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ANALYSING OIL SPILLAGE AT THE MUKUYU WELL IN MUZARABANI DISTRICT ZIMBABWE

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***Abstract*:** Oil spills are of extraordinary concern since they force a risk to the to the environment counting people. In coastal operations spillage may happen due to spillage from the well pipeline, tubing or Christmas tree. Oil spill imperil open wellbeing, jeopardize drinking water, demolish characteristic assets, and disturb the economy. Spilled oil promptly starts to move into the ground and climate, breaking down and changing its physical and chemical properties. As these forms happen, the oil debilitates surface assets and a wide extend of subsurface life forms connected in a complex nourishment chain. Oil spills come in into the structure of the plumage of feathered creatures and the hide in evolved creatures, lessening their protection ability, making them more vulnerable to temperature uncertainties and much less buoyant in water. Cleaning and restoration from oil spill is upsetting and depends upon abundant components, counting sort of oil leaked and extraordinary of spillage. Spills might take hebdomads, months or indeed a long while to clear up. This paper will be centered on analyzing a case of oil spillage in Muzarabani Zimbabwe so as to do hazard examination and come up with strategies to dispense with the dangers caused by the spill. The Muzarabani well has not however started its commercial investigations however but amid the testing and finding of the oil is when the well experienced a spillage consequently this study centers on analyzing the spillage and moderating the dangers to plan for commercial explorations.

***Index terms*:** Spillage, environmental risk, risk assessment.

1. Introduction

Crude oil starts from old fossilized materials having been changed over into oil over millions of a long time through geochemical forms. It is found within the subsoil of the soil and seas, and bored in grungy frame, to be prepared into petroleum items for utilize. Rough oil is valuable for different businesses, and its items are used for both residential and mechanical utilize. In any case, due to the exceptionally nature of the arrangement of unrefined oil, it is misused from pressurized areas, and unregulated release or spillage of unrefined oil can have critical results for the environment into which it is spilled.

Zimbabwe found its oil saves inside the 1990s by an American oil company called ExxonMobil. The company ended oil investigation in Zimbabwe afterward within the 1990s after choosing that any disclosures were more likely to contain gas than oil. In Walk 2022, Australia's Invictus Essentialness detailed a typical gas and condensate disclosure at its Mukuyu-2 well in Zimbabwe, on a past ExxonMobil-operated wander. Invictus utilized Mobil's data from the 1990s for its examination. From these reserves they discovered that there is good quality oil in large quantities which when explored can be used to boost the economy of Zimbabwe. During the testing phase the well experienced an oil spillage and this study focuses on analysis the case and doing a risk analysis to be able to do risk management when explorations begin.

1.2 Problem Statement

Spillage of oil from investigation exercises within the numerous parts of the world has lead to massive natural debasement within the past decades. Such issues incorporate defilement of water bodies, peril to oceanic life, annihilation of vegetation and farmlands which incorporates resort centers, devastation of properties, misfortune of lives and numerous more. In expansion, oil spillage impacts to the environment can lead to undesirable relocation individuals from the right ranges.

Oil refineries are major polluters, expending expansive sums of vitality and water, creating huge amounts of squander waters, discharging dangerous gasses into environment and producing strong squander that are troublesome both to treat and to arrange of. In term of the oil spill effect on ground water quality, it is seen in water defilement due to gushing, wash water and cooling water releases, water defilement due to releases water effluents wealthy inorganic salts without suitable treatment.

Oil spills are basically caused by gear disappointment, operational blunders, and spills from out-of-date channels or willful harm. A case of spillage in Muzarabani is being studied as the spillage his causing environmental damage. If a solution for the case is not found the effects of the spill will seriously harm the environment, contributing to increased biodiversity misfortune, contamination of water and arrive asset, deforestation which has culminated in destitution. Due to numerous shapes of conceivable oil-generation can cause natural contamination all through distinctive locales in Muzarabani, cultivating and angling have yielded restricted yield compared to the pre- oil investigation a long time. Moreover, drinking water sources are contaminated, hence consumable water has gotten to be exceptionally rare.

1.3 Justification

Oil spillage may be a major source of marine contamination which impacts contrarily on the environment when it happens. This think about will basically examine and examine the causes, affect and give proposals for the advancement of the oil spillage administration in Muzarabani Zimbabwe, in arrange to diminish and where possible prevent the event of oil spillages within the locale.

This think about will make the mindfulness for the government and Environment Managment Agency(EMA) to define arrangements and alter their arrangements to direct the oil investigation companies to take after in arrange to maintain a strategic distance from contamination and to check the coming about contamination that will sterm out from their exercises.

The ponder discoveries will sensitize the indigenes, the oil showcasing companies and the administrative bodies on the difficulties and give the preface to upgrade and change existing rules and controls to cultivate the assurance of marine life and environment as a entire. The consider carefully analyzes the perils it postures to the neighboring community, the oceanic life and the stylish magnificence of the coastal regions.

1.4 Aim

This ponder is on oil spillage and its natural impacts. It centers on detail gathering and using some examination methods for risk analysis and the causes, impacts of Oil spillage and advance conceivable impacts in Muzarabani Zimbabwe and the remediation frameworks practiced in controlling oil spills within the range. Thus, to avert or decrease occurrence regularity of oil spills proceedings and to minimize its penalties and environmental damage. This thesis work will recognize what kind of enhancements or actions are looked-for concerning the management system or those moderation risk measures that could avert the occurrence of an oil spill for upcoming explorations.

1.5 Objectives

1. Analyze Mukuyu-1 well case study in Muzarabani.
2. Risk Identification through brain storming and using Delphi Technique method.
3. Risk classification according to the level of effect, consequences, parts affected and the rate of

recurrence.
4. Risk evaluation
5. Risk response
6. Recommendations to Muzarabani well management and Environmental Management Agency that will help control oil spillage and minimize its effects to protect the environment.

2. Literature Review

2.1 Definition of crude oil

Unrefined oil begins from antiquated fossilized materials having been changed over into oil over millions of a long time through geochemical forms. It is found within the subsoil of the soil and seas, and penetrated in grungy shape, to be prepared into petroleum items for utilize. Rough oil is valuable for different businesses, and its items are used for both household and mechanical utilize. In any case, due to the exceptionally nature of the arrangement of rough oil, it is misused from pressurized areas, and unregulated release or spillage of unrefined oil can have critical results for the environment into which it is spilled.

Crude oil may be a blend of comparatively unstable fluid hydrocarbons, in spite of the fact that it moreover contains a few nitrogens, sulfur, and oxygen. Those components shape an expansive assortment of multipart microscopic structures, a few which cannot be on time recognized. In any case of varieties, nearly all rough oil arrays from 82 to 87 per hundred carbons in bulk and 12 to 15 per hundred hydrogens by bulk.

Unprocessed oils stay commonly branded through the sort of hydrocarbon composite that's most predominant in them: alkanes, naphthene, and aromatics. Paraffins stay the foremost public hydrocarbons in unrefined oil; some fluid alkanes are the key elements of gasoline then are hence profoundly esteemed. Naphthene is a vital portion of all unsolidified refinery substances, but also outline a few of the overwhelming black-top like residues of refinery forms. Aromatics by and large constitute as it were a slight rate of utmost crudes. The foremost common fragrant in unrefined oil is benzene, a well-known building piece within the petrochemical industry

2.2 Oil in Zimbabwe

Zimbabwe found its oil saves within the 1990s by an American oil company called ExxonMobil in the Muzarabani District. Figure 1 shows the map area of the Muzarabani district. The company halted oil exploration in Zimbabwe later in the 1990s after choosing that any revelations were more likely to contain gas than oil. In Walk 2022, Australia's Invictus Vitality reported a normal gas and condensate revelation at its Mukuyu-2 well in Zimbabwe, on a previous ExxonMobil-operated venture. Invictus utilized Mobil's information from the 1990s for its investigation. The compositional investigation affirms tall quality normal gas containing negligible debasements (beneath 2% CO2 substance and no H2S), which can entail negligible handling to get ready for deal to downstream clients. Condensate gas proportions (CGR) are assessed between 14-22 bbl/MMcf gas from the Mukuyu-2 tests with an API gravity of 50-60. Mukuyu-1 sludge gas examination comes about affirmed the nearness of light weight oil and gas yielding 30-135 bbls/MMscf and tall eminence characteristic gas through negligible debasements.

