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Protecting Cape Town's Groundwater from Fuel Stations: An In-Depth Analysis of Regulatory Requirements

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Abstract: In the face of mounting water supply challenges, Cape Town has increasingly turned to alternative sources, like groundwater. However, the utilisation of groundwater carries inherent risks, particularly the contamination stemming from land-based activities, such as fuel stations. Leaks from underground tanks at these stations represent a major global cause of groundwater pollution, and Cape Town is no exception. To safeguard public health and mitigate potential harm, it is imperative to examine the legal regulations governing fuel station development, assess measures for controlling their environmental impacts and evaluate strategies for managing the associated risks. This study aims to provide an exhaustive review of the regulatory framework concerning the environmental impacts of fuel stations, focusing on groundwater protection in Cape Town. A combination of desk research and interviews was employed to gather and analyse data. The findings show a deficiency in precautionary measures for safeguarding groundwater near fuel stations. Consequently, through this study, the existing legal framework's effectiveness is called into question, with this study suggesting actions to address these identified shortcomings.

Keywords: groundwater; contamination; legal framework; environmental regulations; fuel station; land-use; Cape Town

Citation: Nsimba, E.A.; Malaza, N.; Marazula, T. Protecting Cape Town's Groundwater from Fuel Stations: An In-Depth Analysis of Regulatory Requirements. *Sustainability* **2023**, *15*, 15135. https://doi.org/10.3390/su152015135

Academic Editors: Zongjun Gao and Jiutan Liu

Received: 14 September 2023
Revised: 12 October 2023
Accepted: 20 October 2023
Published: 22 October 2023

1. Introduction

Global water resources are facing unprecedented challenges driven by a combination of factors, prominently including climate change and population growth [1]. In addition to these pressures, the contamination of water resources through anthropogenic activities has emerged as a pressing concern [2]. These multifaceted challenges are progressively diminishing the availability of freshwater reserves accessible to human populations, underscoring the critical need for an effective regulatory system to manage and safeguard these invaluable resources [3].

Several decades ago, policymakers recognised the imperative to enact legislation, regulations and policies aimed at preserving the environment in a holistic sense, with a particular emphasis on water resources [4,5]. However, the efficacy of a legal framework governing environmental concerns can be compromised if it fails to comprehensively address relevant theoretical and practical parameters. These parameters encompass a range of elements, including the implementation of robust mitigation measures to preclude negative environmental impacts [6,7]. The central focus of this study is the examination of fuel stations as potent sources of groundwater contamination. Despite their undeniable socio-economic importance [8,9], fuel stations also engender significant environmental challenges, notably groundwater contamination stemming from leakages in underground storage tanks and associated pipelines [10]. Groundwater pollution originating from fuel stations assumes heightened significance, especially when neighbouring communities rely on groundwater sources for their water supply [11]. This dynamic has been conspicuously observed in the Western Cape province in South Africa, particularly during episodes of

water scarcity and drought. In Cape Town, the recurring and severe drought events in the past years have prompted many residents to install private boreholes, and this trend shows no signs of abating in the face of ongoing climate-induced scarcity [12–15]. Therefore, sustained attention must be given to the protection of groundwater to prevent further risks, such as contamination resulting from anthropogenic activities.

Groundwater contamination by petroleum products is a pervasive issue encountered worldwide, with particular prevalence in urban areas [16]. South Africa, including the city of Cape Town, is no exception to this environmental challenge [17]. This is a concern that becomes especially evident when assessing the density and distribution of fuel stations in major South African cities [18]. According to Ahmed et al. [8], fuel stations represent facilities where substantial quantities of petroleum-based fuels, such as petrol, diesel and various refined products, are stored for commercial purposes. However, the inherent technical complexities and environmental vulnerabilities of underground storage tanks (USTs) and associated equipment at fuel stations can lead to leaks, resulting in soil and groundwater contamination [10]. Such contamination incidents often involve the release of hazardous compounds, like Benzene, Toluene, Ethylbenzene, Xylene (BTEX) compounds, polycyclic aromatic hydrocarbons (PAHs), lead and methyl tert-butyl ether (MTBE), an oxygenate blended in unleaded fuel, among others [6].

