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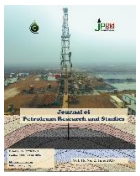

Determining and Estimating Drilling Mud Loss Levels Using the Landmark System in the X Oil Field

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Abstract

The X Oil Field oil field, is a giant field facing operational challenges during drilling activities, the most prominent being drilling mud loss in various geological formations. This issue adversely affects drilling efficiency and increases operational costs. This study aims to identify the levels of drilling mud loss in the X Oil Field wells and estimate these levels for new wells to support decision-making related to optimal drilling site selection and risk mitigation associated with mud loss. Data on well locations, formation tops, and mud loss values were analyzed using the Landmark system. A database was created within the OpenWorks platform, and the data were processed with the VIR10 (DSG) program for seismic and geological analysis. The study covered data from 56 wells. Four contour maps were prepared to show the distribution of mud loss levels (low, moderate, and high). Additionally, four representative wells were selected for detailed analysis of mud loss levels: X-53, X-54, X-55, and X-56. The results revealed mud loss in the A, B, C, and D formations, with three levels of occurrence identified across the entire field: low, moderate, and high. Low levels were concentrated in the southern and western parts of the field, moderate levels were distributed in the northern and eastern parts, and high levels were primarily located in the central area. The contour maps showed significant variation in mud loss even among adjacent wells, limiting the ability to generalize spatial data across the whole field. The A formation exhibited the highest drilling mud loss compared to the other formations. Calculation tables developed using Microsoft Excel demonstrated a high capability to estimate mud loss levels for new wells based on data from nearby wells, making them an effective tool for supporting future drilling planning. The study recommends incorporating these results into the geological drilling programs of the X Oil Field, exercising caution when drilling wells at the structural highs of the field where high mud loss occurs. It also advises preparing a lithological distribution map for the A formation correlated with 3D seismic data to better delineate potential mud loss zones. Moreover, acquiring updated 3D seismic data in (Segy-PSTM) format is necessary to improve assessment accuracy. This study serves as a model that can be generalized and applied to other oil fields operated by Basrah Oil Company facing similar mud loss challenges.

Keywords: Drilling Mud loss, Landmark Software, Well Data Analysis.

تحديد وتخمين مستويات فقدان طين الحفر بإستخدام منظومة Landmark في حقل X النفطي

الخلاصة:

يقع حقل X النفطي على بُعد 100 كم غرب مدينة البصرة جنوب العراق، وهو من الحقول العملاقة التي تواجه تحديات تشغيلية أثناء عمليات الحفر، من أبرزها فقدان طين الحفر في التكوينات الجيولوجية المختلفة، الأمر الذي يؤثر سلبًا على كفاءة الحفر ويزيد من التكاليف التشغيلية. تهدف هذه الدراسة إلى تحديد مستويات فقدان طين الحفر في آبار حقل X، وتقدير هذه المستويات للآبار الجديدة، لدعم اتخاذ القرارات المتعلقة بتحديد مواقع الحفر المثلى وتقليل المخاطر المرتبطة بفقدان الطين. تم تحليل بيانات مواقع الآبار وقمم التكاوين وقيم فقدان الطين باستخدام نظام Landmark، حيث أنشئت قاعدة بيانات في منصة OpenWorks، وأُدخلت البيانات إلى برنامج VIR10 (DSG) لتحليل البيانات الزلزالية والجيولوجية. شملت الدراسة بيانات 56 بئرًا، وتم إعداد أربع خرائط كونتورية توضح توزيع مستويات فقدان الطين (منخفض، متوسط، وعالٍ). كما تم اختيار أربع آبار ممثلة لتحليل مستويات الفقدان، وهي:X-53، X-54، X-55، و X-56.

أظهرت النتائج وجود فقدان طين في تكوينات A، B، C، وD، مع تحديد ثلاثة مستويات لحدوث الفقدان عبر الحقل بالكامل: منخفض، متوسط، وعالٍ. تمركزت المستويات المنخفضة في جنوب وغرب الحقل، بينما توزعت المستويات المتوسطة في شمال وشرق الحقل، وتركزت المستويات العالية بشكل رئيسي في المنطقة المركزية. وأظهرت خرائط الكونتورية أن فقدان الطين يختلف حتى بين الآبار المجاورة، مما يحد من إمكانية تعميم البيانات المكانية على كامل الحقل. كما أشارت النتائج إلى أن تكوين A سجل أعلى مستويات فقدان طين الحفر مقارنةً بالتكوينات الأخرى. أظهرت الجداول الحسابية التي تم تطويرها باستخدام برنامج Microsoft Excel قدرة عالية على تقدير مستويات فقدان الطين للآبار الجديدة، وذلك باستخدام بيانات من الآبار القريبة، مما يجعلها أداة فعالة لدعم التخطيط المستقبلي لعمليات الحفر. توصي الدراسة بإدراج نتائجها ضمن برامج الحفر الجيولوجية لحقل X، مع توخي الحذر عند حفر الآبار في القمم التركيبية للحقل، حيث تتواجد مستويات عالية من فقدان الطين. كما يُنصح بإعداد خريطة لتوزيع الخصائص الليثولوجية لتكوين A وربطها بالبيانات الزلزالية ثلاثية الأبعاد لتوضيح مناطق الفقدان المحتملة. من الضروري أيضًا توفير بيانات زلزالية ثلاثية الأبعاد حديثة بصيغة (Segy-PSTM) لتحسين دقة التقييم. تُعد هذه الدراسة نموذجًا يمكن تعميمه وتطبيقه على حقول نفطية أخرى ضمن شركة نفط البصرة التي تواجه تحديات مماثلة في فقدان طين الحفر.

1. Introduction

Mud loss during drilling operations, commonly referred to as Lost Circulation, is one of the most critical and costly challenges in the oil and gas industry. It occurs when drilling fluid escapes from the wellbore into surrounding geological formations rather than circulating back to the surface. The severity of mud loss depends on formation characteristics, such as porosity, permeability, natural fractures, and the balance between formation pressure and mud weight.

The causes of mud loss are diverse and include naturally fractured formations, unconsolidated zones, high-permeability intervals, and operational factors like excessive mud pressure or rapid drilling rates. Mud losses are typically classified based on severity into four categories: seepage, moderate, severe, and total loss, each requiring specific diagnosis and mitigation strategies. In formations like fractured carbonates or weak sandstones, these losses pose significant risks, including non-productive time (NPT), stuck pipe, well control issues, or even blowouts.

Understanding and managing mud loss is especially vital in complex reservoirs such as those found in the X Oil Field oil field. This field was initially discovered in 1945 following two-dimensional (2D) seismic surveys, with subsequent seismic interpretations conducted in 1954, 1971, 1979, and 1980 [1]. Drilling efforts primarily targeted the Nahr Umr and Zubair formations, resulting in the drilling of wells X-1 through X-26 between 1961 and 1968. Among these, well X-12 reached a

total depth of 4029 meters in the Qaddaniya Formation.

Further development campaigns were executed from 2010 to 2012, adding wells X-27 to X-49, with wells X-50 to X-56 drilled in later stages leading up to this study. Production officially began in 1970, and the field is classified as a giant oil field, with an estimated 500 million barrels of proven oil reserves [2]. Geographically, the field stretches approximately 20 kilometers in length and ranges from 5 kilometers in width in the north to about 10 kilometers in the central and southern regions [3].

Given the geological complexity and the extensive drilling history of X Oil Field, evaluating and predicting mud loss behavior is essential for optimizing drilling performance, minimizing operational risks, and reducing costs. This study employs advanced tools such as the Landmark System (OpenWorks and VIR10 DSG) to analyze well data and classify mud loss levels, thereby enhancing future decision-making in drilling operations.

1.1.Study Area:

The field is located west of Basra in southern Iraq. It is approximately 20 km long, with a width ranging from about 5 km in the southern part to 10 km in the northern part [4]. The number of wells drilled in the X Oil Field reached 56, penetrating the Nahr Umr and Zubair formations. Well X-12, in particular, reached the Qataniya formation at a depth of 4029 meters from the rotary level. The A, B, C, and D formations were examined in this study where a repeated of mud losses was observed, [5]. Figure (1) illustrates the stratigraphic sequence of the study area formations for well X-12.