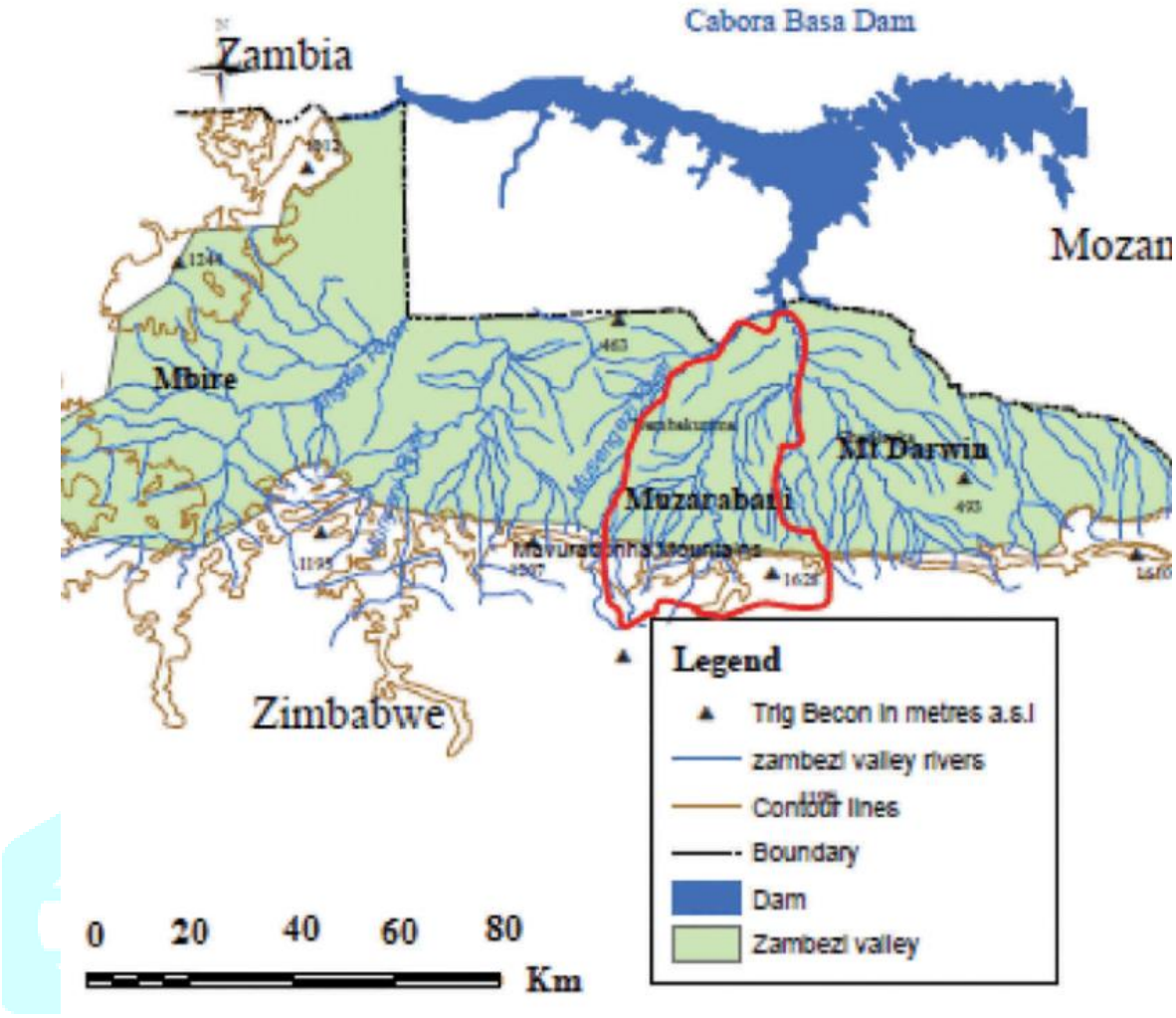

Figure 2.1- Map are of Muzarabani District

The preparatory examination from Mukuyu-2 and results from Mukuyu-1 are reliable with Invictus' topographical demonstrating, which appears expanding fluid hydrocarbon substance within the south of Mukuyu towards the bowl edge (where numerous drill-ready prospects have been mapped), and expanding dry gas commitment from the more profound kitchen and higher development source rock to the north of the Mukuyu structure.

The preparatory gas form investigation beginning handled downhole reservoir fluid tests trendy Mukuyu-2 are reliable through mud gas tests from analogous profundities which are able to permit for extra bits of knowledge to remain produced from the broad set of tests assembled from the Mukuyu-1 and 2 wells.

Reliable with the Mukuyu-1 comes about, gas tests from Mukuyu-2 appear a common expanding dryness (lower fluid hydrocarbon / condensate abdicate) with profundity. Extra downhole reservoir fluid and mud gas tests are being prepared and anticipated to be reported to the ASX once completed. Encourage examination is progressing which can be coordinates into the geographical prototypical over the Mukuyu field and the more extensive range of projections and leads within the company's permit region.

Overseeing said they are greatly satisfied with the early comes about from the downhole supply liquid test examination which affirms an expansive and rich gas-condensate revelation by Mukuyu. The analyzed tests illustrate a unswerving, first-class quality common gas composition, showing moo dormant substance, comprising less than 2% CO2 and no H2S which can require negligible handling. The comes about from Mukuyu-2 are reliable with our topographical displaying of the Cabora Bassa Basin and the nearness of both light weight oil and gas-condensate gives us through certainty as we plan for the succeeding stage of our evaluation program and labor towards the monetization of the Mukuyu gas disclosures in addition encourage

investigation of the energizing set of numerous penetrate prepared diagnoses which has stood significantly upgraded by the constructive comes about from Mukuyu. Mukuyu-2 downhole test investigation affirms wealthy gas-condensate revelation.

2.3 Effects of oil to the environment

In later a long time, huge consideration has been coordinated towards natural disintegration by man's exercises which unfavorably influence the lives of plants and creatures on arrive, water and discuss and indeed job of individuals. One action that has stirred impressive intrigued over the globe is unrefined oil investigation. Unrefined oil investigation is one of such movement that can influence the environment contrarily particularly when mishaps happen in operations coming about to spillage of oil. As a result of the impacts of rough oil operations to the environment, there have been activities within the exercises of unrefined oil investigation over the globe to anticipate the tall chance of oil spillage and the going with natural risks. In any case, the introduction to chance has not been helped by the players within the oil industry who bump for the 'liquid gold' subsequently putting weight on the oil creating communities and the encompassing environment. One of the components that cause release of oil to the natural is the untrustworthy building operations practiced by the businesses included.

An example case of the disastrous effect of oil spill is the Exxon Valdez oil spill which happened in Ruler William Sound, Gold country, on Walk 24, 1989 with an assessed rough oil spill of 260,000 to 750,000 barrels and more as of late the BP deep-water skyline oil spill on 20 April 2010 within the Inlet of Mexico caused by the blast and sinking of the Deepwater Skyline oil fix. It caused an oil release for 87 days with an evaluated the overall release at 4.9 million barrels. As a result of lessons learnt from these and other oil spills, the avoidance, reaction and administration of oil spills is being given best need around the world particularly in oil creating nations in arrange to delude the financial and natural dangers of an oil spill. To this conclusion, a few initiatives have come to the fore. One of such activities is to create and uphold laws and possibility plans for the anticipation and control of oil spills. It is be that as it may inquisitive that in most creating oil creating countries counting Zimbabwe, Ghana, Nigeria etc, the administration of oil spill to anticipate and react to undesirable oil release indeed after so numerous a long time of petroleum investigation and generation exercises have not seen a lessening within the number of spillage event. This has caused the government to resolve to terribly insufficient degree of financial stipend to the victims of oil spill instead of concerning itself with the more fitting arrangement of avoidance and management to defend the environment, society and economy from the threat that's an oil spill.

Oil spillage is the discharge of unsolidified petroleum hydrocarbon into the environment, particularly aquatic regions, due to social movement, in addition may be a shape of infection. This is shown in Figure 2. Oil spill is ordinarily connected to aquatic oil spills, someplace where oil is discharged inside the ocean water or coastal regions, but spills might moreover transpire on arrive. Oil spills may remain due to discharges of rough oil from tankers, seaward stages, boring rigs and wells, as well as tumbles of refined petroleum items (such like gas, diesel) and the products that come from them, substantial fills utilized by expansive vessels such as trench fuel, or the spill of any sleek deny otherwise squander oil.

