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The Use of Artificial Bayesian Intelligence for Development of Optimum Well Control Practices

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Abstract— Many well control incidents have been analyzed, resulting in the optimum practices, as outlined in this paper. To the best of the authors' knowledge, there are no systematic guidelines for well control practices. The objective of this paper is to propose a set of guidelines for the optimal well control operations, by integrating current best practices through a decision-making system based on Artificial Bayesian Intelligence. Best well control practices collected from data, models, and experts' opinions, are integrated into a Bayesian Network BN to simulate likely scenarios of its use that will honor efficient practices when dictated by varying operation, kick details, and kick severity.

The proposed decision-making model follows a causal and an uncertainty-based approach capable of simulating realistic conditions on the use of well control operations. For instance, as the user vary the operation, rig and crew capabilities, kick details (such as slim hole, deviated or horizontal well), the system will show the optimum practices for circulation method.

Well control experts' opinions were considered in building up the model in this paper. The advantage of the artificial Bayesian intelligence method is that it can be updated easily when dealing with different opinions. The outcome of this paper is user-friendly software, where you can easily find the specific subject of interest, and by the click of a button, get the related information you are seeking.

Index Terms— artificial intelligence, Bayesian, well control, drilling and uncertainty-based approach.

1 Introduction

The purpose of development of well control procedure is to prevent catastrophes that could result from blowouts. The objective of this paper is to propose a model to serve as a training tool. The development of up to date source of proper well control practices is a challenging task. Using current methods of flow charts in decision making does not allow enough room for different or changing well control practices to be included.

The design of optimum well control practises depends mainly on previous experience and knowledge to successfully complete with a degree of confidence. Effective communication is also an important factor for successful well control operations. Good coordination is required between the engineer, the service company and the rig foreman. Knowledge transfer in well control operations is therefore fundamental for the optimal design of the job.

Field experiences are required for well control specialists to select optimum practices. In some instances, well control operation failures can occur because of the lack of knowledge or lack of knowledge transfer.

There are different methods that companies have approached to make guidelines for their engineers to save on operations cost and time. However, these methods can not be used by other companies or experts with different opinions or with different field conditions.

Al-Yami et al. (2010) were the first to propose a systematic approach to build expert systems that can be used in optimum selection and execution of successful cementing operations using Artificial Bayesian Intelligence.

The Bayesian paradigm can be defined as:

$$p(hypothesis|evidence) = \left(\frac{p(evidence|hypothesis)\, p(hypothesis)}{p(evidence)} \right)$$

Representing the probability of a hypothesis conditioned upon the availability of evidence to confirm it. This means that it is required to combine the degree to plausibility of the evidence given the hypothesis or likelihood p(evidence|hypothesis), and the degree of certainty of the hypothesis or p (hypothesis) called prior. The intersection between these two probabilities is then normalized by p (evidence) so the conditional probabilities of all hypothesis can sum up to 1.

This work introduces the use of Bayesian networks as a way to provide reasoning under uncertainty, using nodes representing variables either discrete or continuous. Arcs are used to show the influences among the variables (nodes). Thus, Bayesian networks can be used to predict the effect of interventions, immediate changes, and to update inferences according to new evidences.

Bayesian networks are known as directed acyclic graphs because generating cycles are not allowed. The terminology for describing a Bayesian Network follows a hierarchical parenting scheme. A node is named a parent of another node named child if we have an arc from the former to the later. The arcs will represent direct dependencies. Evidence can be introduced to the Bayesian network at any node, which is also known as probability propagation or belief updating. It is important to define the conditional probability distributions to each node (Korb and Nicholson, 2004).

In order to prove the concept and the benefits of using this approach, one simple BDN model simulating the decision-making process of the selection of swelling packer is introduced in **Fig.1,** Al-Yami et al. (2011). This model contains one decision node (swelling packer), three uncertainty nodes (treating fluid, type of drilling fluid, and Consequences), and one value node (Completion Expert System). In this model, our selection for swelling packers is affected by our selection of treating fluid and drilling fluids.

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Once the structure of the BDN is defined, it is required to define the probability states associated with each node. These are given in Table 1 through Table 5. The model is designed in a way that the engineer will select his uncertainty nodes (treating fluid and/or type of drilling fluid) to get the recommended type of swelling packer (oil swelling or water swelling packer, Table 1). Table 2 shows the probability states of treating fluids based on swelling packers. Table 3 shows the probability states of type of drilling fluids based on swelling packers and treating fluids. Table 4 defines the extent of the probability states of the consequences, which are defined as recommended and not recommended. The input utility value associated with the consequences is given in Table 5. The expected utility outcomes considering all possible cases of evidence set a minimum value of zero, which is the "not recommended" case, and a maximum value of one, which assumed to be the "recommended" case.

Table 1: Swelling Packers

water swelling packer
oil swelling packer

Table 2: Probability states of treating fluids based on swelling packers

Swelling packer	water swelling packer	oil swelling packer
Lactic acid	0.9	0.5
HCl acid	0.1	0.5

Table 3: Probability states of type of drilling fluids based on swelling packers and treating fluids

Swelling packer	water swelling		oil swelling	
Treating Fluid	lactic acid	HCl acid	lactic acid	HCl acid
Formate drilling fluid	0.8	0.2	0.8	0.2
$CaCO_3$ drilling fluid	0.2	0.8	0.2	0.8

Table 4: Probability states of the consequences

swelling packers	water swelling packer				oil swelling packer			
Type of drilling fluid	Formate drilling fluid		$CaCO_3$ drilling fluid		Formate drilling fluid		$CaCO_3$ drilling fluid	
treating fluid	Lactic acid	HCl acid	lactic acid	HCl acid	lactic acid	HCl acid	lactic acid	HCl acid
Recommended	0	0	1	0	1	0	0	1
Not recommended	1	1	0	1	0	1	1	0

Table 5: Input utility values associated with the consequences

Consequences	Recommended	Not recommended
Value	1	0

The main goal after the required inputs are entered into the model is to simulate the uncertainty propagation from the existing sources of evidence, which means moving the information forward starting from the swelling packers node.

First the total probability is calculated for the type of drilling fluid. The above model shows that our selection of drilling fluid will affect the treating fluid and our swelling packers. The below equation is used:

$$\sum_{i=1}^{m} P(B|A_i)\, P(A_i)$$

The results are shown in **Table 6**. **Tables 2&3** are used for this calculation for example:

Table 6: Total probability for type of drilling fluid

$$\sum_{i=1}^{m} P(\text{formate drilling fluid}|\text{lactic acid}_i)\, P(\text{lacticacid}) = (0.9\times 0.8) + (0.1\times 0.2) = 0.74$$

Swelling packer	water swelling packer	oil swelling packer
Formate drilling fluid	0.74	0.5
CaCO3 drilling fluid	0.26	0.5

Then Bayesian equation can be used as shown below:

$$p(\text{hypothesis}|\text{evidence}) = \left(\frac{p(\text{evidence}|\text{hypothesis})\, p(\text{hypothesis})}{p(\text{evidence})}\right)$$

Which is the same thing as:

$$P(A_j|B) = \frac{P(B|A_j)P(A_j)}{\sum_{i=1}^{m} P(B|A_i)P(A_i)}$$

The results are shown in **Table 7**. **Tables 2, 3 and 6** are used for this calculation. The calculation shows the probabilities of selecting treating fluids (lactic acid or HCl acid) when the engineer wants to use a certain drilling fluid (formate or $CaCO_3$) for a particular swelling packer (oil or water swelling). The detailed calculations for water swelling packer are shown below:

$$p(\text{lacticacid}|\text{formate}) = \left(\frac{p(\text{formate}|\text{lacticacid})\, p(\text{lacticacid})}{p(\text{formate})}\right)$$

$$= \frac{0.8\times 0.9}{0.74} = 0.9729$$

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$$p(HCl\,acid|\,formate)=\left(\frac{p(\,formate|HCl\,acid)\,p(HCl\,acid)}{p(\,formate)}\right)$$

$$=\frac{0.2\times 0.1}{0.74}=0.0270$$

$$p(lactic\,acid|CaCO_3)=\left(\frac{p(CaCO_3|lactic\,acid)\,p(lactic\,acid)}{p(CaCO_3)}\right)$$

$$=\frac{0.2\times 0.9}{0.26}=0.6923$$

$$p(HCl\,acid|CaCO_3)=\left(\frac{p(CaCO_3|HCl\,acid)\,p(HCl\,acid)}{p(CaCO_3)}\right)$$

$$=\frac{0.8\times 0.1}{0.26}=0.3076$$

For oil swelling packer, the calculations are:

$$p(lactic\,acid|\,formate)=\left(\frac{p(\,formate|lactic\,acid)\,p(lactic\,acid)}{p(\,formate)}\right)$$

$$=\frac{0.8\times 0.5}{0.5}=0.8$$

$$p(HCl\,acid|\,formate)=\left(\frac{p(\,formate|HCl\,acid)\,p(HCl\,acid)}{p(\,formate)}\right)$$

$$=\frac{0.2\times 0.5}{0.5}=0.2$$

$$p(lactic\,acid|CaCO_3)=\left(\frac{p(CaCO_3|lactic\,acid)\,p(lactic\,acid)}{p(CaCO_3)}\right)$$

$$=\frac{0.8\times 0.5}{0.5}=0.8$$

$$p(HCl\,acid|CaCO_3)=\left(\frac{p(CaCO_3|HCl\,acid)\,p(HCl\,acid)}{p(CaCO_3)}\right)$$

$$=\frac{0.2\times 0.5}{0.5}=0.2$$

Table 7: Using Bayesian equation for the proposed model

Swelling packer	Water swelling		Oil swelling	
Treating Fluid	Updated values		Updated values	
Lactic acid	0.9729	0.6923	0.2	0.8
HCl acid	0.027	0.3076	0.8	0.2
Type of drilling fluid	Updated values		Updated values	
Formate drilling fluid	Selected by user		Selected by user	
$CaCO_3$ drilling fluid		Selected by user		Selected by user

Now, once the Bayesian calculations are completed, there are two approaches for the engineers to use this model. The first approach is to specify the type of drilling fluid he wants to use to drill the well and this will determine the suitable decision in this model which is the suitable swelling packer. For example if $CaCO_3$ is required to drill the well, then the probabilities of using the packers (consequences) are read from **Table 7** as shown below in **Table 8**.

Table 8: Consequences when selecting $CaCO_3$ drilling fluid (from table 7)

Swelling Packers	water swelling packers	oil swelling packers
Recommended	0.6923	0.8
Not recommended	0.3076	0.2

The utility is finally calculated using below equation from **Table 8** and **Table 5**:
For water swelling packer it is:

$$Expected\,utility=\sum_i consequence\,result\times input\,believe$$

$$=0.6923\times 1+0.3076\times 0=0.6923$$

For oil swelling packer it is:

$$Expected\,utility=\sum_i consequence\,result\times input\,believe$$

$$=0.8\times 1+0.2\times 0=0.8$$

Table 9: Expected utility values (first approach)

Swelling packer	water swelling	oil swelling
Expected utility	0.6923	0.8

The other option for the engineer to use this model is to specify all the uncertainties (drilling fluid and treating fluid) to determine the optimum selection of swelling packers. **Table 4** can be used directly. For example selecting formate drilling fluid and lactic acid indicate that oil swelling packer is recommended, **Table 10**.

Table 10: Consequences when selecting formate drilling fluid and lactic acid (from table 4)

Swelling Packers	water swelling packers	oil swelling packers
Recommended	0	1
Not recommended	1	0

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The utility is calculated as mentioned above, **Table 11**.

Table 11: Expected utility values (2nd approach)

Swelling packer	water swelling	oil swelling
Expected utility	0	1

For this study, GeNIe (Graphical Network Interface) was used for calculations of the uncertainty propagation to build up the expert system. **Fig.2** shows the results for the first approach example (selecting $CaCO_3$ drilling fluid) which agrees with the calculation above. **Fig.3** shows the results for the second approach example (selecting formate drilling fluid and lactic acid treating fluid) which also agrees with the calculation above.

Using Bayesian intelligence allows the design of expert systems that can be used in different fields and/or by different experts with different opinions. The system can be updated easily with the new opinions by changing the probability states shown above (**Tables 2-4)** and the model will update the calculation to show the recommended type of swelling packer.

2 Well Control Expert System

The calculation shown above was performed for a small model with limited options. To develop a model that can be used to assist in performing successful well control operations, a more comprehensive model is needed. Literature review and well control experts' opinions were used as evidence to build these models using the proposed Bayesian Network. Variable nodes allow the user to input desired conditions that allows for generating the corresponding best practices.

The model is divided into three parts or decisions. Each decision has uncertainties and consequences nodes. The consequences node combines the uncertainty nodes where well control expert opinions were used to assign and define the conditional probability distribution. The model then calculates the optimum practices decision.

Fig.4 shows the model which is divided into three parts of uncertainty and decision nodes. The first provides the proposed circulation method decision based on the kick details provided. The second part provides the user about the optimum recommended practice based on the possible scenarios and operations in well control. The third part provides the user with a quick check list for trouble shooting in case of problems while controlling the well.

Kick indicators' uncertainities are shown in **Fig.5.** The kick can be verified by checking the flow when pumps are off, **Fig. 6.**

The kick details' uncertainity (**Fig.7**) affects the user selection of proposed circulation methods shown in **Fig.8**.

Experts' opinions were used to build up the node known as consequences for optimum method of circulation method, **Fig.9** by assigning 1 to the optimum circulation method. This node can be updated easily when different opinions are presented.

The second part is related to proper well control practices under different scenarios such as driller method, killing deep wells, etc as shown in **Fig.10**. A long list of possible operations (probabilities) was assigned to the possible operation node as shown partially in **Fig.11**.

The recommended practice probabilities for proper well control are shown in **Fig.12**. Experts' opinions were used to assign probability values in the consequence of proper well control practices. Part of the assigned values is shown in **Fig.13**. Again these probabilities can be updated easily by different experts or at different field conditions.

The third part is designed to assist the user to find the optimum solution for a list of potential problems that can be faced during well control operations. A check list of trouble shooting is shown in **Fig.14**. The model also recommends a list of actions and observes their results by using the action and results node. This node is affected by the user selection from the check list for trouble shooting node. Part of actions and results are shown in **Fig.15**.

Based on the user selection of action taken and result node the problem can be identified. A list of problem probabilities is shown in **Fig.16**. Finally, once the problem is identified, an optimum solution from the solution decision can be recommended. Part of solutions is shown in **Fig.17**. Experts' opinions are used to assigne probabilities values to the conequencs of trouble shooting node. Part of thses values are shown in **Fig.18**.

The user can select which part he needs individually or can use all parts together at the same time by selecting probability values from desired uncertainity nodes. The final sequence will select the optimum practice from each consequence (optimum method of circulation method consequence, trouble shooting guide consequence and consequence of proper well control practice), part of the final consequence is shown in **Fig.19**.

The user can select the kick indication observed by assigning a probability of one to any of the available probabilities. For example the user selects increase in flow and pit gain, **Fig.20**. Once the kick has been verified (**Fig.21**) the user needs to select his kick details. The kick is from a horizontal or deviated well, **Fig.22**. Then the optimum circulation method is the driller method as shown in **Fig. 23**.

The user wants to use driller method to probability control the well, **Fig.24**.

The user enters his conditions probability from the possible operation node (**Fig.25**) and the recommended practice of increasing pump rate is calculated by the model, **Fig. 26**.

The user selects that drill pipe pressure is up and casing pressure is up about the same amount as the drill pipe pressure, **Fig.27**. Possible probabilities due to the selection from the check list for trouble shooting node are shown in **Fig.28**.

