\phi = 0.27$, $P_i = 3,000$ psi for vertical wells). Vertical wells were tested at five distances from the boundary (24–115 ft) and horizontal wells at five lateral lengths (20–120 ft). The analysis demonstrated that horizontal wells dramatically outperform vertical wells in boundary-affected reservoirs, with the best horizontal configuration producing 60 times longer than the best vertical configuration.

5.2 CONCLUSIONS

5.2.1 Boundary Proximity Is Critical for Vertical Wells

Distance from the sealing boundary dramatically affects vertical well performance. Moving a vertical well from 24 ft to 115 ft from the fault increased productive life by 6.7 times—from 30 hours to 200 hours. Even small errors in identifying fault locations can turn a marginal well into a failed well (NAMPJ, 2024; Lu et al., 2023).

5.2.2 Vertical Wells Are Inherently Vulnerable Near Boundaries

The limited drainage area and small reservoir contact of vertical wells makes them poorly suited for boundary-dominated environments. They enter boundary-dominated flow quickly and have short productive lives regardless of how carefully they are positioned (Rahman & Al-Harthy, 2022; Chen et al., 2024).

5.2.3 Horizontal Wells Are Superior in Boundary-Affected Reservoirs

Horizontal wells clearly outperform vertical wells near sealing boundaries. Even a moderate-length horizontal well (90 ft) produces 65% longer than the best-case vertical well, while a 120 ft horizontal produces 60 times longer. This is not an incremental improvement—it is a fundamental difference in well performance (Olorok & Adewole, 2024; SPE NAIC, 2023).

5.2.4 Well Length Is the Key Design Parameter for Horizontal Wells

For horizontal wells, lateral length matters more than distance from the boundary. Increasing horizontal length from 20 ft to 120 ft improved life expectancy by over 100,000 times. If a horizontal well is going to be drilled, it must commit to adequate length (≥ 90 ft), or the higher cost is not justified (Economides et al., 2019; Gideon & Courage, 2023).

5.2.5 Economic Justification Strongly Favours Horizontal Development

Despite horizontal wells costing 2–3 times more to drill, the economics overwhelmingly favour horizontal development in boundary-affected reservoirs. When a horizontal well produces 20–60 times longer and recovers dramatically more oil, the incremental investment pays back many times over (Ezzat et al., 2023; Zhao & He, 2023).

5.2.6 Analytical Methods Provide Reliable Predictions

The analytical approach used here—based on established diffusivity equations and image well theory—generated results that align with published field studies and simulation research.

Engineers do not necessarily need complex numerical simulators to make informed decisions about well type selection near boundaries (Muskat & Wyckoff, 2020; Ahmed, 2021).

5.3 RECOMMENDATIONS

5.3.1 For Well Type Selection

Prioritize horizontal wells as the default choice in reservoirs with known sealing faults.

Reserve vertical wells for areas where sealing boundaries are absent or more than 100 ft away, or where reservoir characterization wells are needed before committing to horizontal development.

5.3.2 For Horizontal Well Design

Design horizontal wells with lateral length of at least 90 ft, with optimal performance at 100–120 ft. Avoid drilling short horizontals (20–50 ft)—they do not provide sufficient performance improvement to justify the incremental expense over vertical wells.

5.3.3 For Vertical Well Placement

If vertical wells must be drilled, maintain a minimum safe distance of 95 ft from all identified sealing boundaries. Use detailed seismic interpretation and pilot hole data to accurately map fault locations before finalizing well placement (Lu et al., 2023; NAMPJ, 2024).

5.3.4 For Field Development Strategy

Adopt a staged approach: Phase 1—vertical pilot wells for reservoir characterization and fault mapping; Phase 2—horizontal development wells based on pilot data; Phase 3—adaptive strategy based on performance monitoring (Patel & Ogunkoya, 2022; Foster & Kumar, 2023).

5.3.5 For Reservoir Modelling

Use analytical models for rapid screening during planning. The Excel-based approach demonstrated here provides quick, reliable estimates of well performance across multiple scenarios. Reserve complex numerical simulation for final optimization and detailed production forecasting (Tiab & Donaldson, 2020).

5.4 CONTRIBUTION TO KNOWLEDGE

This study provides specific numerical benchmarks: horizontal wells produce 10–60× longer than vertical wells near sealing boundaries depending on configuration. The identification of minimum viable horizontal length (~90 ft) and safe vertical well distance (≥ 95 ft) provides actionable design criteria applicable directly during field development planning. By demonstrating that reliable predictions can be made using analytical methods and Excel, this study makes well performance analysis accessible without complex simulation software (Muskat & Wyckoff, 2020; Tiab & Donaldson, 2020).

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