The human health consequences of exposure to contaminated groundwater can be extremely disastrous [19,20]. Notably, the risk to human health escalates significantly when individuals are regularly exposed to petroleum-contaminated water [21]. Exposure to petroleum hydrocarbons can induce a spectrum of acute health effects, encompassing flu-like symptoms, coughing, headaches, dizziness and eye and skin irritation. With prolonged exposure, chronic health effects can manifest, potentially leading to more severe and enduring issues, such as cancer, cardiotoxicity and endocrine disruptions [22].

Over the years, countries have implemented measures aimed at enhancing regulations and preventing groundwater contamination by fuel stations, particularly addressing concerns arising from ageing USTs [23]. Measures, such as secondary containment for USTs, have emerged particularly as an effective proactive means for controlling the dispersion of fuel released from problematic tanks into soil and groundwater [6]. Ooi et al. [23] also underline the significance of robust monitoring practices and the adoption of state-of-the-art technology for preventing the pollution of water. Furthermore, the role of land-use management cannot be overstated. Precautionary land-use management plays a pivotal role in minimising the environmental risks associated with high-risk activities such as fuel stations [24]. Land-use management assumes critical importance in risk mitigation, particularly concerning safety from risks of human installations, thereby safeguarding communities residing in proximities to major hazard installations [25].

The inherent unpredictability and severity of fuel leakages from USTs necessitate stringent government measures in the form of laws and regulations to avert undesired occurrences such as groundwater contamination [23]. However, it is essential to recognise that laws, regulations and policies may, at times, fall short of achieving their intended effectiveness. Since the advent of modern environmental regulations, the development and implementation of effective regulations have posed one of society's most pressing challenges [26]. Consequently, the continuous refinement of laws and policies is imperative, particularly in the current time earmarked by heightened public awareness of environmental risks [27].

Thus, when existing laws prove inadequate to address burgeoning environmental challenges, reviewing them to develop adequate legal measures to prevent risks becomes imperative [28]. Aven and Renn [27] advise that governments must incorporate clear risk strategies into the formulation of governance policies to enhance risk prevention. Among the several risk strategies that are often discussed in scientific literature, the precautionary approach stands out as a frequently recommended tool in environmental risk governance, especially in the context of activities with a high potential to impact public health and water availability [3,27].

Existing literature and information suggest that fuel stations are among the major contributors to polluters in South Africa [11,17,18,29–31]. This may, therefore, pose a considerable risk to those who rely on groundwater for additional supplies, particularly in cities like Cape Town. Given the escalating reliance on groundwater in the region, a comprehensive understanding of the effectiveness of the current environmental legal framework in safeguarding groundwater resources and the communities dependent upon them is of paramount importance. Currently, only a limited number of studies have endeavoured to assess the effectiveness of the legal frameworks governing the environmental aspects of fuel stations in South Africa [31,32]. However, given the proliferation of fuel stations in densely populated areas of Cape Town, it is reasonable to hypothesise that these facilities pose substantial risks to groundwater users in the city, especially when considering the cases of registered contaminated land cases attributed to fuel stations in the Western Cape Province (Figure 1).

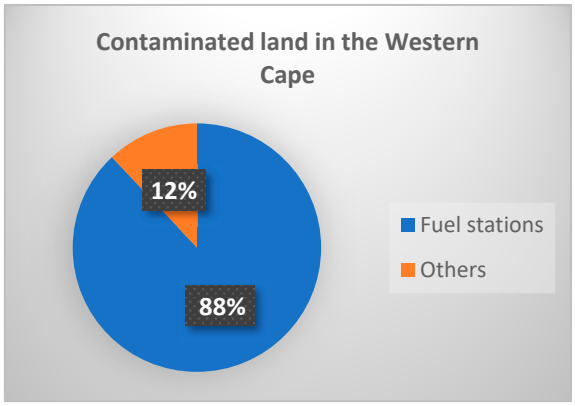

Figure 1. This graph shows that fuel stations account for 88% of the contaminated land registered in the National Contaminated Land Register for the Western Cape.

Thus, the primary objective of this study is to meticulously investigate the legal framework governing the environmental impacts of fuel stations, with a specific focus on the risk mitigation measures applied to fuel station developments in Cape Town.