Selection of one of the five probabilities shown in **Fig.28** is shown in **Fig.29** to identify the problem while controlling the well (the choke manifold has started to plug up), **Fig.30**. The optimum solution is calculated by the model to switch to alternate choke line and clear the manifold, **Fig.31**. Again, expert opinions are used here in the trouble shooting guide consequenc which can be updated easily in case of different opionions or field cases.

If no pre-recorded data is available probability is selected

(**Fig.32**) and a possible operation is selected (**Fig.33**) then the optimum well control practice is calculated as shown in **Fig. 34**.

Additional examples of proper well control part are shown below. **Figs 35-37** is related to pumps troubles during a kick. **Figs. 38-40** are related to having a kick in deep water.

3 Discussion

The above example showed how using the model in selecting the optimum practices for well control practise. The states of probabilities in the above tables were obtained by experts' opinions. In case new practices or different experts' opinions are presented then all we need to do is simply change the states of probabilities. In case that the above model is missing other factors then we can also update the model and its corresponding states of probabilities. The flexibility of Bayesian network in terms of updating the structure model and its beliefs makes this method the first systematic approach to build experts systems.

In **Fig.22-23** the Driller's method is well suited for horizontal well control, as immediate circulation is important. Using the Driller's method can help in avaoiding complicated pressure schedule calculations associated with the Wait and Weight method. Driller's method is simple and is considered to be a good circulation method in horizontal well control situations.

In **Fig.32-34**, increasing pump rate is recommended to avoid another bubble from entering the bore hole on bottom. In **Fig.35-37**, stopping the pump and closing in the well is the recommended practice because the well can not be killed if the pump rate is not constant. The increase in pump rate and decrease in pipe pressure might indicate a hole in the drill pipe or a bad pump. The unstability movment of the Kelly hose might indicate that the problem is at the pump.

The third part in the above model is designed to assist the user to find the optimum solution for a list of potential problems that can be faced during well control operations. In general there are rules that can serve as good guides, Rehm et al. (1975):

- Unstable movment of Kelly hose or surging pump pressure gauge are a sign of pump problems.
- If the pipe pressure only goes up then the bit or nozzle is plugged.
- If the drill pipe and casing pressure increase suddenly then the choke or manifold is plugged.
- If the drill pipe pressure is decreased then there might be a hole in the pipe.
- If the drill pipe pressure and casing pressure does not respond to the choke, you might have a lost circulation problem.

4 Conclusions

The Bayesian approach was found suitable for designing expert system based on the factors mentioned above. The model can work as a guide to aid drilling engineers and scientists to design and execute optimum well control practises. Using this approach to build up expert systems is more flexible than using flow charts. Updating flow charts is time consuming and might require redesigning them again to be used by different experts or in different fields. Using Bayesian network allows us to update our industry practices by updating the probabilities states mentioned in this paper.

5 References

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Abbreviations

BHST	:	Bottom hole static temperature
BWOC	:	By weight of cement
Gps	:	Gallons per sack
Hp	:	Horse power
Ibpg	:	bounds per gallon
PPA	:	Pound of proppant added per gallon of clean fluid
ROP	:	Rate of penetration
TD	:	Total depth
UCA	:	Ultrasonic cement analyzer
YP	:	Yield point

SI Metric Conversion Factors

in. × 2.54* E–02	=	m
(°F-32) / 1.8* E+00	=	°C
ft × 3.048* E–01	=	m
gal× 3.785 412E–03	=	m^3
lbm × 4.535 924E–01	=	kg
psi × 6.894 757E-03	=	Mpa
lbm/gal× 1.198 26E-01	=	S.G
bbl × 1.58987 E-01	=	m^3

*Conversion factor is exact

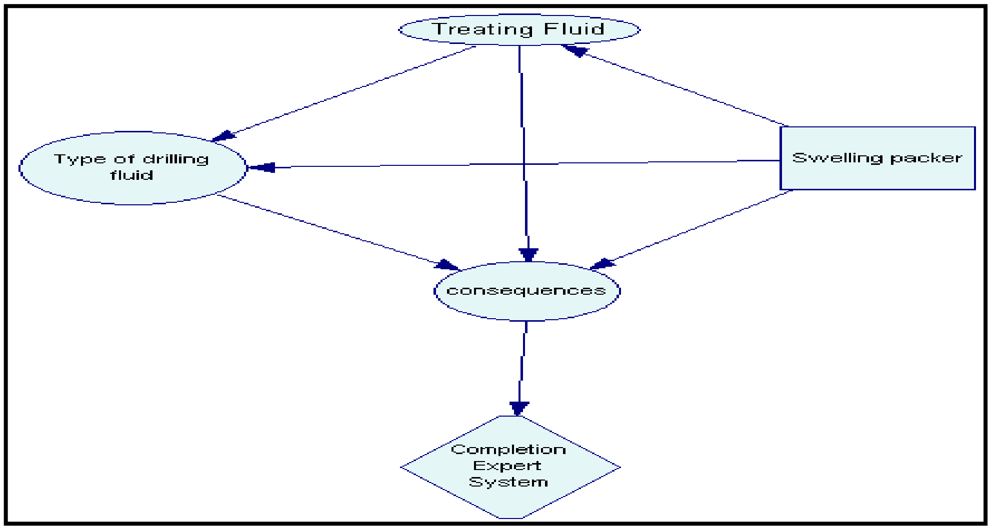

Fig.1: BDN model for the proof of the concept

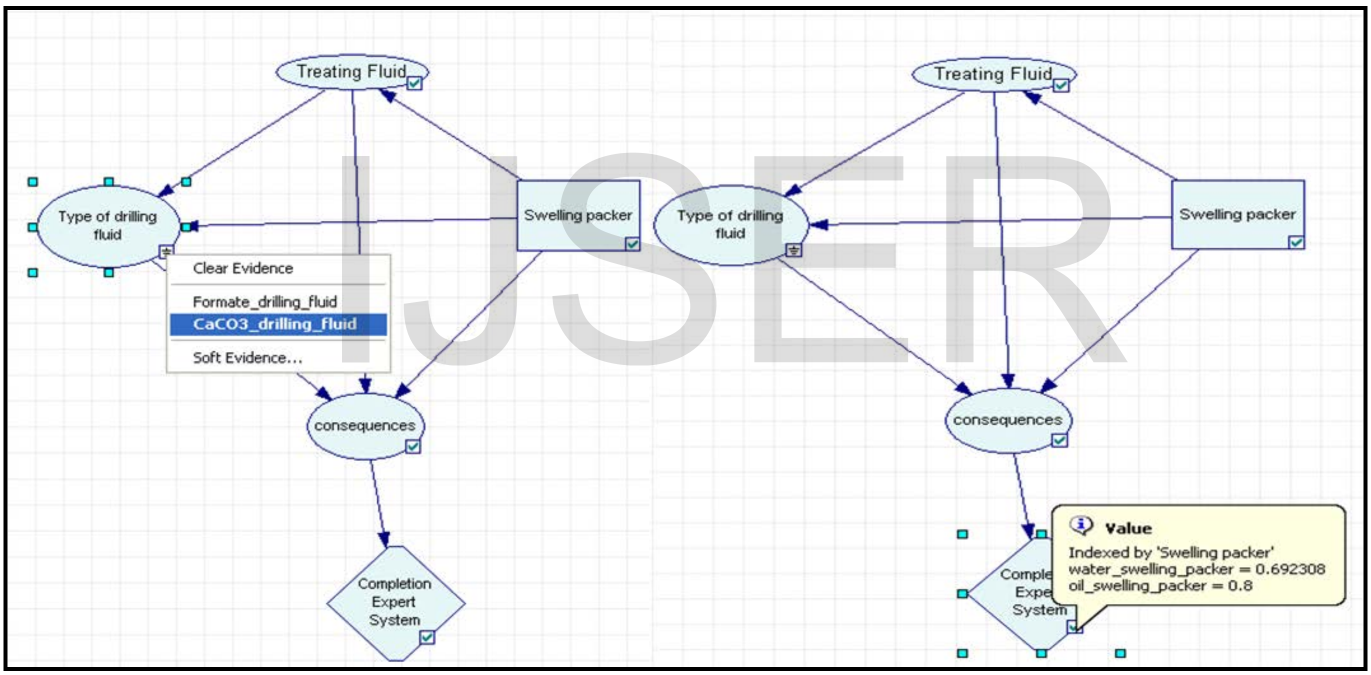

Fig.2: Model for the proof of concept (first approach)

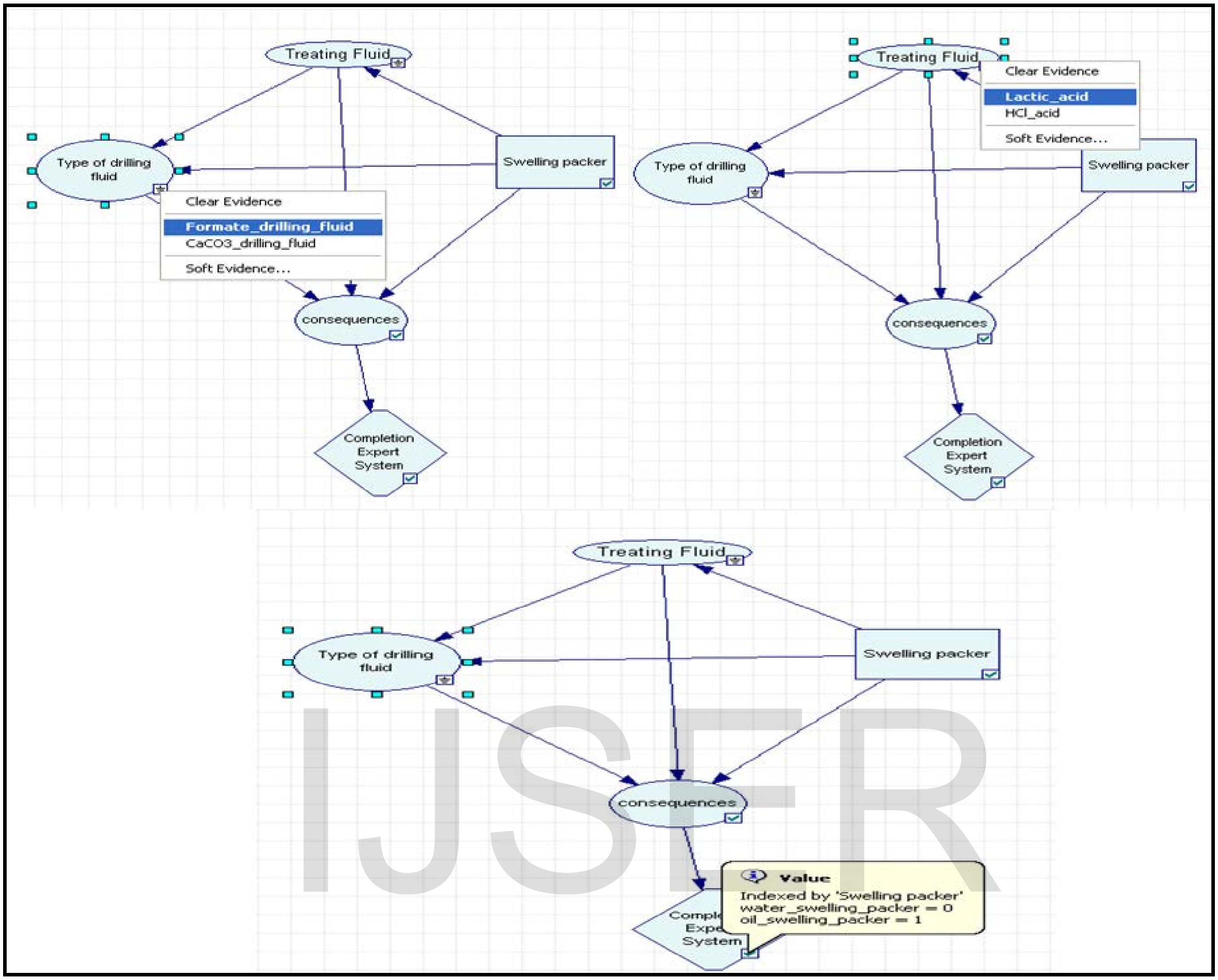

Fig.3: Model for the proof of concept (second approach)