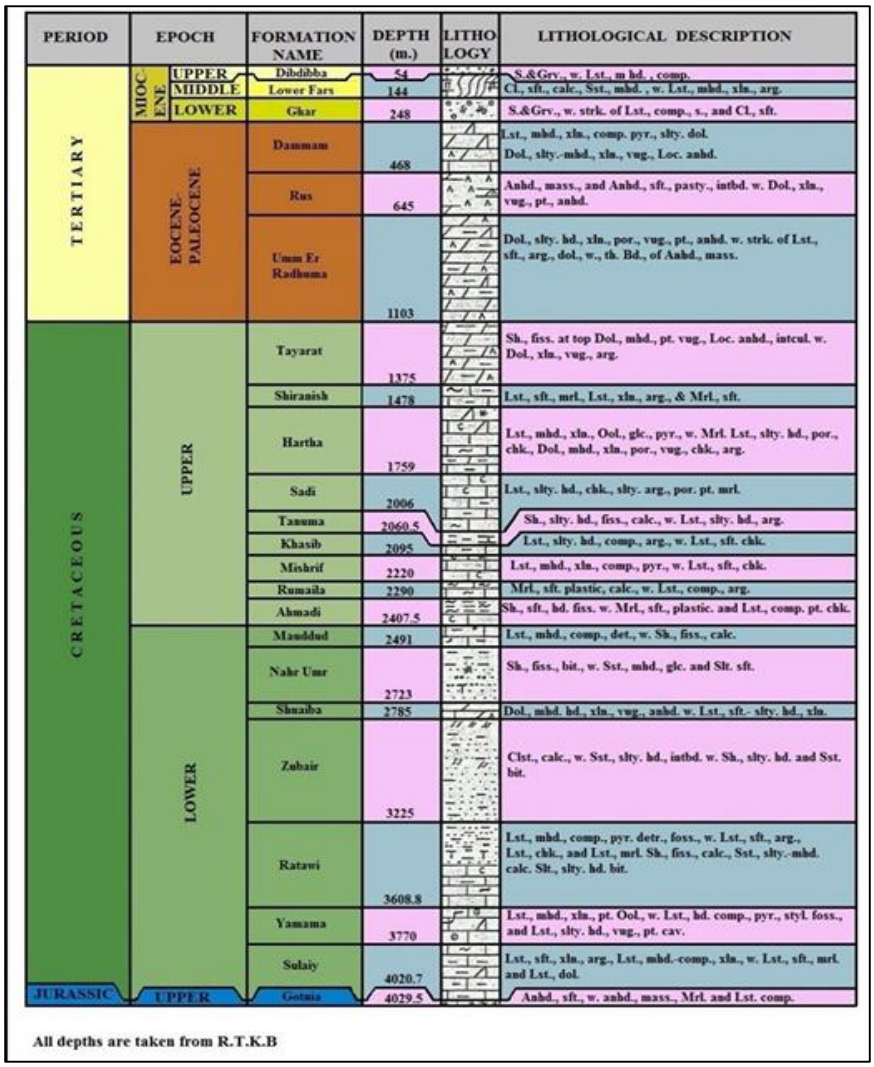

Fig. (1): Stratigraphic sequence of the formations in the study area for well X-12, [6].

1.2. Aim of the Study:

The objective of this study is to identify the levels of drilling mud loss in the wells of the X Oil Field, as well as to estimate the types of mud loss levels when drilling new wells. It aims to provide a clear understanding of the areas with high occurrences of mud losses to avoid these areas and mitigate the potential future damages caused by such losses.

2. Methods:

The Landmark system was used to conduct this study and to create the OpenWorks database, which included well locations, formation tops, and drilling mud loss values for wells (X_1 to X_56). The VIR10 DSG program within the system was utilized for data analysis. The methods employed in this study included the following:

2.1. Determining the Drilling Mud Loss Levels for X Oil Field Wells:

Based on geological and technical reports, mud loss can be classified into four types according to its severity, as follows:

1. **Seepage Losses:** The amount of drilling mud lost is less than 2 m^3/hour.
2. **Partial Losses (PL):** In this type of loss, the amount of drilling mud lost ranges from 2 to 15 m^3/hour.
3. **Severe Losses (SL):** The amount of drilling mud lost is between 15 and 45 m^3/hour.
4. **Complete Losses (CL):** The amount of drilling mud lost is greater than 45 m^3/hour [7].

The drilling mud loss levels for the wells in the X Oil Field were determined within the studied formations based on these levels, categorizing them based on the type of mud loss. The classification was divided into three levels: low, moderate, and high occurrence, as shown in Table (1). It should be noted that the values presented in the table are estimated for the purpose of calculation and analysis.

Table (1): Drilling Mud Loss Levels. [7]

Type of Loss	No	No	PL	SL	CL
Loss Levels	**Data**	**Losses**			
Lower chance of losses	0	1	1	0	**0**
Moderate chance of losses	0	0	1	1	**1**
Higher chance of losses	0	0	0	1	**1**

2.2. Estimating Drilling Mud Loss Levels for Selected Wells:

The type of mud loss levels for a well, or several selected wells, was estimated by projecting the coordinates of the proposed well along with the neighboring wells within a radius of 1500 meters, as shown in Figure (2). After creating tables in Excel, which included calculations based on the mud loss values for selected wells, the type of mud loss level for the proposed well was then calculated as shown in the computational model, Table (2), based on the classification presented in Table (1).

Table (2): Drilling Mud Loss Levels for a New Well, Averaged from [7]

No.	Wells within 1500m	Distance to X_ (m)	Formation Losses (m3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & Percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	_X												
2	_X												
3	_X												
4	_X												
				Total									
				%							%	%	%

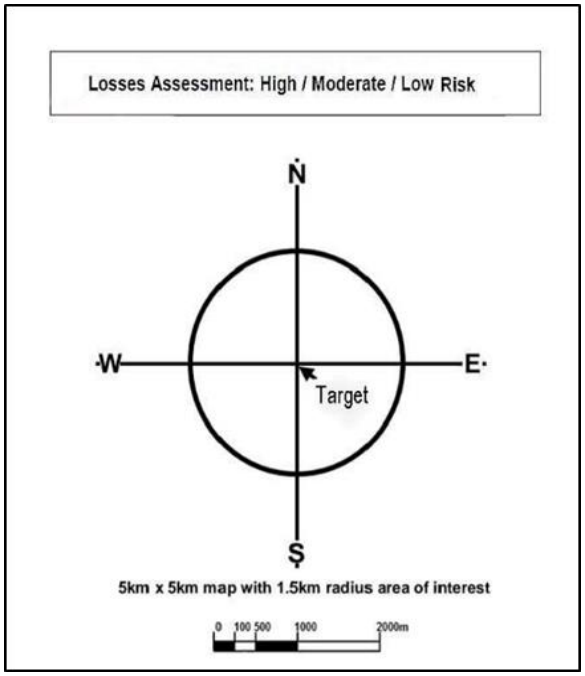

Fig. (2): Projection of the Coordinates of a New Well with Neighboring Wells, Averaged from [7]

3. Results and Discussion

3.1. Analysis of Drilling Mud Loss Data:

The drilling mud loss levels for the wells in the X Oil Field were determined and estimated, as well as the loss levels for selected well locations. Contour maps were drawn to represent the distribution of loss levels for wells (X_1 to X_56) within the formations (A, B, C, and D) with a contour interval of 30 m^3/hour. It was observed that the contour maps did not match the distribution of drilling mud loss levels for the wells in the area, and this is natural because the basis for drawing contour maps is the concept of "spatial analysis" for each value. This method distributes the value spatially, not just quantitatively, meaning that transforms non-spatial values from a set of points

into a surface map that reflects the spatial variation of this value across the study area.

3.1.1. Discussion of Drilling Mud Loss Levels for the Wells in the X Oil Field:

- **A Formation:** The first value of drilling mud loss in the A Formation at a depth of 380 meters showed three different loss levels [8], as shown in Figure (3). It is evident that the high-frequency loss levels were generally concentrated in the central part of the field, while the moderate-frequency loss levels were distributed in the southern parts. In contrast, the low-frequency loss levels extended from the central to the northern parts of the field.

