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A Systematic Literature Review of Risk Assessment in Water Supply System Project

Benjamin Julies Lekatompessy [1], Humiras Hardi Purba [2]*

[1] Civil Engineering Department, University of Mercu Buana, Jakarta, Indonesia.*

(55719120004@student.mercubuana.ac.id)

[2] Industrial Engineering Department, University of Mercu Buana, Jakarta, Indonesia.

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ABSTRACT

Risk is often assumed that the word implies a negative outcome. It is commonplace that risk is uncertain. Although a feasibility study had been carried out before the construction of water supply project started but it could not be avoided that risks would still occur. The risks that arise in real are very diverse, such as the risk of rejection by the community, the design is not good, the construction that is not by the design, the uncertain quality of raw water so that water treatment is inefficient and the risk of Public-Private Partnership (PPP). Referring to the risk phenomenon that occurs in the water supply project, so this research is carried out on research on risks in drinking water projects that have been carried out before to find out about the description of more likely risks that occur. This summary literature review shows that Technical Risk risks have the greatest impact on water supply risk projects either in the internal or projects category.

Keywords:

Risk Assessment, Risk Management, Risk Analysis, Water Supply Project.

1. Introduction

Risk is often assumed that the word implies a negative outcome. It is commonplace that risk is uncertain. The risk may have either positive or negative outcomes. A negative risk is defined as a threat while a positive risk is defined as an opportunity (Cretu et al., 2011) [1]. In a construction project, are sensitive to an extremely large matrix of hazards and thus to risks. This sensitivity is due to some of the inherent characteristics of construction projects (Bunni, 2003) [2]. Risk is a combination of the probability or frequency of a hazard occurring and the magnitude of the consequences of that event. Risk assessment is an integrated analysis of the likelihood of an event occurring and its effects in terms of extent and also in terms of significance. The likelihood, the extent, and the significance of an event can be assessed either from previous experience or from calculations using the theories of probability (Bunni, 2003). The management of risk is a continuous process and should span all the phases of the project due to a project is divided into several separate phases. Construction projects are dynamic so that a risk assessment is required at the end of a project phase before activities continue to the next phase (Smith et al., 2006) [3]. In water supply infrastructure projects, risk assessments are carried out from a technical and non-technical perspective. From a technical point of view, the risks are assessed starting from raw water to house connections from the water supply development system. Meanwhile, from a non-technical perspective, it is assessed that risks arise from the environment, socio-economic, legal and institutional aspects as well as finance and investment. Although a feasibility study had been carried out before the construction of water supply project started but it could not be avoided that risks would still occur. The risks that arise in real are very diverse, such as the risk of rejection by the community, the design is not good, the construction that is not by the design, the uncertain quality of raw water so that water treatment is inefficient and the risk of Public-Private Partnership (PPP). Referring to the risk phenomenon that occurs in the water supply project, so this research is carried out on research on risks in drinking water projects that have been carried out before to find out about the description of more likely risks that occur.

2. Research Methodology

This paper is carried out by searching for journals on trusted source sites and then selecting journals based on "risk assessment", "risk analysis", "risk identification" in water supply projects. The risks reviewed are technical and non-technical risks from external, internal as well as from the project. The following is a research framework in this paper.