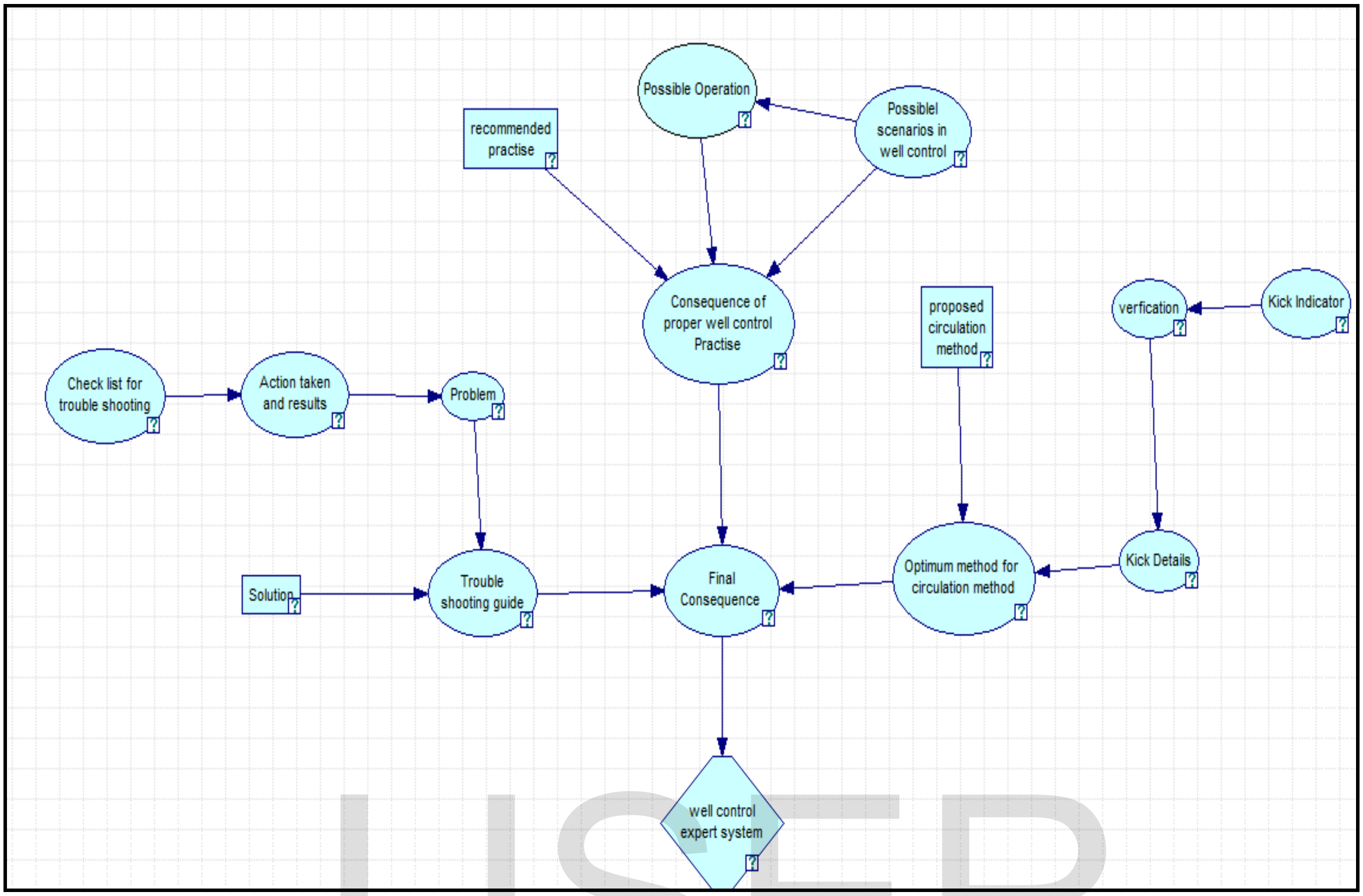

Fig.4: Well control expert model

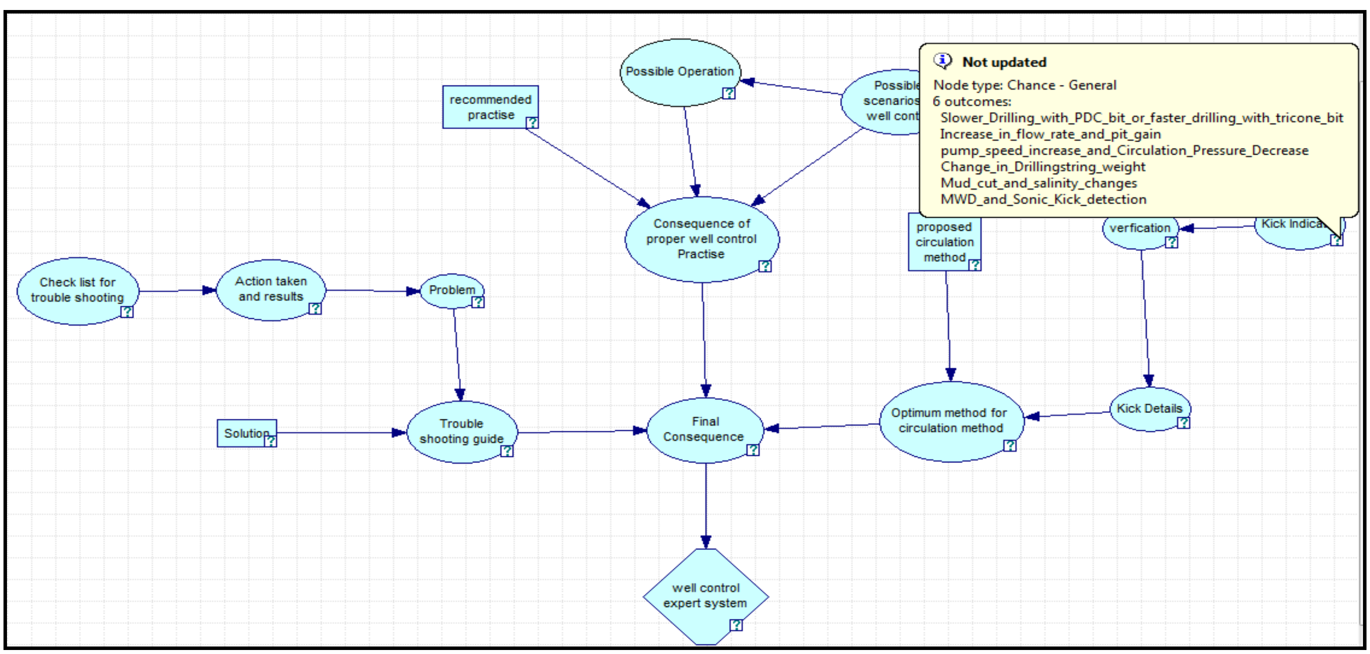

Fig.5: Kick indicators

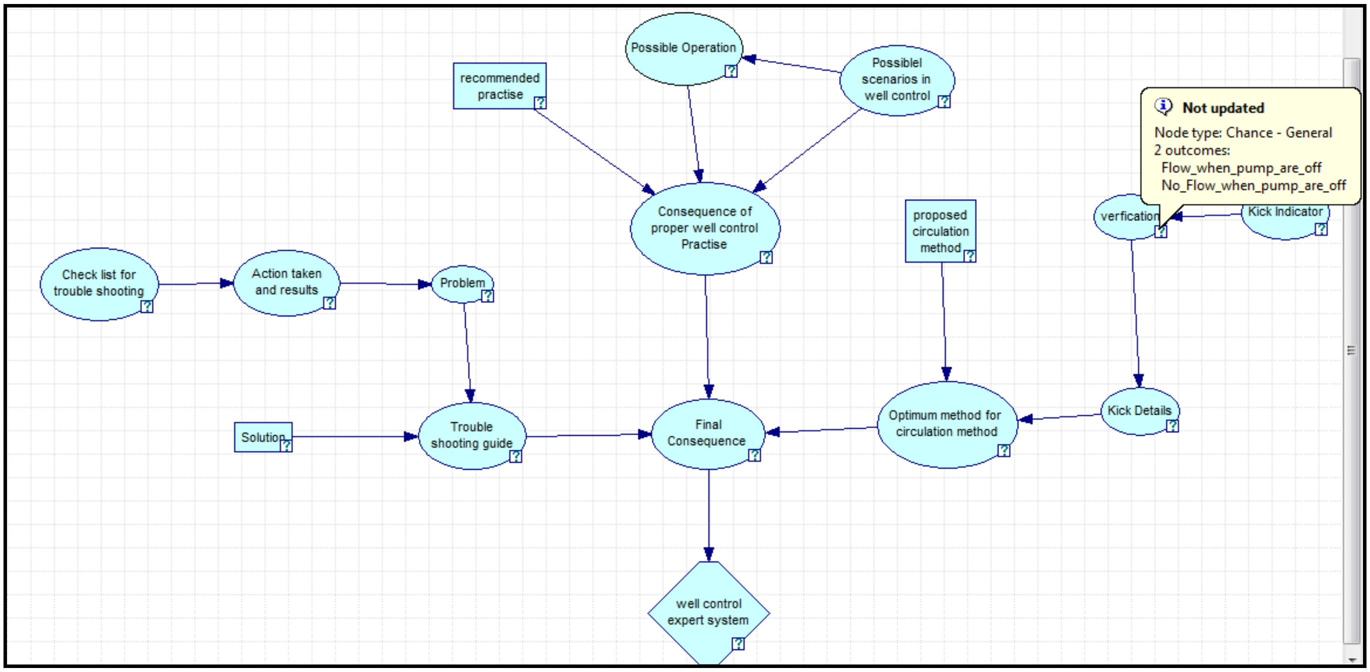

Fig.6: Verification

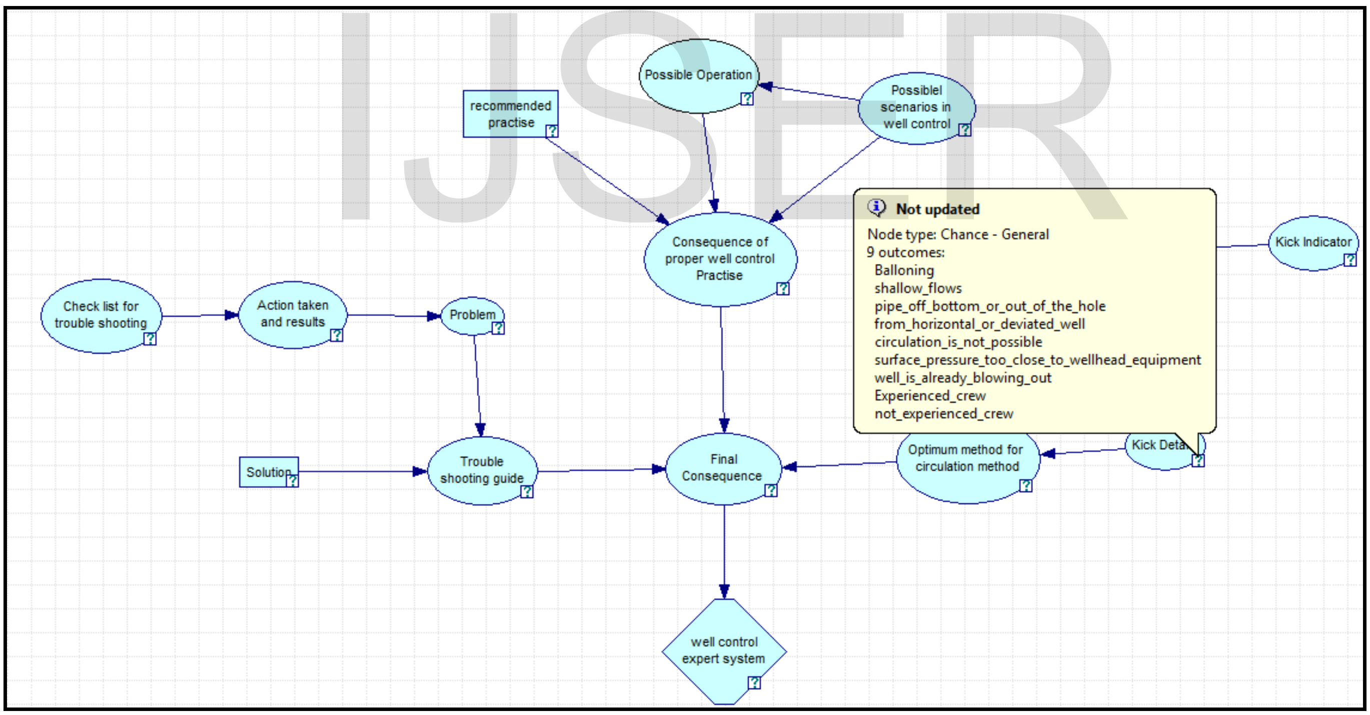

Fig.7: Possible kick details

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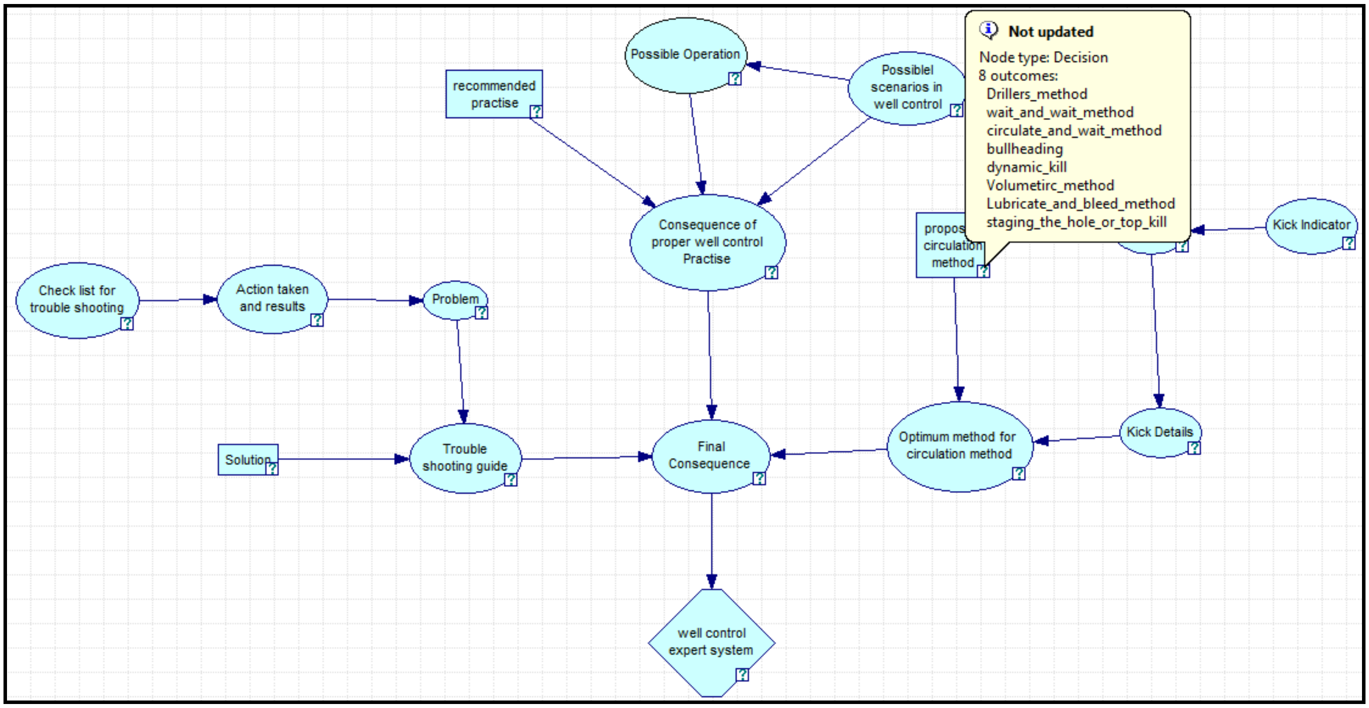