2. Research Methodology

The main objective of this study is to investigate the risk prevention measures adopted for fuel stations' impacts on groundwater in Cape Town. The key research question guiding this inquiry is: What regulatory conditions are currently in place to govern the establishment of fuel stations and the control of their impacts on groundwater? To answer this question, an exploratory research methodology was adopted, involving a combination of qualitative research techniques. Data collection included a desk review of policies, legal documents and literature, followed by semi-structured interviews with selected key participants to supplement the review of documents. A total of seven (7) semi-structured interviews were conducted in Cape Town with participants from different layers of the environmental sector locally. The data extracted in response to the research question were then analysed using content analysis.

2.1. Desk Review

An initial curation process for legal and policy instruments yielded a list of nine relevant regulatory documents using specific keywords. These regulatory instruments were rigorously analysed alongside literature to address the research question and to find best practices. A summary of the legal documents and policies reviewed to address the research question is presented in Table 1. In South Africa, environmental governance is underpinned by the Constitution, statutes such as the National Environmental Management Act, 107 of 1998, Specific Environmental Management Acts and subordinate legislation at

both national and local levels. For this study, an inclusive examination of South African National Standards (SANS) pertaining to the petroleum industry was conducted, with a focus on standards related to the installation of USTs and associated equipment. These standards were scrutinised to extract relevant technical recommendations.

Table 1. Reviewed legal and policy documents.

Document	Level
The Constitution of the Republic of South Africa Act 108 of 1996	National
National Environmental Management Act 107 of 1998 (NEMA)	National
Environmental Impact Assessment Regulations of 2014 (EIA Regulations)	National
National Environmental Management: Waste Act 59 of 2008 (NEMWA)	National
National Water Act 36 of 1998 (NWA)	National
Municipal Planning By-Law, 2015	Local/Cape Town
Framework for the Management of Contaminated Land (2014)	National
South African National Standards (SANS 10089-1, SANS 1830 and the SANS 1535)	National
EIA Administrative Guideline for Installation and Upgrade of Underground Storage Tank and Associated Equipment	Local/Gauteng

2.2. Semi-Structured Interviews

In tandem with the comprehensive review of legal and policy documents, semi-structured interviews were an additional component of this study, serving as a vital means of gathering insights and perspectives from key stakeholders entrenched in the fields of environmental management and fuel station oversight within Cape Town. The selection criteria for interview participants were stringent, with an emphasis on expertise and substantial knowledge pertaining to environmental regulatory frameworks and management of fuel stations. Rigorous scrutiny of the professional backgrounds of potential participants preceded the interview process to ensure their qualifications met the study's objectives. A total of seven (7) semi-structured interviews were conducted, involving participants from diverse backgrounds and roles (Table 2). The interview discussions were crafted to encompass a range of topics (Appendix A) related to the Environmental Impact Assessment (EIA) process, the potential impacts of fuel stations on groundwater and boreholes, land use management and risk management strategies. A purposive sampling methodology was employed to select the participants for the interviews. It is important to acknowledge that purposive sampling, while invaluable for exploratory studies, presents certain limitations, particularly in terms of the generalisability of findings [33]. However, the use of this sampling method was deemed appropriate to ensure that participants possessed the requisite expertise to provide meaningful insight into the study's specific context.

Table 2. Participants who participated in this study.

Participant	Sector	Function
Participant 1	Government	Environmental Officer
Participant 2	Government	Environmental Officer
Participant 3	Research institution	Researcher (Land use planning)
Participant 4	Environmental consulting	Consultant
Participant 5	Fuel station	Site Manager
Participant 6	Fuel station	Site Manager
Participant 7	Fuel station	Fuel station attendant

3. Regulatory Framework for Groundwater Protection and Gaps

This study placed its focus on the key national legislative and regulatory instruments that shape the landscape, including NEMA, NWA and EIA Regulations. Although these three legislations serve complementary functions, NEMA holds a central role in the broader enforcement of environmental regulation.

Cape Town, as the metropolitan municipality of the Western Cape Province, is subject to a regulatory landscape where fuel stations' impacts on groundwater are primarily governed by national environmental legislation. The Western Cape government, acting as the competent authority under NEMA, is tasked with adjudicating environmental impacts associated with fuel stations. Our investigation unveiled several factors that could potentially undermine the efficacy of the legal measures designed to protect groundwater and borehole users. Foremost among these concerns is the inadequate consideration of sensitive land uses in the vicinity of fuel stations, manifesting as the absence of specific criteria for fuel station siting and safe distances between fuel stations and other land uses. Additionally, no explicit legal provisions mandate the installation or upgrading of USTs and associated pipes equipped with groundwater protection mechanisms within fuel stations. Lastly, the legal framework governing the impacts of fuel stations on groundwater is notably fragmented, introducing complexity in its implementation. The outcomes of this study offer valuable insights and may catalyse policy dialogues aimed at formulating additional legal measures to safeguard groundwater and borehole users potentially exposed to groundwater contamination from fuel stations in Cape Town.