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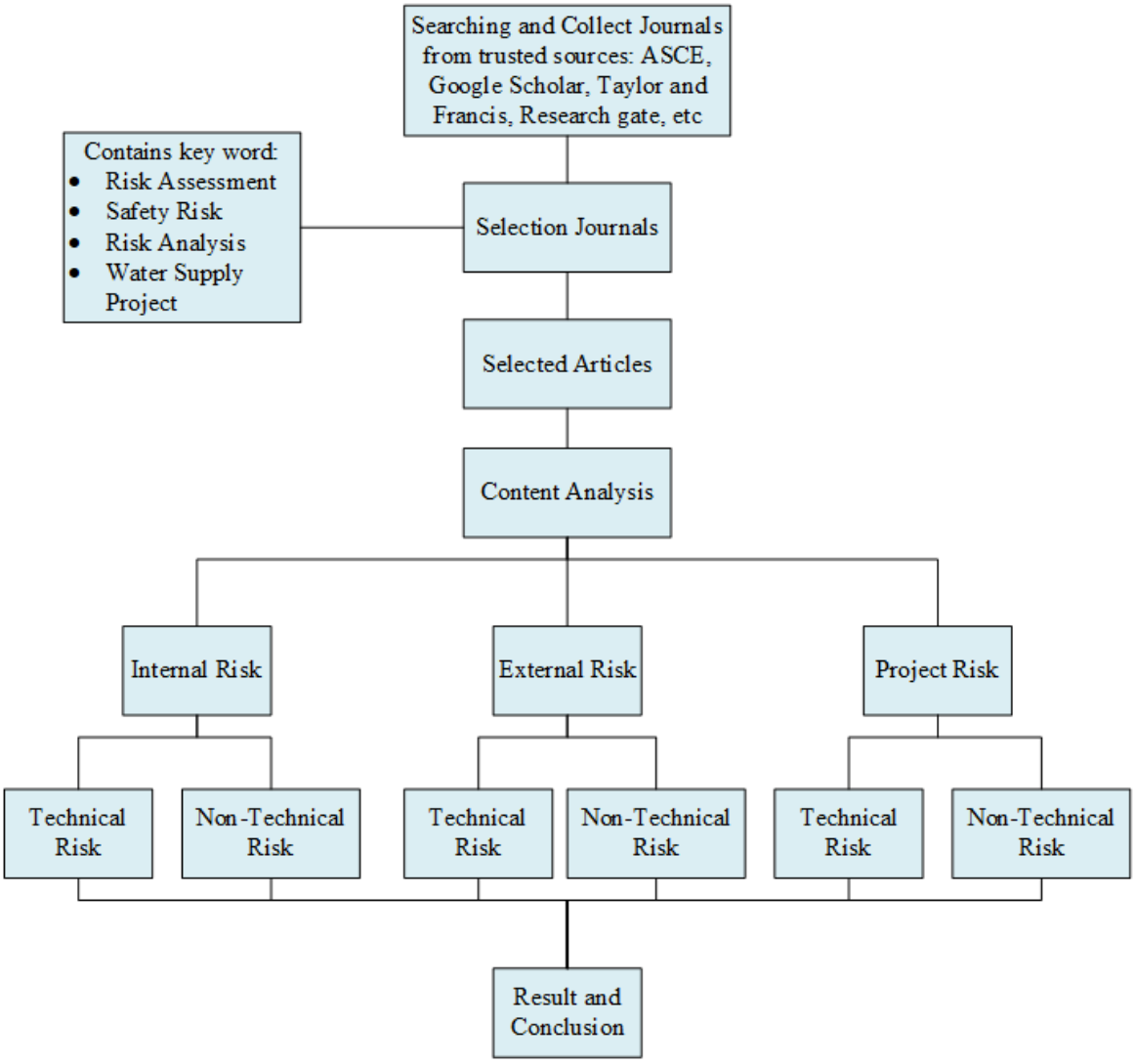

Figure 1. Research Framework.

3. Result and Discussion

Water is a basic human need in carrying out daily activities. Therefore, in terms of water supply, it is necessary to carry out a risk assessment from various sides. In this study, a risk assessment was conducted which was divided into 3 (three) categories according to (Petr Rehacek, 2017) [4], that is: (a) Internal risk; Internal risk can be divided according to the party who might be originator risk events such as stakeholders, designer, contractor, etc. internal risk in project construction like resource risk, project member risk, stakeholder's risk, designer risk, contractor risk, subcontractor risk, supplier risk, team risk, construction site risk and documents and information risk, (b) External risk; External risk are those that risk is beyond the control of project management team like political risk, economic risk, social risk, and weather risk, (c) Project risk; Project risk construction criteria is time risk, cost risk, work quality, construction risk, and technology risk.