Fig.8: Proposed circulation method

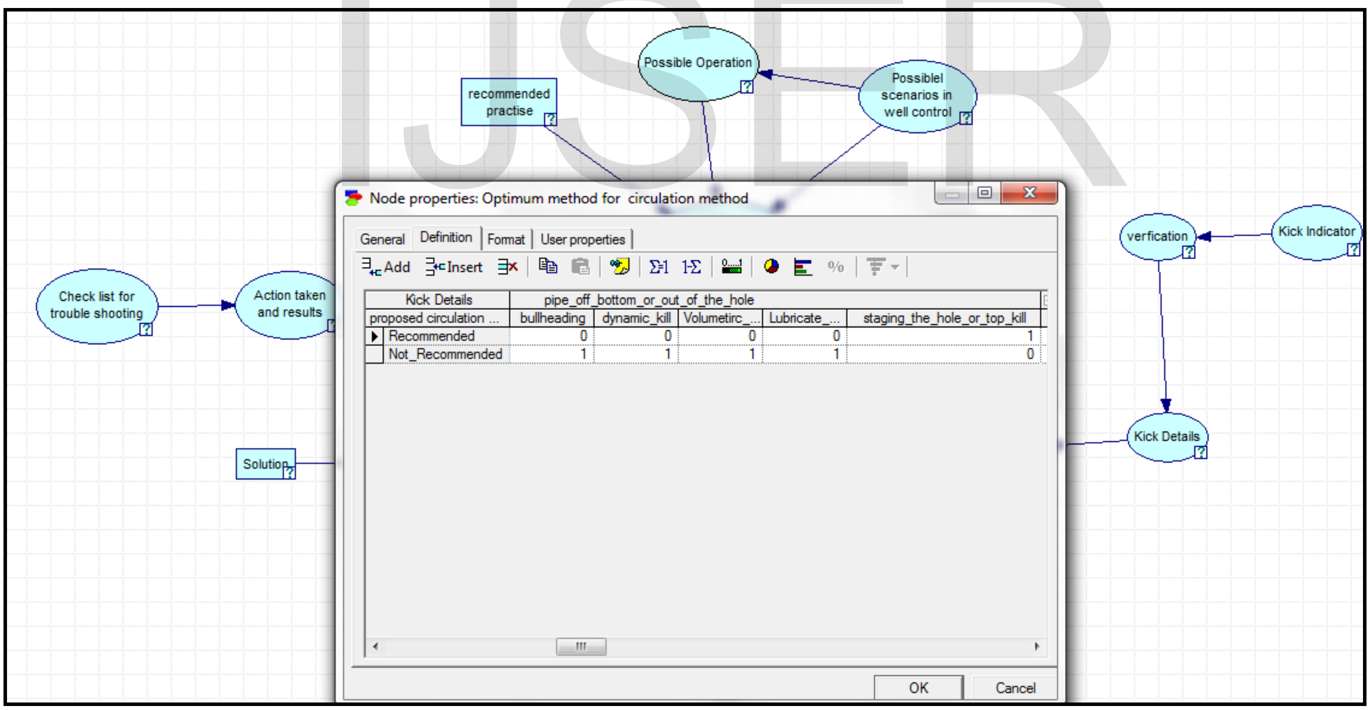

Fig.9: Part of consequences for optimum method of circulation method

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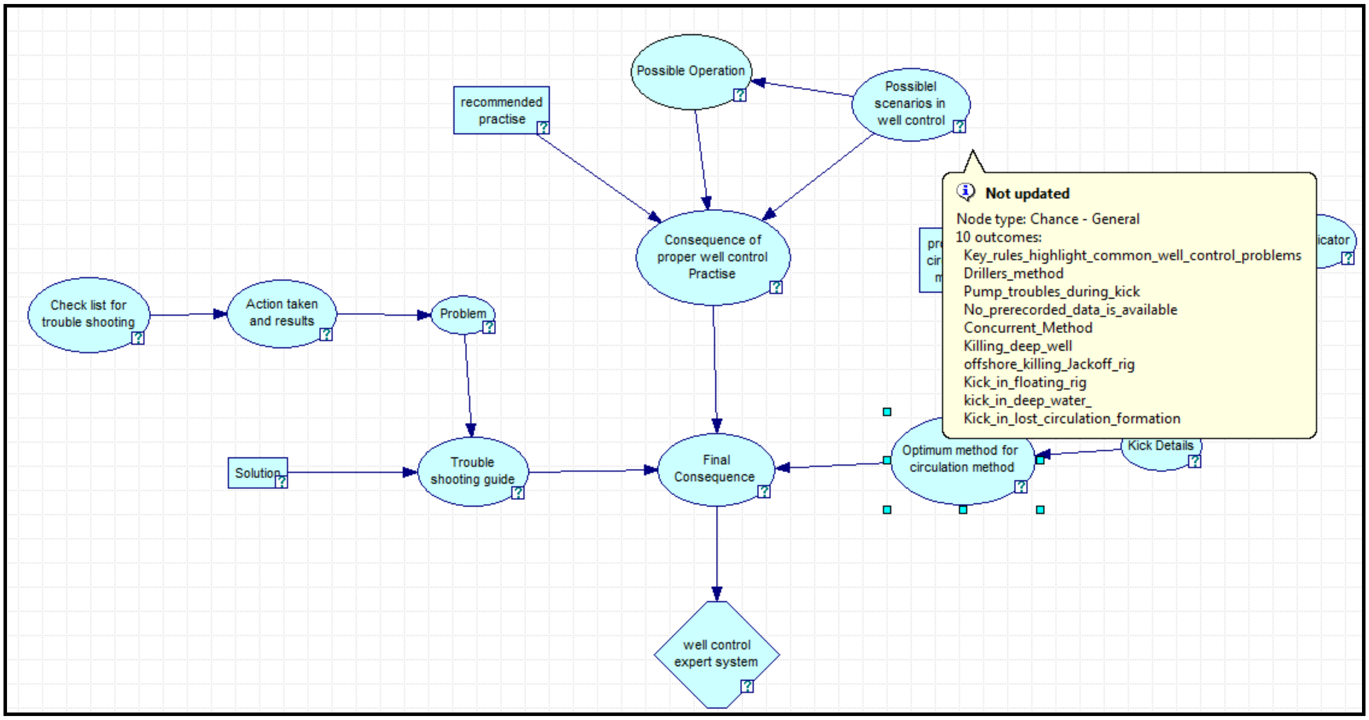