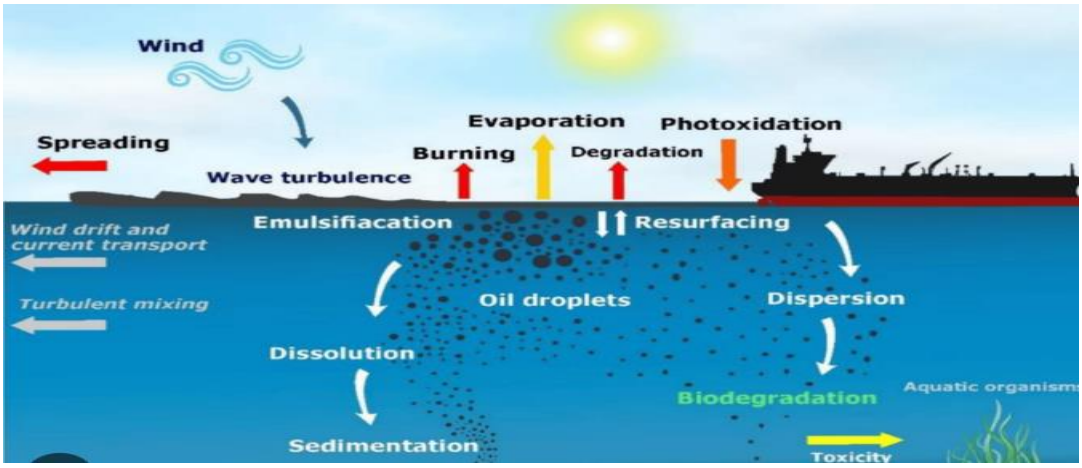

Figure 2.2 - Oil spill in aquatic region

Oil spills pass inside the structure of the feathers of fowls and the fleece of warm-blooded creatures, weakening its protection ability, and making them more unguarded to fever and much fewer buoyant within the aquatic regions. Clear-out and restoration after an oil spill is wearisome and depends upon abundant variables, counting the sort of oil spilled, the water's temperature (prompting degeneracy and biotransformation), and the categories of shorelines also shorelines included. Spills might take weeks, months or indeed an extended while to straighten away. Oil spills at ocean are by and large much more harming than those on arrive, since they can spread for hundreds of marine miles in a lean oil smooth which can cover beaches with a lean coating of oil. This may slaughter ocean creatures, warm blooded animals, shellfish and other life forms it coats as shown in Fig 3. Oil spills on arrive are more promptly containable in case a temporary soil dam can be quickly bulldozed around the spill location some time recently most of the oil get away, and arrive creatures can dodge the oil more effectively.

Figure 2.3 - Effect of oil spill to marine creatures

When we think of oil spills, we more often than not think of oil tankers spilling their cargo in seas or oceans. Be that as it may, oil spilled on arrive frequently comes to lakes, streams, and wetlands, where it can moreover cause harm. Seas and other saltwater bodies are alluded to as marine situations. Lakes, streams, and other inland bodies of water are called freshwater situations. The term oceanic alludes to both marine and freshwater situations. When oil is spilled into a sea-going environment, it can hurt living beings that live on or around the water surface and those that live beneath water. Spilled oil can too harm parts of the nourishment chain, counting human nourishment assets.

The seriousness of the effect of an oil spill depends on an assortment of components, counting characteristics of the oil itself. Common conditions, such as water temperature and climate, moreover impact the behavior of oil in sea-going situations. Different sorts of territories have varying sensitivities to oil spills as well. Oil

enters to the inside of the structure of the feathers of winged creatures and then conceal in well-developed creatures, weakening its protection capacity, resulting in them being more powerless to temperature discrepancies and much less buoyant within the water.

Creatures that depend on fragrance to discover their babies or moms cannot due to the solid fragrance of the oil. This causes an infant to be rejected and deserted, taking off the babies to starve and in the long run kick the bucket. Oil can impede a bird's capacity to fly, anticipating it from scrounging or getting away from predators. As they trim, winged creatures may ingest the oil coating their plumes, chafing the stomach related tract, modifying liver work, and causing kidney harm. In conjunction with their reduced scavenging capacity, this will quickly result in lack of hydration and metabolic awkwardness. A few winged creatures uncovered to petroleum moreover involvement changes in their hormonal adjust, counting changes in their luteinizing protein. The larger part of winged creatures influenced by oil spills pass on from complications without human intercession. A few thinks about have proposed that less than one percent of oil-soaked birds survive, indeed after cleaning, in spite of the fact that the survival rate can to surpass ninety percent, as within the case of the treasure oil spill.

Intensely furred marine well evolved creatures uncovered to oil spills are influenced in comparable ways. Oil coats the hide of ocean otters and seals, diminishing its protection impact, and driving to variances in body temperature and hypothermia. Oil can moreover daze a creature, taking off it helpless. The ingestion of oil causes parchedness and impedes the stomach related prepare. Creatures can be harmed, and may kick the bucket from oil entering the lungs or liver.

There are three sorts of oil-consuming microscopic organisms. Sulfate-Reducing Microbes (SRB) and acid-producing microbes are anaerobic, whereas common oxygen consuming microbes (Jabber) are high-impact. These microscopic organisms happen normally and will act to evacuate oil from a biological system, and their biomass will tend to supplant other populaces within the nourishment chain.

When there's an oil spill on water, spreading promptly takes put. The vaporous and fluid components dissipate. A few get broken up in water and indeed oxidize, and however a few experiences bacterial changes and in the long run sink to the foot by gravitational activity. The soil is at that point sullied with a net impact upon the earthbound life. As the dissipation of the unstable lower atomic weight components influence ethereal life, so the disintegration of the less unstable components with the coming about emulsified water, influences sea-going life.

The destructive impacts of oil spill on the environment are many. Oil murders plants and creatures within the estuarine zone as described in Fig 4 below. Oil settles on shorelines and murders life forms that live there, it moreover settles on sea floor and murders benthic (bottom-dwelling) life forms such as crabs. Oil harms green growth, disturbs major nourishment chains and diminishes the abdicate of consumable shellfish. It moreover coats feathered creatures, disabling their flight or diminishing the insulative property of their quills, in this way ensuing the fowls are further defenseless to lower temperatures. Oil imperils angle incubation centers in seaside waters and also sullies the substance of an economically important angle.

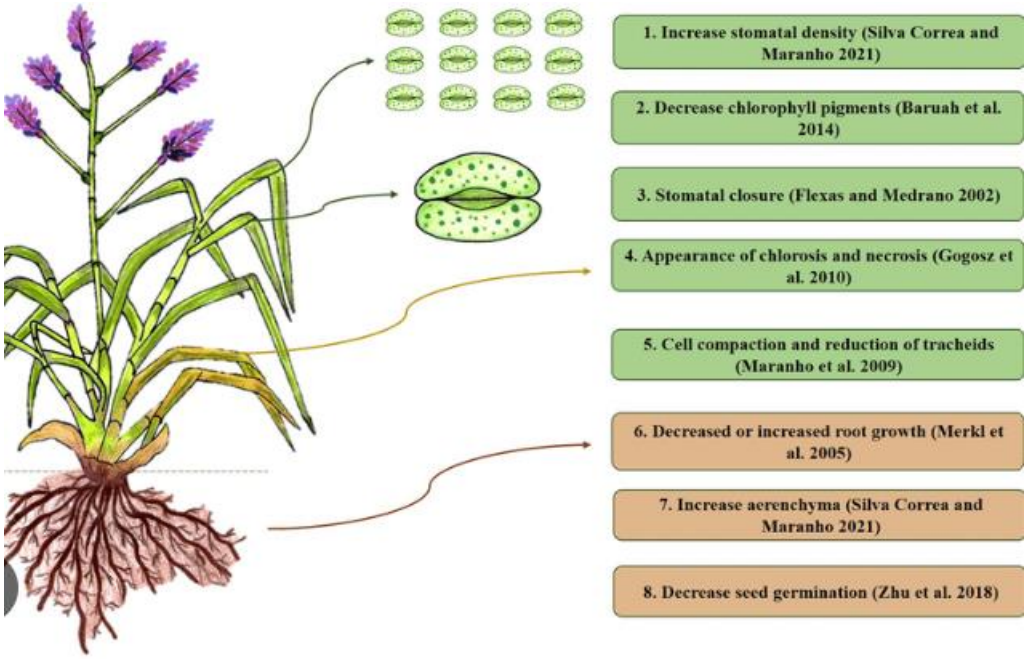

Figure 2.4 - Effect of oil on plants

The results of oil spill are far-reaching as it impacts adversely on the economy of a locale, contaminates water subsequently wellbeing of the nearby community, sullies soils rendering it futile for cultivating and the notoriety of the oil companies included.