The three categories above are divided by 2 (two) categories as well as (a) Technical risk; Technical risk assessment is concerned with assessing the probability that the system embodied in a design when constructed meet the performance requirements it is intended to meet, and, if a shortfall in performance is expected, how serious the shortfall is likely to be (Klein & Cork, 1998) [5]. Technical risk is explained in this article including pollution and hygienic risk in water, construction method, water supply system design from raw water transmission and distribution pipes, water treatment plant and service area, availability of material, work quality, etc (b) Non-Technical risk; Non-technical risk (NTR) is a risk that can affect a particular project directly, the cause is an unplanned and unexpected event that results in unwanted deviations from the original project delivery location carried out by an external stakeholder (non-contractor). The existence of a clear relationship between risk and external stakeholders differentiates NTR from technical risk in the project context. In other words, NTRs (also known as above-ground risks) usually originates from external stakeholders/environment (Ite, 2016) [6]. In this article, non-technical risk related to financial risk, operational institution, land acquisition, the risk from stakeholder or government, political risk, legal, partnership, socio-economic, weather risk, etc.

3.1. Internal technical risk

Internal technical risk in the water supply project is affected by various problems. In Harbin, Northern China there is a risk of water supply engineering. This risk is from the water supply factory (Li & Dai, 2012) [7]. The total risk status of Urmia urban water system is medium and the most contributing component in increasing the system risk level is the old water treatment plant (WTP1) for which some structural and nonstructural risk mitigation measures should be adopted (Roozbahani et al., 2013) [8]. The contamination risk water supply system in sources, distribution, and costumer are low to very high respectively (Budiyono et al., 2014) [9]. The most critical risk rate is an improper estimate of quantity and quality of water needed for each individual the customer (Wali & Hamadameen, 2019) [10] while according to (Ameyaw & Chan, 2015) [11], the risk in water supply project is faulty demand forecasting. Faulty design documentation has the biggest impact on the high level of cost risk in water and sewerage system construction projects (Rybka et al., 2016) [12]. The same result that is explained by (Sutantiningrum et al., 2019) [13] is the high risk in is difficulty in immature design. In the pipe network, there is a risk as suck hydraulic parameters where demand has been an unfavorable factor since it has the most important impact. (Ataoui & Ermini, 2017) [14], the whole risk level of the long-distance water transmission system relatively high and the most serious risk is the technical risk (Zhang et al., 2014) [15].

3.2. Internal Non-technical risk

The presence of high-risk levels reflects the difficulty for controlling water quality in water supply system mainly due to the lack of governance by the service provider company, the existence of multiple stakeholders (health institutions, designers and builder sector, administrators, community, etc) (Vidal et al., 2013) [16]. The non-technical risk of pipe construction is labor, material, and HSE (Sari, 2014) [17]. The risk that must be considered is about design. (Wali & Hamadameen, 2019) said that the third most considerable risk was a change of design, risk on Bregas Transmission Pipe Line Project is on the study and design risk (Septiani et al., 2015) [18],

and poor contract design (Ameyaw & Chan, 2015). Potential occupational hazards in the water treatment industry are exposed to chemicals to workers, the potential danger of leaking chlorine gas can also greatly affect the safety and health of the industrial environment. (Falakh & Setiani, 2018) [19].

3.3. External technical risk

The risk of Salyankot Water Supply Project for smooth operation and management particularly in a post-earthquake scenario. After the heavy rainfall, there was more probability of landslide in this area and swift away the transmission pipeline, as a result, there can be major damage that affects a large percentage of beneficiaries. So there was a significant risk due to landslide (Mishra, 2018) [20].

3.4. External Non-technical risk

In China, the extreme shortage of infrastructure certainly has the potential to suffocate economic growth and social development. The risks associated with BOT projects in different infrastructure sectors would be different. The critical risk factors for water supply BOT projects were short-listed into categories such a: (i) change of taxation policy, (ii) fluctuation of loan interest rate, (iii) variation of water resources price, (iv) fluctuation of foreign exchange rates and (v) competitors (Zeng et al., 2008) [21]. On Chinese water PPP projects, completion risk, inflation, and price change risk have a higher impact whereas government corruption, an imperfect law and supervision system, as well as a change in market demand, have a lower impact on the water supply sector (Chan et al., 2015) [22]. (Ameyaw & Chan, 2015) said that the risk in PPP projects in the water supply system is water pricing and tariff review uncertainty, political interference, public resistance to PPP, non-payment of bills, and lack of PPP experience. Three priority risks were the focus of the analysis in this study, including the risk of the drinking water production capacity, fluctuations in the IDR exchange rate against the USD, and increases in electricity prices. (Hidayatno et al., 2015) [23]. The most important (high-risk score) economic risk of the studied project is a commercial risk, namely the risk of falling demand hence the risk of non-payment of bills for water supply and sewer services, because of their high tariffs and low affordability of the population of Dâmbovia County (Frone & Frone, 2015) [24]. The other external risk in water supply project is risks based on drought climate and risks based on engineering accidents (Li & Dai, 2012), land acquisition in the construction phase, legal license in pre-construction (Septiani et al., 2015), disruption of local community due to mobilization and demobilization of equipment and materials (Putra et al., 2018) [25]. The high risk in each phase is difficulty in land acquisition, changes in regulations (Sutantiningrum et al., 2019) [26].