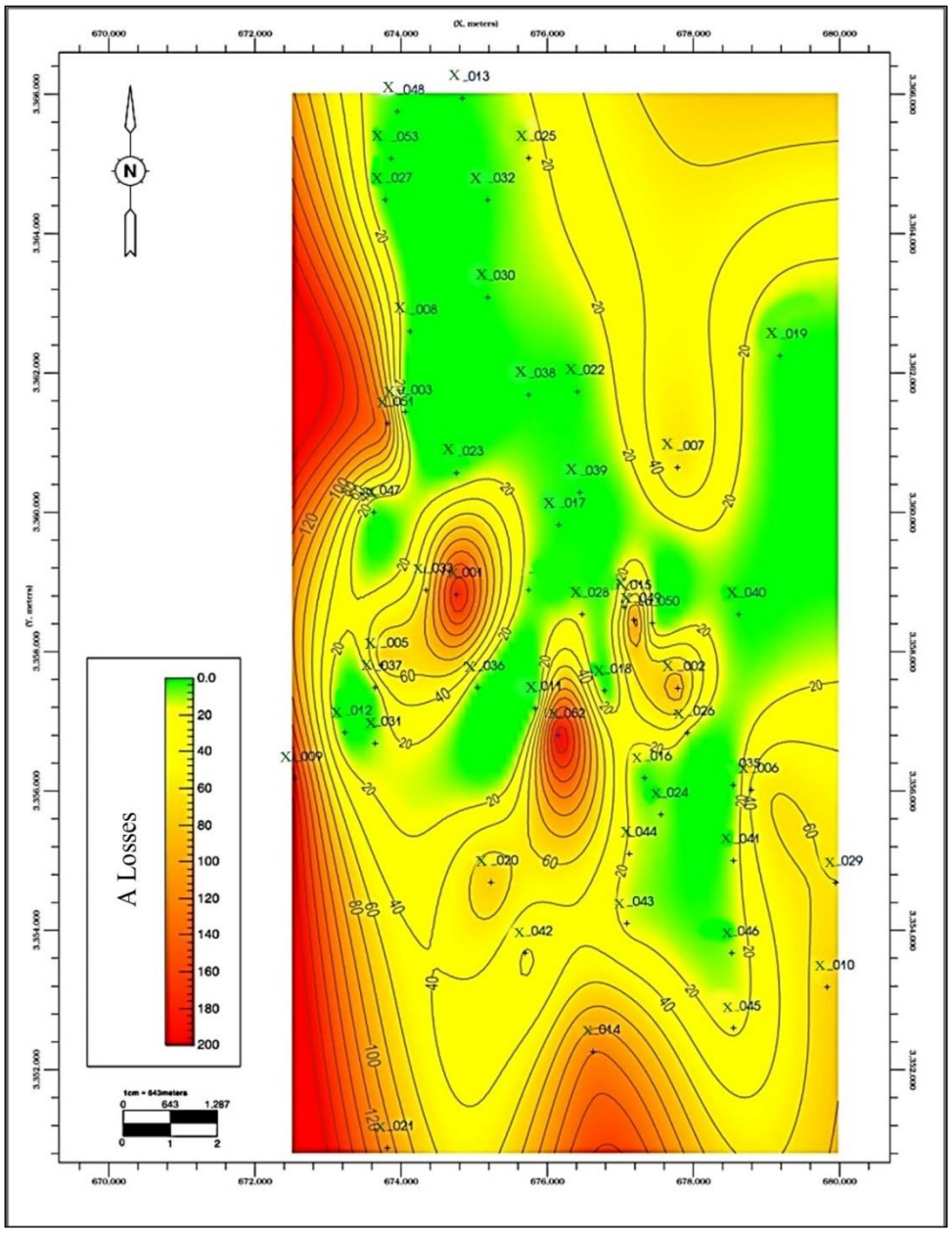

Fig. (3): Contour map of the distribution of drilling mud loss levels in A Formation.

- **B Formation:** The first value of drilling mud loss in the formation at a depth of 1200 meters showed three different loss levels, [8]. It is evident that the high-frequency loss levels were concentrated in the central part of the field, while the moderate-frequency loss levels were distributed in the eastern parts. The low-frequency loss levels were found in the northern or southern parts of the field, as shown in Figure (4).

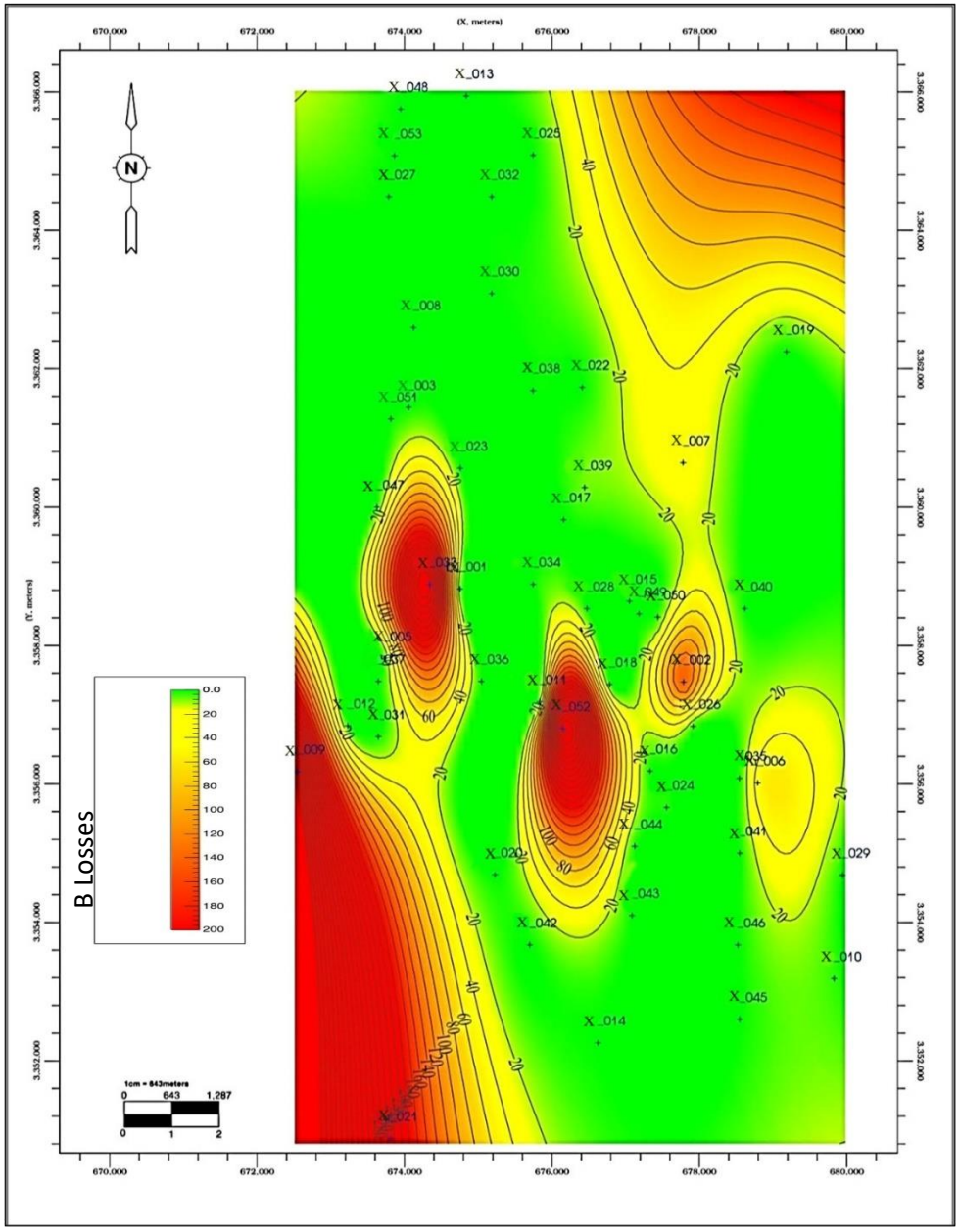

Fig. (4): Contour map of the distribution of drilling mud loss levels in B Formation.