Fig.10: Possibel scenarios in well control

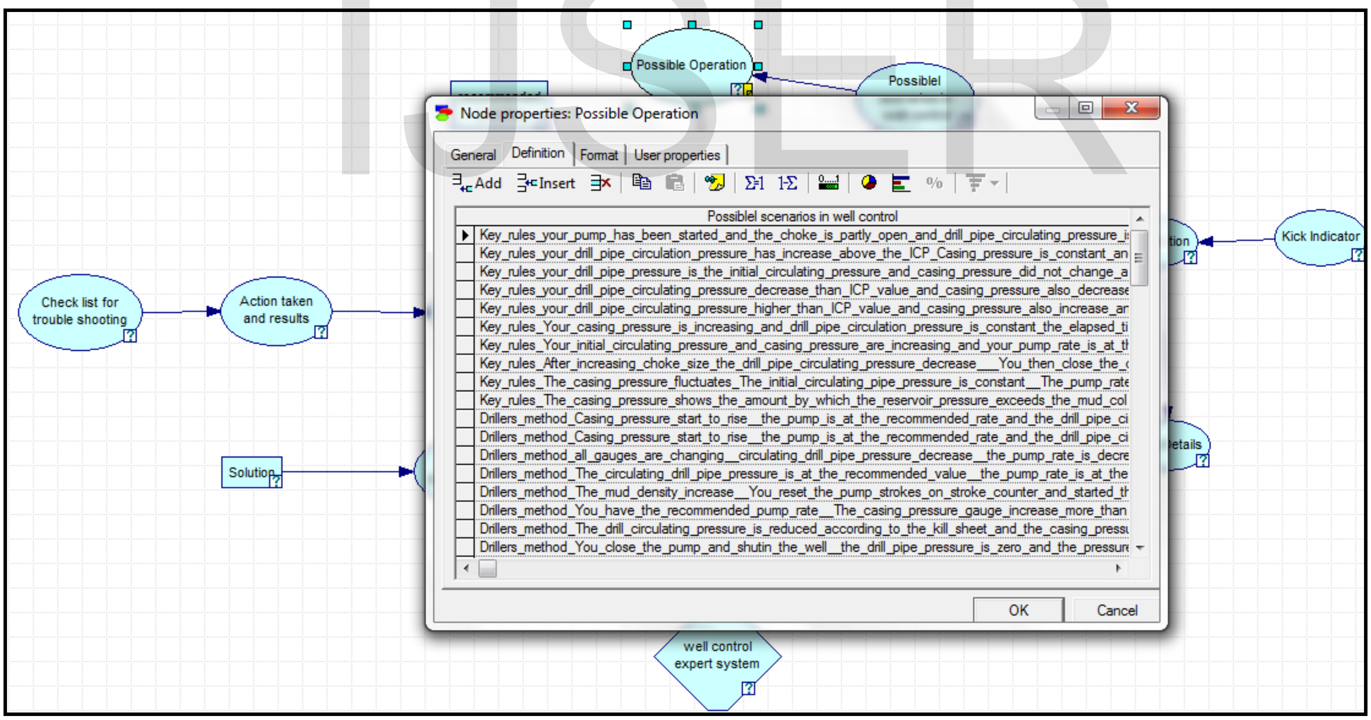

Fig.11: Part of possibel operations

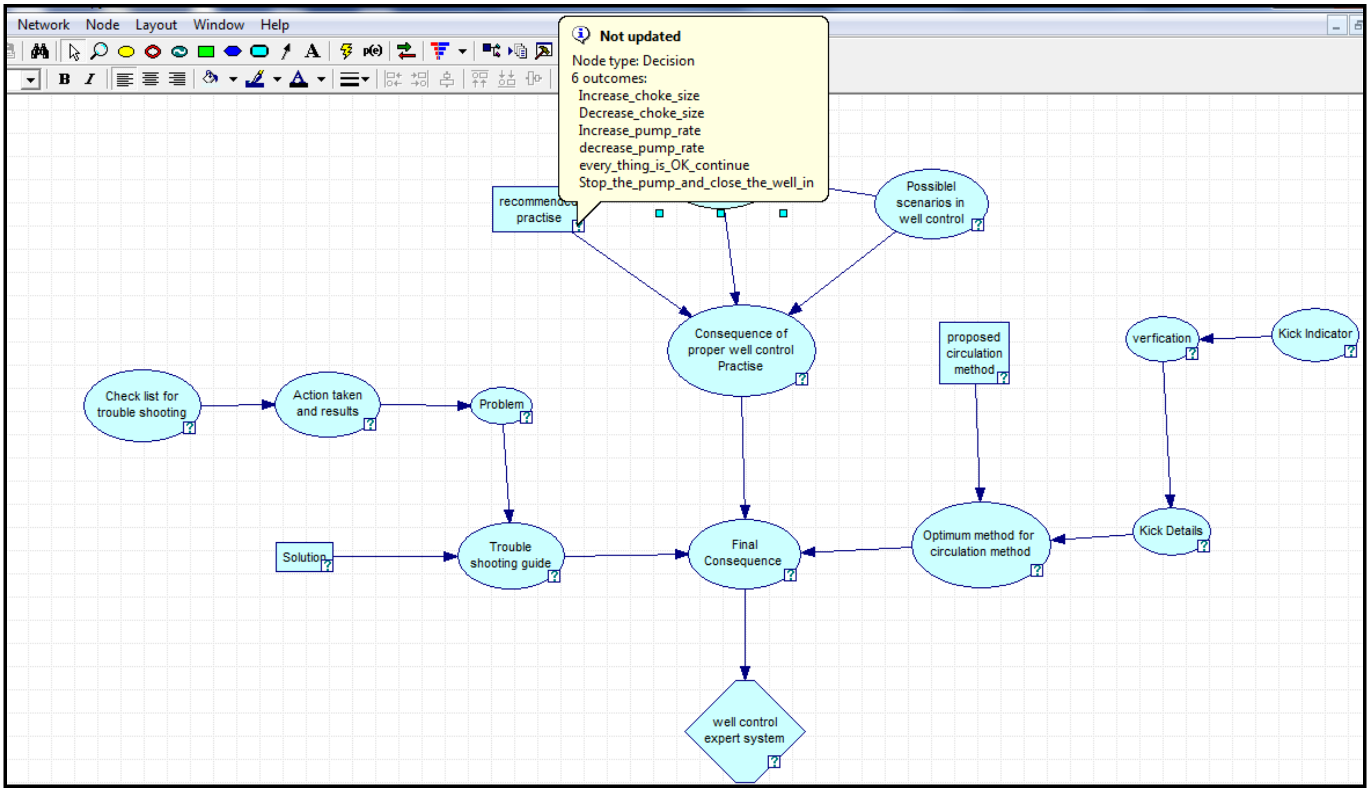

Fig.12: A list of recommended practices

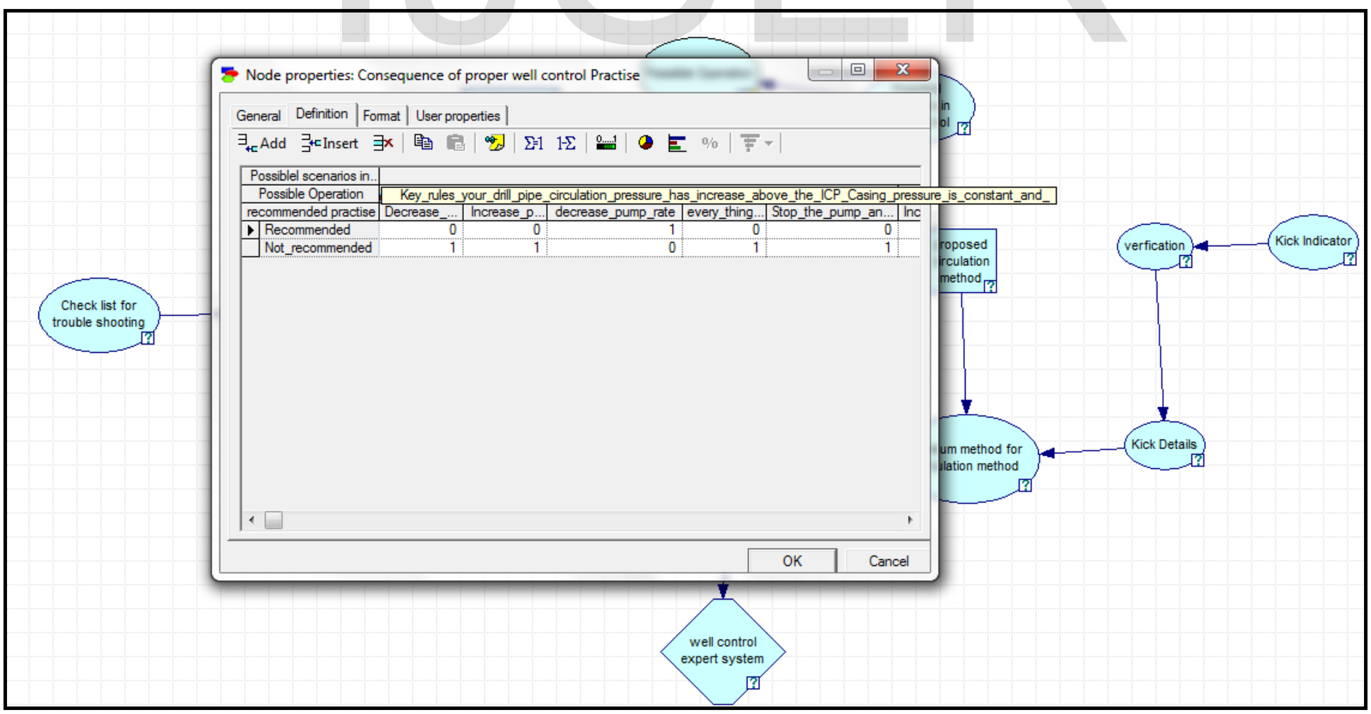

Fig.13: Part of consequences of proper well control practices

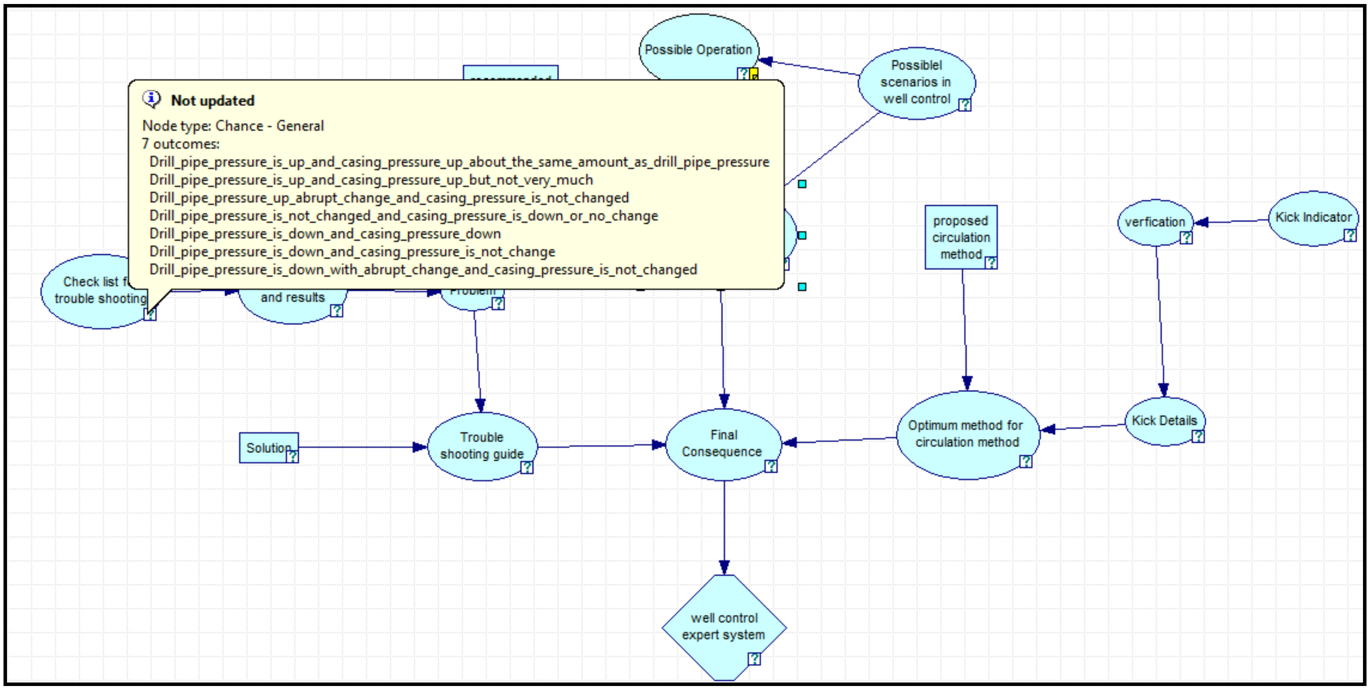

Fig.14: Check list for possible trouble shooting

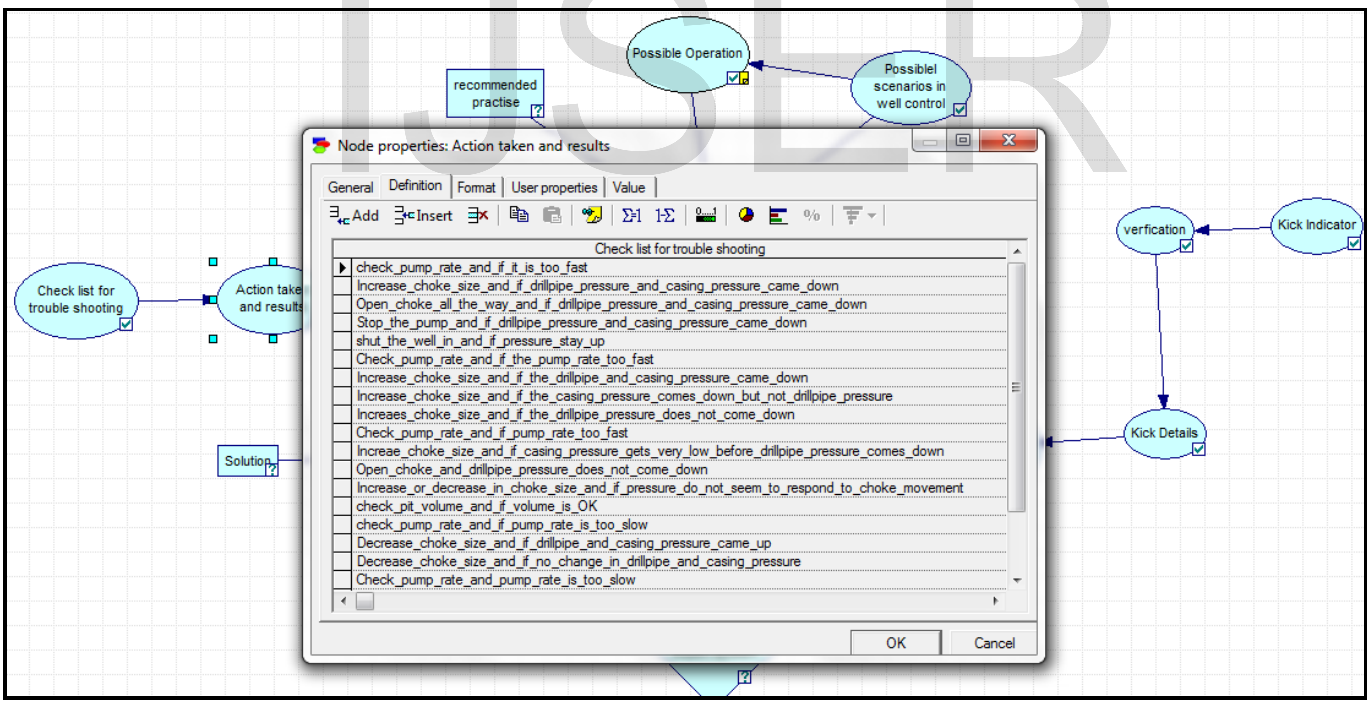

Fig.15: A list of possible actions and results

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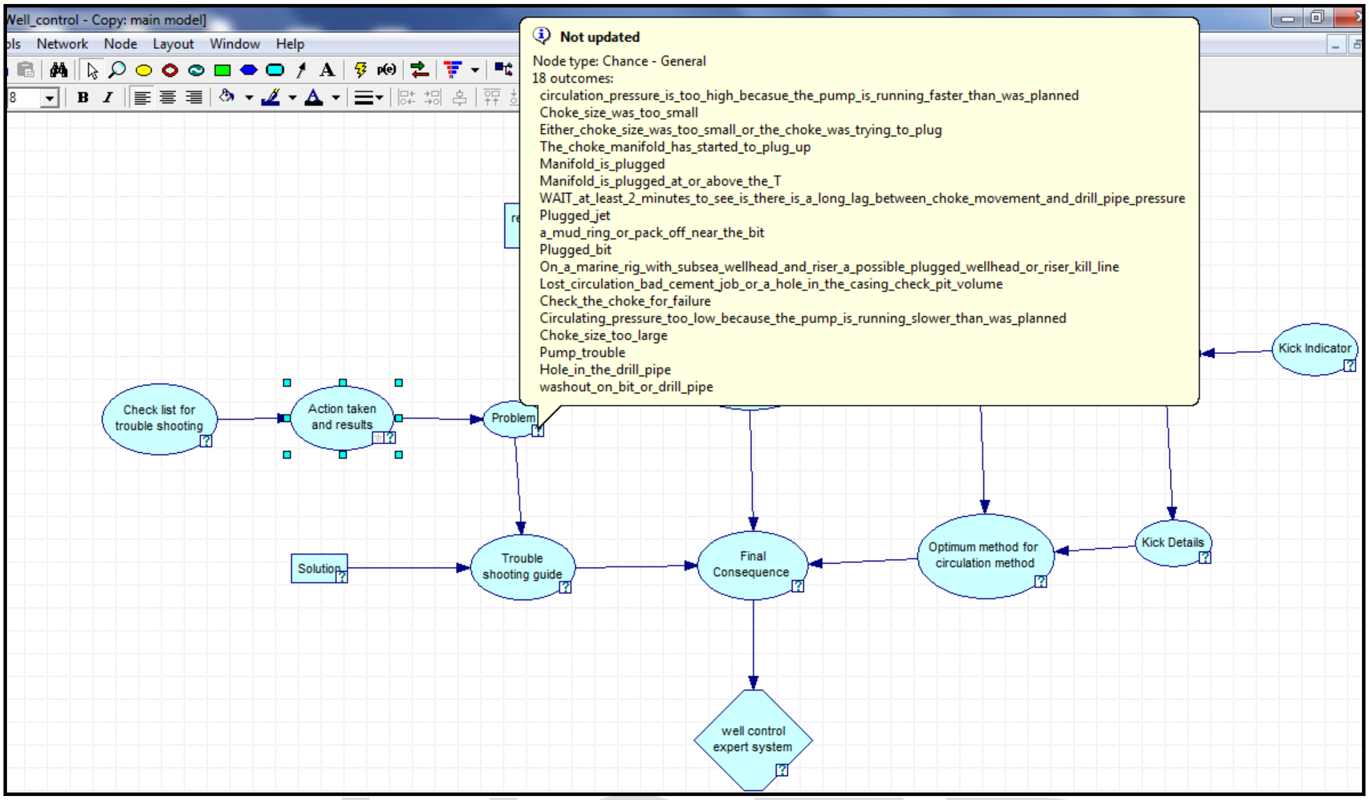

Fig.16: A list of possible problems

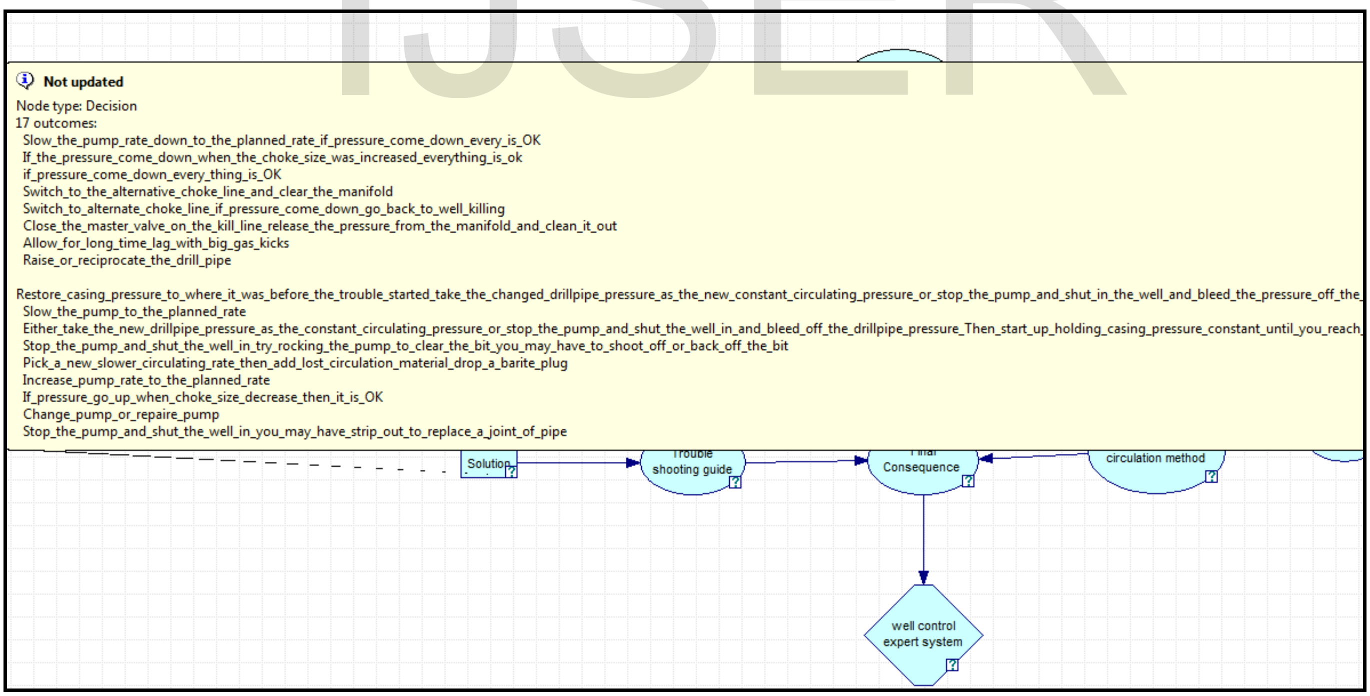

Fig.17: Part of possible solutions

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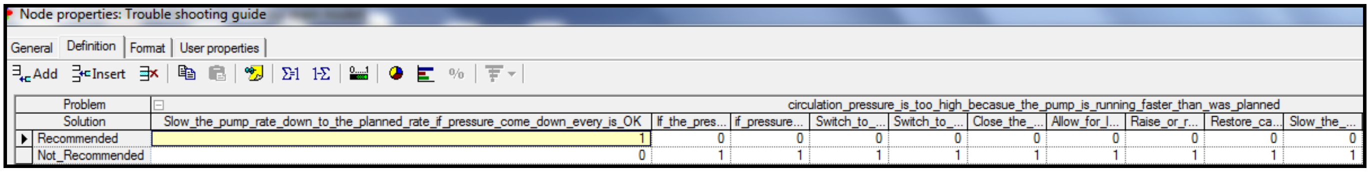
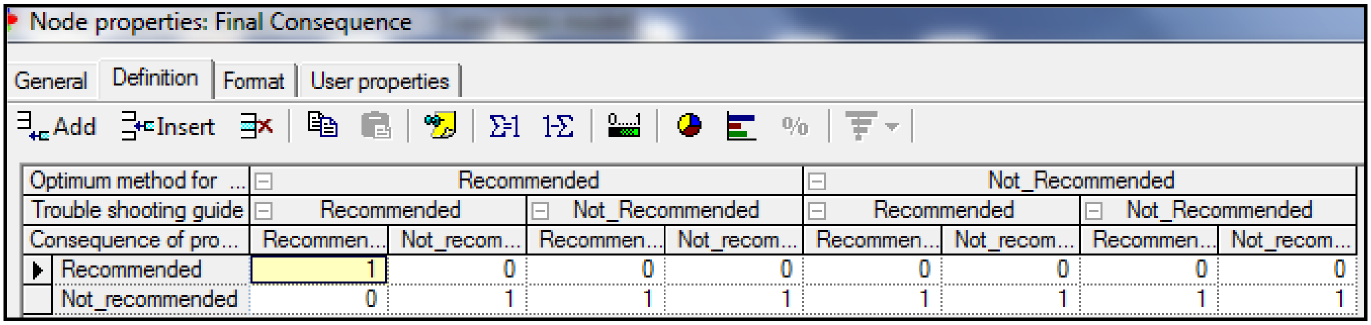


Node properties: Trouble shooting guide

General | Definition | Format | User properties

Problem	circulation_pressure_is_too_high_becasue_the_pump_is_running_faster_than_was_planned									
Solution	Slow_the_pump_rate_down_to_the_planned_rate_if_pressure_come_down_every_is_OK	If_the_pres...	if_pressure...	Switch_to_...	Switch_to_...	Close_the_...	Allow_for_l...	Raise_or_r...	Restore_ca...	Slow_the_...
Recommended	1	0	0	0	0	0	0	0	0	0
Not_Recommended	0	1	1	1	1	1	1	1	1	1

Fig.18: Part of conequencs of trouble shooting



Node properties: Final Consequence

General | Definition | Format | User properties

Optimum method for ...	Recommended				Not_Recommended			
Trouble shooting guide	Recommended		Not_Recommended		Recommended		Not_Recommended	
Consequence of pro...	Recommen...	Not_recom...	Recommen...	Not_recom...	Recommen...	Not_recom...	Recommen...	Not_recom...
Recommended	1	0	0	0	0	0	0	0
Not_recommended	0	1	1	1	1	1	1	1