2.4 Current regulations from Environmental Management Act

According to Section 73 of the Environmental Management Act (EMA) Act shown in Fig 5, it is denied to release oil or oil blends into any waters or parts of the environment in Zimbabwe. The Serve of Environment moreover has the control to make natural assurance measures for mineral oil and common gas investigation, extraction, and improvement exercises.

73 Prohibition of discharge of hazardous substances, chemicals and materials or oil into the environment

(1) No person shall discharge any hazardous substance, chemical, oil or a mixture containing oil into any waters or any other or any parts of the environment contrary to the criteria prescribed in terms of section *seventy-two*.

(2) A person who discharges a hazardous substance, chemical, oil or a mixture containing oil into any waters or any parts of the environment in contravention of subsection (1) commits an offence and if convicted of that offence shall—

(*a*) pay the cost of the removal of the hazardous substance, chemical, oil or a mixture containing oil including any cost which may be incurred by any Government agency or organ in the restoration of the environment damaged or destroyed as a result of the discharge; and

(*b*) pay the cost of third parties in the form of reparation, restoration, restitution or compensation as may be determined court on application of such third parties.

(3) The owner or operator of a production or storage facility or transport conveyance from which a discharge occurs in contravention of subsection (1) shall—

(*a*) be required to give immediate notice of the discharge to the Board or relevant Government officers; and

(*b*) be required to immediately begin clean-up operations using the best available clean-up methods; and

(*c*) be required to comply with such directions Board may from time to time issue or cause to be prescribed.

(4) Where the owner or operator of a production or storage facility or transport conveyance has refused, neglected or failed to take appropriate action in terms of subsection (3) upon the expiry of such period, not exceeding six months, as the Board may direct—

(*a*) the Board may take temporary possession of the production or storage facility or transport conveyance for the purpose of taking or causing to be taken the necessary remedial measures to stop the discharge of the hazardous substance, chemical, oil or a mixture containing oil concerned and restore any damage to the environment caused thereby; and

(*b*) meet the costs of any measures taken in accordance with paragraph (*a*) by disposing of the production or storage facility or transport conveyance.

Figure 2.5 - Section 73 on EMA

3. Methodology

The purpose of this analysis is to determine the cause of the oil spill. The case will be analyzed by taking after the Risk management rules provided by ISO31000 and EMA Zimbabwe. This method includes an arrangement of phases that must be carefully created in arrange to keep on trial and to overcome with valuable data and comes about.

3.1 Steps

1. Analyzing the case study at the Mukuyu well in Muzarabani.

This step involved interviewing the workers from the Muzarabani plant as the incident was never reported.

2. Risk Identification

Identification of probable hazards was done through Devising and Delphi 1 Techniques methods. Delphi embraces the interviewing of professionals or petroleum engineers which are supervisors of the oilfield operators and that are the proprietors of all those pumping and drilling wells projects in Muzarabani and accountability

3. Risk categorization.

According to the near of impact and significances, areas pretentious inside and outside the organization as well as to its manifestation will catalogue all risks. This is a phase to create three dissimilar risk analysis models of HAZOP2, What-if3 and FMEA4 in harmony with our study situation. We will define each item should be encompassed in the table, such as, risks, frequency, impact, measures, etc.

4. Risk Evaluation

After to create the proposed examination strategies, we will have to categorize the risks and distinguished causes and impacts with respect to this sort of oil spills, the reason will be to compare the strategies and at long last distinguish those major risks. Based on the things in our show, we will allow a point-by-point examination to each hazard one by one, additionally discover out the causes of risks. Assessment will be based on preventive measures, possibly arranging and elective techniques to all dangers.

5. Risk Response

At last, we will appraise what will the best risks rejoinders in order that Muzarabani be able to lessen the number of events and advance its current performs in those areas that needed.

We will track the above stages in three sections of Risk Matrix & Scatter Diagram, HAZOP and FMEA discretely, so it is easier to liken and analyze diverse results from different models.

6. Recommendations to Management and Environmental Management Agency

At last, once we get to understand and get what happened, what caused and what come up short amid method that drove to the spill, we are going to conduct and recommend to Muzarabani and its stakeholders attainable risk reaction activities in order to duck, transfer, moderate or admit the dangers

4. Case Study

This case study is considered as a little scale occurrence since it happened before commercial explorations started, but the information gotten from this occurrence is utilized to create chance examination so as to dispose of or minimize the impact of oil spillage afterward when commercial investigation starts. In the midst of a normal operation day in May 2023, after starting the regular checkup of the wells it was pointed out by one of the administrators that there was an oil spill. The oil well was working with powered pumping gear. In attendance are 2 devices that sense within the gear that are associated towards a recurrence, which guides a flag once the hardware halts. This was not the scenario in this case, the gear was still at work and open-handed the strokes per diminutive that stood relegated. This nature of gear was continually observed via sensors and recurrence and a corporeal supervision is done at slightest thrice per day. Within the last move

no unruly were detailed or identified. Since of this a near to the ground to direct bulk of oil was discharged within encompassing range to the oil well, it is evaluated around 8hrs. Subsequently been detailed the staff settled the issue in about 4 hours, counting the cleaning of the assortment. Later, overseeing the location, the description informed that the occasion comprised as it were fashionable an oil slime also there was none contamination after gas or other impurities. Indeed, in spite of the fact that, the encompassing regions are utilized to bolster animals otherwise for rural resolutions, it was not assessed that the bulk of oil leak and the evaluated influenced zone was about 50 m^2. Following assessment, it was distinguished that the spill came from a outflow in a release line.

The interruption was fair for about 4 hours, which generation sum misplaced isn't agent to obliging a tall level of seriousness with respect to the commerce benefit. Results depend of the reason of the issue also might basis from inebriation individuals or wildlife that survives within encompassing regions triggering their passing till unfeasible agrarian earths or else water fonts. This type of occasion is not disastrous but then again isn't negligibly imperative. The purpose, is since recurrent occasions alike these transpired in arrive oil areas in addition regularly, they remain undetailed or else reported aimed to encourage take after out or soil recuperation to ideal environments owing that are contemplated as minor oil spill and bearings haven't led to enormous mislays or zone security. Meaning that utmost of the while there's a changeless harm to earths. The case is categorized as little spill as beneath 500 barrels and thus, boss concurred that after been performed the crisis reaction activities and to relieve the unsafe circumstance take after by a add up to clear out the range but remain considered obligatory to take after the case not one or the other to require future activities for the occasion.

The next are figure were taken before cleanup:

Figure 4.1- Oil spill at Muzarabani

Figure 4.2 - Oil spill by the Christmas tree

Another occurrence occurred adjacent a water source was uncovered to an oil spill produced from the well for more than 24 hours. Occupants of the range claimed that the spill was identified from Wednesday noon till the next day. The oil spill was spreading to adjacent cultivate lands as well. Fortunately, not an expansive region was influenced and the spill was identified and illuminated quickly without being detailed.

Figure 4.3- Oil spill spreading to water source

4.1 Data Analysis

5.1 Root- cause analysis

The case examination beginning argument is the Root- cause investigation, with which can help direct over the origins and results that driven to the occasions. Root analysis could be a precise prepare that includes collecting and analyzing prove to illuminate an issue. It can be utilized to distinguish the root causes of oil spills, which are regularly caused by mischances including, pipelines, penetrating rigs, Christmas tree. In this manner to distinguish the major number of dangers or causes oil spills or spills will be doable. A vital portion of this prepare was information gathering around the events, recognizing the forms and dependable individuals of each range or activities for a much better, a higher, a stronger and improved thoughtful in arrange to create protective actions or changes within the contemporary methods or strategies. In spite of the fact that this case study was a minor circumstance utilized the opportunity to inquire about more almost worser circumstances that might have conceivable happened in case the plant was fully functional and exploration operations were being done at huge scale. This permits to for see the potential causes of oil spillage and come up with strategies to play down them or dispose of them.