- **C Formation:** The first drilling mud loss in the C Formation was observed at a depth of 1500 meters, [8]. where these values also showed three different levels of loss, representing the distribution of drilling mud loss levels for the formation in the field. It was observed that the high occurrence levels of loss were concentrated in the central part of the field, while the moderate occurrence levels were distributed in the eastern parts. Meanwhile, the low occurrence levels were found in the northern or southern parts of the field, as shown in Figure (5).

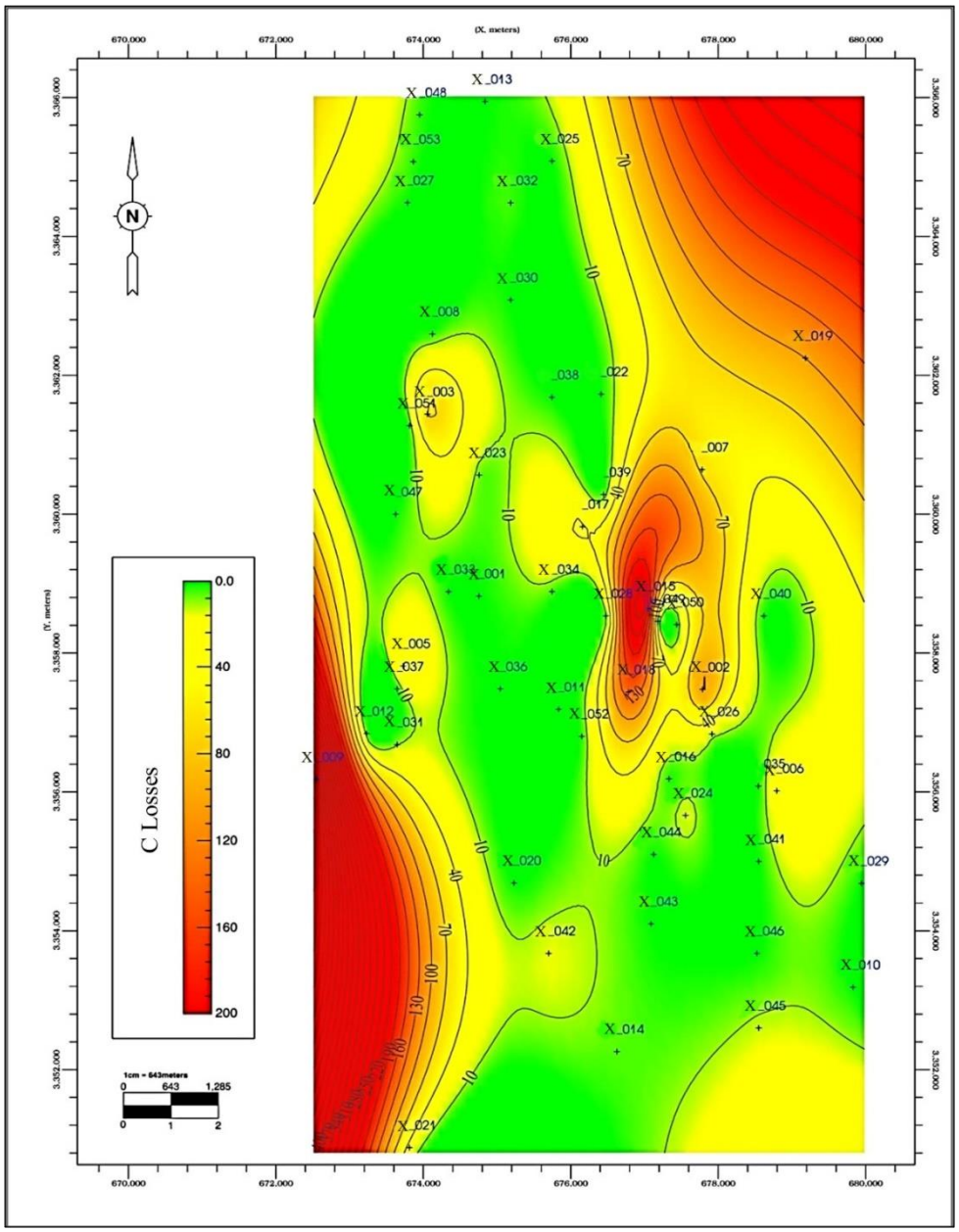

Fig. (5): A Contour Map Showing the Distribution of Drilling Mud Loss Levels in C Formation.

- **D Formation:** The first occurrence of drilling mud loss in the D Formation was observed at a depth of 2750 meters, [8]. where these values showed three different levels of loss, as shown in Figure (6), representing the distribution of drilling mud loss levels for the formation. It was observed that the high occurrence levels of mud loss were concentrated in the central part of the field, while the moderate occurrence levels were found in the eastern and northern parts of the field. The low occurrence levels were distributed across the remaining parts of the field.

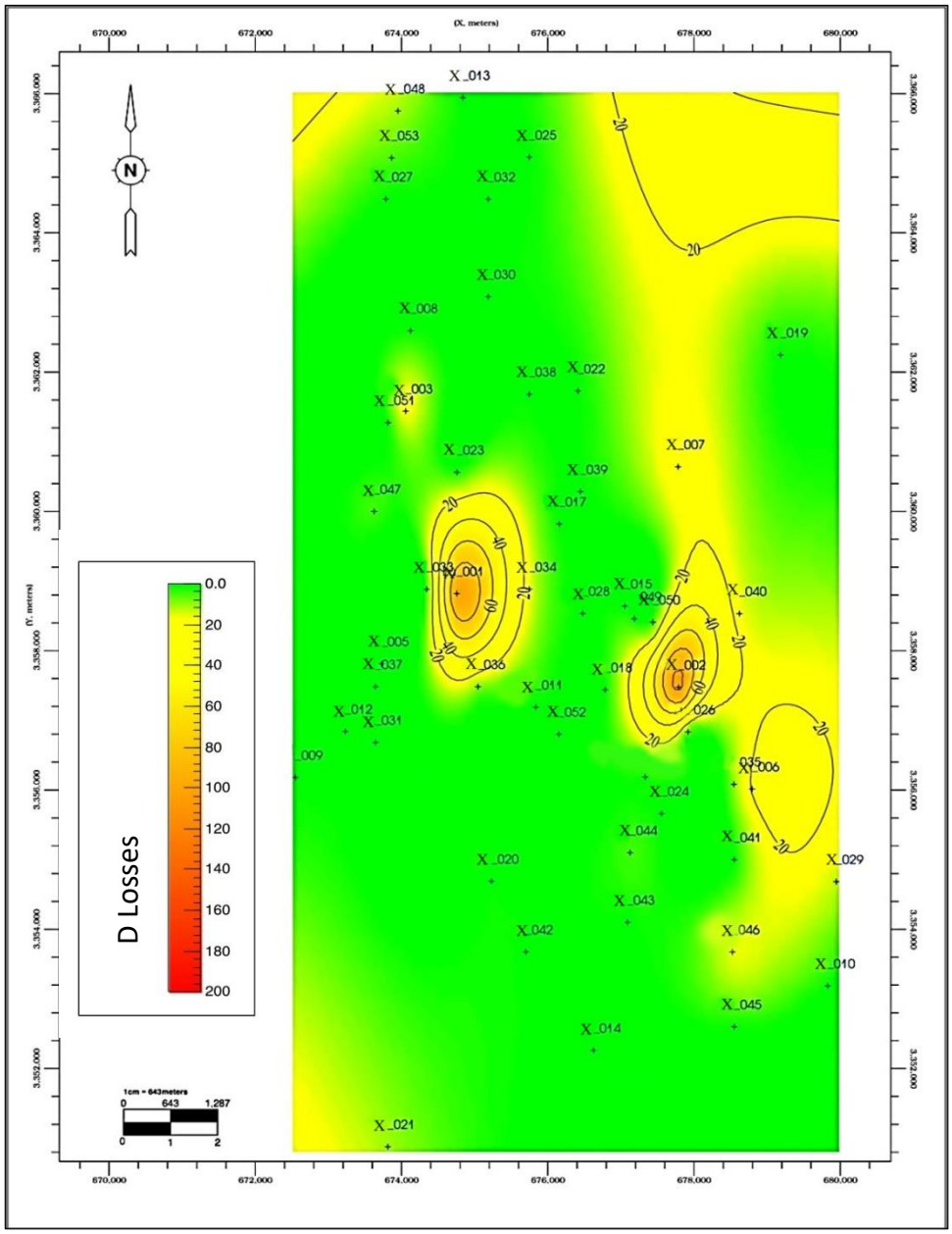

Fig. (6): A Contour Map Showing the Distribution of Drilling Mud Loss Levels in the **D** Formation / X Oil Field.