3.1. Environmental Authorisation for the Development of Fuel Stations

The foundational condition for the initiation of activities bearing the potential for substantial environmental impacts is enshrined in Section 24(1) of NEMA, which articulates, "In order to give effects to the general objectives of the integrated environmental management laid down in this chapter, the potential consequences for or impacts on the environment of listed activities or specified activities must be considered, investigated, assessed and reported on to the competent authority or the Minister responsible for the mineral resources, as the case may be, except in respect of those activities that may commence without having to obtain an environmental authorisation in terms of this Act".

Fuel stations, characterised as integrated activities, feature prominently within the ambit of "listed activities" as delineated by the Department in Charge of Environmental Affairs by the EIA Regulations of 2014. Notably, fuel stations are specifically classified under the category of "the construction of facilities for storage or handling of dangerous goods" (Table 3). Consequently, in South Africa, the establishment of fuel stations is contingent upon securing the environmental authorisation as they trigger the legal requisite of an EIA due to the installation of storage tanks for the handling of "dangerous foods". This prerequisite serves as an effective precautionary mechanism against the potential impacts of proposed fuel station developments. However, it is imperative to underscore that the current EIA regulations do not additionally suggest conspicuous provisions addressing groundwater and potential boreholes in the vicinity of fuel stations. In this context, the Gauteng Province stands out among other South African provinces, as they have instituted provincial EIA guidelines, the "EIA Administrative Guideline for Installation and Upgrade of Underground Storage Tank and Associated Equipment (referred to hereafter Gauteng's EIA guideline)", aligning with Section 24 of NEMA.

Table 3. EIA-requiring activities triggered by fuel stations (EIA Regulations of 2014).

Listing and Activity No.	Description of Activity	Assessment
Listing 1 GNR 983 Activity 14	The construction of a facility for storage or for the storage and handling of dangerous goods, where storage occurs in containers with a combined capacity of 80 but not exceeding 500 cubic metres.	Basic assessment
Listing 1 GNR 983 Activity 51	The expansion of a facility for storage or for the storage and handling of dangerous goods, where the capacity of such facility will be expanded by 80 cubic metres or more.	
Listing 1 GNR 983 Activity 31	The decommissioning of existing facility or infrastructure for (v) storage or the storage and handling of dangerous goods of more than 80 cubic metres.	
Listing 2 GNR 984 Activity 4	The construction of a facility or infrastructure for storage or for the storage and handling of dangerous goods, where such storage occurs in containers with a combined capacity of 80 exceeding 500 cubic metres.	Full EIA

3.2. Contrasting Regulatory Approaches for Environmental Authorisation

In stark contrast to the Western Cape Province, where the environmental authorisation process for fuel stations is solely governed by the stipulations of Section 24 of NEMA, the Gauteng Province has adopted a more rigorous approach to evaluating the risks posed by fuel stations, as expounded by Kruger [30] and Qonono [18]. Among all the provinces in South Africa, it is the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (GDAELA) that has taken the initiative to develop a comprehensive provincial EIA guideline. In addition to conforming to the mandates of Section 24 of NEMA, this guideline proffers specific measures to be considered during the application for an environmental authorisation for the construction of a fuel station and upgrading of USTs in existing ones. A distinctive feature of Gauteng's EIA guideline is its central emphasis on land use considerations, prescribing conditions for the siting of fuel stations and establishing safe distances from sensitive land uses [30].

According to Gauteng's EIA guidelines, those seeking environmental authorisation to construct a fuel station must provide detailed information pertaining to the location of boreholes on the proposed site and adjacent properties. Furthermore, developers must determine the extent to which the public depends on groundwater in the areas to ensure that the proposed location of the station does not affect the users of groundwater. The guidelines strictly prohibit new fuel stations that do not meet the stringent criteria established by Gauteng Province's regulatory framework. Additionally, the Gauteng EIA guideline stipulates that no new fuel stations can be approved "within 100 metres of residential properties, schools, or hospitals, unless it can be clearly demonstrated that there will be no significant noise, visual intrusion, safety concerns or fumes and smells."