Fig.19: Final consequences

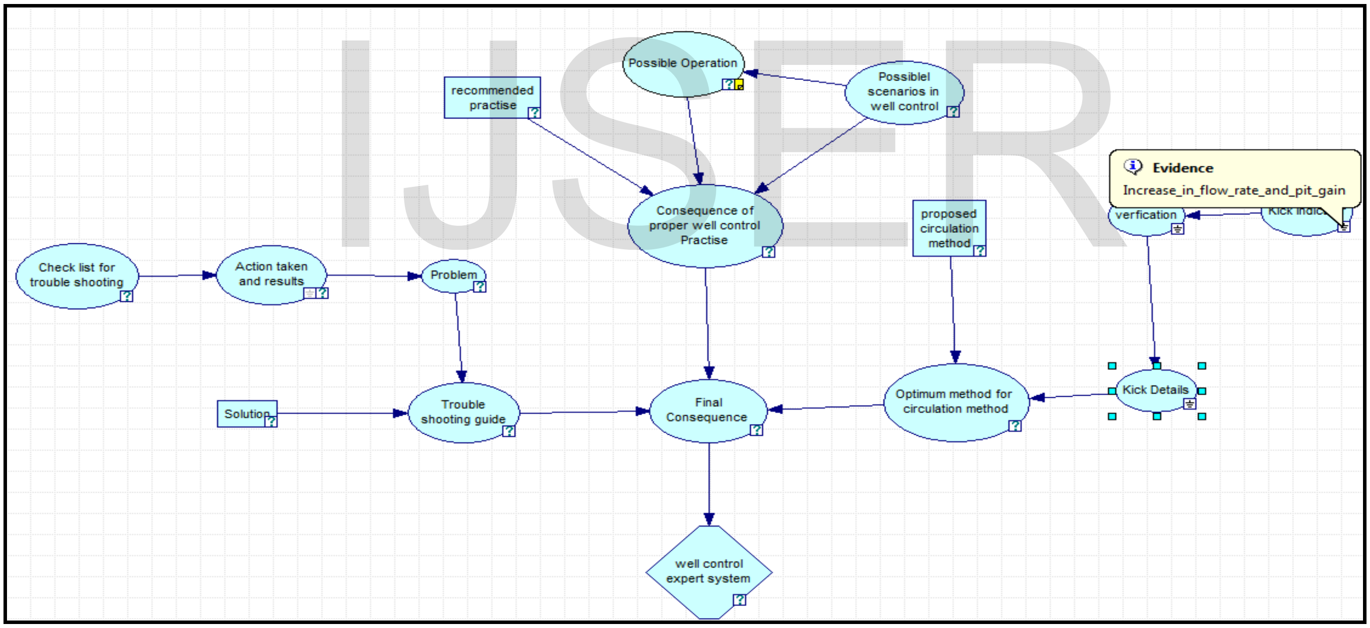


Fig.20: kick indicator example

ISSN 2229-5518

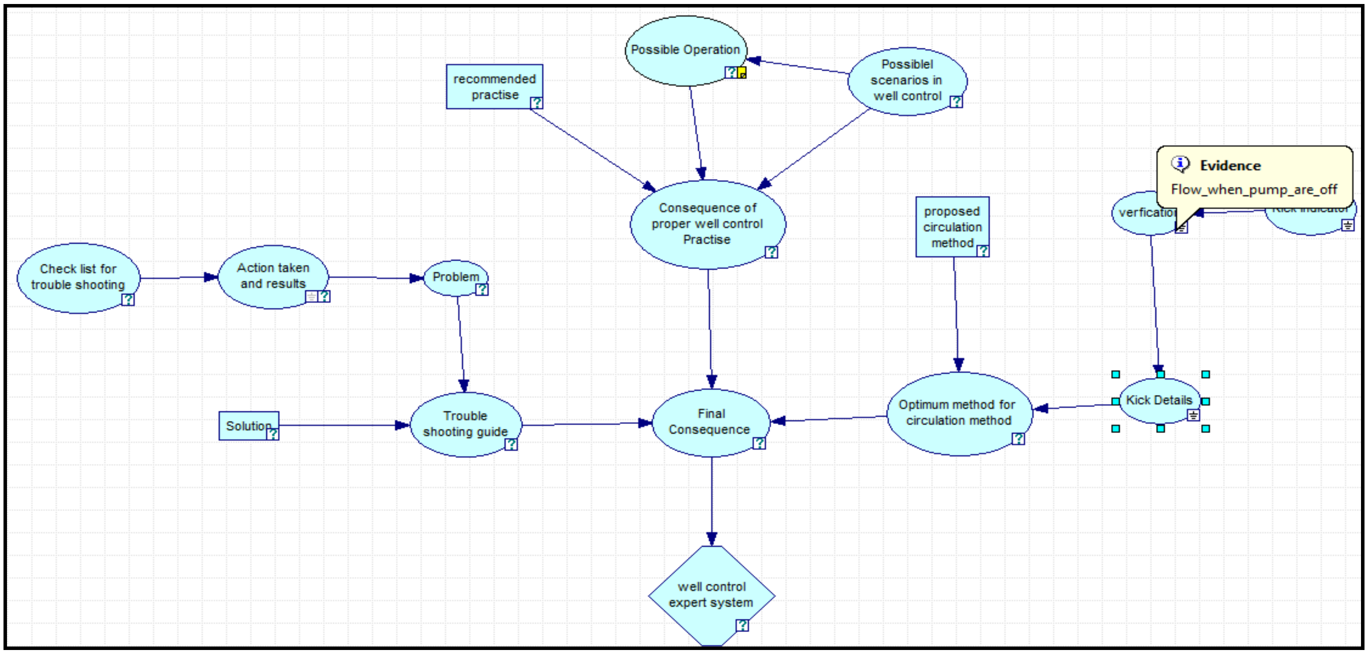


Fig.21: Verification of the kick

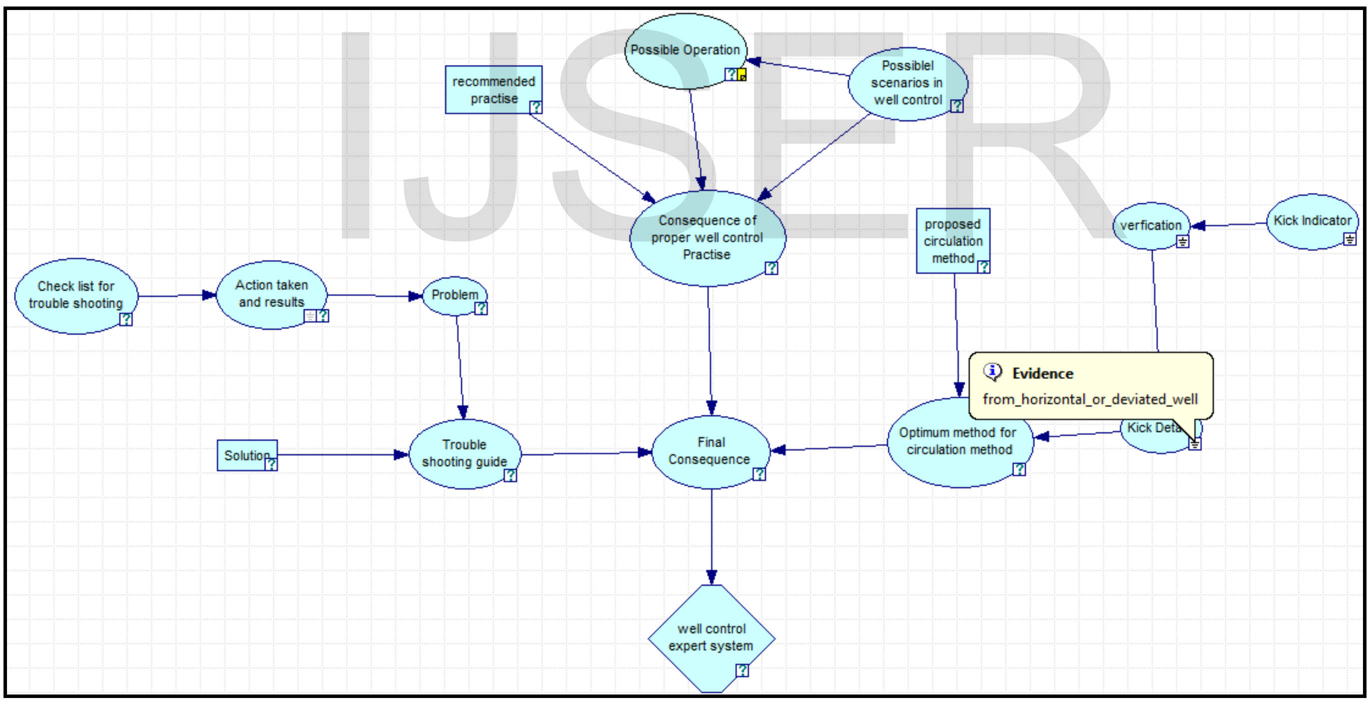
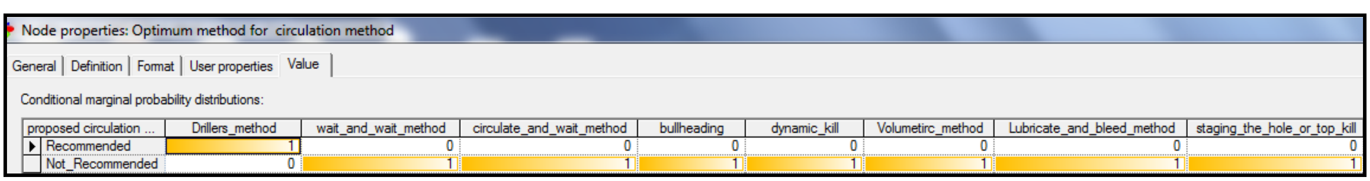


Fig.22: The kick is from a horizontal or deviated well


Node properties: Optimum method for circulation method

General | Definition | Format | User properties | Value

Conditional marginal probability distributions:

proposed circulation ...	Drillers_method	wait_and_wait_method	circulate_and_wait_method	bullheading	dynamic_kill	Volumetric_method	Lubricate_and_bleed_method	staging_the_hole_or_top_kill
Recommended	1	0	0	0	0	0	0	0
Not_Recommended	0	1	1	1	1	1	1	1

Fig.23: The recommended circulation method of this example is driller method

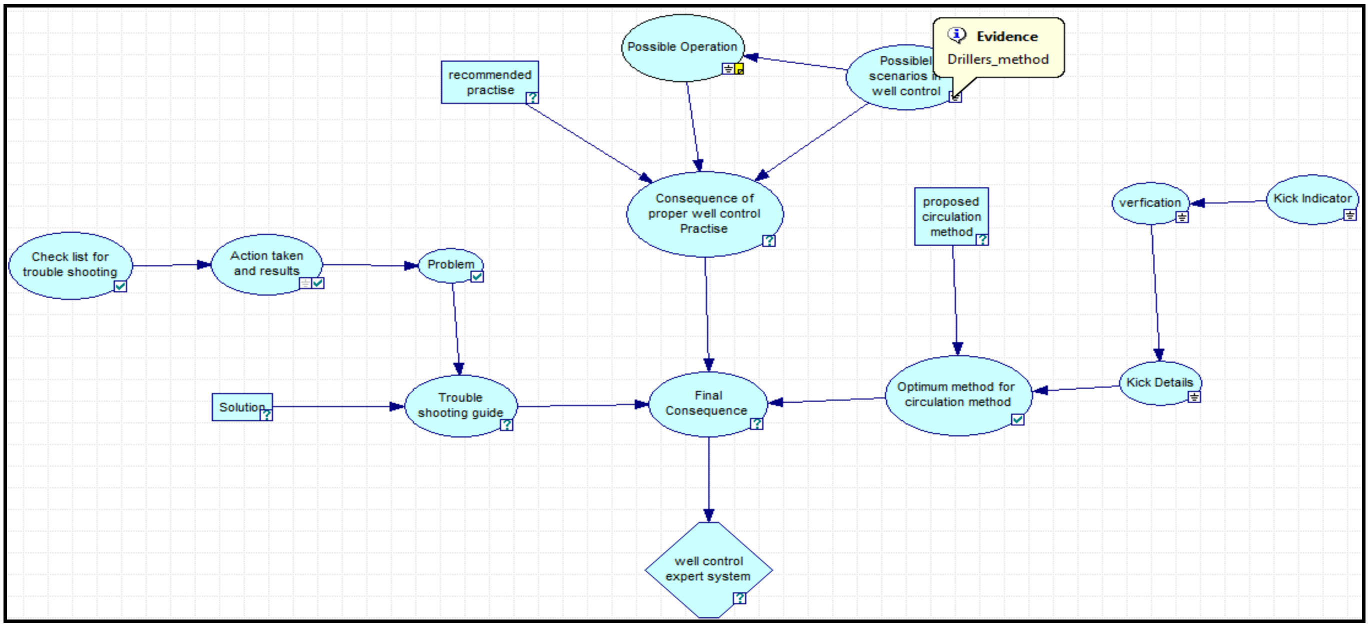


Fig.24: The user is controlling the well using driller method

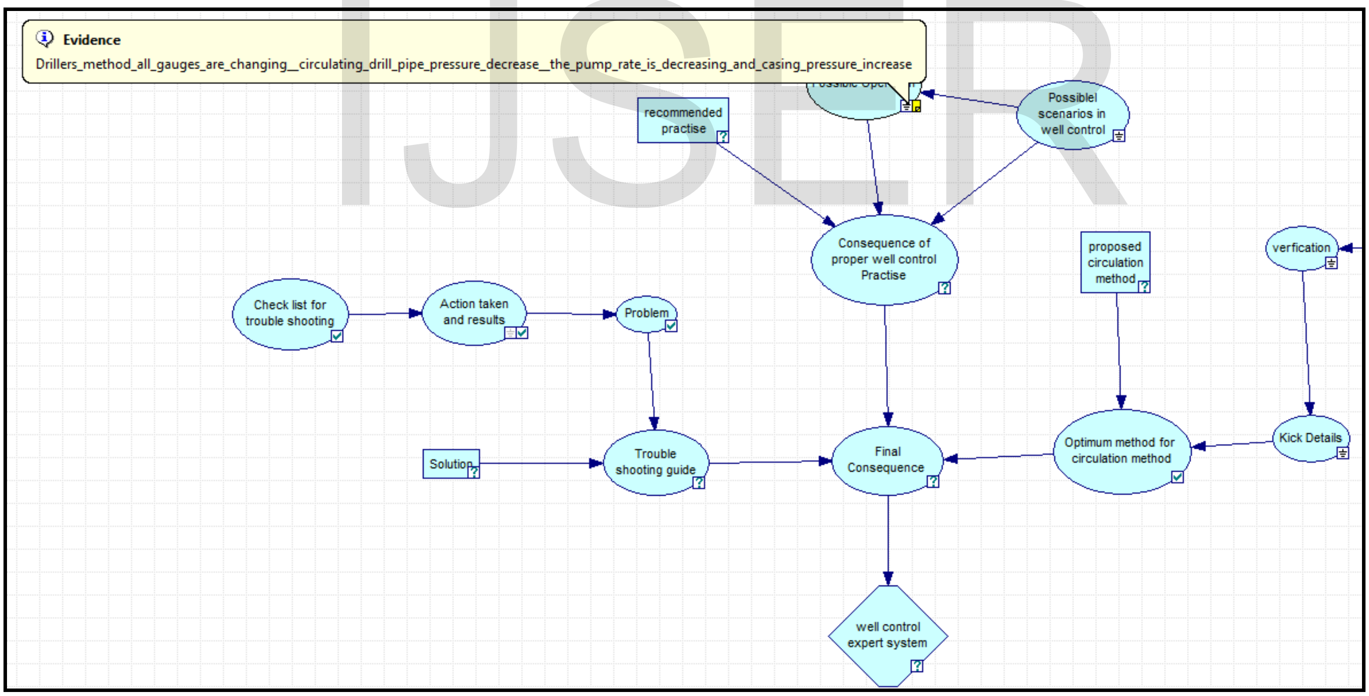


Fig.25: The user is entering his pipe, casing and pump operational conditions

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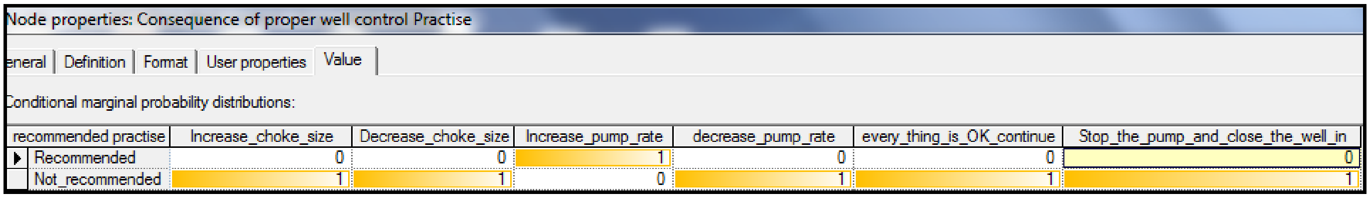
Node properties: Consequence of proper well control Practise

eneral | Definition | Format | User properties | Value

Conditional marginal probability distributions:

recommended practise	Increase_choke_size	Decrease_choke_size	Increase_pump_rate	decrease_pump_rate	every_thing_is_OK_continue	Stop_the_pump_and_close_the_well_in
Recommended	0	0	1	0	0	0
Not_recommended	1	1	0	1	1	1