3.1.2. Interpretation of Drilling Mud Loss Levels for Proposed Well Locations:

The drilling mud loss levels for selected well locations were estimated based on the selected wells (X-56, X-55, X-54, X-53). The wells X-54, X-55, and X-56 were selected based on the availability of actual data obtained from previous drilling records in the X Oil Field. These wells were used as key references for matching and analyzing mud loss levels, aiming to enhance the accuracy of the computational model by integrating data from multiple wells representing the spatial distribution of mud loss within the field. The data from these wells were matched with the data obtained from the computational method and cross-referenced with the mud loss distribution maps of X Oil Field wells. The results were as follows:

- **A Formation:** By cross-referencing the results of the selected wells with the mud loss distribution map for the A Formation (Figure 8), these wells were identified within a radius of 1500 meters. After entering the corresponding loss values into the computational tables, the loss levels for the A Formation were estimated. Tables (3, 4, 5, 6) shows that the loss level for the selected wells in the A Formation was of the "Lower chance of losses" type (i.e., low occurrence) for wells (X-53 and X-55) at 100%. Meanwhile, the loss level for wells (X-54 and X-56) ranged from "Moderate chance of losses" to "Higher chance of losses." When comparing the loss levels obtained from the computational method with the mud loss distribution map for the A Formation, it is evident that the results from both methods match, as shown in Figure (7).

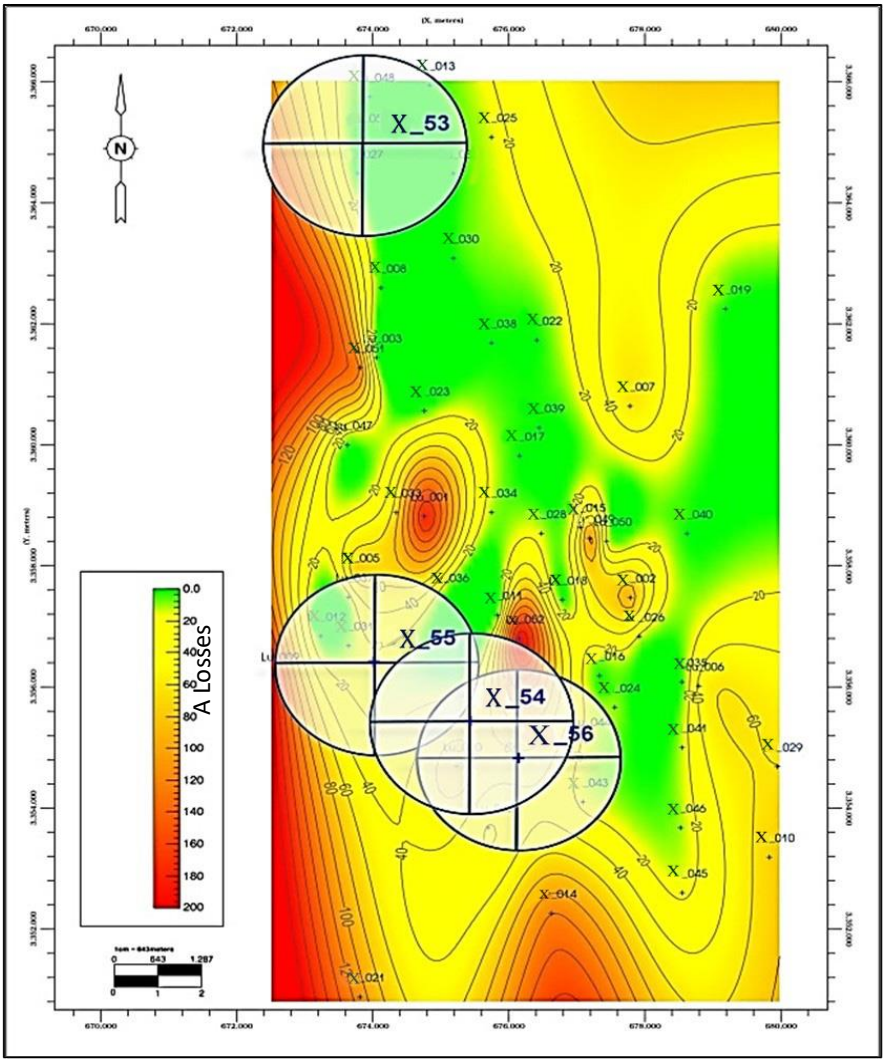

Fig. (7): Estimated Drilling Mud Loss Levels Map for the A Formation for the Wells (X-53, X-54, X-55, X-56)

Table (3): Estimated Drilling Mud Loss Levels for A Formation (Well X-53)

No.	Offset Wells within 1500 m Radius	Distance to X_053 (m)	A Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_027	700	0	No Losses	0	1	0	0	0				
2	X_048	750	0	No Losses	0	1	0	0	0				
3	X_013	1400	0	No Data	1	0	0	0	0				
4	X_032	1500	0	No Losses	0	1	0	0	0				
				Total	1	3	0	0	0	4			
				%	25%	75%	0%	0%	0%	100%	0%	0%	0%

Table (4): Estimation of Drilling Mud Loss Levels for A Formation (Well X-54)

No.	Offset Wells within 1500 m Radius	Distance to X_054 (m)	A Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_056	700	46	Complete	0	0	0	0	1				
2	X_020	750	75	Complete	0	0	0	0	1				
				Total	0	0	0	0	2	2			
				%	0%	0%	0%	0%	100%	100%	0%	0%	0%

Table (5): Estimation of Drilling Mud Loss Levels for A Formation (Well X-55)

No.	Offset Wells within 1500 m Radius	Distance to X_055 (m)	A Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_031	350	6	Partial	0	0	1	0	0				
2	X_012	750	0	No Data	1	0	0	0	0				
3	X_037	1000	15	Partial	0	0	1	0	0				
				Total	1	0	2	0	0	3			
				%	33.33%	0%	66.6%	0%	0%	100%	0%	0%	0%

Table (6): Estimation of Drilling Mud Loss Levels for A Formation (Well X-56)

No.	Offset Wells within 1500 m Radius	Distance to X_056 (m)	A Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_054	700	25	Severe	0	0	0	1	0				
2	X_020	900	75	Severe	0	0	0	0	1				
3	X_044	1000	16	Severe	0	0	0	1	0				
4	X_043	1100	16	Severe	0	0	0	1	0				
5	X_042	1200	20	Severe	0	0	0	1	0				
				Total	0	0	0	4	1	5			
				%	0%	0%	0%	80 %	20 %	100%	0%	0%	0%

- **B Formation:** By intersecting the wells (X-56, X-55, X-54, X-53) on the map showing the distribution of drilling mud loss levels for the B Formation (Figure 8), the wells that close to them within a radius of 1500 meters were identified. The loss values corresponding to these wells were included in the calculation tables for estimating loss levels. The Tables (7, 8, 9, 10) indicate that the loss level for these wells within the B Formation is of the low occurrence type at 100%. However, the loss type for Well (X-56) ranged from moderate to rare occurrence, with percentages of 40% to 60%, respectively. These levels are in close

agreement with the results obtained from both the first and second methods.