3.5. Project technical risk

The risks of urban water-supply quality in Harbin can be divided into conventional pollution risk as well as pollution emergency and hygienic accident risk (Li & Dai, 2012). To reduce the vulnerability of people affected by the waterborne disease, risk assessment of the water supply system can be carried out. Several factors such as pipe age, susceptibility to flooding, pipe

materials, and layout are often subject to excavation or road repair work along the pipeline are responsible for leaks (Shams et al., 2016) [27] . Leakage from transmission/ distribution pipeline/ joints (Mishra, 2018). The treatment and distribution of drinking water are not unique control (Vidal et al., 2013). The most important is the source of supply and at the point of use is the entry of human waste and wells drilled in residential houses to provide drinking water (Hoshyari et al., 2019) [28]. The technical risk on the pipe construction is land condition, construction equipment, construction technology (Sari, 2014). The high risk in each phase is difficulty in risks at the testing & commissioning stage, safety and security risks, difficulties in unexpected pipe planting site conditions, risk of technology failure, risk of poor quality of bulk water, risk of distribution network connectivity, and connecting facilities. (Sutantiningrum et al., 2019).

3.6. Project Non-technical risk

The effect of inefficient construction and cost control practices and lack of coordination within the construction firm and of subcontractors is construction time and cost overrun, high operational cost, and conflict between partners. (Ameyaw & Chan, 2015). The problem has the consequences is delayed operation and increased interest on loans. The list of selected articles that were reviewed and analyzed from the aspect of risk assessment in the water supply project is as shown in Table 1.

Table 1. Summary Literature Review of Risk Assessment in Water Supply System Project.

No	Paper Identity	Risk Category						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
1	(Zeng et al., 2008)	x	x	x	v	x	x	The critical risk factor for water supply projects in BOT model were short-listed into categories such as (i) change of taxation policy, (ii) fluctuation of loan interest rate, (iii) variation of water resources price, (iv) fluctuation of foreign exchange rates, (v) competitor
2	(Li & Dai, 2012)	v	x	x	v	v	x	Urban water supply risks in Harbin are divided by: • Characteristics of risk • Risk of urban water supply quantity • Risk of urban water supply quality • Risk of urban water engineering
3	(Vidal et al., 2013)	x	v	x	x	v	x	The presence of high-risk levels reflects the difficulty for controlling water quality due to the lack of service provider company, the existence of multiple stakeholders, the treatment and distribution of drinking water are not unique control.
4	(Roozbahani et al., 2013)	v	x	x	x	x	x	The most contributing component in increasing system risk level in Urmia urban water system is old water treatment plant (WTP1)
5	(Zhang et al., 2014)	v	x	x	x	v	x	The risk assessment result shows that the whole risk level of the long-distance water transmission system relatively high and the most serious risk is a technical risk.