A few root causes of oil spills include:

1. Equipment
Imperfect hardware parts, hardware breakdown, and need of compelling organizational measures over operational hones

2. Human error
Upkeep insufficiencies, operational blunders, inaccurate methods, and human carelessness

3. Design
Plan that did not expect conditions, and disgraceful administration of changes

4. Climate
Weather-related occasions

5. Others
Infringement of pipeline snugness, pipe wear due to inside erosion, auxiliary disappointments, affect with objects, vandalism, and fear-based oppression.

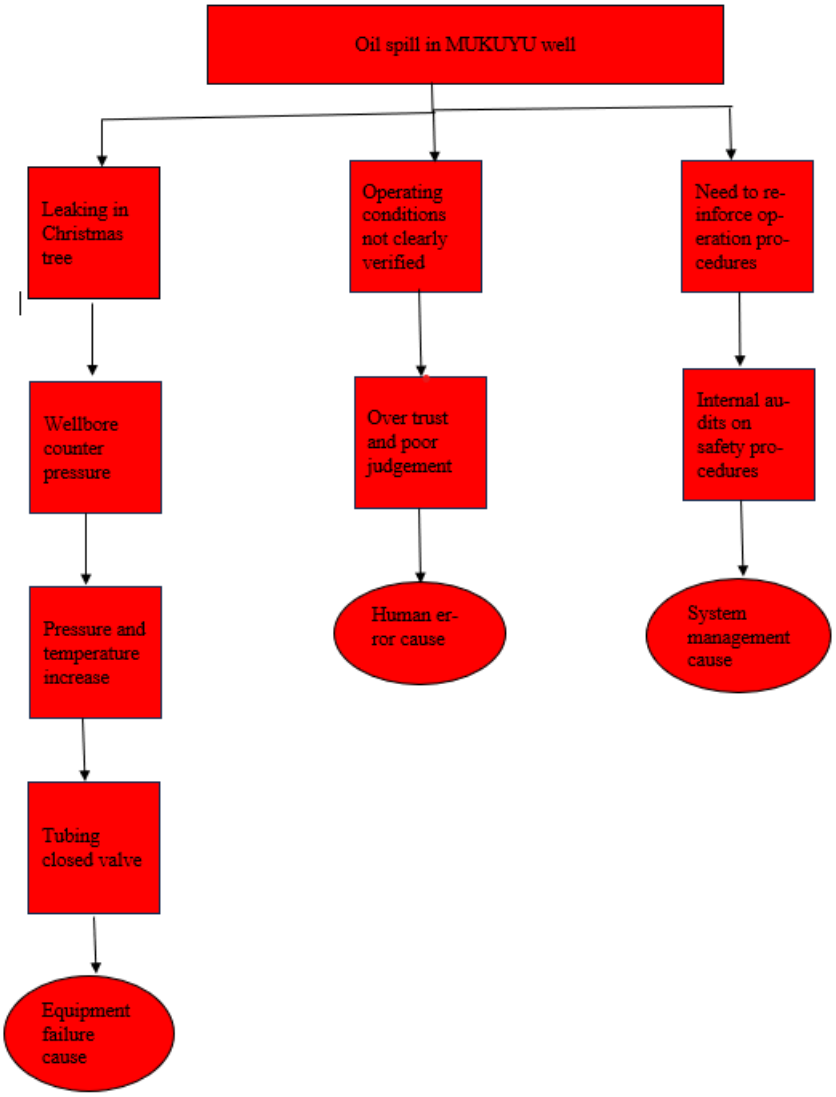

Figure 5.1- Root analysis for the case study

The results of the root cause analysis showed that the main causes of the oil spillages are resulting from equipment failure, human error and/or system management cause.

5.2 Types of risks

Based on our investigation and specialized inquire about on oil spill mischances, The distinguished dangers that will result stay classified to three groupings as takes after: management, technical and operational fields. So, a risk analysis was performed for the listed risks.

1. **Management Risks**

Table 5.1- Management Risk

Risk	Risk explanation	Severity	Regularity	Risk value
1	No supervision	3	2	6
2	Laws and regulations that are not clear	2	1	2
3	Lack of risk management plan	4	3	12
4	Lack of homogeneous practices	2	3	6
5	Deficiency of proper drill and actions to guarantee proper follows are performed	2	2	4
6	Lack of contingency plan	2	2	4
7	Legal effects	2	1	2
8	Media attention to incidents	2	2	4
9	Lack of environmental evaluation system	3	3	9
	Lack of contingency plan	5	2	10

Management risks are summarized above, these risks are calculated based on the case study but putting future explorations into consideration it can be seen that the risk value is likely to increase hence the great need to take action now before large-scale explorations begin.

1. **Technical Risks**

Table 5.2 - Technical Risks

Risk	Risk explanation	Severity	Regularity	Risk value
10	Leakage in pipelines and or valves	3	5	15
11	Corrosion in pipeline and equipment	2	1	2
12	High pressure hoses, connections and valves	2	2	4
13	Extreme high temperature	2	2	4
14	Wellbore blowouts and explosions	5	1	5
15	Damages in equipment, hoses, connections or Christmas tree	1	2	2
16	Mechanical failure in equipment	1	2	2
17	Use of inadequate equipment	2	3	6
18	No regular testing	2	2	4

19	Failure in sensors	2	2	8
20	Friction between equipment components	3	3	9
21	Clogs in pipelines and other parts that affect fluid flow	3	2	6

Technical risks are also summarized above and it can be noted that the risks values are not alarmingly too high which may be because proper exploration has not yet started and there is less equipment set up. As the plant continues to grow and expand the risk values will evidently increase as shown from research hence the more reason to plan and eliminate the risks beforehand so to reduce the risks as much as possible.

1. **Operational Risks**

Table 5.3- Operational Risks

Risk	Risk explanation	Severity	Regularity	Risk value
22	Inexperienced personnel	2	2	4
23	Lack of maintenance	2	1	2
24	Inadequate monitoring of the well	4	2	8
25	Lack of proper communication channel	2	4	8
26	Lack of commitment and poor attention	2	2	4
27	Not using proper safety PPE	2	4	8
28	Over trust	2	1	2
29	Wrong criteria wen evaluating risks	3	2	6
30	Long response periods	2	3	6

The operational risks as well are not as intense because there is not yet full production occurring on the plant but the risks values already show that as operations will be starting so will the risk values be increasing so it is important to predict the potential risks now and work towards eliminating or minimizing them.

5.3 Risk Matrix

Figure 5.1- Risk Matrix Chart

Severity is first axis of a risk assessment and it measures the expanse of impairment or harm a threat could form. Severity it is every so often hierarchical on a four-point scale within a risk matrix as tails:

- **Catastrophic – 4:** Working conditions are such that human blunder, environment, plan insufficiencies, component, subsystem or component disappointment, or procedural lacks may commonly cause extreme harm or sickness or major framework harm in this manner requiring prompt remedial activity**.**
- **Critical – 3:** Effective surroundings are such that social error, atmosphere, design absences, element, subsystem or factor failure, or routine deficiencies may frequently origin unembellished damage or ailment or foremost system mutilation thereby needing instantaneous counteractive action.
- **Marginal – 2:** Working conditions may frequently origin minor grievance or sickness or minor structures injury such that social fault, location, design absences, subsystem or section failure, or practical deficits can be responded or exact lacking unadorned grievance, sickness, or major organization harm.
- **Negligible – 1:** Operational situations are such that employees blunder, situation, design deficits, subsystem or factor catastrophe, or practical insufficiencies will upshot in no, or less than minor, ailment, grievance, or arrangement hurt.

Probability is the next axis of a matrix and it trials the prospect of the jeopardy stirring. Probability is often ordered on a five-point scale:

- **Frequent – 5:** Prospective to occur habitually in the life of an item.
- **Probable – 4:** Will transpire more than a few whiles in the lifecycle of an item.
- **Occasional – 3:** Expected to befall onetime in the lifespan of an item.
- **Remote – 2:** Doubtful but probable to transpire in the lifespan of an item.
- **Improbable – 1:** So questionable, it can be presumed an existence may not be practiced.