Fig.26: The optimum practice of proper well control is shown

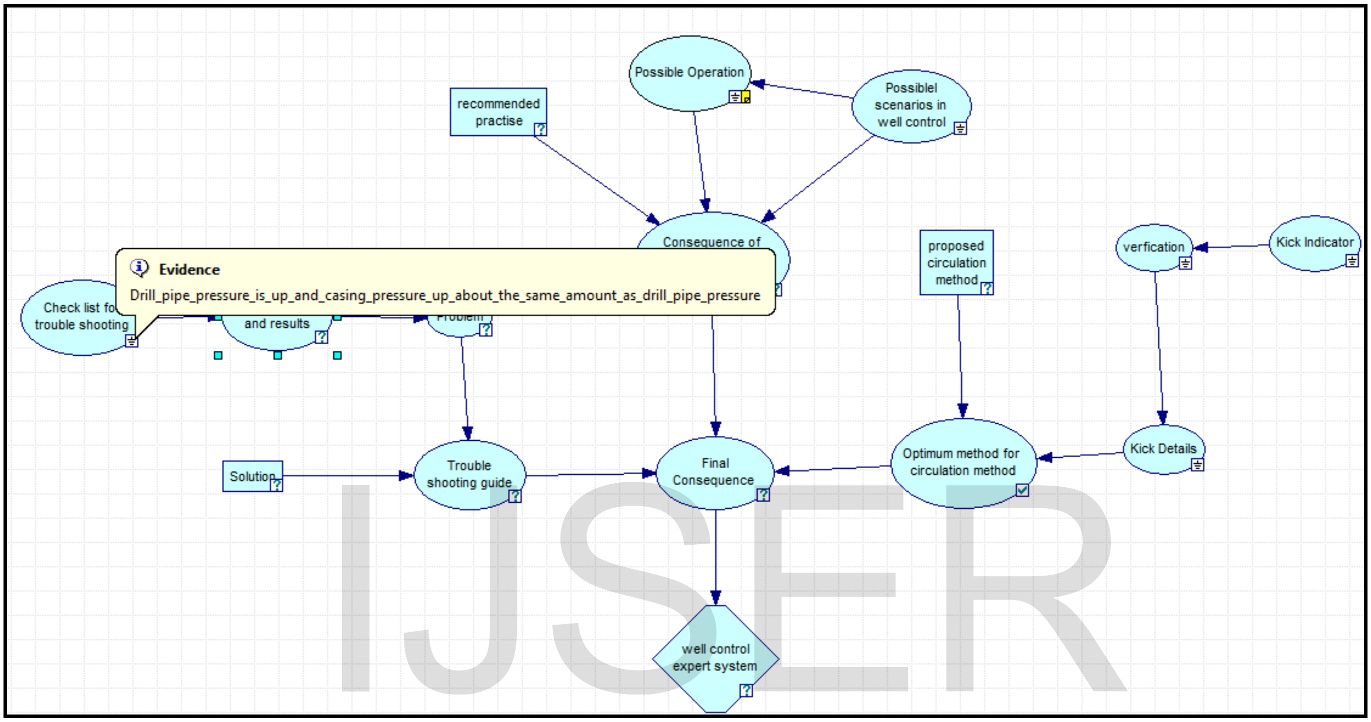

Fig.27: The user shows his problem by selecting drill pipe and casing pressure response

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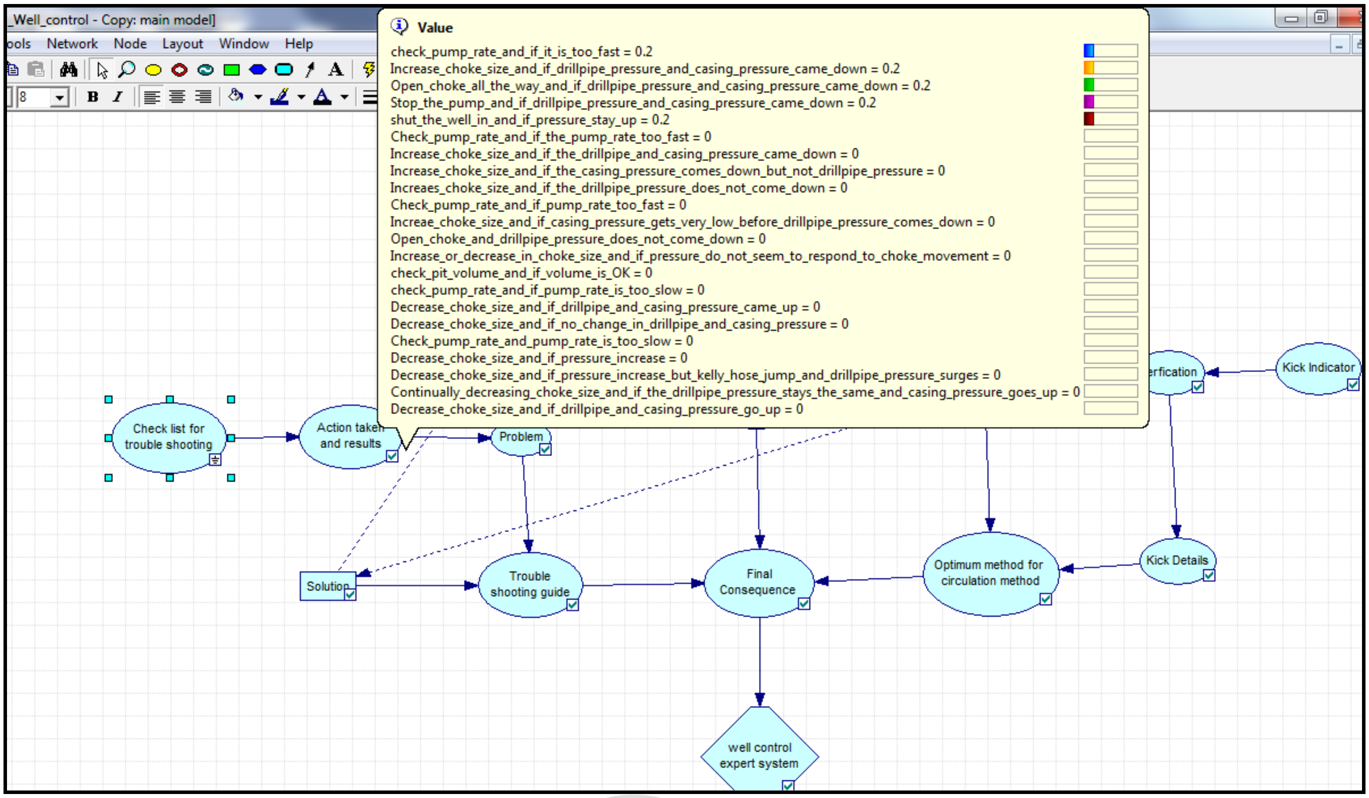


Fig.28: Possible probabilities due to the selection from the check list for trouble shooting node are shown

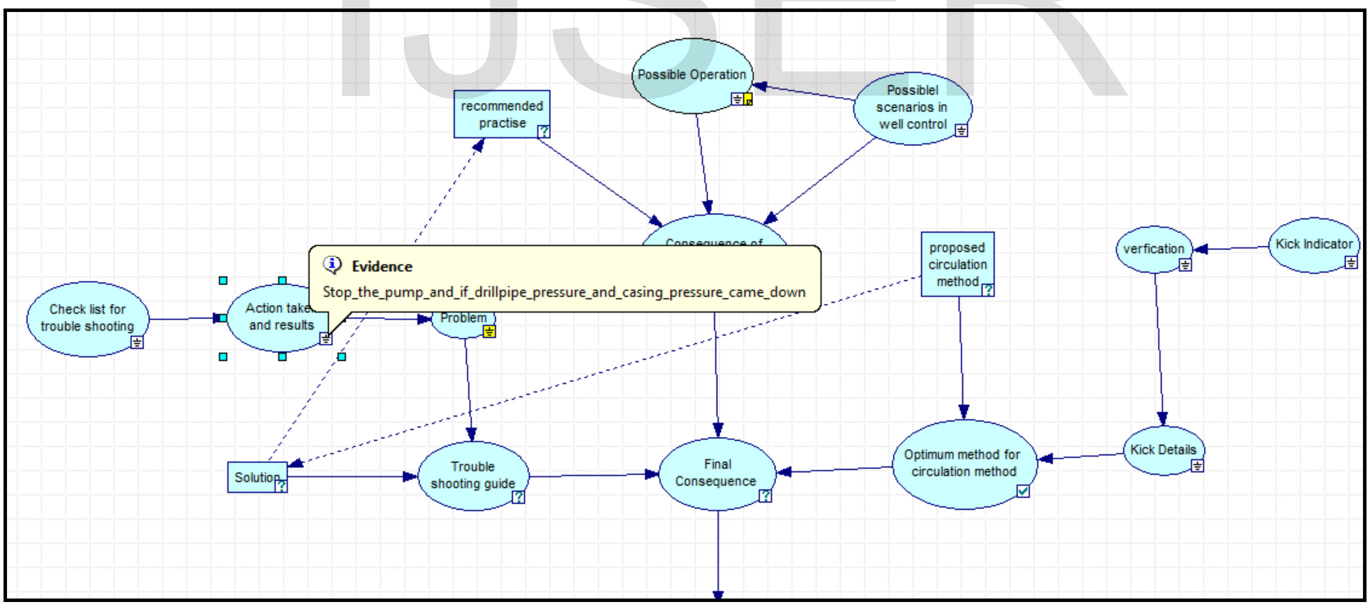


Fig.29: The user then selects an action and its corresponding result in an attempt to identify the problem

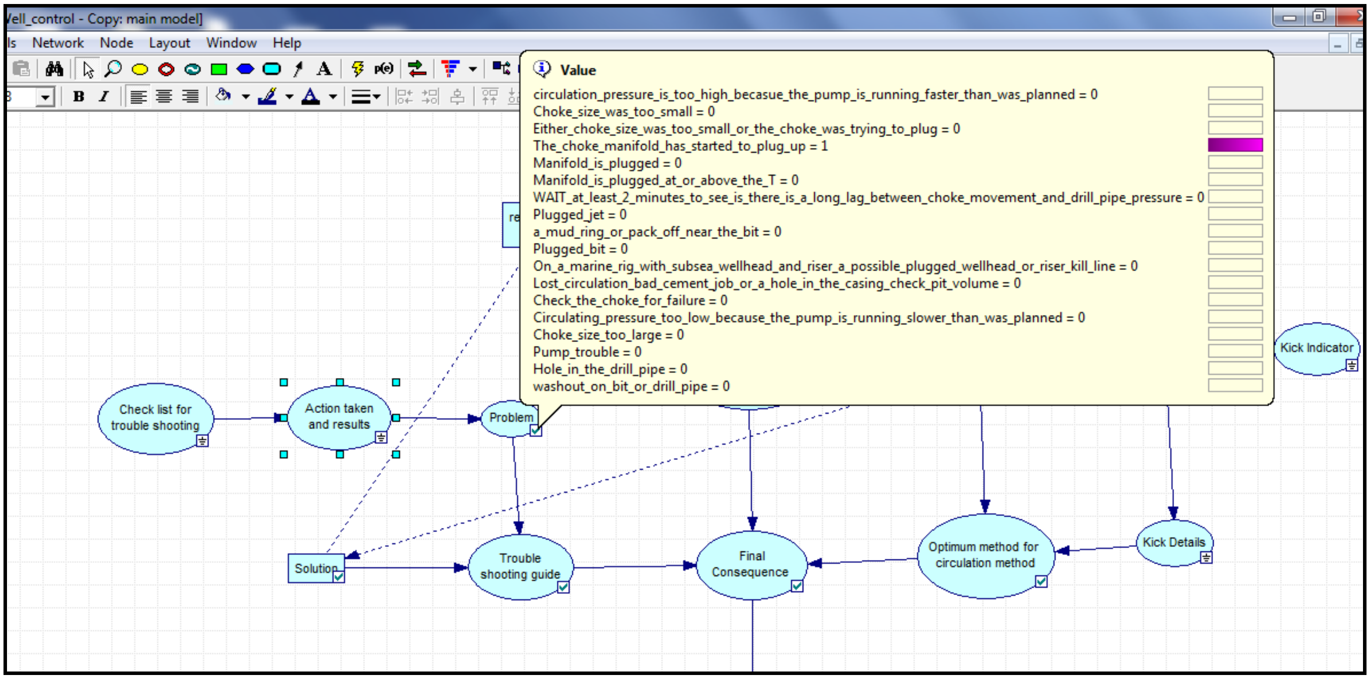
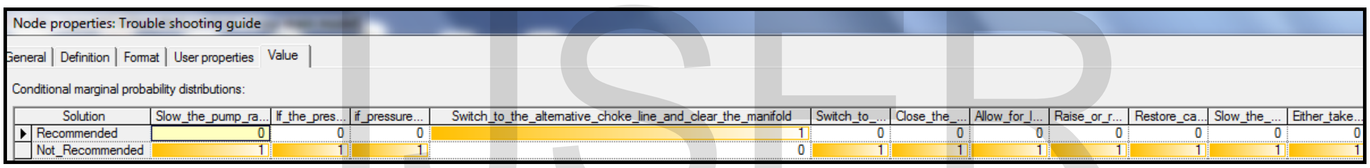


Fig.30: The problem is identified


Node properties: Trouble shooting guide

General | Definition | Format | User properties | Value

Conditional marginal probability distributions:

Solution	Slow_the_pump_ra...	If_the_pres...	if_pressure...	Switch_to_the_alternative_choke_line_and_clear_the_manifold	Switch_to_...	Close_the_...	Allow_for_l...	Raise_or_r...	Restore_ca...	Slow_the_...	Either_take...
Recommended	0	0	0	1	0	0	0	0	0	0	0
Not_Recommended	1	1	1	0	1	1	1	1	1	1	1