No	Paper Identity	Risk Category						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
6	(Budiyono et al., 2014)	v	x	x	x	v	x	The contamination risk water supply system in sources, distribution, and customer is low to very high respectively.
7	(Sari, 2014)	x	v	x	x	v	x	The open trench method has a high risk consecutively is on the land condition, construction equipment, construction technology, labor, material, and HSE. While on Microtunnel method has the high risk consecutively is on construction technology, land condition, HSE, equipment, material, and labor
8	(Chan et al., 2015)	x	x	x	v	x	x	By comparing the 37 risk factors, further analysis found that completion risk, inflation, and price change risk have a higher impact on Chinese water PPP projects
9	(Ameyaw & Chan, 2015)	v	x	x	v	x	v	The top-ranked risk factor in water PPPs based on their impact values were identified a: (i) poor contract design, (ii) water pricing and tariff review uncertainty, (iv) political interference, (v) public resistance to PPP, (v) construction time and cost overrun, (vi) non-payment of bills, (vii) lack of PPP experience, (viii) financing and refinancing risk, (ix) faulty demand forecasting, (x) high operational cost and conflict between partners.
10	(Hidayatno et al., 2015)	x	x	x	v	x	x	Three priority risks were the focus of the analysis in this study, including the risk of the drinking water production capacity, fluctuations in the IDR exchange rate against the USD, and increases in electricity prices.
11	(Frone & Frone, 2015)	x	x	x	v	x	x	The most important (high-risk score) economic risk of the studied project is a commercial risk, namely the risk of falling demand hence the risk of non-payment of bills for water supply and sewer services, because of their high tariffs and low affordability of the population of Dâmbovia County
12	(Septiani et al., 2015)	v	x	x	v	v	x	Risk on Bregas Transmission Pipe Line Project is on the study and design risk, land acquisition and construction phase, legal license in pre-construction.
13	(Shams et al., 2016)	x	x	x	x	v	x	Several factors such as the age of pipes, vulnerability to flooding, pipe materials, and layout subjected to frequent excavation or repair works of roads along the pipelines are responsible for leaks
14	(Rybka et al., 2016)	v	x	x	x	x	x	Faulty design documentation has the biggest impact on the high level of cost risk in water and sewerage system construction projects.
15	(Ataoui and Ermini, 2017)	v	x	x	x	x	x	Only a few nodes (redpoint) show a high level of risk, these nodes are considered as the most critical nodes in the network. As the model is

No	Paper Identity	Risk Category						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
								hierarchical, it reveals that the high-risk level is due essentially to the hydraulic parameters where demand has been an unfavorable factor since it has the most important impact.
16	(Putra et al., 2018)	x	x	x	v	x	x	Risk in the construction phase is the disruption of the local community due to mobilization and demobilization of equipment and materials.
17	(Falakh & Setiani, 2018)	x	v	x	x	x	x	Potential occupational hazards in the water treatment industry are exposed to chemicals to workers, the potential danger of leaking chlorine gas can also greatly affect the safety and health of the industrial environment.
18	(Mishra, 2018)	x	x	v	x	v	x	Significant Risk of the project based on the system: • Transmission system: Disruption by landslides • Distribution system: Leakage from transmission/ distribution pipeline/ joints
19	(Sutantiningrum & Dwi, 2019)	v	x	x	v	v	x	The high risk in each phase is difficulty in land acquisition, changes in regulations, immature design, risks at the testing & commissioning stage, safety and security risks, difficulties in unexpected pipe planting site conditions, risk of technology failure, risk of poor quality of bulk water, risk of distribution network connectivity and connecting facilities.
20	(Wali & Hamadameen, 2019)	v	v	x	x	x	x	The most critical risk rate is improper estimate quantity and quality of water needed for each individual of the costumer, the second crucial risk factor is an inaccurate selection of the standard and specifications of materials and the third most considerable risk was a change of design
21	(Hoshyari et al., 2019)	x	x	x	x	v	x	The most important is the source of supply and at the point of use is the entry of human waste and wells drilled in residential houses to provide drinking water

Note: Technical (T), Non-Technical (NT)

Based on the review of the articles above, it is found that the most likely risk in the water supply project is a technical risk either in the project or internal risk.

Table 2. The Recapitulation of Selected Journals Analyzed

Risk Category		Research Journal
Internal	Technical	2, 4, 5, 6, 9, 12, 14, 15, 19, 20
	Non-Technical	3, 7, 17, 20
External	Technical	18
	Non-Technical	1, 2, 8, 9, 10, 11, 12, 16, 19
Project	Technical	2, 3, 5, 6, 7, 12, 13, 18, 19, 21
	Non-Technical	9

Figure 2. Barchart Analysis of Research Articles Based on Risk Category in Water Supply Project.

While the recapitulation of risk in the water supply system projects based on articles review is showed in the figure below.