Information gathered during interviews revealed that the process is less stringent compared to the Gauteng Province. Participant 2, an integral figure involved in the evaluation of applications for environmental authorisation within the Western Cape, provided insights into the prevailing regulatory landscape. The Western Cape lacks a provincial regulatory or policy requirement akin to Gauteng's EIA guideline for USTs. However, Participant 2 elucidated that, in practice, when assessing applications for environmental authorisation for fuel stations, there exists a prevailing ethos to prohibit the construction of fuel stations near residential areas. Furthermore, Participant 2 emphasised the vital role of public participation during the EIA process. This fact of the regulatory demands empowers the public to voice their concern regarding proposed developments, which can, in turn, lead to the rejection of applications for fuel station developments.

Given the argument of Participant 2, it is imperative to recognise that the effectiveness of public participation hinges on the environmental health literacy of the concerned individuals. Not all members of the public may possess the requisite understanding to anticipate the cumulative impacts that might ensue if a fuel station is permitted in close proximity to their properties. Consequently, there arises a compelling need for clearly

defined regulations stipulating specific conditions that must be satisfied before the issuance of environmental authorisation.

Drawing inspiration from the Gauteng Province's approach, it becomes evident that establishing a comprehensive guideline in the Western Cape, particularly in Cape Town, is imperative. This guideline should delineate unambiguous requirements aimed at safeguarding sensitive land uses in the vicinity of proposed fuel station developments, thereby mitigating the risks of land-use conflicts. Such a standardised approach would foster consistency in the evaluation of applications for environmental authorisations, departing from the prevalent case-by-case methodology observed in the Western Cape Province. As previously asserted by Qonono [18], the absence of criteria governing the siting of fuel stations in the Western Cape carries inherent risks for the surrounding environment. Given the pervasive nature of petroleum fuels in groundwater, as attested to by [34], it is imperative to prioritise the formulation of precautionary criteria delineating the location of fuel stations and establishing a regulatory safe distance (100 metres in the case of Gauteng's EIA guideline) between fuel station stations and groundwater users. This approach is essential to facilitate the evaluation of environmental authorisation, thereby safeguarding both the environment and public health.

3.3. The Duty of Care and Legal Measures for the Protection of Groundwater

In the realm of environmental law in South Africa, a fundamental concept is the imposition of a "duty of care" on activities deemed high-risk, such as fuel stations, given their potential to jeopardise the environment. This duty of care is enshrined within Section 28 of NEMA, which statutorily mandates individuals or entities responsible for environmental degradation to assume responsibility for its prevention, minimisation and remediation. While the NEMA establishes this duty, other related acts like the NEMWA and NWA contain provisions that directly address pollution control emanating from high-risk activities, including fuel stations. However, during the review of pertinent legal documents, two legal measures pertaining to the duty of care emerged as critical in the regulation of environmental risks associated with fuel stations, particularly in relation to groundwater protection. These measures are:

(1) Management of Emergency Incidents: Regulated by NEMA Section 30 (also covered in Part 5 of Chapter 3 of the NWA), this measure outlines procedures for handling emergency incidents related to environmental contamination;
(2) Management of Contaminated Land: This is governed by Part 8 of NEMWA and encompasses legal provisions for soil and groundwater monitoring and remediation. Furthermore, the Framework for the Management of Contaminated Land (2010) complement Part 8 of NEMWA, providing guidelines, including acceptable levels of contamination for different land-use types.

While both these measures are pertinent concerning groundwater contamination caused by fuel stations, they are inherently reactive rather than proactive. This means that these provisions are only pivotal for assessing and correcting the consequences of an incident which may potentially affect receptors such as borehole users. Adding to this concern is the absence of legal provisions compelling the installation of fuel station equipment that is up to current standards and adequate groundwater contamination prevention systems. In contrast, the South African Bureau of Standards has formulated several SANSs relevant to groundwater protection, including SANS 10089, SANS 1830 and SANS 1535 [35–37]. These standards offer up-to-date recommendations and best practices for equipment designed to prevent corrosions, leaks and UST failure that could lead to groundwater contamination. However, these SABS-approved standards are currently voluntary, lacking the legal mechanisms necessary for enforcement.