Constructed on the points and the oil industry acknowledged guidelines principles in Zimbabwe dangers were assessed in arrange to urge the ultimate risk values. In the interim, risks scatter diagrams will be displayed, these can permit taking an outline of the hazards concurring to an area either in worthy before unsatisfactory regions, hence diverse moderation measures might be connected to distinctive levels of dangers.

5.3.1 Scatter diagram analysis

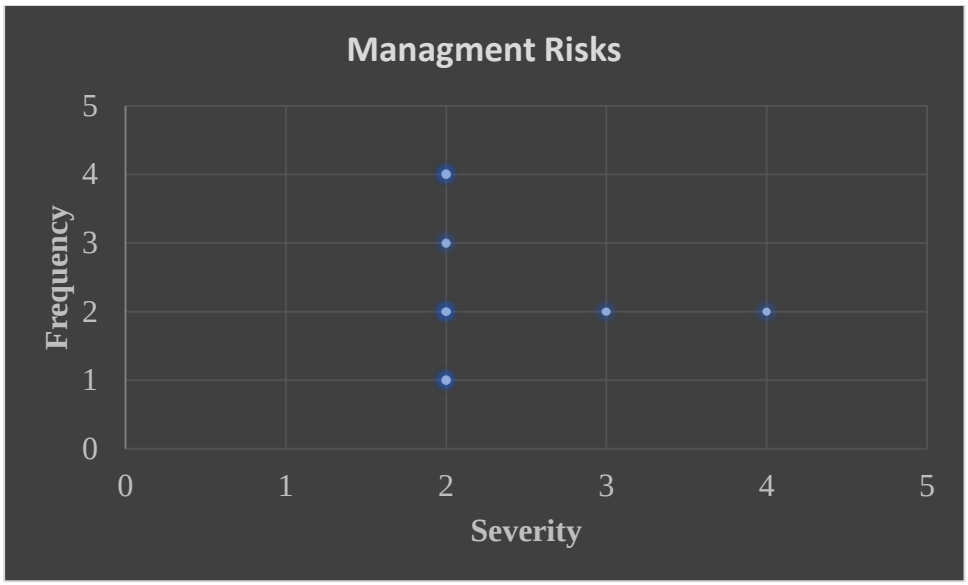

Figure 5.2 - Scatter analysis for Management Risks

As appear within the chart we will distinguish that fifty out of a hundred of the administration dangers entails quick activity then ought to stay redressed. They have a place within the undesirable locale. The common design is a continuous insufficient administration, obstructing to upgrade organizational execution because to a need of framework assessments and administration.

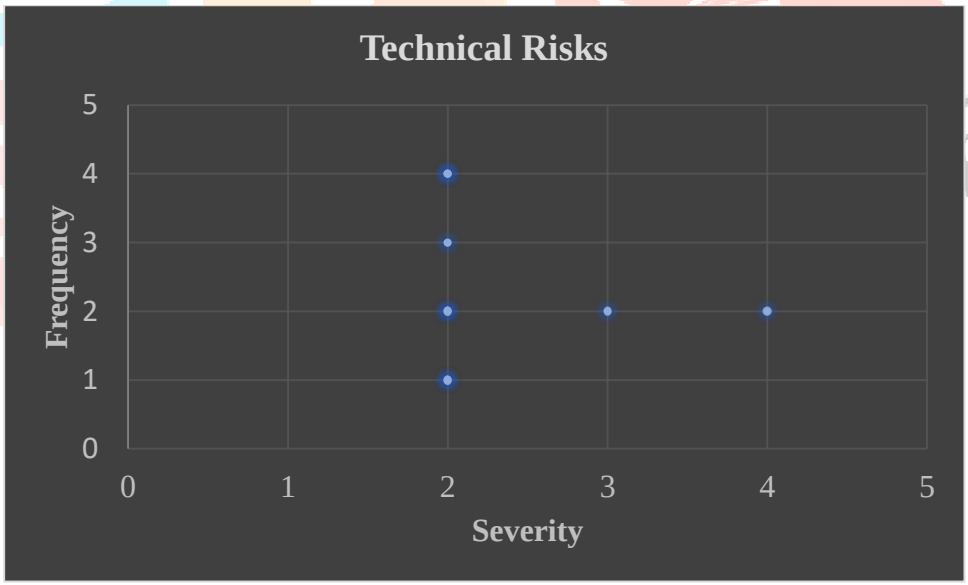

Figure 5.3 - Technical Risks

Technical dangers are unsatisfactory in the framework are linked to tall weights taking place wells, spillage in addition to sporadic trying or reviews. Fundamental sources of these sorts of dangers were associated with social mistakes and within the other hand it is plainly a result of the insufficient administration.

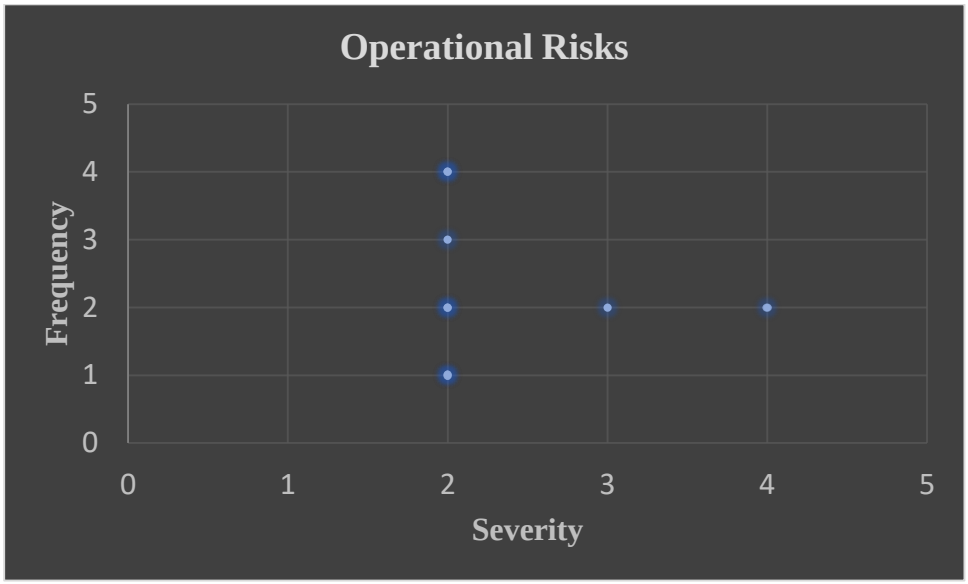

Figure 5.4 - Operational Risks

Operational risk is more within the undesirable dangers and controllable region, entirely must be illuminated like before long as conceivable with a relief reaction over controls and teachings cultured ought to be recorded and take considered. Herein network, communal design of the chance is the social blunder, owing to the need of preparing or aptitudes to illuminate crises or issues, off-base measures, improper statement and not execution work agreeing superlative observes trials. Moreover, we are able demonstrate the criticalness to

make strides administration hones interior the organization conjointly with the administrator. Hence, these dangers ought to be moderated.

5.3 Risk analysis models

5.3.1 Failure Mode and Effects Analysis

Failure Mode and Effects Analysis (FMEA) is a designed method for detecting probable failures in an invention or course design. FMEA includes reviewing the succeeding:

- Failure modes: What can slipup
- Failure causes: Why will the catastrophe occur
- Failure effects: What will be the costs of respective failures

Table 5.4 shows summary of the failure and effect analysis mode of the Mukuyu well case study.