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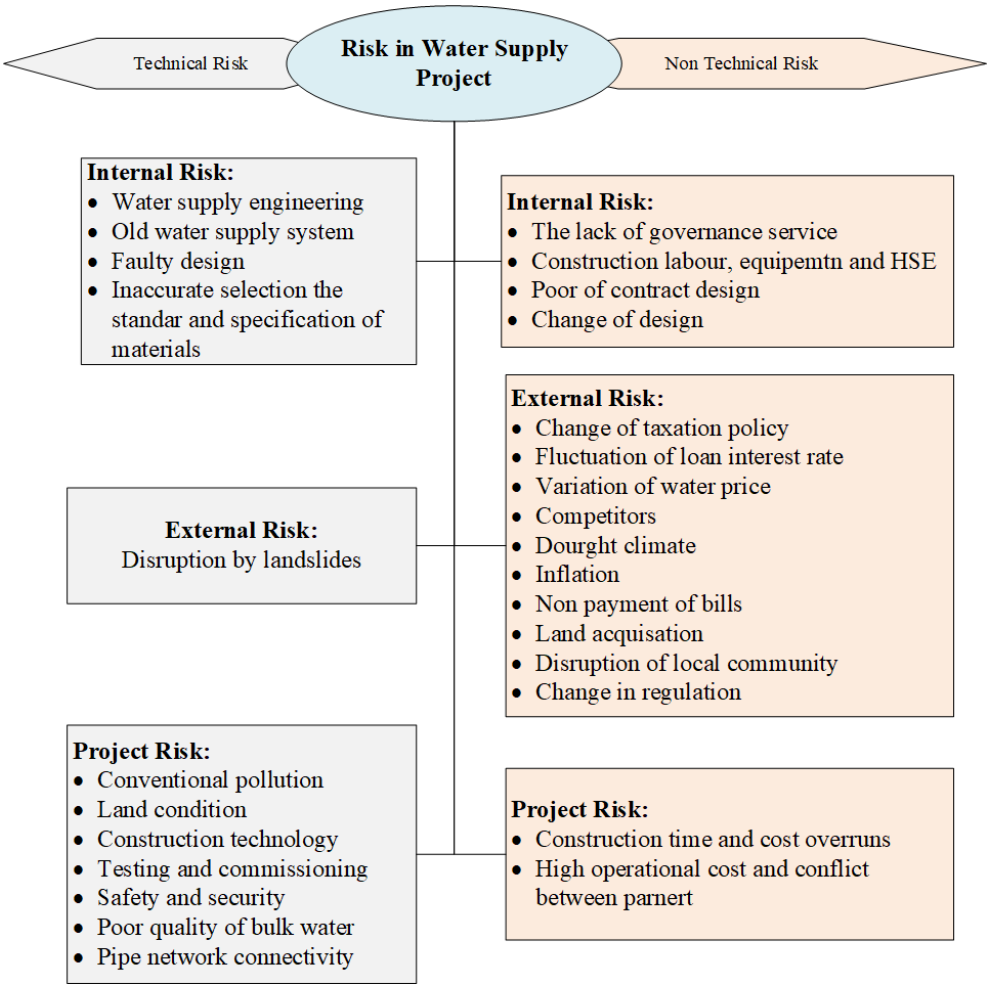

Figure 3. Risk in Water Supply System Project Based on Articles Review.

If it is viewed from the technical risk category, it is known that project risk has quite a lot of risk items compared to the internal risk and external risk. Meanwhile, in a non-technical risk category, it can be seen that external risk has more risk items. However, even though there are many items of risk, it does not mean that there is too many potential risks as well. As a result of the review article above that the technical risk project and internal technical risk have the most likely risk in the water supply project.

4. Conclusion

From the review of the articles, can be concluded that (i) The Technical Risk risks have the greatest impact on water supply risk project for either internal or project category, (ii) Project technical risks are the construction of water distribution, controlling of water treatment quality, operation of water distribution pipes, water contamination due to there is no regular water flushing at distribution pipeline, construction time, design risk, leakage of pipe, poor quality of bulk water, the quantity of water needed inaccurate selection of the standard and specification materials, entry of human waste and wells drilled in residential houses to provide drinking water.

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