The risk of groundwater contamination remains particularly significant in older fuel stations established before the development of recent groundwater protection technologies. These older stations are problematic due to their antiquated equipment, which lacks effective pollution prevention mechanisms, such as UST double walls, protective coatings,

or glass-reinforced polyester (GRP). This issue mirrors challenges faced by China, which, in 2011, enacted the National Groundwater Pollution Control Plan (2011–2020) to compel fuel stations to upgrade underground tanks to state-of-the-art pollution prevention equipment [6].

Given historical incidents of groundwater pollution caused by fuel stations, proactive measures are imperative to avert contamination, such as the case in Beaufort West, a town neighbour to Cape Town in the Western Cape. In Beaufort West, a release of fuel that went unnoticed for several years in three fuel stations in the semi-desert Karoo town, where people are heavily reliant on groundwater, resulted in detrimental consequences, with more than 30 boreholes polluted [11]. Although these incidents are not widely discussed in public discourse in Cape Town, Participant 1 pointed out that it is a serious concern, especially in large cities, such as Cape Town, given the data on fuel station incidents over the years. The Contaminated Land Register of South Africa lists more than 70% of cases resulting from fuel station incidents, alerting on the necessity for proactive legal measures for groundwater protection. According to Participant 1, these measures should encompass mandatory groundwater prevention technology requirements for fuel stations, with urgency for older stations that did not undergo the same EIA scrutiny mandated by NEMA.

Regrettably, the review of selected environmental legal instruments reveals that South Africa lacks an integrated instrument governing the environmental aspects of fuel stations. Pertinent legal provisions addressing the protection of boreholes from fuel station risks are primarily found within the NEMA, NEMWA and NWA. However, these acts, while comprehensive, do not specifically stipulate obligations or preventive measures for the scenario of groundwater abstraction points in proximity to fuel stations. Provisions such as Section 28 of NEMA and Section 19 of NWA, while broadly addressing pollution prevention, lack clarity regarding the regulation of fuel stations' proximity to potential boreholes. Interviews with participants from the fuel retail industry (Participants 5, 6 and 7) indicate that, aside from fire hazards, some fuel stations may not prioritise attention to potential contamination near residential areas. Furthermore, interviews with Participants 5, 6 and 7 revealed that there is a necessity to strengthen requirements for effective groundwater near fuel station operations as this aspect seems to be an aspect that retains little attention from fuel retail operators.

Although the South African Constitution guarantees the right to access sufficient water for everyone, a lack of adequate monitoring provision may result in the public relying upon unsafe and contaminated water. According to Seyler, Witthüser and Sunaitis [38], water pollution stands as a prominent impediment to full access to groundwater in South Africa. Monitoring plays a pivotal role in the protection of groundwater resources [38]. South African water legislation provides mechanisms for monitoring water resources, particularly through Chapter 4 of the NWA, which establishes "National Monitoring Systems". However, small-scale water monitoring, such as groundwater monitoring for fuel station sites, is regulated under Section 24(4) of NEMA. This provision assigns monitoring and impact management responsibilities to those undertaking authorised activities. Notably, the governance of groundwater in South Africa is characterised by insufficient monitoring measures [38]. The deficiency in robust monitoring, especially around fuel stations, poses a significant risk to the public, particularly considering the growing reliance on groundwater in the Cape Town region.

4. Land-Use Policies in Cape Town and Groundwater Protection

The crucial task of land use planning and management rests with municipal governments. In Cape Town, the Municipal Planning By-Law of 2015 plays a pivotal role in providing the framework for land-use zoning conditions. This by-law delineates specific zonings under which fuel stations can be established (Table 4). One can identify various zoning specifications pertaining to land-based structures in fuel stations, including aspects such as buildings, land surface and roads, walls and the like. However, a conspicuous omis-

sion is the absence of conditions relating to groundwater abstraction points or dictating a safe distance between fuel stations and neighbouring land users. Groundwater abstraction can influence the migration of petroleum fuel plume contaminants. Consequently, the absence of a designated protection zone for groundwater raises the spectre of groundwater users potentially being exposed to the intake of fuel substances [39].

Table 4. Zonings for fuel station development (Municipal Planning By-Law, 2015).