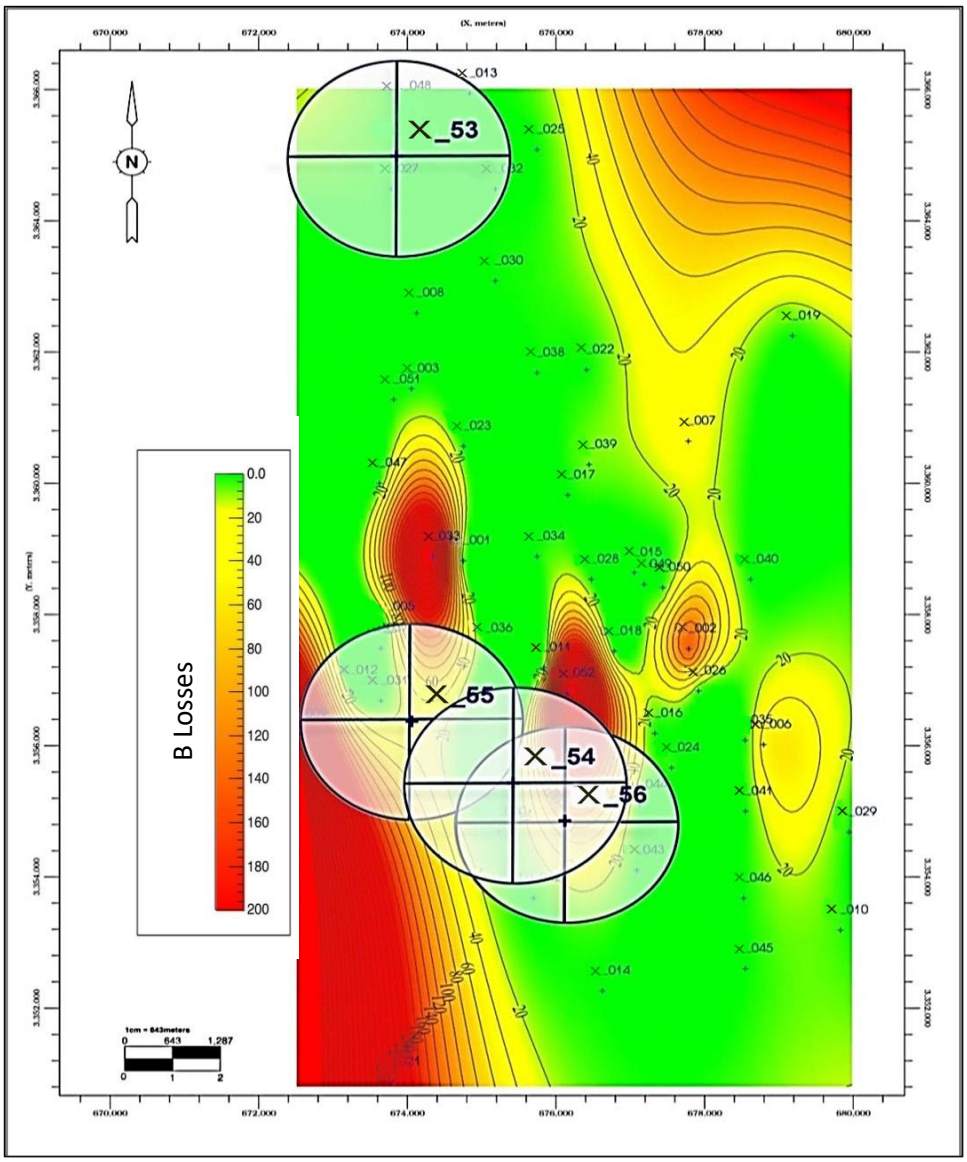

Fig. (8): Map of Estimation of Drilling Mud Loss Levels for B Formation in Wells (X-53, X-54, X-55, X-56)

Table (7): Estimation of Drilling Mud Loss Levels for B Formation in Well X-53

No.	Offset Wells within 1500 m Radius	Distance to X_053 (m)	B Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_027	700	0	No Losses	0	1	0	0	0				
2	X_048	750	0	No Losses	0	1	0	0	0				
3	X_013	1400	0	No Data	1	0	0	0	0				
4	X_032	1500	0	No Losses	0	1	0	0	0				
				Total	1	3	0	0	0	4			
				%	25%	75%	0%	0%	0%	100%	0%	0%	0%

Table (8): Estimation of Drilling Mud Loss Levels for B Formation in Well X-54

No.	Offset Wells within 1500 m Radius	Distance to X_054 (m)	B Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_056	700	0	No Losses	0	1	0	0	0				
2	X_020	750	0	No Losses	0	1	0	0	0				
				Total	0	2	0	0	0	2			
				%	0%	100%	0%	0%	0%	100%	100%	0%	0%

Table (9): Estimation of Drilling Mud Loss Levels for B Formation in Well X-55

No.	Offset Wells within 1500 m Radius	Distance to X_055 (m)	B Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_031	350	0	No Losses	0	1	0	0	0				
2	X_012	750	0	No Data	1	1	0	0	0				
3	X_037	1000	0	No Losses	0	1	0	0	0				
				Total	1	3	0	0	0	4			
				%	25%	75%	0%	0%	0%	100%	100%	0%	0%

Table (10): Estimation of Drilling Mud Loss Levels for B Formation in Well X-56

No.	Offset Wells within 1500 m Radius	Distance to X_056 (m)	B Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_054	700	18	Severe	0	0	0	1	0				
2	X_020	900	0	No Losses	0	1	0	0	0				
3	X_044	1000	17	Severe	0	0	0	1	0				
4	X_043	1100	0	No Losses	0	1	0	0	0				
5	X_042	1200	0	No Losses	0	1	0	0	0				
				Total	0	3	0	2	0	5			
				%	0%	60%	0%	40%	0%	100%	60%	40%	0%

- **C Formation**: The coordinates of the selected wells were dropped onto the map showing the distribution of drilling mud loss levels for the C Formation (Figure 9) within a 1500-meter radius. This allowed for the identification of wells close to the aforementioned wells. The corresponding mud loss values for these wells were then included in the calculation tables to determine the types of loss levels within the formation. The calculation Tables (11, 12, 13, 14) indicated that the drilling mud loss level in all four selected wells was of the "Lower chance of losses" type in the C Formation, with a 100% occurrence. The correlation with the map of drilling mud loss distribution for the C Formation was clearly evident.