Table 5.4- Failure Mode and Effect Analysis

Risk analysis. Failure Mode and Effects Analysis										
Installation Muzarabani Oilfield				System: Mechanical Pumping Unit Mukuyu well						
Subsystem										
Risk number	**Description**	**Function**	**Potential Failure mode**	**Potential failure Effects**	**S**	**Causes**	**F**	**Action**	**RV**	**Recommendations**
11, 12, 15	Pipelines and tubing	To transport crude oil from the well	Corrosion/ leakage/ deterioration/ clogs/ eg construction works	Wellbore counter. Petroleum fluids spills which may cause pollution or soil intoxication which may lead to deaths	4	1)Wellbore counter 2)Corrosion from salinity in the environment failures on separators allowing accumulation of sand	3	1)Suitable orientation, tuning and housework. 2)Intensive care of well pressures and flows to dodge extreme situations that may perhaps harm it	12	1) Should improve maintenance and condition of tubing. 2)Place sensors that can detect leaks

11, 26	Stuffing box	To protect rotating part against a fluid thus preventing leakage	Oil leakage/ Friction with polished rod	Oily water spillage which causes contamination and unsafe waste that can cause passion. Due to friction total damage of equipment which causes blowouts.	3	1)Not lubricated 2)Disturbed equipment 3)wellbore counter 4)Skewed polished rod	4	1)Replace deteriorated seals. 2) Inspect vertical alignment of the item with the well if polished rod is at work to one side of the stuffing box.	12	1)Regular maintenance 2)Replace seals as soon as possible to avoid more leakage
11, 13, 31	Pressure relief valve	Controls pressure and allows flow in either direction	Fails open either by: 1)Mechanical failure or 2)External impact	Reverse flow, minor leakages and poor pressure control can result in failure of the valve.	4	1)Inadequate training to grip the pressures of the valve. 2)Absence of maintenance 3)Enterprise failure	5	1)Proper training of responsible personnel. 2)Regular maintenance	20	Management systems to ensure proper training of operators so they may have good judgement and follow quality practices
13	High pressure hoses	Prevents spills and maintain proper system function	Leakage/ Deterioration/ Burst	Petroleum fluids can cause pollution or intoxication resulting in death.	3	1)Deterioration 2)Closed valves 3)Pipeline clogging	5	1)Regular checkups	15	1)Monitoring the well flow and pressure. 2)Install high pressure sensors.

12, 16, 30	Christmas tree	Controlling flow out of the well and allowing to flow to pipelines	Failure to control flow/ failure to open or close	Affects further adjustments of pressure and flow. Changing internal well conditions that might negatively impact fluid levels and production.	4	1)Corrosion 2)Lack of maintenance	2	1)Lubricating 2)Repairing 3)Regular testing	8	1)Regular training of operators
16, 31, 32	Pressures	Controls pressure limits	Backpressures	Damages in some portions of the apparatus e.g. valves, hoses, Christmas tree etc.	5	Social blunder when shutting or initial opening of valves to control pressure arrays	5	Unvarying repair together withmaintenance	25	Pressure sensors to forecast pressure peaks
21	Proximity sensors	Sends signal to PLC to allow flow	Malfunction or total failure	No signal sent when failure occurs affecting production Damages stuffing box	3	1)Problems on sensor faces 2)Rapid changes in voltage 3)Extreme temperatures	2	1)Regular inspection and maintenance. 2)Avoid dust and dirt accumulation	6	Insert surge absorber near source

5.3.2 Hazard and operability study (HAZOP)

Table 5.5 - HAZOP Analysis for Management Risk

Safety evaluation and operational study		Section: Mukuyu oil well in Muzarabani, Zimbabwe System: Pumping units oil spills Name of study: Management risk in oil spill events		Date 11/02/2024
Key word	Deviation	Causes	Consequences	Action
Less	Less supervision	1)With holding of important information for better well monitoring. 2)No consistent daily checkups	1)Sudden accidents which may put people and the environment at risk 2) Risks observed when it is too late. 3)Risk management cannot be improved.	1)Establish a detailed supervision system. 2)Proper training and sharing of information with operators.
Ambiguous	Unclear laws and regulations	1)The government does not have clear or enough laws and restrictions in this field. 2)No strict follow up of these rules, regulations are more oriented to penalties than corrective action. 3)Loopholes in management.	1)Risks not taken seriously 2)No accountability for the pollution.	1)Formulate more specific and clear regulations with making sure they are seriously enforced and followed. 2)Make the penalties very extreme so the risk may be taken seriously.
No	No risk management plan	No homogeneous or written procedure just depends on the experience of the operator.	No proper criteria or layout plan on how to respond to emergencies.	1)Establish manuals on risk management plan. 2)Follow up to make sure operators follow established procedures

Different	Different criteria and no homogeneity	1)Different manuals from subcontractors and no joint efforts to eradicate the problem. 2)no proper communication with contractors.	1)Corrupt impact on cooperation and permanency of work. 2)Communication problems which increase the risks.	1)Share homogeneous practices with all subcontractors so everyone knows what action to take in case of emergency. 2)Improve communication channels with feedback.
No	No training of negligent staff	1)No follow up evaluations to ensure trained personnel is performing well. 2)No rewards to those doing well or disciplinary measure to those being negligent.	1)Increased among staff as there is no follow-up training. 2)Incompetent work.	1)Continuous training staff to keep performance at maximum. 2)Establish rewards and incentive system to motivate workers.
No	No formal contingency plan from subcontractors	Subcontractors tend to come up with a plan based on their experience and what they can do at that moment not a proper written plan.	1)No checklist when responding to emergencies. 2)Over trust based on experience. 3)Increased diagnosis time hence longer shut down period. 4)Solutions might not be permanent.	1)Establish as plan on how to attend to an emergency so as to reduce diagnosis time. 2)Try look for a permanent solution.
No	No environmental evaluation system	1)If spillage are small they might be neglected with no follow ups. 2)Restoration actions might be very expensive hence might not be carried out to complete.	1)No measures to protect environment. 2)Lack of accountability.	1)Establish standard environmental evaluation systems. 2)Prepare preventative measures to protect environment.

Table 5.6- HAZOP Analysis for Technical Risks

Safety evaluation and operational study		Section: Mukuyisi oil well in Muzarabani, Zimbabwe System: Pumping units oil spills Name of study: Technical risk in oil spill events		Date 11/02/2024
Key word	Deviation	Causes	Consequences	Action
Leak	Pipeline or valves leak	1)Equipment not being maintained. 2)Technical failures	1)Petroleum spillage 2)Environmental pollution 3)Safety accidents	1)Regular checkups and maintenance. 2)Install sensors with alarms to report leaks.
Corrosion	Corrosion of equipment	1)Equipment not being properly maintained. 2)External factors	1)Oil spillage 2)Equipment failure	1) Regular checkups and maintenance. 2)Replace old equipment.
Explosion	Fire explosions	1)Flammable liquids leak. 2)Lack of fire preventative measures e.g fire exstinguisher	1)Fire explosion leading to injuries and even loss of equipment. 2)Air pollution	1)Have fire equipment always ready in case of emergency. 2)Fire drills and training. 3)Extra caution for flammable materials.

Damage	Damaged equipment	1) Friction or wearing of equipment. 2)Old equipment. 3)Improper use 4)Quality problem	1) Spillage incidents 2)Risk of injuries and accidents.	1)Purchase good quality equipment. 2)Regular maintenance. 3)Manuals on how to use equipments.
Failure	Design failure of equipment	1)State of affairs at site was not well-thought-out in the equipment design. 2)Poor quality designers.	1)Increased down time. 2)Safety risks.	1)Purchase equipment from qualified designers with a good reputation. 2)Third party audit.
Less	Less monitoring of well activity	1)Negligent operators. 2)Staff not properly trained. 3)Existing monitoring systems not working.	Risks cannot be for seen and action might be taken after it is already too late.	1)Establish monitoring systems with sensors and alarms. 2)Regular maintenance
Change	Sudden chances of fluid properties.	1)Environmental or climate or geological changes. 2)Failure of any equipment or leakage.	1)Spillage incident 2)Safety risks.	1)Monitoring system of fluid flow. 2)Alarms to notify of changes.