Zoning/Subzoning	No.	Brief Description
Local Business Zoning 2	57	Provides for low-intensity commercial and mixed-use development, which serves local needs for convenience goods and personal service.
General Business subzoning	61	Provide for general business activity and mixed-use development of a medium to high intensity.
Mixed Use subzoning	65	Accommodate a mixture of business and appropriate industrial and residential development.
General Industry subzoning	75	GI accommodates all forms of industry except noxious trade and risk activity in order to promote the manufacturing sector of the economy.
Risk Industry	77	Provides for noxious industries which carry high risk in the event of fire or accident.

This regulatory gap highlights the importance of incorporating protective land-use conditions into local policies governing fuel station establishments. Doing so can bolster preventive measures against the risks posed to borehole users in Cape Town. By integrating protective land-use conditions within local land-use policies, a critical step forward in holistic environmental risk management will be reached. This will ensure that the vulnerabilities of groundwater users are duly considered in the spatial planning of fuel stations. This strategic alignment between land use policies and groundwater protection not only minimises environmental hazards but also upholds the right to an environment that is not harmful, as enshrined in the South African Constitution. Ultimately, this promotes a sustainable and healthy environment for all Cape Town residents.

5. Fragmentation Existing Regulatory Instruments and Suggestions for Integration

The issue of fragmentation within South Africa's environmental governance framework is a widespread and well-documented problem. This fragmentation has been a significant hurdle, undermining the effectiveness and efficiency of environmental governance efforts in many instances [40,41]. Consequently, there is a growing recognition of the need to integrate the various elements of the environmental governance framework to enhance implementation efficiency [38].

In the context of regulating the impacts of fuel stations on groundwater, the review of regulatory frameworks and relevant documents highlighted a concerning level of fragmentation within the legal framework. The conditions and requirements for the protection of groundwater and control of the impact of fuel station stations are dispersed across multiple pieces of legislation (NEMA, NEMWA, NWA) and their subordinate documents, often managed by distinct government departments rather than consolidated into a unified document designated aspects related to fuel stations. This fragmentation poses a potential threat to the effectiveness of regulation governing environmental aspects related to fuel stations. Moreover, it introduces complexity in the implementation and compliance with legal measures aimed at safeguarding groundwater.

To address the pervasive issue of fragmentation, the establishment of a specialised regulatory instrument dedicated to governing fuel station aspects in general and groundwater protection, in particular, will be necessary. This is arguably a more pragmatic approach that can circumvent challenges posed by the fragmentation of regulatory documents for fuel stations' environmental aspects. Furthermore, the harmonisation of the disparate legal instruments and requirements currently applicable to fuel stations would culminate in the creation of an

integrated and cohesive regulatory process for all aspects of fuel stations (Figure 2), thereby facilitating compliance with legal measures for environmental protection.

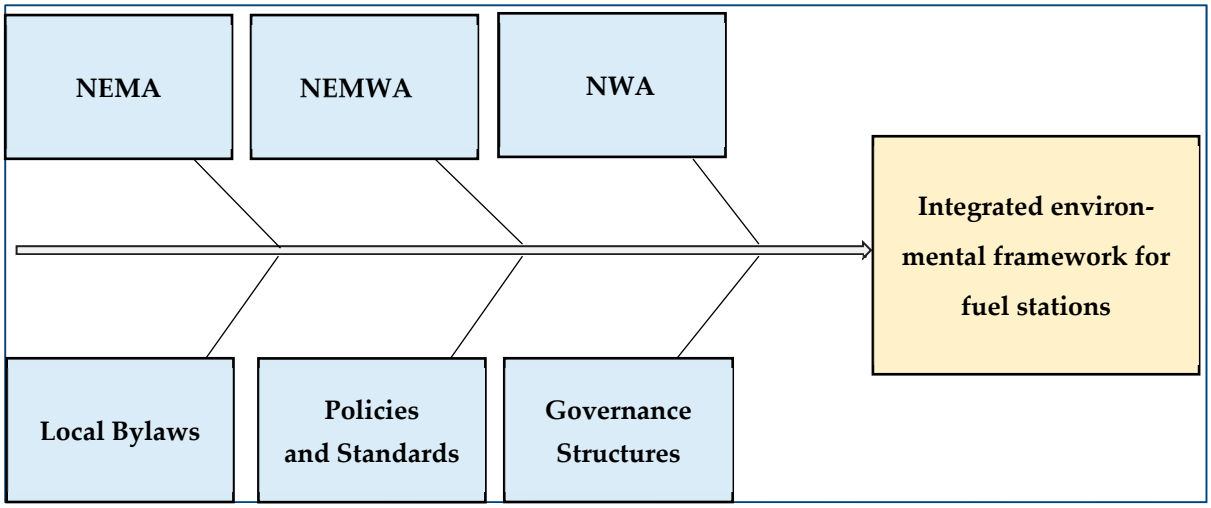

Figure 2. Elements to consider for an integrated framework for fuel stations.