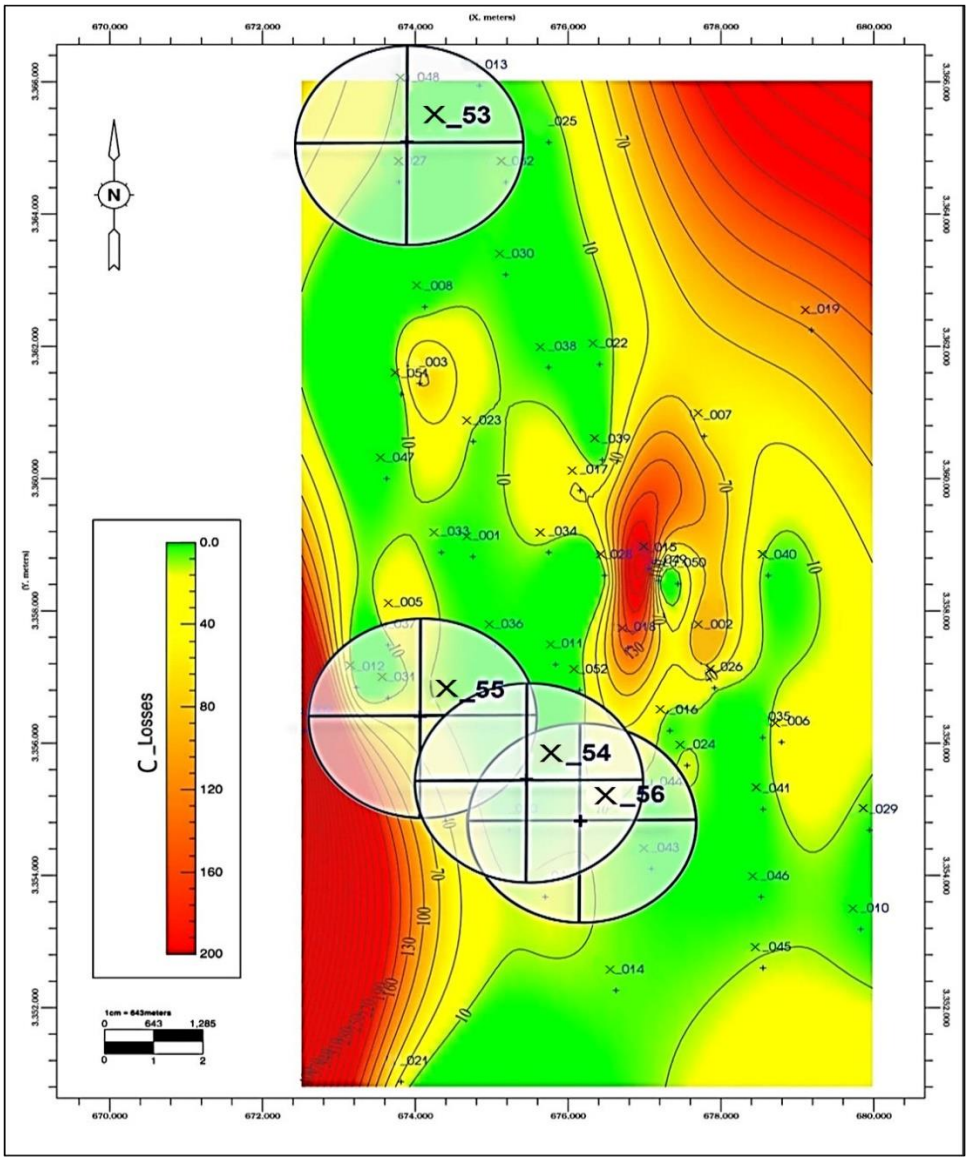

Fig. (9): Map of Estimation of Drilling Mud Loss Levels for the C Formation in Wells (X-53, X-54, X-55, X-56)

Table (11): Estimation of Drilling Mud Loss Levels in C Formation (Well X-53)

No.	Offset Wells within 1500 m Radius	Distance to X_053 (m)	C Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_027	700	0	No Losses	0	1	0	0	0				
2	X_048	750	3	Partial	0	0	1	0	0				
3	X_013	1400	0	No Data	1	0	0	0	0				
4	X_032	1500	4	Partial	0	0	1	0	0				
				Total	1	1	2	0	0	4			
				%	25%	25%	50%	0%	0%	100%	100%	0%	0%

Table (12): Estimation of Drilling Mud Loss Levels in C Formation (Well X-54)

No.	Offset Wells within 1500 m Radius	Distance to X_054 (m)	C Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_056	700	0	No Losses	0	1	0	0	0				
2	X_020	750	0	No Losses	0	1	0	0	0				
				Total	0	2	0	0	0	2			
				%	0%	100%	0%	0%	0%	100%	100%	0%	0%

Table (13): Estimation of Drilling Mud Loss Levels in C Formation (Well X-55)

No.	Offset Wells within 1500 m Radius	Distance to X_055 (m)	C Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_031	350	7	Partial	0	0	1	0	0				
2	X_012	750	0	No Data	1	1	0	0	0				
3	X_037	1000	0	No Losses	0	1	0	0	0				
				Total	1	2	1	0	0	4			
				%	25%	50%	25%	0%	0%	100%	100%	0%	0%

Table (14): Estimation of Drilling Mud Loss Levels in C Formation (Well X-56)

No.	Offset Wells within 1500 m Radius	Distance to X_056 (m)	C Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_054	700	4	Partial	0	0	1	0	0				
2	X_020	900	0	No Losses	0	1	0	0	0				
3	X_044	1000	0	No Losses	0	1	0	0	0				
4	X_043	1100	0	No Losses	0	1	0	0	0				
5	X_042	1200	15	Partial	0	0	1	0	0				
				Total	0	3	2	0	0	5			
				%	0%	60%	40 %	0%	0%	100%	100%	0%	0%

- **D Formation**: By projecting the coordinates of the selected wells (X-56, X-55, X-54, X-53) onto the map showing the distribution of drilling mud loss levels for the D Formation

(Figure 10) and within a radius of 1500 meters, the wells close to these wells were identified. The loss values corresponding to these wells were then included in the calculation tables to determine the types of loss levels in the formation. The Tables (15, 16, 17, 18) showed that the drilling mud loss level in all the selected wells was of the "Lower chance of losses" type in the D Formation, with a 100% occurrence. As with the results for the previous formations, the type of loss level obtained from the estimation tables matched the map showing the distribution of loss levels for the D Formation.

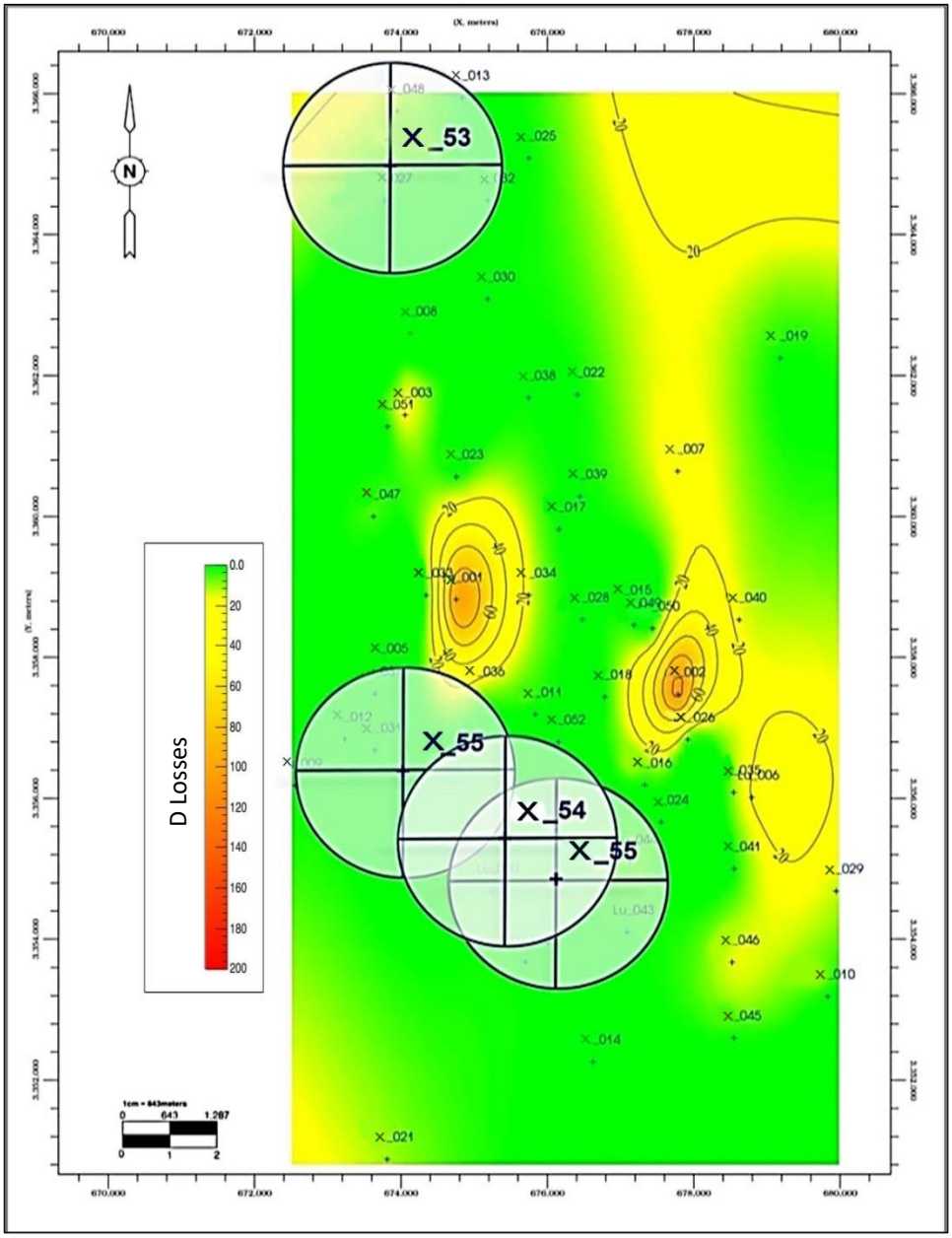

Fig. (10): Map of Estimation of Drilling Mud Loss Levels for the D Formation in Wells (X-53, X-54, X-55, X-56)