No	No maintenance and no spare parts.	1)Judging equipment life by mere observation instead of proper servicing. 2)Limited resources.	1)Increased downtime. 2)Risk of accidents. 3)No permanent solution for problems.	1)Storck up spare parts for incase of equipment damage. 2)Consider redundancy in design.
Less	Not enough on pollution treatment methods.	1)Not taking pollution problems seriously. 2)No guidelines or regulations.	Oil spillage pollution affect environment.	1)Take pollution seriously and enforce regulations. 2)Proper research on how to solve pollution problems. 3)Environmental management agency can help in training employees on pollution treatment.
Less	Less response measures	1)Lack of a contingency plan 2) Existing oil spillage response are not practical hence not applicable.	1)Recurrent amount of oil spill incidents 2)Successive harm to the location.	1)Study previous spillage incidents and assess. 2)Have a contingency plan. 3)Storck spare parts. Risk management plan

Table 5.7- HAZOP Analysis for Operational Risks

Safety evaluation and operational study		Section: Mukuyisi oil well in Muzarabani, Zimbabwe System: Pumping units oil spills Name of study: Operational risk in oil spill events		Date 11/02/2024
Key word	Deviation	Causes	Consequences	Action
Negligence	Negligent personnel	1)Lack of experience of personnel 2)No proper training 3)Not taking work seriously	1) High risks of accidents 2) Equipment damage 3)Loss of production time due to increased downtime.	1) Regular training of operators. 2)Introduce rewards for and punishments.
Lack	Lack of maintenance	1. Prevailing care manuals are not tailed 2. Slipshod personnel 3. Absence of specialist care	1. Latent risks might not be detected in time 2. Safety coincidences may transpire	1. Progress the maintenance physical and check to follow it 2. Assemble unvarying check to maintenance 3. Display unvarying top refurbishment and whole refurbishment.
Improper	Improper operations procedures	1. Inexpert functioning personnel 2. Working guidebooks are not real or achievable	1. Operation accidents 2. Safety accident or injury	1. Expand procedure procedures or guidebooks 2. Launch reaction system and check slant to observe unsuitable dealings 3. Follow existing standard operation management system of respective area

Deficient	Deficient monitoring of the well	1. Nonexistence of specialist care equipment 2. Careless personnel 3. Flawed specialist care system	1. Recurrent occurrence of oil spill coincidence 2. Fluctuations of pressure, speed, fluid, etc. lead to safety fortune	1.24 hours or regular monitoring 2. Build check list and responsibilities to individuals.
Inappropriate	Inappropriate communications and problems solutions	1. Ineffective communication arrangement 2. Unqualified supervise and administrators could not communicate	1. Congested data message interruptions problem resolution time 2. Unfortunate unruly solutions basis slipups and safety risks	1. Information disclosure and communication between stakeholders 2.Information revelation and message amid design, locating, project and diverse sections 3. Create typical communication structure, and create initiative culture
Breakdown	Breaking any pipe maneuver when any installation or dismantling	1. Product breakdown 2. Careless work	1. Pipe leak and oil spill 2. Other safety accident	1. Product inspection 2. Careful work
Unsuitable	Unsuitable to solve problems or emergencies	1. Unexperienced or unqualified operator 2. Absence of catastrophe management	1. Holdup the period to solve glitches or emergencies 2. Intensifies the likelihood of risks and accidents 3. Convey greater harm	1. Catastrophe managing is required 2. Emphasize staff drill to improve their skills to solve glitches or emergencies
Damage	Causing damages when performing daily operations without noticing.	1. Inconsiderate work 2. Flawed work manual 3. Absence of monitoring 4. Superiority problem of apparatus or product	1. Harm to apparatus and product 2. Unpredicted risks will disturb other work 3. Enlarged cost	1. Careful work 2. Intensification staffs' logic of charge to work 3. Advance daily harm response actions

			4. Rise in probable hazard	
None	Not accomplishing the exertion conferring to the manuals or postulated actions	1. Ambiguity of manuals or postulated procedures 2. Inconsiderate and careless staff	1. Upsurge redundant work cost and time 2. Surge administration cost 3. Fashion likely perils 4. Surprising fortunes are more expected to transpire	1. Intensification staffs' sense of responsibility to work 2. Expand manuals or postulated trials to minimize loopholes 3. Reprove inconsiderate and careless staffs
More	Shutting valves more than it is mandatory by the performance or fluids of the well.	1. Mistakes of judgment 2. Operation mistakes	Oil spill and other safety accidents	1.expand worker's specialized skill 2.Upsurge persons for recheck the procedure
None	Not wearing correct protective clothing	1. Low safety awareness 2. Short of safety equipment, clothes and tools	Safety accidents and injuries are more likely to occur	1. Launch obligatory items in safety manual 2. Progress staff safety consciousness 3. Verify enough safety kit, clothes and tools obtainable before work begins
Inadequate	Wrong standards when evaluating potential failures or risk	1. Insufficient assessing method. Inadequate understand of real-world situation at position	1. Slipup potential letdowns or risks, so incorrect risk retort actions will be engaged 2. Problematic resolving stretch can be deferred Leading to safety fortunes or grievances	1. Accomplished criteria and appraisal system shall be permitted by professional persons 2. Wide-ranging examination to the situation, hazard and other settings at site is required

				before starting evaluation measures. Formulate exigence plan for risks from erroneous measures
None	No performance	1. Neglectful staff 2. Over trust 2. Lacking supervision and restrictions 3. Letdown of work	1. Probable risks 2. Safety fortunes or damages 3. Intensification prospect of accidents	1. Improve staff restrictions and running 2. Use spec to follow and monitor routine of everyday errands 3. Improve staffs' sense of accountability and expand their work insolence in daily work 4. Progress staffs' work skills over training

After comprehension of the study, I was prepared to complete and affirm that key hazard that remained confronted amid the occurrence remained a wellbore weight. This over-the-top weight was an outcome of a valve closure, when an administrator overlooked to open within the initial circular, indeed education was specified to him. Subsequently after the meet with the labor force, it was noticeable that concluded believe was the most key calculate of the occurrence additionally aptitudes and constrained information to steadfast firm issues. The foundation of the administrators is ordinarily a moo instruction near and frequently unpracticed. Hence, the staff it is prepared the obligation depends on administration generally of the organization, quick administrator and zone mindful ought to guarantee all the exercises are executed concurring to the pact and company arrangements and guidelines nevertheless when occupied it is calm to diminish security dealings and over believe once occurrences stand not appointment. As appeared by the hazard lattices, it is clear that Muzarabani has got to adapt and to choose how to tackle utmost of the dangers which were found to be in B and C zones, which ought to be adjusted in not more than 3 months' time. It has been demonstrated that they are not portion of the methods or habits to take were recorded in hazard examination, they will be as it were carrying out an observational tactic that it has being executed. In this manner will hinge on a part of the individual in control, how dangers drive be accomplished and frequently similar issues can be displayed amid the cycle of the venture.
The dangers categorized as "B" sort, are ones who got to be moderated.

6 Conclusion and Recommendations

6.1 Conclusion

It isn't as it were through improving or acquiring the most excellent hazard administration arrange or framework, which is able permit the oil trade to accomplish procedures under a less expected of spills or dangerous chance occasions nevertheless the individuals. It is required to form a mindfulness and security propensities on workers whereas companies ought to assess more regularly their alternatives and exertions to reply otherwise relieve dangers in addition to the preparing also increment the take after up.

For the case investigation we are able complete that the origins were:
• Wellbore counter (intemperate tall weight) By reason of over-the-top gas gathered otherwise an expanding of oil consistency.

• Need of administration.

• Destitute finding to controller the gear and over believe from administrator when implementing every day strategies.

• Wasteful administration since there are not persistent faculty assessments and reviews to guarantee they take after the leading hones methods.

Results:

• Oil spill, spillage and little sum of gas discharge in discuss.

• Defilement, contaminate soil.

At this minute the temporary worker doesn't have a solid taken a toll valuation of oil spills and clear-out costs and thus the policymaking of handling strategies hinge on more within the professional effect, alluding to punishments or required activities to accomplish agreed by the administrator.

Expenses of oil spills regularly are troublesome to appraise, around are about strategies that can be utilized but once missing of data may be doable to do a basic assessment by including up the fetched that can be assembled fetched can be distinguished in three distinctive bunches:

cleanup (evacuation, investigate and other costs), financial misfortunes and natural fetched of an oil spill.

6.2 Recommendations

It is vital to distinguish and analyze dangers as early as conceivable amid the investigation and generation ventures, which ordinarily includes a 3 a long-time life cycle. Amid the improvement of Muzarabani and Invictus vitality are working on altering their framework in arrange to be congruous and anticipate spillage. Through this, future reactions and communications ought to have move forward meanwhile will be sighted after the same point of view and direness. Not as it where the examination will donate the reaction required nonetheless from this argument, it is anticipated the advancement of an activity arrange in arrange to redress insufficiencies and to move forward the current methods.

The best administration in synchronization with the engineers in control of the oilfields will choose which activities will be required to diminish the recurrence and seriousness of oil spills and will be through the taking after choices:

Evasion, Relief, Transference or grasping.

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