Fig.31: A recommendation is given to solve this problem

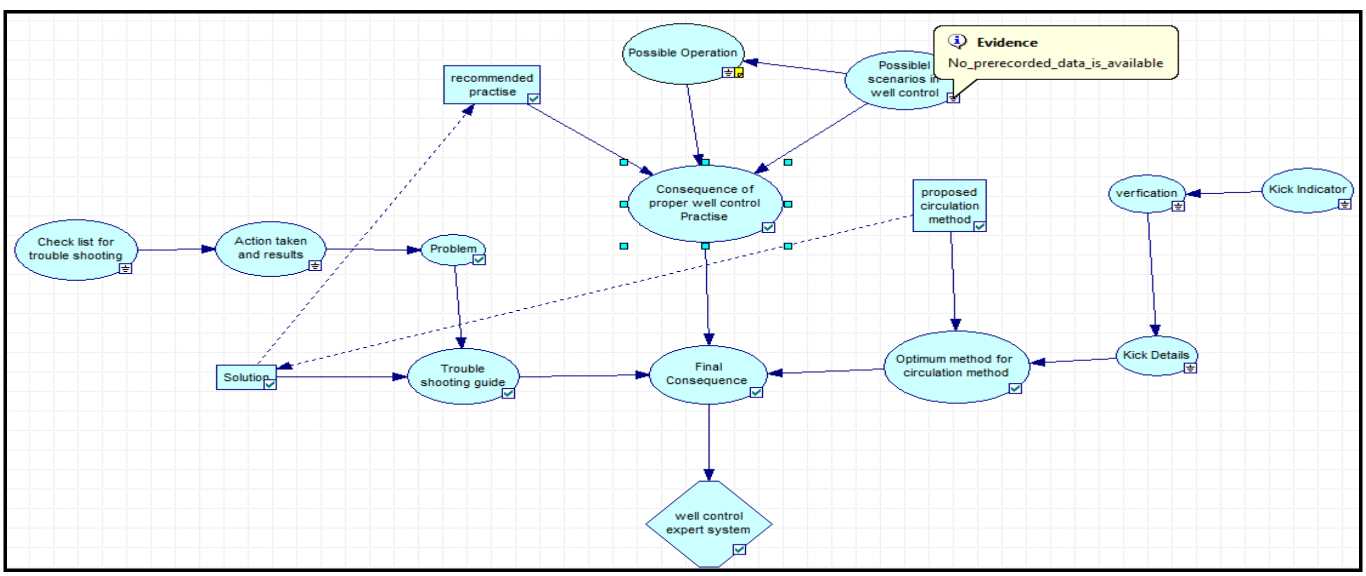


Fig.32: The user is controlling the well without any prerecorded data

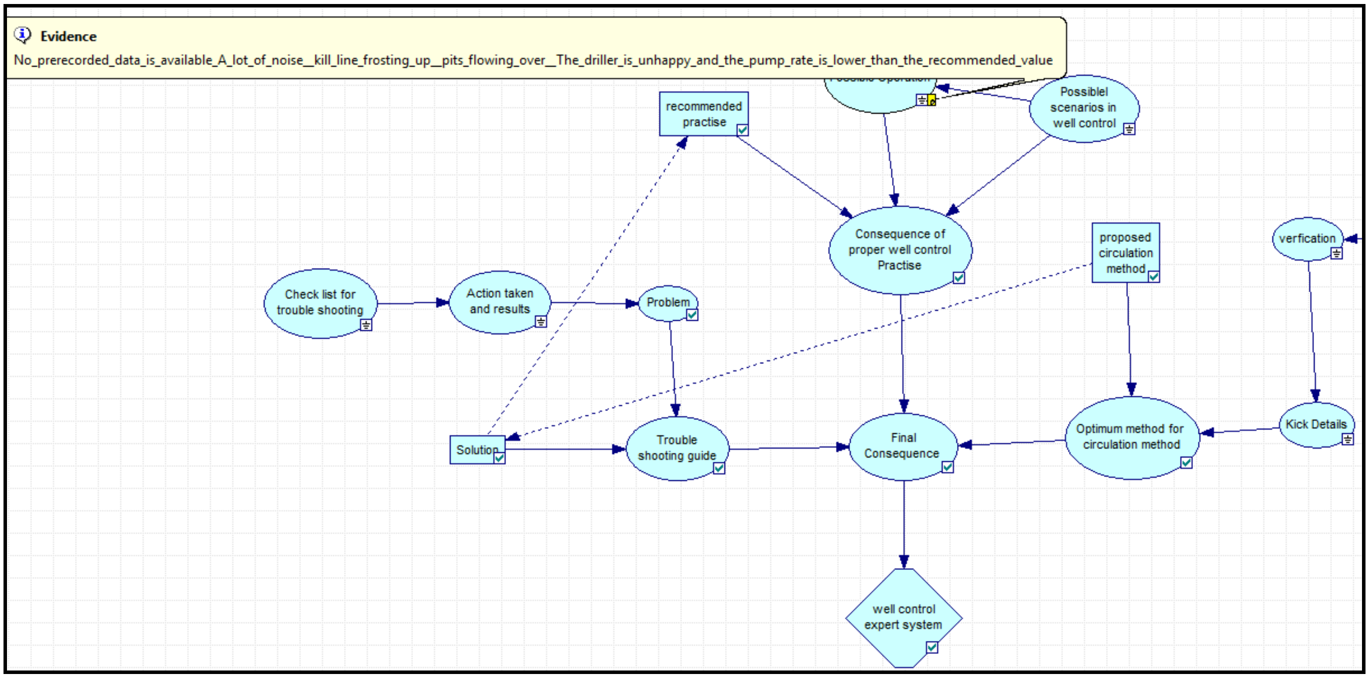


Fig.33: The user is entering his observations

Node properties: Consequence of proper well control Practise

General | Definition | Format | User properties | Value

Conditional marginal probability distributions:

recommended practise	Increase_choke_size	Decrease_choke_size	Increase_pump_rate	decrease_pump_rate	every_thing_is_OK_continue	Stop_the_pump_and_close_the_well_in
Recommended	0	0	1	0	0	0
Not_recommended	1	1	0	1	1	1

Fig.34: The recommended proper well control practice is shown

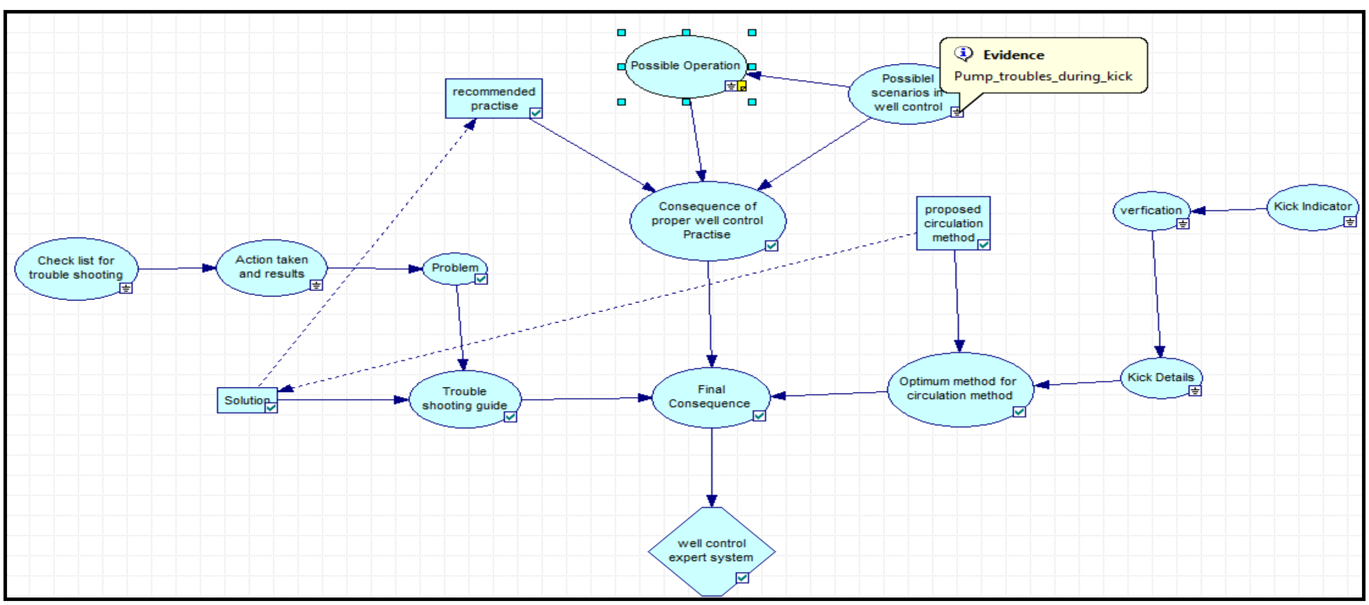


Fig.35: The user is controlling the well and he has pump troubles during a kick

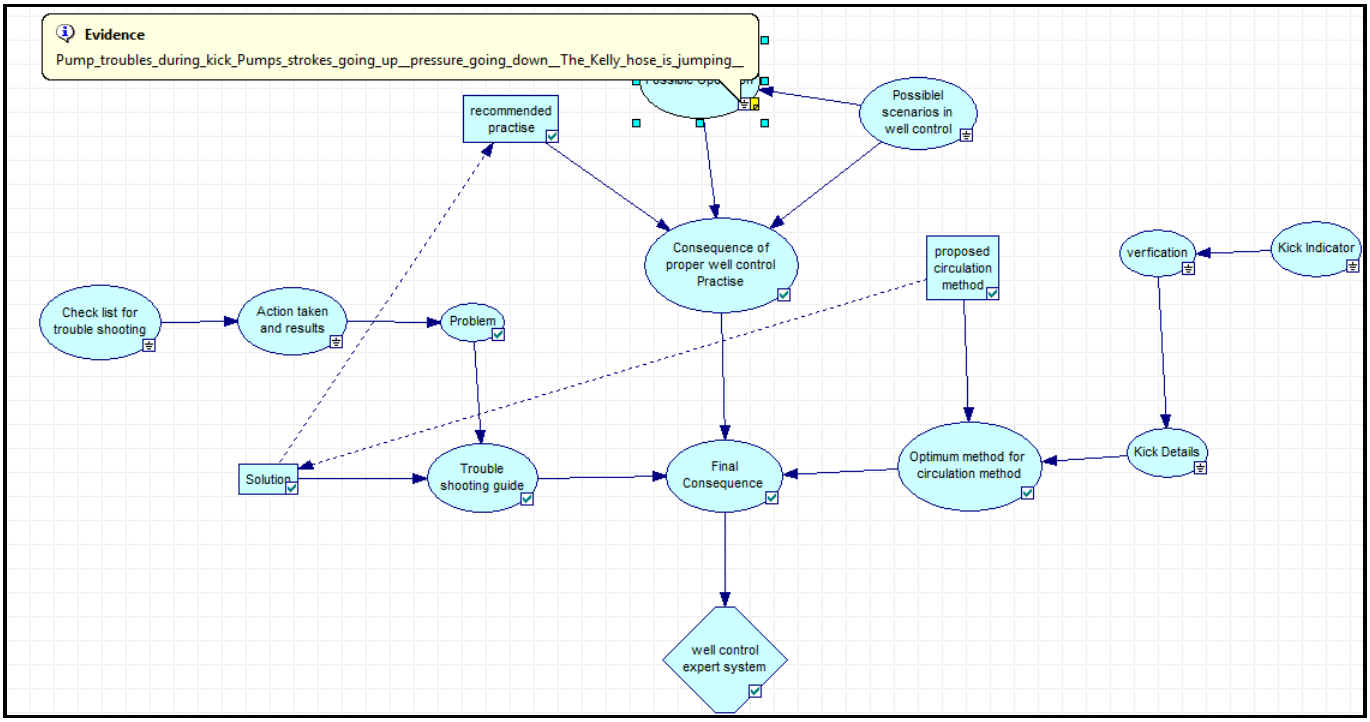


Fig.36: The user is entering his observations during the pump trouble

Node properties: Consequence of proper well control Practise

General | Definition | Format | User properties | Value

Conditional marginal probability distributions:

recommended practise	Increase_choke_size	Decrease_choke_size	Increase_pump_rate	decrease_pump_rate	every_thing_is_OK_continue	Stop_the_pump_and_close_the_well_in
Recommended	0	0	0	0	0	1
Not_recommended	1	1	1	1	1	0

Fig.37: The recommended proper well control practice is shown for the selected conditions for the pump trouble during a kick

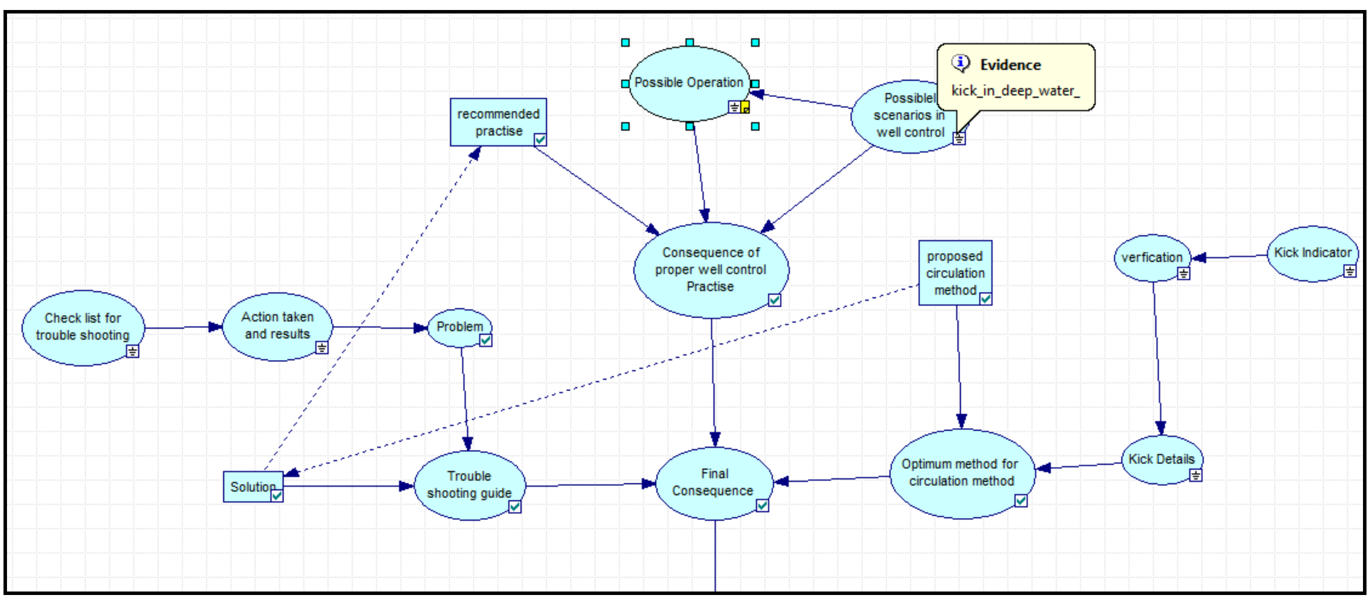


Fig.38: The user is facing a kick in deep water

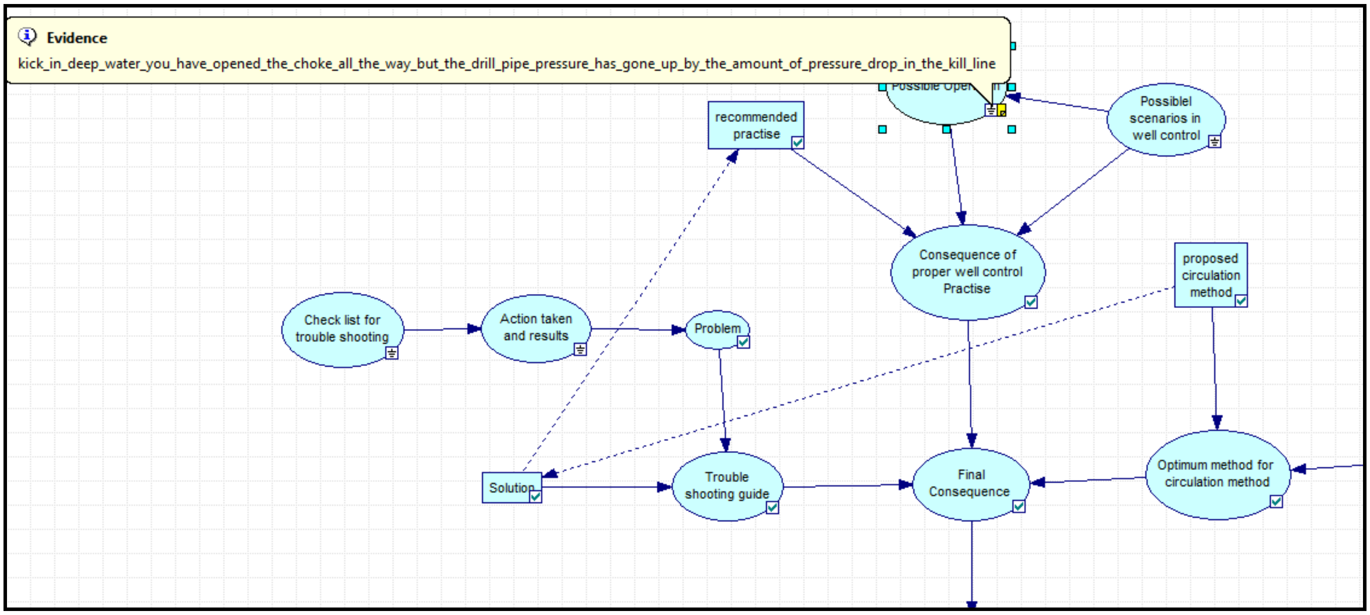


Fig.39: The user is entering his observations for the deep water kick

Node properties: Consequence of proper well control Practise

General | Definition | Format | User properties | Value

Conditional marginal probability distributions:

recommended practise	Increase_choke_size	Decrease_choke_size	Increase_pump_rate	decrease_pump_rate	every_thing_is_OK_continue	Stop_the_pump_and_close_the_well_in
Recommended	0	0	0	0	1	0
Not_recommended	1	1	1	1	0	1

Fig.40: The recommendation for the kick in deep water