Table (15): Estimation of Drilling Mud Loss Levels for the D Formation in Well X-53

No.	Offset Wells within 1500 m Radius	Distance to X_053 (m)	D Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_027	700	0	No Losses	0	1	0	0	0				
2	X_048	750	10	Partial	0	0	1	0	0				
3	X_013	1400	0	No Data	1	0	0	0	0				
4	X_032	1500	0	No Losses	0	1	0	0	0				
				Total	1	2	1	0	0	4			
				%	25%	50%	25%	0%	0%	100%	100%	0%	0%

Table (16): Estimation of Drilling Mud Loss Levels for the D Formation in Well X-54

No.	Offset Wells within 1500 m Radius	Distance to X_054 (m)	D Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_056	700	15	Partial	0	0	1	0	0				
2	X_020	750	0	No Losses	0	1	0	0	0				
				Total	0	1	1	0	0	2			
				%	0%	50%	50%	0%	0%	100%	100%	0%	0%

Table (17): Estimation of Drilling Mud Loss Levels for the D Formation in Well X-55

No.	Offset Wells within 1500 m Radius	Distance to X_055 (m)	D Losses (m³/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_031	350	0	No Losses	0	1	0	0	0				
2	X_012	750	0	No Data	1	1	0	0	0				
3	X_037	1000	0	No Losses	0	1	0	0	0				
				Total	1	3	0	0	0	4			
				%	25%	75%	0%	0%	0%	100%	100%	0%	0%

Table (18): Estimation of Drilling Mud Loss Levels for the D Formation in Well X-56

No.	Offset Wells within 1500 m Radius	Distance to X_056 (m)	D Losses (m^3/h)	Event Details	No Data	No Losses	PL	SL	CL	Total & percentage of Events	Lower chance of losses	Moderate chance of losses	Higher chance of losses
1	X_054	700	0	No Losses	0	1	0	0	0				
2	X_020	900	0	No Losses	0	1	0	0	0				
3	X_044	1000	4	Partial	0	0	1	0	0				
4	X_043	1100	0	No Losses	0	1	0	0	0				
5	X_042	1200	0	No Losses	0	1	0	0	0				
				Total	0	4	1	0	0	5			
				%	0%	80%	20%	0%	0%	100%	100%	0%	0%

3.2. Comparison with Loss Tables:

The collected mud loss data were compared with the values provided in the relevant loss Tables (19, 20, 21, and 22), which serve as benchmarks for expected losses b**a**sed on geological and technical conditions. The results showed a consistent agreement between the actual loss levels and the data recorded in the geological and technical reports during the drilling operations of the selected wells, confirming the accuracy of the reported losses.

Table (19): Drilling Mud Loss Values for Well X-53 [8]

No.	Date	Quantity of cement (m^3)	Density of cement	Top of cement (m)	Dis. Mud m^3	Formation
1	20/1/2020	6	1.85	2684	24	D
2	25/1/2020	8	1.85	2545	25	D
3	1/2/2020	3	1.85	2670	25	D

Table (20): Drilling Mud Loss Values for Well X-54 [8]

Formation	Interval Depth(m)		Rate (m^3/hr)	Remarks
	From	To		
A	350	354	2	partial
	399	401	6	partial
	401	429	2	partial
	429	464	20-25	sever
B	1146	1148		complete
	1148	1150	18	sever
	1150	1194	5	partial
C	1667	1668	4	partial

Table (21): Drilling Mud Loss Values for Well X-55 [8]

Formation	Interval Depth (m)		Rate (m^3/hr)	Remarks
	From	To		
A	371	478	…	complete
A	478	492	30	sever
D	2736	2749	25	sever
D	2749	2753	18	sever
D	2753	2782	20	sever

Table (22): Drilling Mud Loss Values for Well X-56 [8]

Formation	Interval Depth (m)		Volume (m^3)	Remarks
	From	To		
D	2,740.0	2,754.0	15.0	severe
			20.0	

4. Conclusions

This study aimed to estimate and classify the levels of drilling mud loss within four geological formations (A, B, C, and D) in the X Oil Field. The analysis was based on actual well data and computational estimation methods using Microsoft Excel. The primary objective was to determine the spatial distribution and intensity of mud loss to support future drilling operations. The main findings of the study are summarized as follows:

1. The current study found drilling mud loss in the formations (A, B, C, and D). Three levels of occurrence for this loss were identified across the entire X Oil Field, ranging from low and moderate to high occurrence within the studied formations.
2. The low occurrence levels were concentrated in the southern and western parts of the field, while the moderate occurrence levels were distributed in the northern and eastern parts. High occurrence levels were generally located in the central area of X Oil Field.
3. In the A Formation, the high occurrence levels of drilling mud loss were higher compared to the other studied formations.
4. The calculation tables developed using Microsoft Excel are a reliable tool for estimating drilling mud loss levels in new wells. They have proven effective by providing promising results in identifying the type of loss, based on data from wells neighboring the wells under study. Due to the repetition and similarity in the discussion of loss levels across the four

formations, the fluid loss occurrence results must be presented in a unified table alongside the contour maps to enhance clarity of analysis and facilitate comparison between the different formations, Table (23).

Table (23): Summary of Drilling Mud Loss Occurrence Across Formations.

Mud Loss Level	Formation Name			
	A	B	C	D
High chance of losses	Central parts	Central parts	Central parts	Central parts
Moderate chance of losses	Southern parts	Eastern parts	Eastern parts	Eastern & Northern parts
Low chance of losses	From the central to the northern parts	Northern & Southern parts	Northern & Southern parts	Distributed across the remaining parts

5. It is recommended to include the results of the current study in the geological drilling program chart for X Oil Field and to generalize it for other national effort fields under the Basra Oil Company.
6. Caution should be taken when drilling new wells at the structural peak of X Oil Field, as there are high levels of drilling mud loss occurrence in the studied formations.
7. A map should be created to show the lithological distribution of the A Formation, as drilling mud loss occurs significantly due to the rock nature of this formation. This should be correlated with 3D seismic data to provide a clearer picture of the areas where loss may occur.
8. It is necessary to provide 3D field seismic data obtained from surveys in (Segy-PSTM) format for X Oil Field oil field.
9. It is recommended that future studies investigate the geological and operational causes of mud losses in the X Oil Field oil field, and propose practical solutions to minimize such losses during drilling operations. This would complement the current findings and support more effective mud loss management strategies.

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References:

[1] Oil Exploration Company, "Geological Evaluation Study for the Yamama Formation in X Oil Field", Baghdad, 2021.

[2] J. A. Al-Sakini, "Summary of Petroleum Geology of Iraq and the Middle East", Internal Report (in Arabic), *Northern Oil Company Press*, Kirkuk, Iraq, 1992.

[3] H. M. Jasim, "Sedimentological and Petrophysical Reservoir Study of the Nahr Umr Formation in the Lahis Field, Southern Iraq", *M.Sc. Thesis*, College of Science, University of Baghdad, 2001.

[4] H. M. Aljanaey, and M. F. Alshahwan, "Evaluation of the performance of the Zubair Reservoir/ Upper Sargelu Member/ Z/1A reservoir unit in the X Field, Southern Iraq, using capillary pressure and relative permeability methods", *Journal of Petroleum Research and Studies*, vol. 7, no. 4, pp. 1-13, Jul. 2017.

[5] South Oil Company, "Geological Evaluation Study of X Oil Field", Internal Report, Basra, 1988.

[6] Oil Exploration Company, "Geophysical Evaluation Study of Subba-X", Internal Report, Baghdad, 2023.

[7] Report for BP, "The Statement of Requirements (SOR) of Rumaila, Iraq,", *Basra Oil Company*, Basrah, 2018

[8] Basra Oil Company, "Geological reports and final drilling reports for the utilized wells", Internal Report, Basra, 2018.