6. Conclusions

This study undertook a comprehensive review of the legal framework governing the impacts of fuel stations on groundwater, focusing on the city of Cape Town, to illuminate the legal measures adopted for preventing and mitigating these impacts. The regulation of fuel station development and the control of their environmental effects predominantly rely on national environmental legislation, especially NEMA, NEMWA and NWA. Notably, the responsibility for land-use management falls under the purview of local municipal authorities, as mandated by the Constitution of South Africa.

The focal point for controlling fuel development lies in Section 24 of the NEMA, which mandates the requirement for environmental authorisation and EIA for activities classified as "listed activities". This precautionary process serves to uncover potential impacts, such as groundwater contamination, before development proceeds. However, a critical deficiency in the legal framework emerges in the absence of specific provisions at the national, provincial and local levels stipulating safe distance between fuel stations and other land uses. This regulatory gap may have inadvertently facilitated the proliferation of fuel stations in close proximity to residential properties. The study finds that the current legal framework governing the impacts of fuel stations on groundwater exhibits limited adequacy due to several factors. This includes the absence of specific provisions addressing groundwater contamination risks specific to fuel stations, posing a significant challenge. This regulatory gap results in inadequate considerations of potential borehole contamination in the vicinity of fuel stations. Furthermore, the fragmented nature of the instruments regulating fuel stations' impacts on groundwater may impede the effective implementation of existing groundwater protection measures.

To address these shortcomings and enhance the protection of groundwater, several recommendations are put forth. These include mandating the SABS-approved petroleum industry standards as legally enforceable norms. Additionally, it is advisable for authorities responsible for land-use planning in Cape Town to establish specific minimum safe distances (buffers) between fuel stations and sensitive land uses as precautionary measures. This study is expected to contribute significantly to bolstering efforts to prevent groundwater contamination and reduce the vulnerability of residents relying on groundwater near fuel station sites, ultimately fostering greater environmental sustainability.

To ensure the effective implementation of the recommended measures, it is essential to foster collaboration among relevant stakeholders, including government authorities, environmental agencies, industry representatives and local communities. This collaborative

effort should focus on developing and implementing necessary policies and regulations. Furthermore, public awareness should be an integral part of this collaboration to educate both communities and fuel station operators about the significance of environmental protection, with a specific emphasis on safeguarding groundwater protection.

Author Contributions: E.A.N.: Conceptualisation, methodology, data collection, data analysis, writing—original drafts and project administration. N.M.: Supervision, project administration and writing—review and editing. T.M.: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical approval was obtained from the Cape Peninsula University Technology's Faculty Research Ethics Committee within the Faculty of Applied Sciences.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data are presented in the paper.

Conflicts of Interest: The Authors declare no conflict of interest.

Appendix A

Table A1. Semi-structured interview framework.

Question 1: In practice, what are the most important pieces of environmental legislation triggered by the development, construction and upgrade of fuel stations in the Western Cape?
Question 2: Generally, what are the criteria guiding the review of an environmental impact assessment report with regard to fuel station development applications?
Question 3: What are the regulatory requirements for the development of fuel stations and control of the risk they pose in the environment in Cape Town, South Africa?
Question 4: Do fuel stations pose risks to groundwater and boreholes in Cape Town?
Question 5: During the EIA process, is there any specific consideration given to the proximity of fuel stations and vulnerable land uses, such as residential, hospital, school, hospital, etc.?
Question 6: How does "contaminated land" relate to groundwater contamination?
Question 7: With regards to land-use management, what are the legal frameworks for the development of fuel stations and control of the risk they pose to the environment?
Question 8: Do you see any potential for land use conflicts between fuel stations and sensitive land uses in the Western Cape?
Question 9: How would you describe the approach to managing the risk posed by fuel stations in Cape Town?
Question 10: Do the legal requirements for the installation and upgrade of underground storage tanks in Cape Town address issues of the vulnerability of boreholes in the surrounding fuel stations?

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